Fish Passage Assessment Tool mobile application

User Guide - Version 2.0

Prepared for Ministry for Business Innovation & Employment and Ministry for the Environment

February 2022

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NIWA CLIENT REPORT No: 2018349HN
Report date: February 2022
NIWA Project: ELF16211/MFE21202

Quality Assurance Statement		
	Reviewed by:	Eleanor Gee
	Formatting checked by:	Alison Bartley
	Approved for release by:	David Roper

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1 Introduction

The objective of the NZ Fish Passage Assessment Tool is to provide an easy to use, practical tool for identifying instream structures and assessing their likely impact on fish movements past the structure. The assessment tool is implemented as a freely available mobile application (app) for both iOS and Android operating systems.

The app can be used to collect information on instream structures that will help to understand the extent to which fish migrations are disrupted in New Zealand. Information that can be gathered includes the location of the structure, photos of the structure, and information about the type of structure and its characteristics. That information is automatically uploaded to a national database and can be viewed and downloaded from the Fish Passage Assessment Tool website.

The tool is consistent with and can be used to collect all the required information set out in the fish passage provisions of the National Environmental Standards for Freshwater (NES-F; New Zealand Government 2020) and National Policy Statement for Freshwater Management (NPS-FM; MfE 2020).

This tool complements the New Zealand Fish Passage Guidelines, which set out recommended practice for the design and monitoring of instream infrastructure to provide for fish passage. The guidelines can be downloaded from: www.niwa.co.nz/fishpassage

This user guide provides information on how to record and assess an instream structure using the Fish Passage Assessment Tool mobile app.

2 Quick start guide

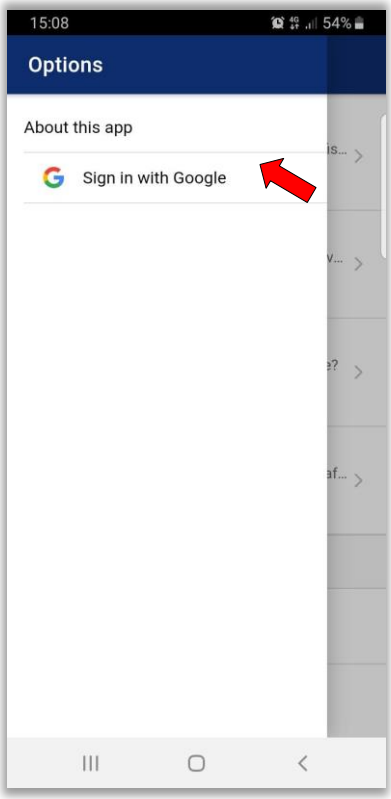
2.1 Install the app

To install the NIWA Citizen Science mobile app visit the Google Play Store or Apple App Store using your mobile device and search for “NIWA Citizen Science”.

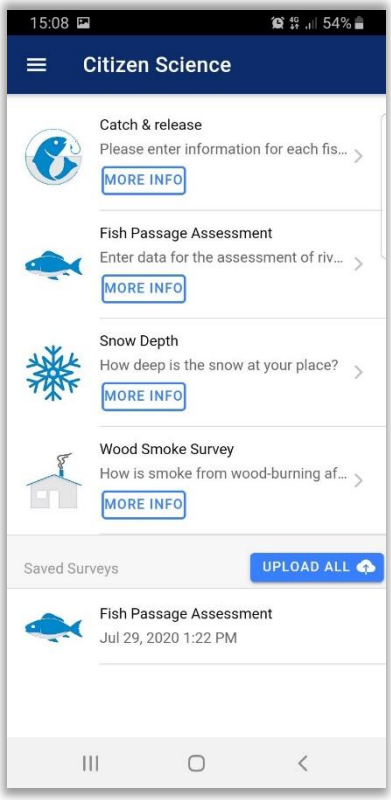
Alternatively follow the direct links to the Android or iOS versions of the app and install it on your device.

2.2 Login to the app

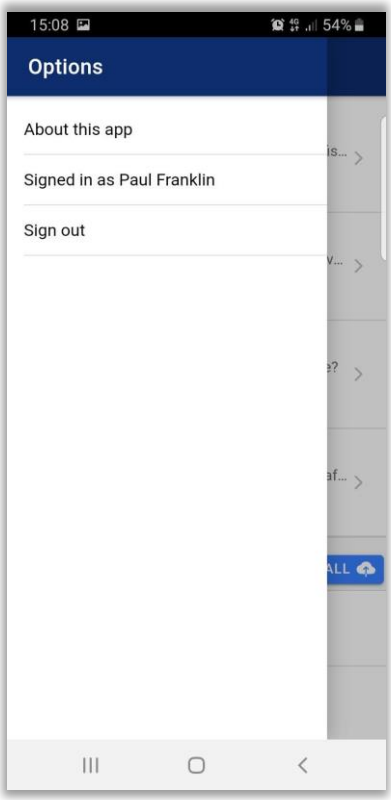
1. Open the NIWA Citizen Science app on your mobile device.
2. When you open the app you must login with your Google account.
3. Tap on the Sign in button and enter your Google account details to login.
4. If you do not have a Google account you can create one by visiting www.google.co.nz



5. Once you have logged in you will see a list of surveys available in the NIWA Citizen Science app.

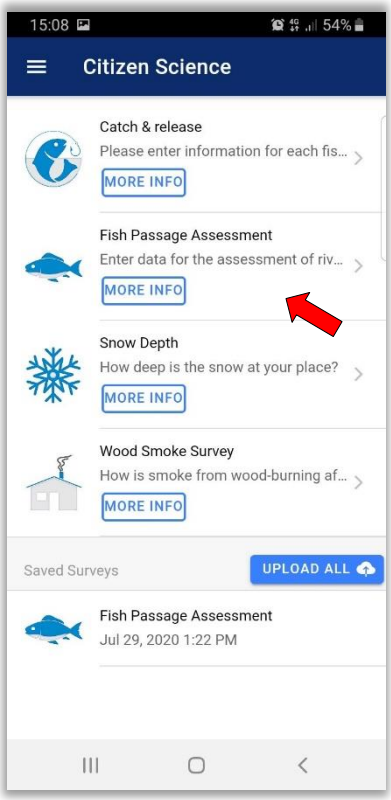


6. You can check to see if you are logged in by tapping on the **Options** menu in the top left corner of the NIWA Citizen Science app.

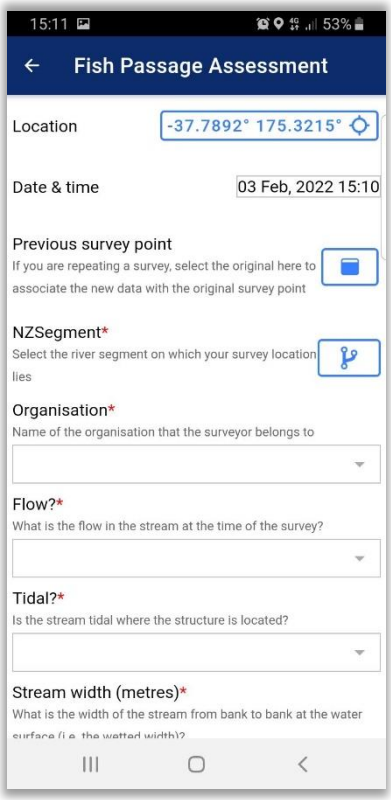


2.3 Start a survey

1. In the NIWA Citizen Science app, tap on the Fish Passage Assessment Tool to start a survey.

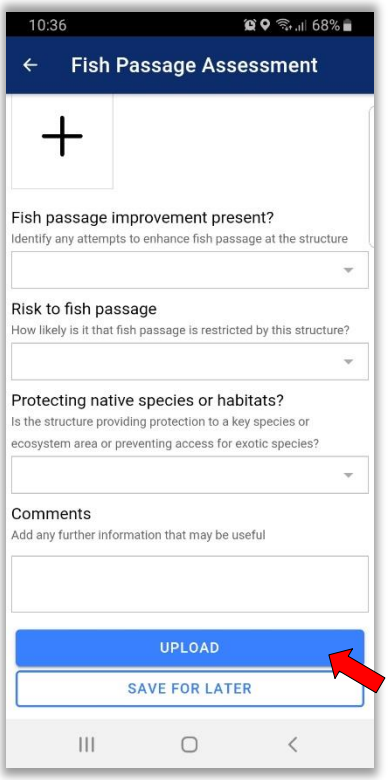


2. When you open the Fish Passage Assessment Tool, the survey will load and you are ready to begin.
3. Answer the questions in the survey. Questions marked * are compulsory and must be completed before a survey can be submitted.
4. For more details on how to complete a survey, see Section 3 below.



2.4 Submit a survey

1. Once you have completed the survey, you can either submit your answers or save them for later.
2. To submit your answers to the fish passage database, tap **Upload**.
3. To save your answers so that you can return to them later, tap **Save for later**.



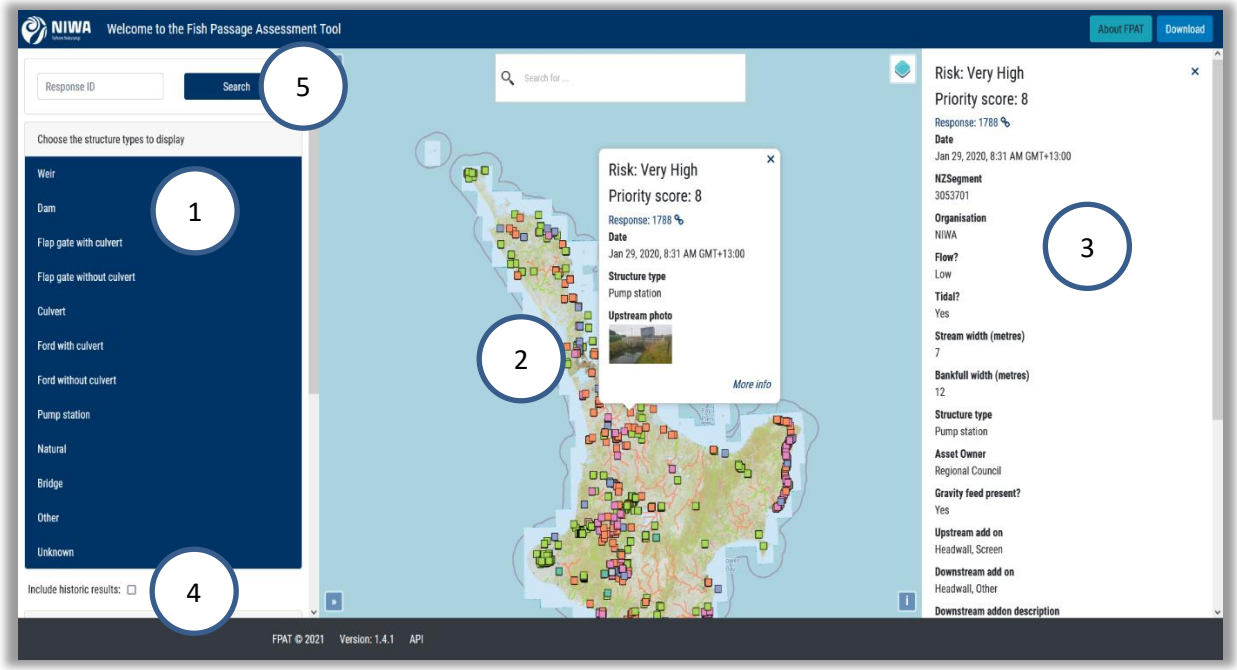
2.5 View and download data

To view and download data that have been uploaded to the database visit the [Fish Passage Assessment tool website](#).

Fish passage risk rankings and prioritisation scores are calculated overnight and will not be available until the day after they records have been submitted using the mobile app.

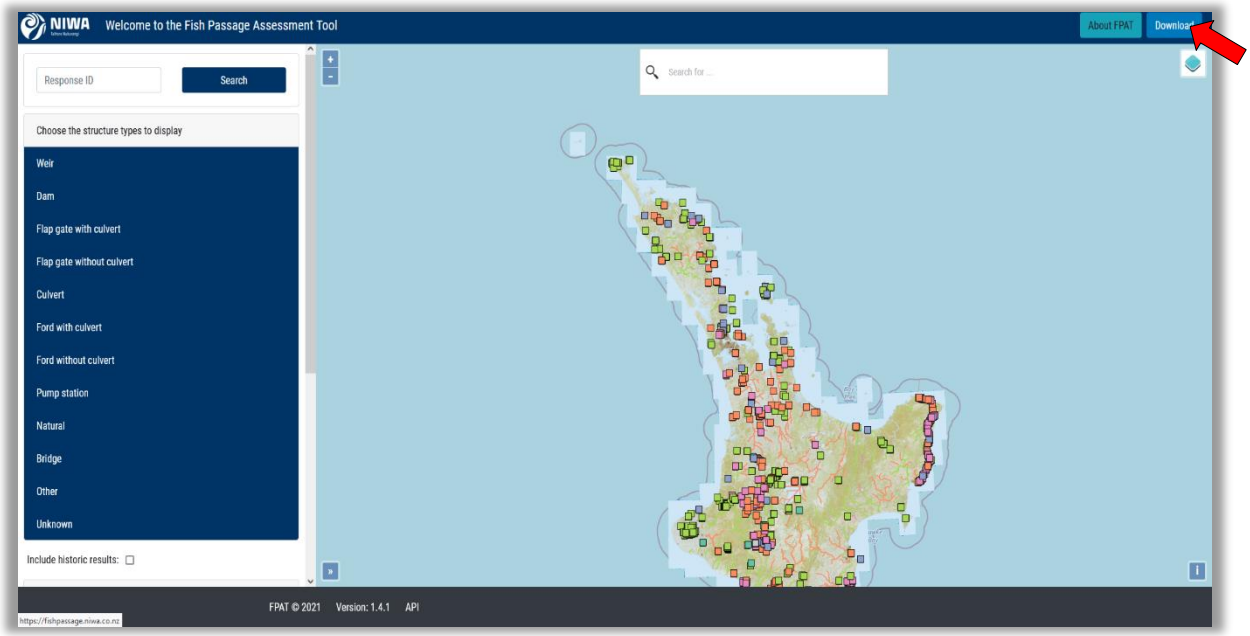
2.5.1 View data

You can choose the structure types you want to display on the map by selecting them in the panel on the left side bar (1). Structures are shown on the map as dots coloured according to their risk rating. Click on a dot to see information about a structure (2). To see more information about the structure, click on **More info** (3). You can also include or exclude the historical data that have been uploaded to the FPAT database by checking or unchecking the box (4). If you know the Response ID number for a specific record in the database you can search for the record by entering the Response ID number in the search box (5).

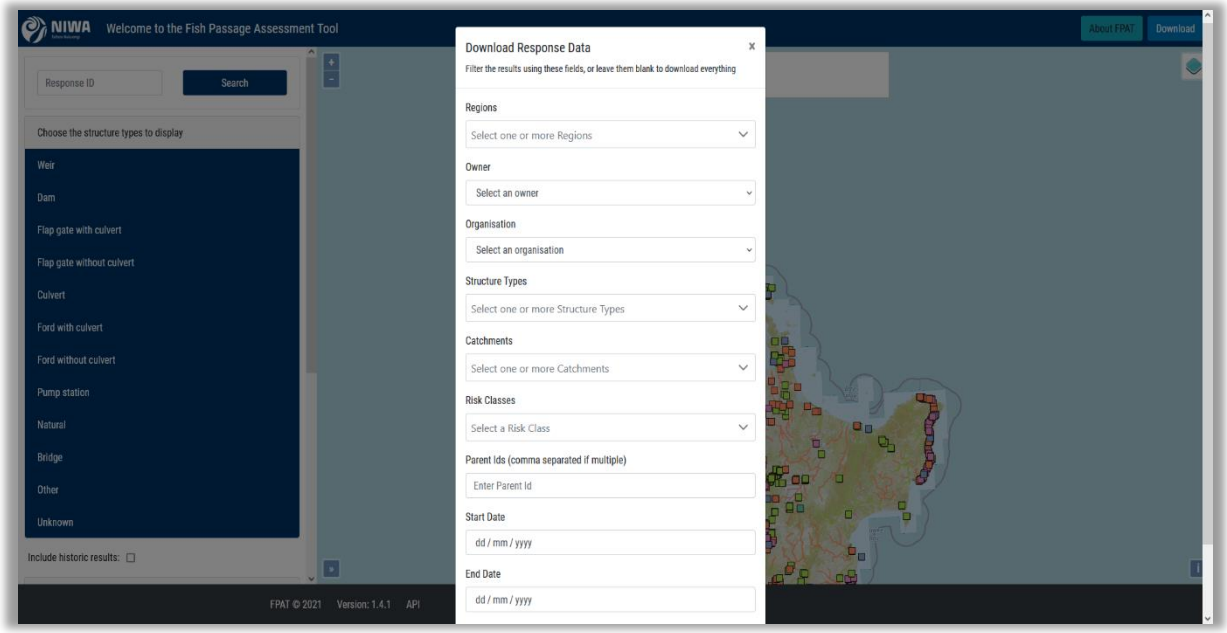


2.5.2 Download data

You can download data from the database in comma-separated value (.csv) format. Click on the **Download** button and **Download Response Data** box will appear.



To download all records, leave all the fields blank and click on the green **Download** button at the bottom of the box. Otherwise, you can filter data using the different fields in the box before downloading the data.



2.5.3 API

Data are also available via the FPAT results search API available at https://api.niwa.co.nz/fpat. Users are required to register an account with NIWA and generate an API key. Information about this process is available at https://developer.niwa.co.nz/get-started. The FPAT API is documented and available at https://developer.niwa.co.nz/docs/fpat/1/overview.

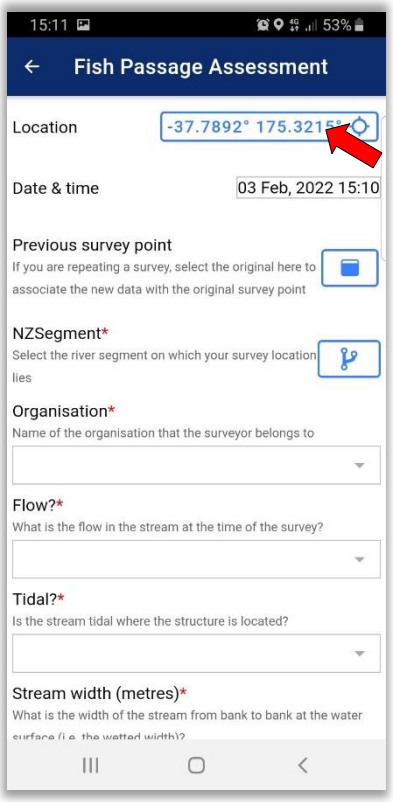
3 How do I complete a survey?

This section provides help on how to complete a survey. Use the Quick Start Guide (Section 2) to get information on how to login to the app and start a survey.

3.1 Select location

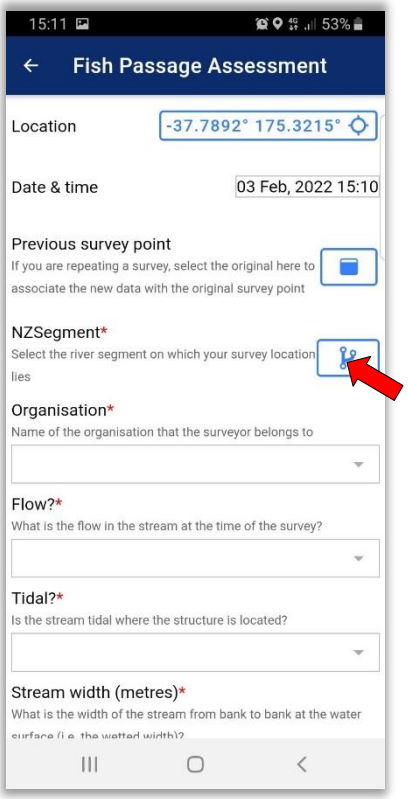
3.1.1 New site

1. The app uses your phone's GPS to determine your location.
2. Stand as close as safely possible to the structure you are about to assess.
3. Tap on the **Location** icon to confirm the location of the site to be assessed.

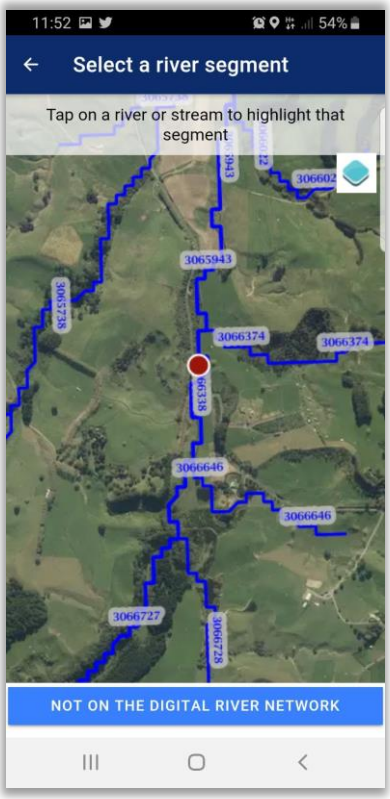


4. A map of the local area will open, with a blue dot marking your location and a red dot showing the location of the structure.
5. You can move the map by dragging it with one finger.
6. You can zoom in and out on the map using a two-fingered pinching motion.
7. Tap the exact location on the map where the structure you are assessing is located. This will move the red dot to that location.
8. When the red dot is in the right place, tap **OK** to confirm the location.

9. Next select the NZSegment number. This is used to link the record to the right place on the New Zealand digital river network.
10. Tap on the icon next to **NZSegment**.



11. A map will be displayed with the digital river network and NZSegment numbers overlaid.

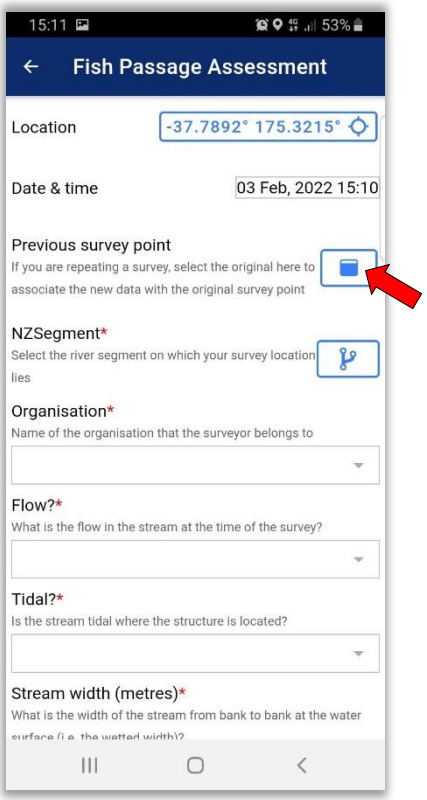


12. Tap on the nearest stream to highlight that section.
13. Tap on **Select river segment** to confirm the NZSegment number that the structure is located on.
14. If the structure is not located on the digital river network (e.g. a small side stream), tap on the **Not on the digital river network** button at the bottom of the screen.

3.1.2 Re-survey an existing site in the database/check for existing records

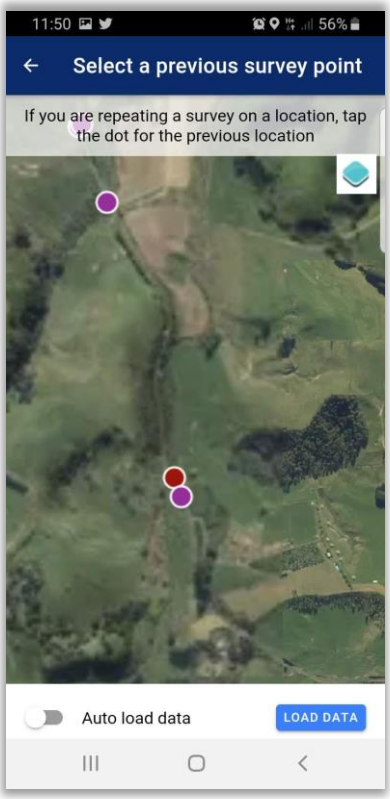
1. Tap on **Previous survey point** if you are repeating a survey at a site that already exists in the database.

2. If you don't know if your site has previously been assessed, you can also check here. It is good practice to check this at every site.



3. A map will be displayed showing your location (red dot) and the location of any records that are already in the database (purple dots).

4. You may need to tap the **Load data** button to show any existing records. Alternatively, you can toggle the **Auto load data** button to **on** so that any existing records automatically load as you scroll around the map.

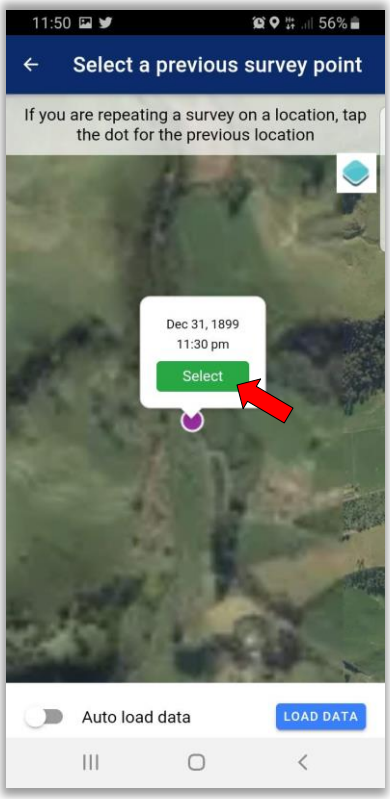


5. If there is an existing record at your location, tap on purple dot to show the date and time of the last assessment at this site. Tap **Select** if you are going to re-survey this point.

6. This will load the existing location data and link this assessment to the existing record in the database. It will also automatically pre-populate some of the key fields in the survey where existing data are available.

7. It is good practice to check the location and NZSegment of the existing record are correct. Follow the instructions in Section 3.1.1 to view this information and update it if it is incorrect.

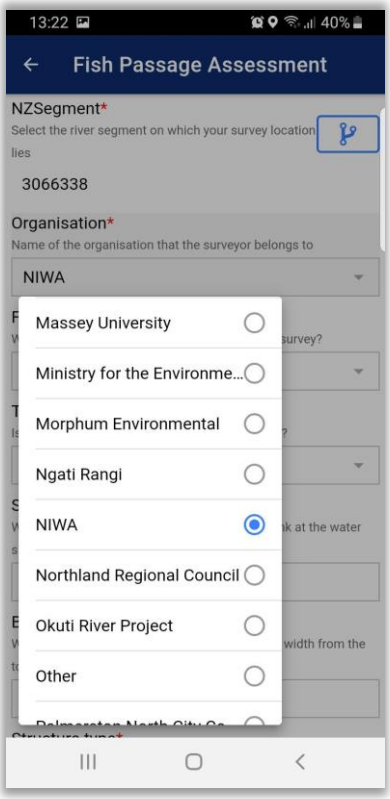
8. Where survey fields are pre-populated from an existing record. It is good practice to check they are still correct.



3.2 Organisation

1. Tap on **Organisation** to select your affiliation from the drop-down list.

2. If your organisation does not exist in the list, you can select **Other** and enter your affiliation manually. Alternatively, you can contact NIWA and have the name of your organisation added to the list.

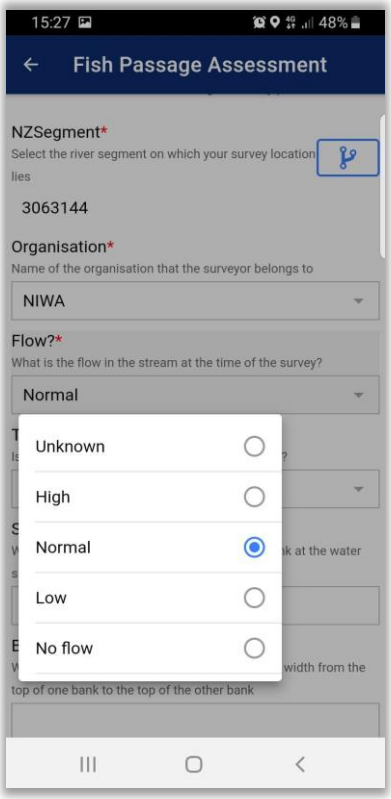


3.3 Record river conditions

1. Tap on **Flow** to record the flow at the time of the survey.

2. Tap on the **radio button** to select your option.

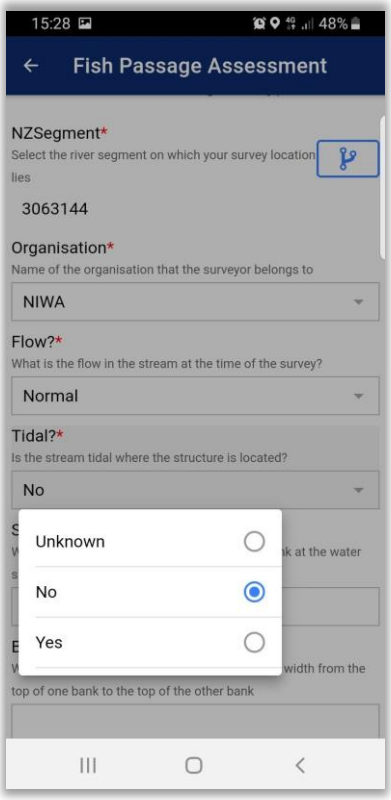
No flow	Select this when the stream bed is dry.
Low	Select this when flows are below normal summer flow levels.
Normal	Select this when the flow is at the normal level for that time of year.
High	Select this when the flow is above normal for that time of year due to rainfall.
Unknown	Select this if you do not know the flow.



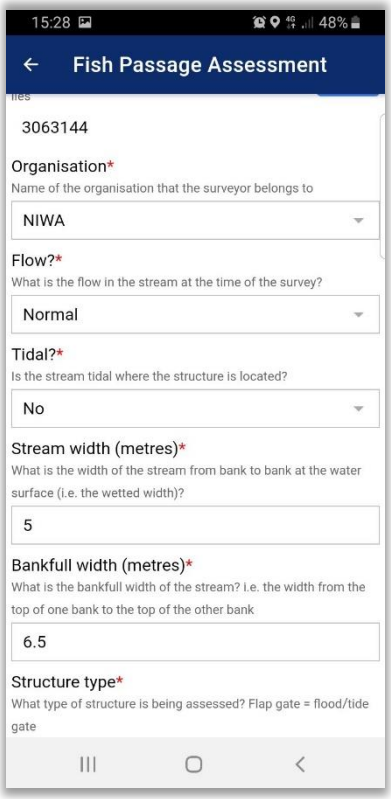
3. Tap on **Tidal** to record if the stream or river is influenced by the tide at the survey site.

4. Tap on the **radio button** to select your option.

Yes	Select this when you know the stream is tidally influenced at the survey location.
No	Select this when you know the stream is not tidally influenced at the survey location.
Unknown	Select this if you do not know if the survey site is tidally influenced.

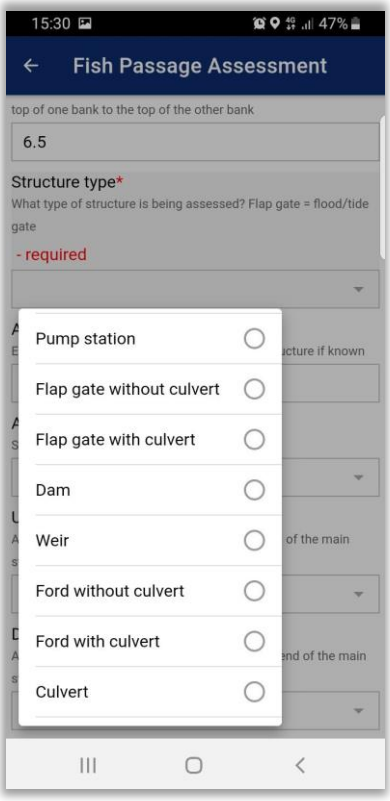


5. Tap **Stream width** and enter the wetted width of the stream in metres using the keypad.
6. The wetted width is the average width of the river at the waters' surface (see Appendix A for more details on how to measure this).
7. Tap **Bankfull width** and enter the bankfull width of the stream in metres using the keypad.
8. The bankfull width is the average width of the river channel at the top of the banks (see Appendix A for more details on how to measure this).



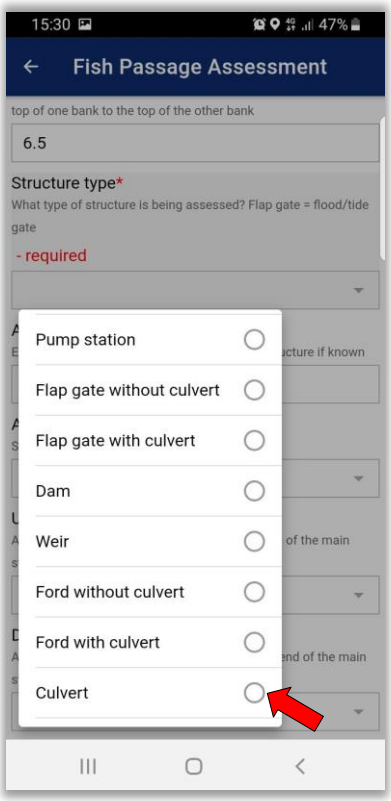
3.4 Record structure type

1. Tap on **Structure type** to select the type of structure that you are assessing.
2. Tap on the **radio button** to select the structure type.
3. Examples of different structure types are provided for reference in Appendix B.

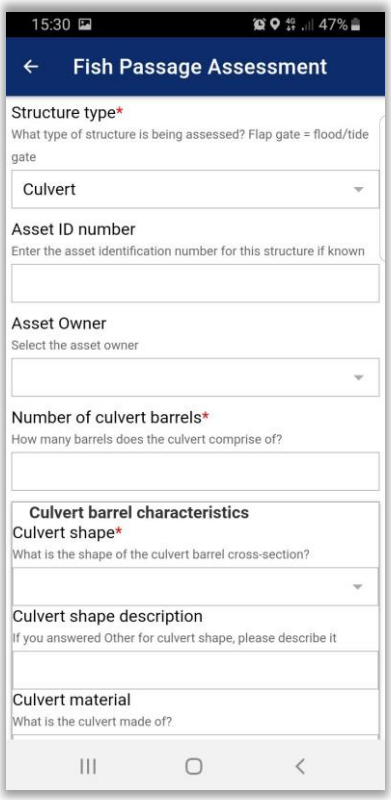


3.4.1 Assess a culvert

1. Tap on **Culvert** to assess a culvert.



2. If you know an **Asset ID number** for the structure enter it using the keypad.
3. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.

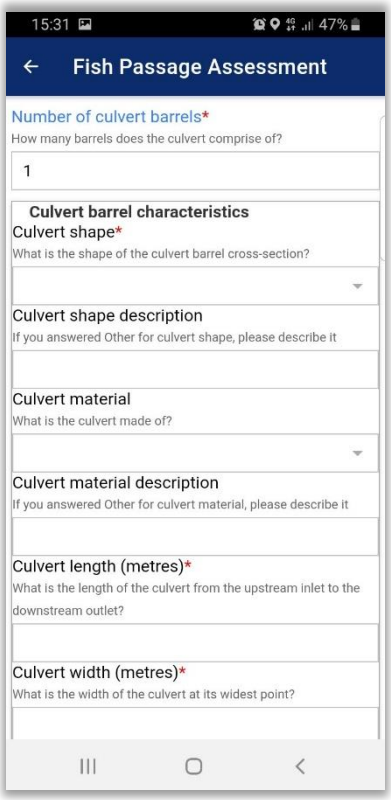


4. Tap on **Number of culvert barrels** and enter the number using the keypad.

5. Next complete the questions describing the **Culvert barrel characteristics**. See Appendix C for further details on what to measure and how.

6. Tap on **Culvert shape** and tap on a **radio button** to select an option.

Pipe	Select this for circular or oval culverts.
Box	Select this for square or rectangular culverts.
Arch	Select this for arch culverts (i.e., they have an open bottom).
Other	Select this if your culvert doesn't fit any of the other descriptions. Add a description in the **Culvert shape description** box.

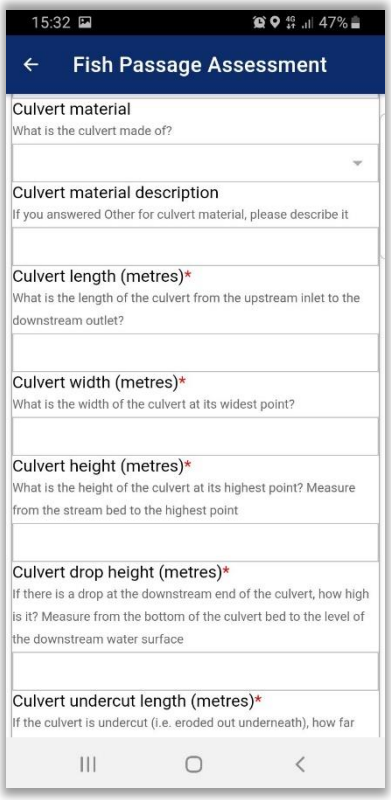


7. Tap on **Culvert material** and select the different materials the culvert is made of by tapping the **Tick boxes**. You can select more than one.

8. Tap **Culvert length** and enter the length of the culvert in metres using the keypad.

9. Tap **Culvert width** and enter the width of the culvert in metres using the keypad. This should be measured at the widest point.

10. Tap **Culvert height** and enter the height of the culvert in metres using the keypad. This should be measured at the highest point to the base of the culvert, or to the stream bed where the culvert is embedded.

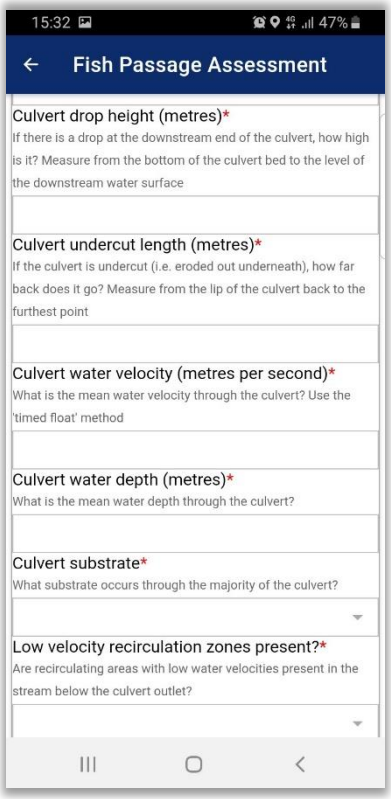


11. Tap on **Culvert drop height** and enter the height in metres of any drop that may exist at the downstream end of the culvert. See Appendix C for details on how to measure drop height.

12. Tap on **Culvert undercut length** and enter the length in metres of any undercut that may exist at the downstream end of the culvert. See Appendix C for details on how to measure undercut length.

13. Tap on **Culvert water velocity** and enter the mean water velocity through the culvert in metres per second. See Appendix C for details on how to measure culvert water velocity.

14. Tap on **Culvert water depth** and enter the mean water depth through the culvert in metres. See Appendix C for details on how to measure culvert water depth.



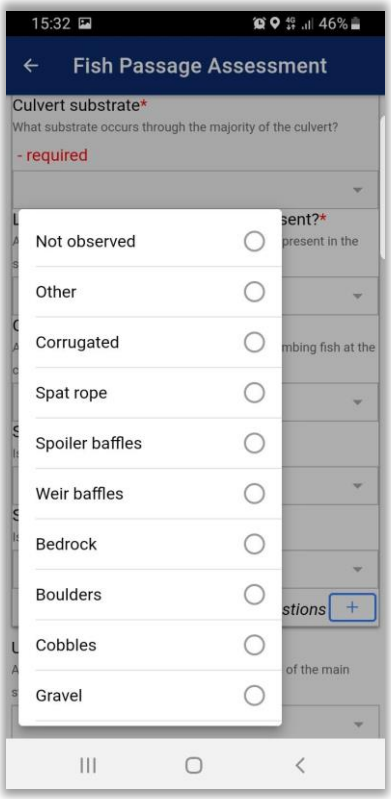
15. Tap on **Culvert substrate** to select the substrate present on the majority of the culvert floor.

16. Tap on **Low velocity recirculation zones present** and select whether they are present or absent. See Appendix C for more details on how to identify this characteristic.

17. Tap on **Culvert wetted margins** and select whether they are present or absent. See Appendix C for more details on how to identify this characteristic.

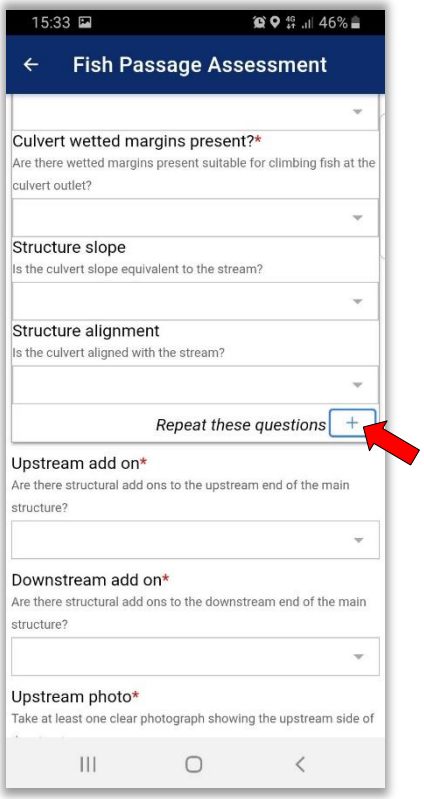
18. Tap on **Structure slope** and select an option from the drop-down list.

19. Tap on **Structure alignment** and select an option from the drop-down list.



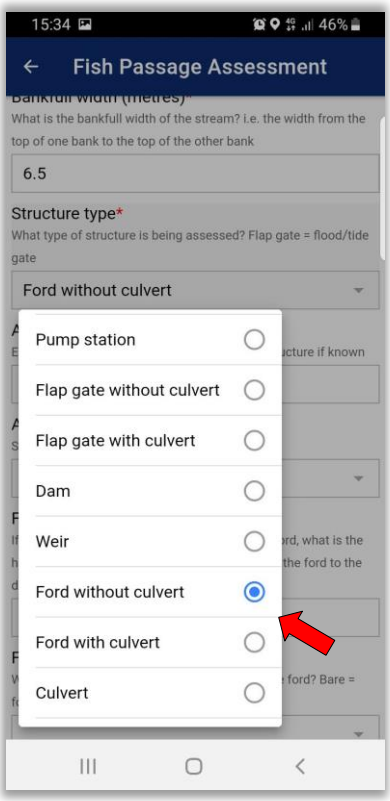
20. If there is more than one culvert barrel (i.e., you are assessing a multi-barrel culvert), you will have to complete the questions on **Culvert barrel characteristics** for each culvert barrel.

21. Tap on the **+** next to **Repeat these questions** to repeat the questions for the next culvert barrel.

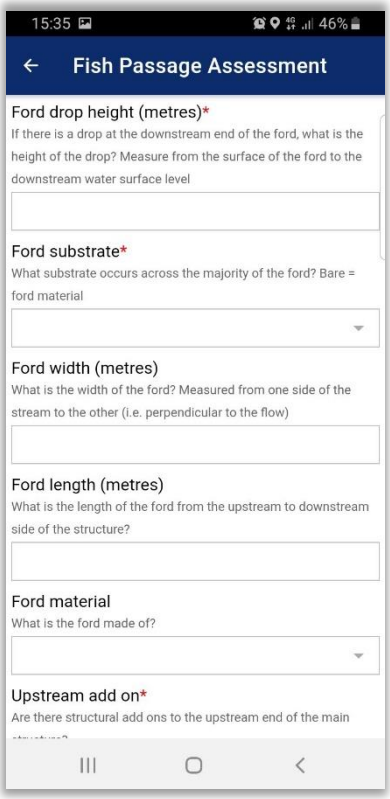


3.4.2 Assess a ford

1. Tap on **Ford with culvert** or **Ford without culvert** to assess a ford (see Appendix B for further explanation of ford types if required).
2. The questions on **ford characteristics** will appear and can now be completed. If Ford with culvert is selected, the questions on culvert barrel characteristics will also appear and must be completed.
3. If you know an **Asset ID number** for the structure enter it using the keypad.
4. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.



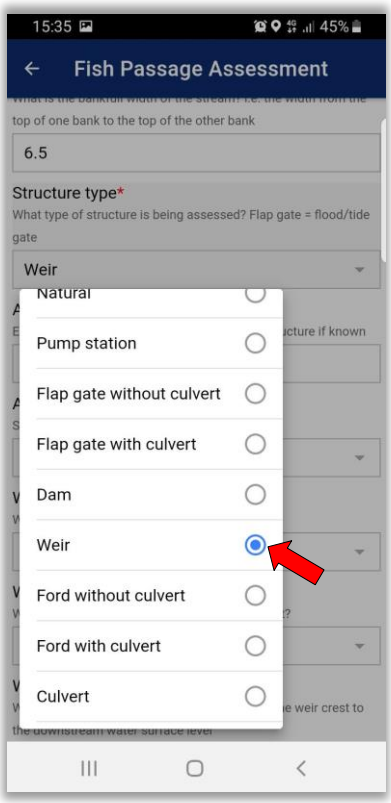
5. Tap on **Ford drop height** and enter the height in metres of any drop that may exist at the downstream side of the ford. This is measured vertically from the surface of the ford to the downstream water surface level.
6. Tap on **Ford substrate** and select an option from the drop-down list. The ford substrate is the material that covers the majority of the top surface of the ford. Only one option can be selected.
7. Tap on **Ford width** and enter the width of the ford in metres. Ford width is measured from one side of the stream to the other.
8. Tap on **Ford length** and enter the length of the ford in metres. Ford length is measured from the upstream to downstream side of the structure.
9. Tap on **Ford material** and select what the ford is made of from the drop-down list. Multiple selections are allowed.



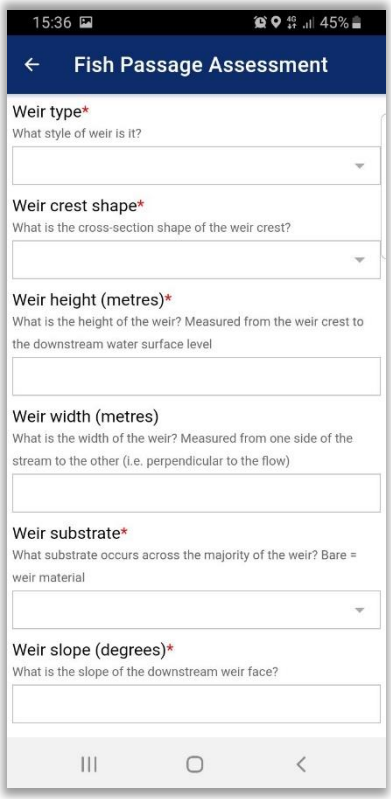
10. If you are assessing a **Ford with culvert**, you must also complete the **culvert barrel characteristics** questions. See Section 3.4.1 for details on how to complete this section.

3.4.3 Assess a weir

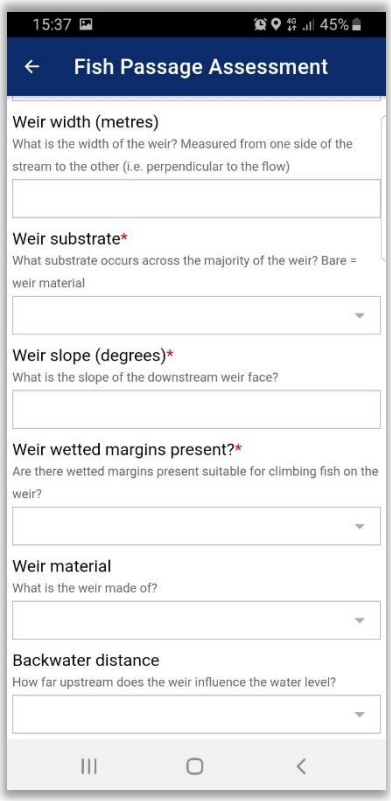
1. Tap on **Weir** in **Structure type** to assess a weir.
2. The questions on **Weir characteristics** will appear and can now be completed.
3. If you know an **Asset ID number** for the structure enter it using the keypad.
4. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.



1. Tap on **Weir type** and select the best description of the weir from the list. More information on weir types can be found in Appendix D.
2. Tap on **Weir crest shape** and select shape of the weir crest cross-section from the list. More information on weir crest shapes can be found in Appendix D.
3. Tap on **Weir height** and enter the height of the weir in metres using the key pad. Weir height is measured as the vertical distance from the weir crest to the downstream water surface level.
4. Tap on **Weir width** and enter the width of the weir in metres. Weir width is measured perpendicular to the flow. More information on how to measure this can be found in Appendix D.

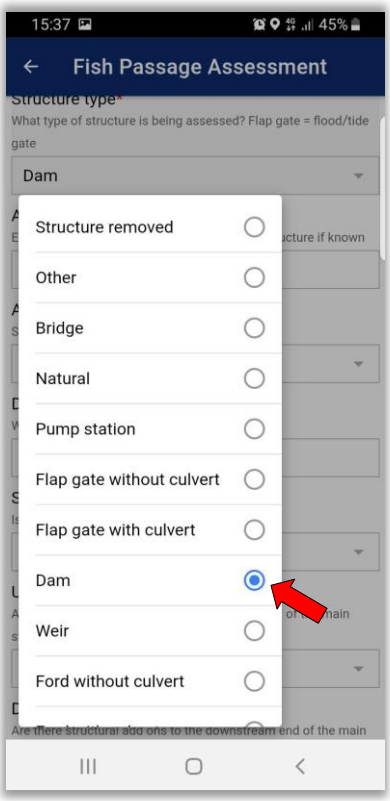


5. Tap on **Weir substrate** and select an option from the drop-down list. The weir substrate is the material that covers the majority of the surface of the weir. Only one option can be selected.
6. Tap on **Weir slope** and enter the approximate slope of the downstream face of the weir. More information on how to measure this can be found in Appendix D.
7. Tap on **Weir wetted margins** and select whether they are present or absent. See Appendix D for more details on how to identify this characteristic.
8. Record the material that the weir is made of by tapping on **Weir material** and selecting from the drop-down list. Multiple options can be selected.
9. Tap on **Backwater distance** and select how far upstream that the weir influences the stream water level. See Appendix D for more details on how to identify this characteristic.

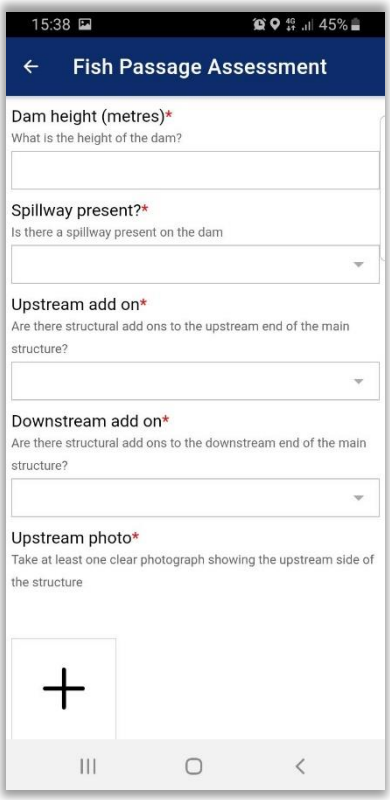


3.4.4 Assess a dam

1. Tap on **Dam** in **Structure type** to assess a dam.
2. The questions on **Dam characteristics** will appear and can now be completed.
3. If you know an **Asset ID number** for the structure enter it using the keypad.
4. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.

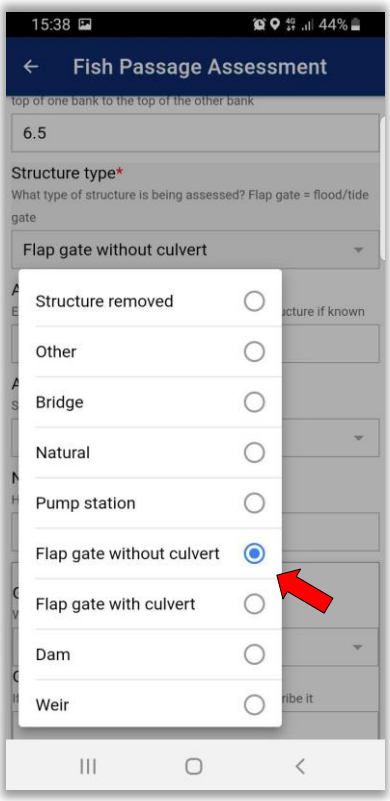


5. Tap on **Dam height** and enter the estimated or measured height in metres using the key pad. This is measured from the dam crest to the level of the water surface on the downstream side of the dam.
6. Tap on **Spillway present** to record whether there is a spillway on the dam.

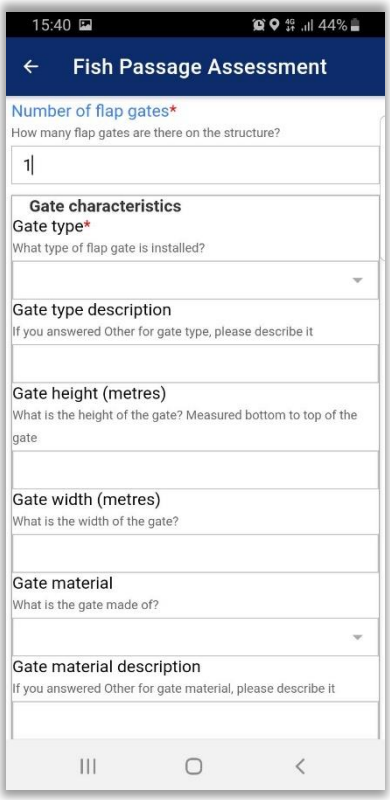


3.4.5 Assess a flap gate

1. Tap on **Flap gate with culvert** or **Flap gate without culvert** to assess a flap gate (see Appendix B for further explanation of flap gate types if required).
2. The questions on **Flap gate characteristics** will appear and can now be completed.
3. If you know an **Asset ID number** for the structure enter it using the keypad.
4. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.



5. Tap on **Number of flap gates** and record the number of gates present.
6. Where more than one flap gate is present, you will need to complete the questions on **Gate characteristics** for each gate.
7. Tap on **Gate type** to select the type of flap gate that is installed. For more information on gate types see Appendix B.
8. Tap on **Gate height** and enter the height of the gate in metres. This is measured vertically from the top to the bottom of the gate.
9. Tap on **Gate width** and enter the width of the gate in metres. This is measured at the widest point of the gate.
10. Tap on **Gate material** to record what the gate is made of. You can select multiple options from this list.



11. If you have another gate to assess, tap on the + button next **to Repeat these questions** to add another set of the **Gate characteristics** questions.

12. If you selected Flap gate with culvert, please complete the Culvert fields as described in Section 3.4.1.

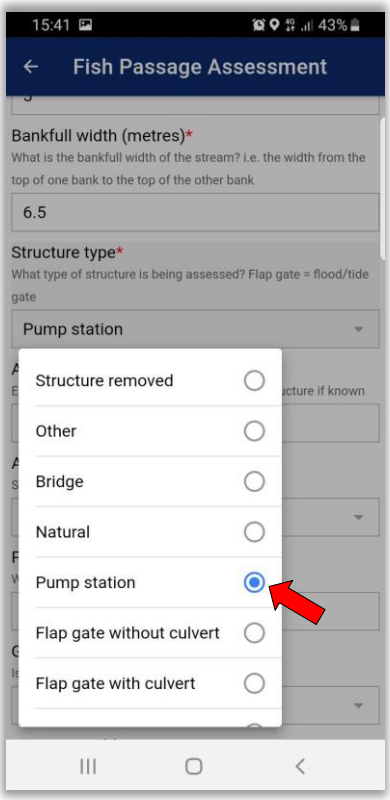
3.4.6 Assess a pump station

1. Tap on **Pump station** in **Structure type** to assess a pump station.

2. The questions on **Pump station** characteristics will appear and can now be completed.

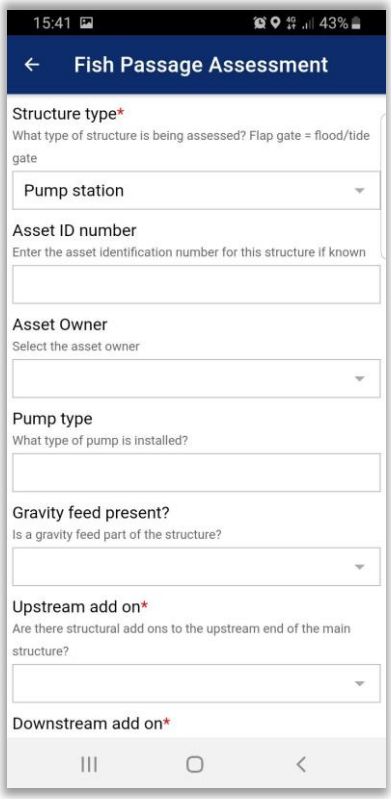
3. If you know an **Asset ID number** for the structure enter it using the keypad.

4. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.



5. If you know the **Pump type** record this by tapping on **Pump type** and enter text using the key pad.

6. Tap on **Gravity feed present** to record if there is a bypass channel as part of the structure.

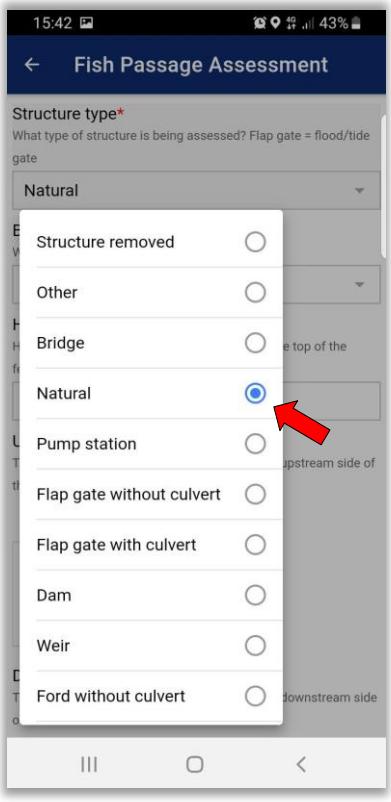


3.4.7 Assess a natural barrier

1. To assess a natural barrier, e.g., waterfall, select **Natural** for the **Structure type**.

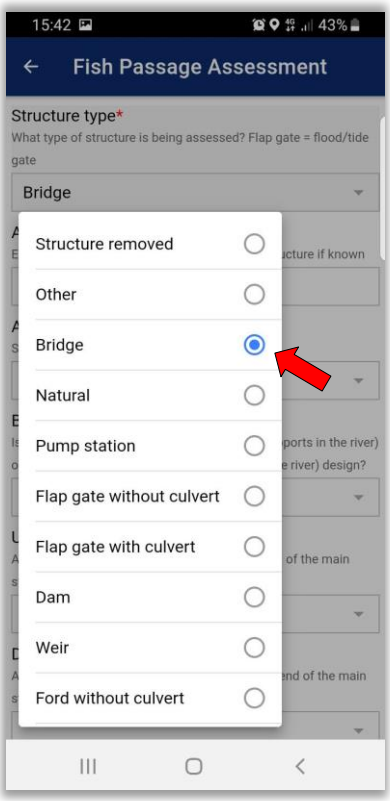
2. Tap on **Barrier type** and select the type of natural barrier you are assessing from the drop-down list.

3. Record the height of the barrier by tapping on **How high is it?** and entering the height in metres.

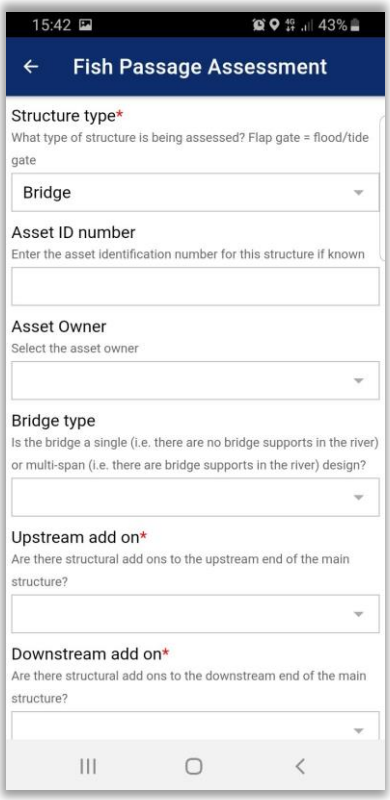


3.4.8 Assess a bridge

1. Tap on **Bridge** in **Structure type** to assess a bridge.

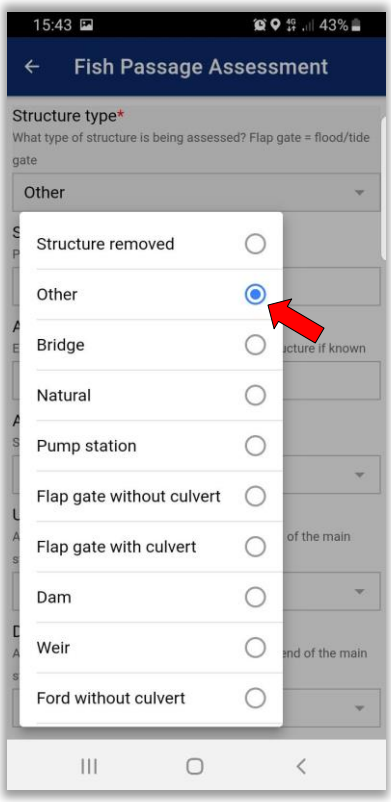


2. If you know an **Asset ID number** for the structure enter it using the keypad.
3. Select an **Asset Owner** from the drop-down list if you know who owns/is responsible for the structure.
4. Record the **Bridge type** by tapping on **Bridge type** and selecting an option from the drop-down list.



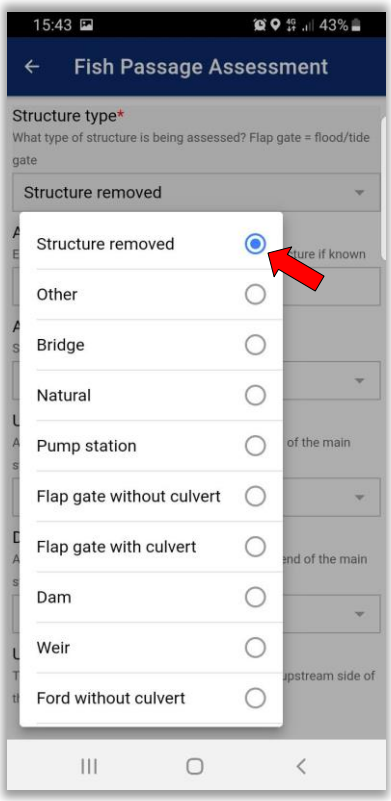
3.4.9 What do I do if the structure type I am assessing is not on the list?

1. If the type of structure you are assessing is not on the list, tap on **Other**.
2. Add a description of the structure in the text box that appears.



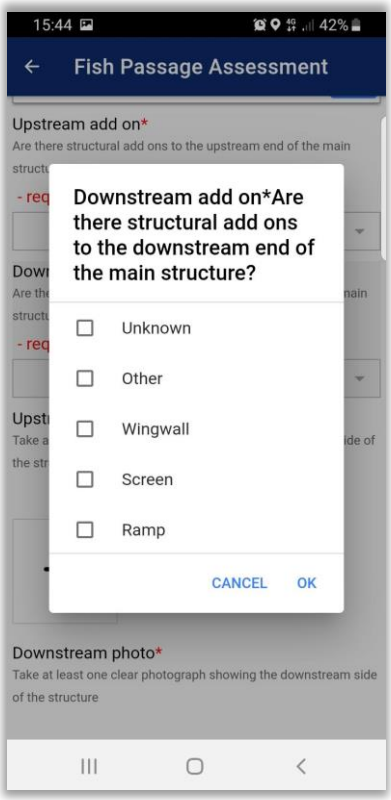
3.4.10 Record a structure that has been removed

1. You can record where a structure has been removed by tapping **Structure removed** in the structure type list.



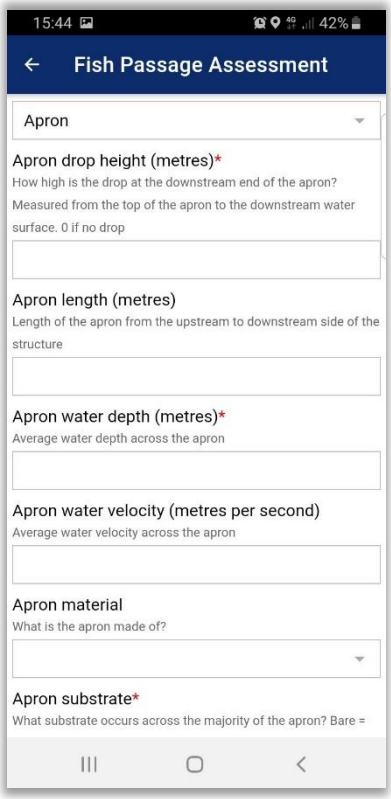
3.5 Record structure add-ons

1. Tap on **Upstream** or **Downstream add on** to record information about add-ons to the structure, e.g., aprons.
2. Select options from the list by tapping the tick box. Multiple options can be selected.
3. If you select **Apron** or **Ramp** additional questions will appear.



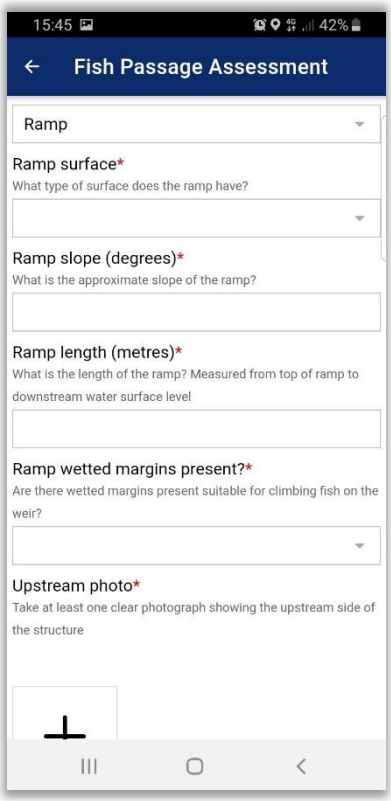
3.5.1 Assessing aprons

1. Tap on each field in the **Apron characteristics** section to add information.
2. **Apron drop height** refers to any drop that may occur at the downstream end of the apron. It is measured in metres from the top of the apron to the downstream water surface level.
3. Refer to Appendix E for further details on what to measure and how for aprons.



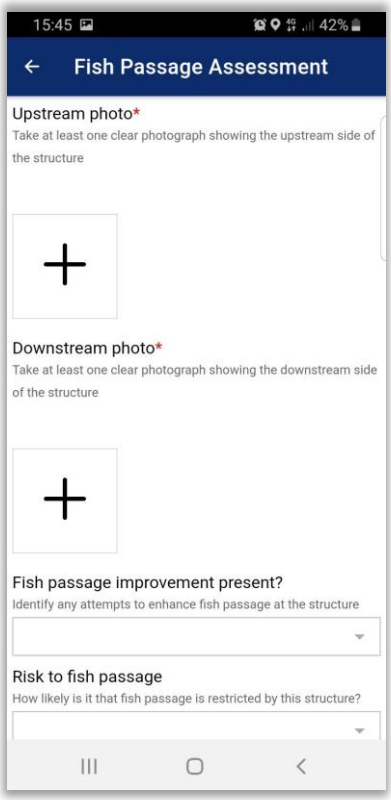
3.5.2 Assessing ramps

1. Tap on **Ramp surface** and select an option to describe what the ramp surface is made of. Only one option can be selected.
2. Tap on **Ramp slope** and enter the approximate slope of the ramp in degrees from horizontal using the key pad.
3. Tap on **Ramp length** and enter the length of the ramp in metres. Ramp length is measured along the ramp from the top of the ramp to the downstream water level.
4. Tap **Ramp wetted margins** and record whether wetted margins are present. See Appendix E for further details on this and other ramp measurements.

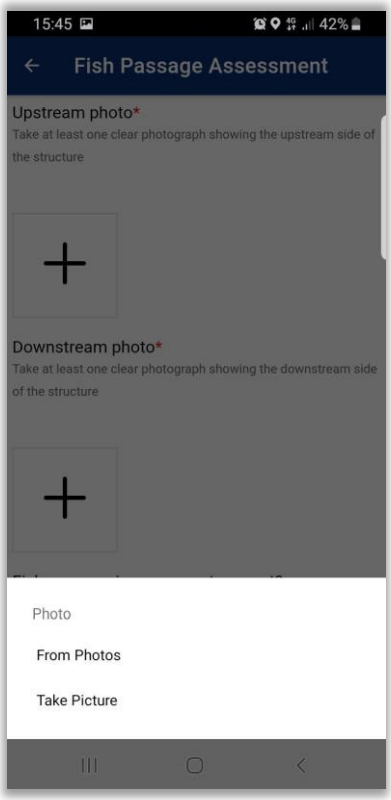


3.6 Add photos

1. Photographs must be added showing both the upstream and downstream side of the structure.
2. At least one **Upstream photo** must be taken that clearly shows the upstream side of the structure.
3. At least one **Downstream photo** must be taken that clearly shows the downstream side of the structure.
4. Add a photo by tapping on the **+** icon.

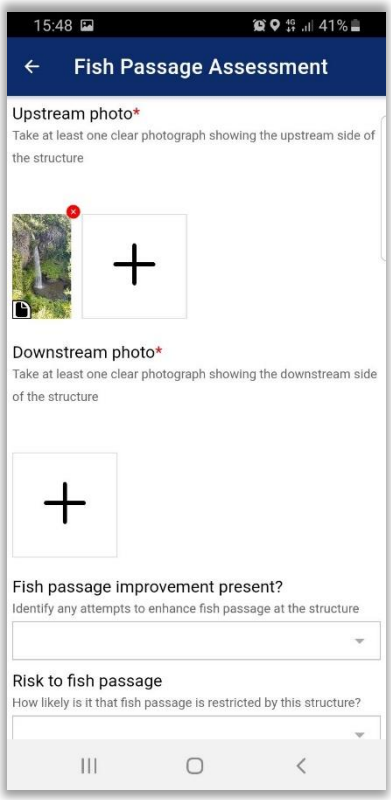


5. The first time you try to add a photo you may be asked to provide access to the image library and/or camera on your mobile device. Please answer Yes.
6. You will be asked where you wish to get your photo from. Tap **From Photos** to select an existing image from the image library on your mobile device, or tap **Take Picture** to take a new picture using the camera on your device.



7. If you choose to select an existing image, you can select a picture from the image library by tapping it.

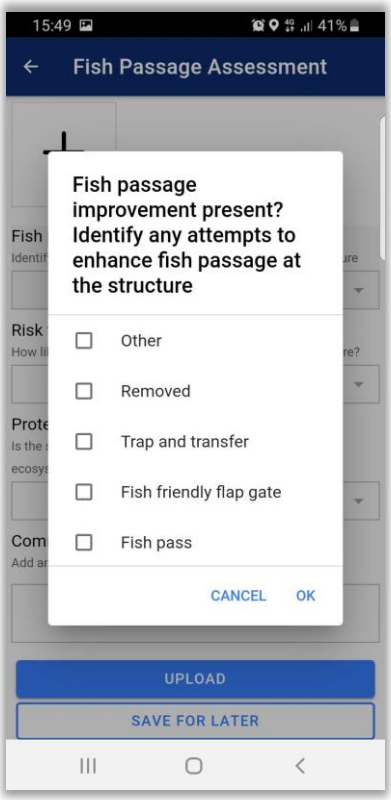
8. You can add up to 5 photos. To add another image, tap the **+** icon again.



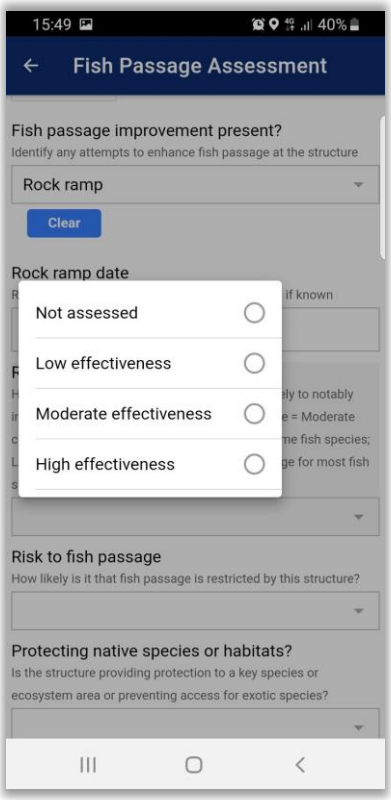
3.7 Record any fish passage improvements

1. A fish passage improvement is any attempt that has been made to enhance fish passage at the structure.

2. Tap on **Fish passage improvement** and select any enhancement that is present from the drop-down list by tapping the tick box. More than one option can be selected.



3. For each improvement you can record the **date** that the improvement was added and record your assessment of its **effectiveness**.

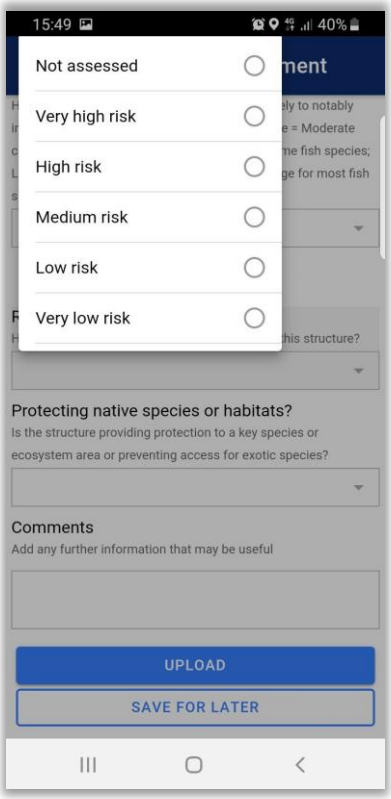


High	Highly likely to noticeably improve passage for most fish species.
Moderate	Moderate chance of some improvement of fish passage for some fish species.
Low	Low likelihood of improved passage for most fish species.
Not assessed	Select this if you are not confident or do not have the right knowledge to determine the effectiveness.

3.8 Identify risk to fish passage

1. You can record an assessment of the risk that the structure impedes fish movements by tapping on **Risk to fish passage** and selecting an option from the list.

Very high	Very high chance that most or all fish species will be blocked most or all the time.
High	High chance that the movements of many fish species and life stages will be restricted for much of the time.
Moderate	Moderate chance that movements of some fish species and life stages are commonly restricted.
Low	Some chance that movements of weaker swimming species are restricted some of the time.
Very low	Movements are unimpeded for most or all fish species and life stages for most or all the time.
Not assessed	Select this if you are not confident or do not have the right knowledge to determine the likely risk.

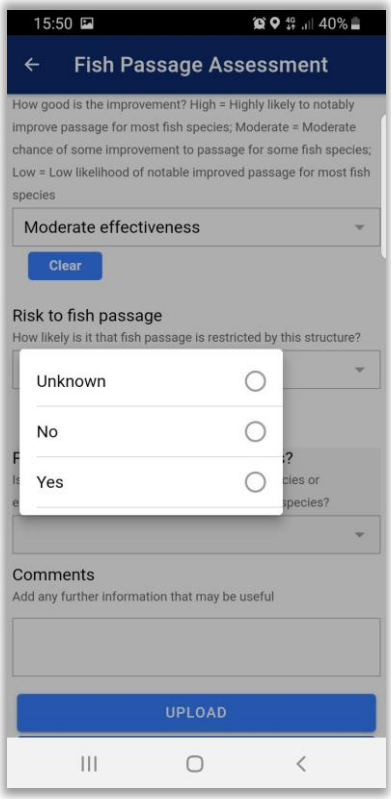


2. For culverts, fords and weirs an automatic risk score will be calculated once the data are uploaded to the national database and will be used by default.

3. See Appendix F for more information on fish passage risk calculations.

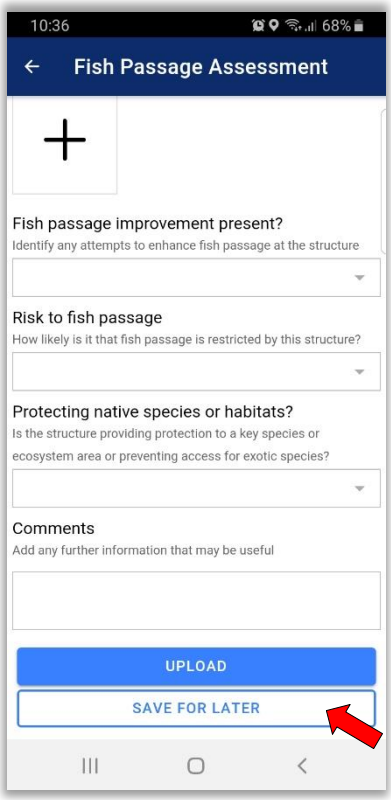
3.9 Does it protect native species or habitats?

1. Sometimes barriers can protect native species or habitats from the impacts of exotic species. This can be recorded in the app under the **Protecting native species or habitats** field.
2. Tap on the field and select your option by tapping on the radio buttons.
3. If you do not know if the structure is protecting a native species or important habitat you should answer **Unknown**.
4. When data is uploaded to the database, if selected threatened fish species have been recorded upstream, this will automatically be noted on the record. See Appendix I for further details.

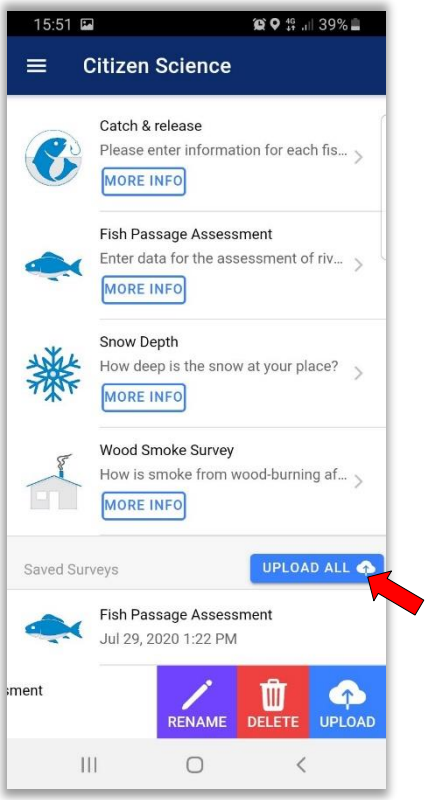


3.10 How to save a survey for later

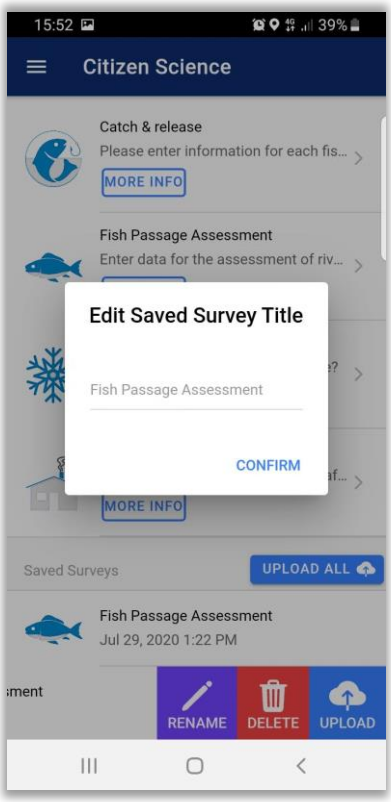
1. Once you have completed a survey, or if you wish to save a partially completed survey, you can tap the **Save for later** button at the bottom of the survey to save it and return to it later.



2. Saved surveys will appear on the Citizen Science app home page.
3. You can review, update and submit a saved survey by tapping on the saved survey record in the Citizen Science app home page.
4. You can upload all saved surveys (assuming they are complete) by tapping on the **Upload All** button.
5. You can **rename**, **delete** or **upload** individual surveys by swiping left on the survey name and tapping the relevant icon.



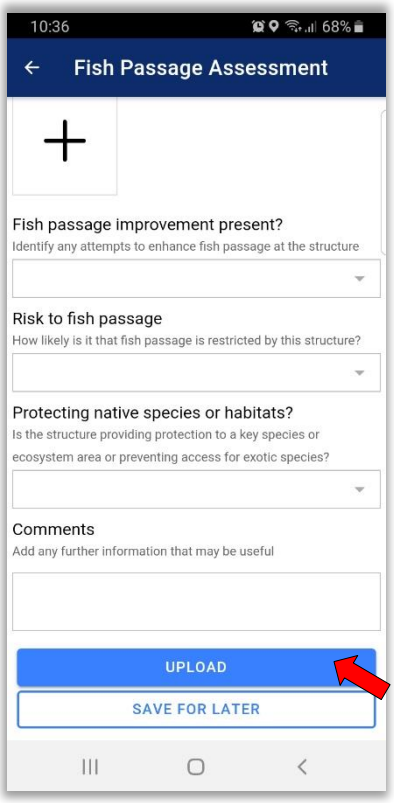
6. You can **rename** saved surveys to help keep track of them. Tap on **Rename** and type a new name into the dialogue box that opens before tapping confirm.



3.11 How to submit a survey

1. To submit your answers to the fish passage database, tap **Upload**.

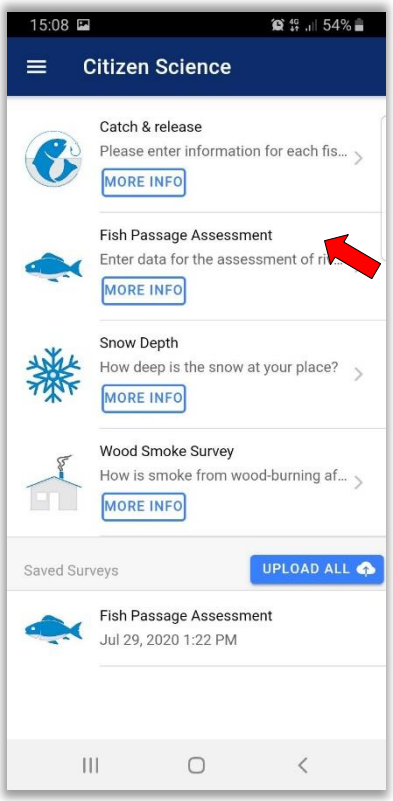
2. Submitting surveys will use mobile data if you do not have a wifi connection. Particularly when submitting several photos, consider saving your surveys for later and submitting them once you have a wifi connection.



4 How do I assess a structure while offline?

The Fish Passage Assessment tool works best when online and with mobile data switched on. However, the app can also be used when offline (e.g., out of mobile reception) to assess new structures. Please follow the instructions below if you know you will be assessing structures in an area where mobile reception is limited or not available.

1. If you are going to be using the app in offline mode, you will need to cache maps and the survey prior to going offline.
2. Before going offline, you must open and load the Fish Passage Assessment survey at least once. This is done by tapping on **Fish Passage Assessment** on the Citizen Science app home page and loading a survey.



3. Once you have loaded a survey, if you know the area that you will be surveying, tap on **Location** to open the map.

4. Zoom in to the area you will be doing surveys. This will cache the maps for that area. Once you have completed this, tap **OK**.

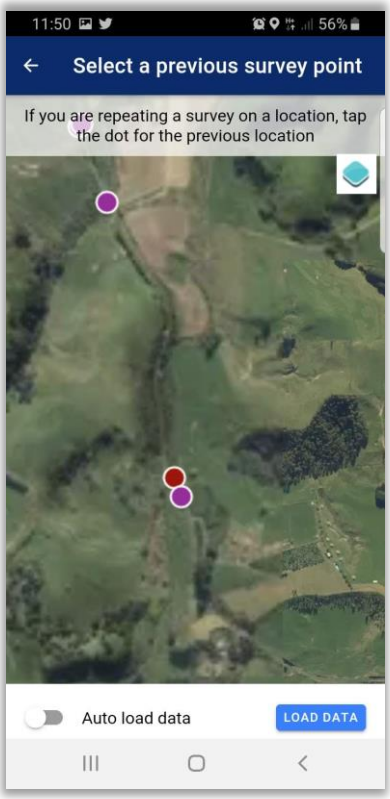
5. Next tap on **NZSegment** to open the map of digital river network reaches.

6. Zoom in to the area you will be doing surveys. This will cache the maps for that area. Once you have completed this, tap **OK** or the **Back** button.

7. Next tap on **Previous survey point**, zoom in to the area you will be doing surveys and tap **Load data** to load the existing records from the database. Once you have completed this, tap the **Back** button.

8. Presently, full functionality of the **Previous survey point** option is not available offline. If you select a previous data point in offline mode it will only connect it to that existing record and not pre-populate fields in the survey. If you wish to take advantage of this additional functionality, we recommend starting a survey for the existing point prior to entering the offline area and saving the pre-populated record for later. That record can then be opened and completed on site.

9. Once you have completed these actions you can perform an offline assessment following the normal instructions.



5 Acknowledgements

This work was funded by Envirolink Tools contract C01X1609 and the Ministry for the Environment Deed 24147 . We would like to acknowledge the contribution of a wide range of stakeholders during the process of developing the Fish Passage Assessment Tool including the Department for Conservation, multiple regional council representatives and the New Zealand Fish Passage Advisory Group. Particular thanks go to Environment Canterbury, Christchurch City Council and Department for Conservation for their support in trialling the assessment protocol.

Trevor James (Tasman District Council) acted as the council champion for this project and his input, drive and enthusiasm has been much appreciated. Trevor was joined on the project steering group by Sjaan Bowie (Department of Conservation), Megan Kennedy (NZTA), Lauren Long (Ministry for the Environment), and Hannah Rainforth (Perception Planning Limited).

I would also like to acknowledge the contribution of the NIWA software development team who have worked tirelessly to deliver this tool.

6 References

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Segurado, P., Branco, P., Ferreira, M.T. (2013) Prioritizing restoration of structural connectivity in rivers: a graph based approach. *Landscape Ecology*, 28: 1231-1238.

Appendix A How do I measure wetted width and bankfull width?

The size of a structure relative to the size of a stream channel is a simple indicator of the likelihood that fish movements may be impeded. The smaller the structure relative to the size of the channel, the greater the likelihood that conditions in or around the structure will restrict fish movements.

Wetted width is easy to measure and is simply the width of the river at the water surface (Figure A-1). The bankfull width is the width of the channel at the bankfull elevation (Figure A-1). The bankfull elevation is the river level just before water overtops the banks on to the flood plain (e.g., Figure A-2).

The stream width measurements should represent the average natural width of the stream. It may be necessary to take the measurements a little way upstream or downstream of the structure as stream width may be modified during installation of the structure, or as a consequence of erosion associated with the structure.

The New Zealand Fish Passage Guidelines (see www.niwa.co.nz/fishpassage) recommend that all new culverts should be sized relative to bankfull width. These measurements help to understand how many structures follow these guidelines.

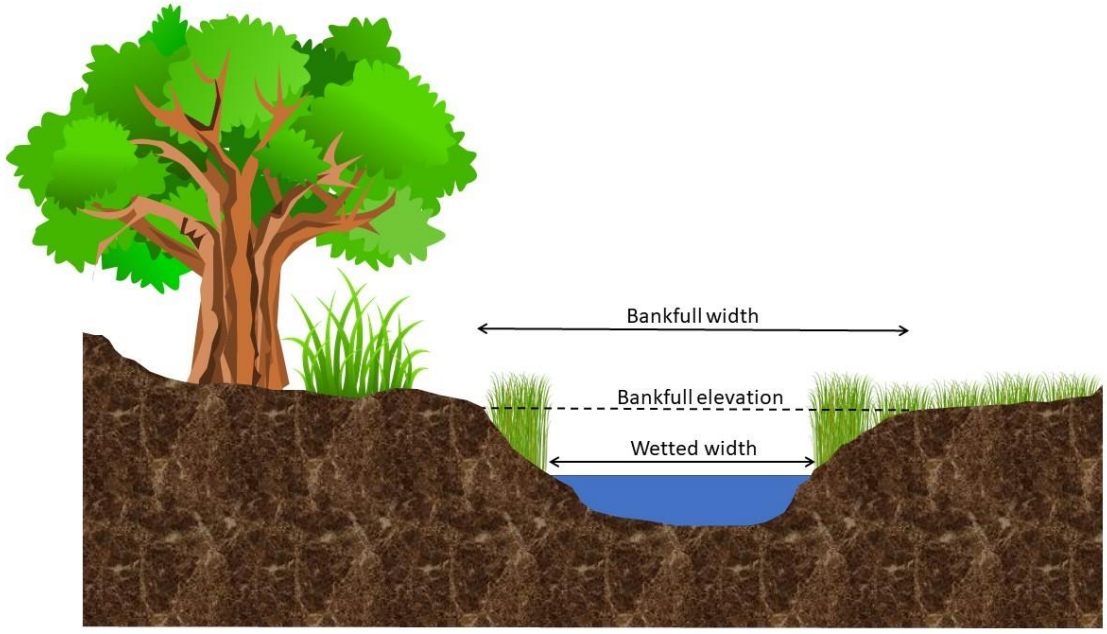


Figure A-1: A river cross-section showing how to measure wetted and bankfull width.

Figure A-2: Example of a stream at bankfull flow. If flow rises any higher it will overtop the banks.

Appendix B What type of structure am I assessing?

The Fish Passage Assessment tool is suitable for capturing information about a range of different structure types. The amount of information captured for different structure types varies with the ease of data collection and with how commonly they are encountered in our rivers and streams. The following pages are provided as a guide to identifying the key structure types.

Culverts

Pipe culverts

Box culverts


Multi-barrel pipe culverts


Arch culverts

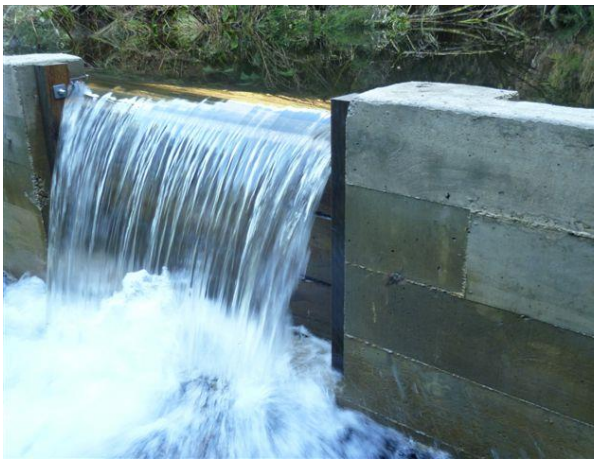
Fords

Fords without culverts

Fords with culverts

Weirs



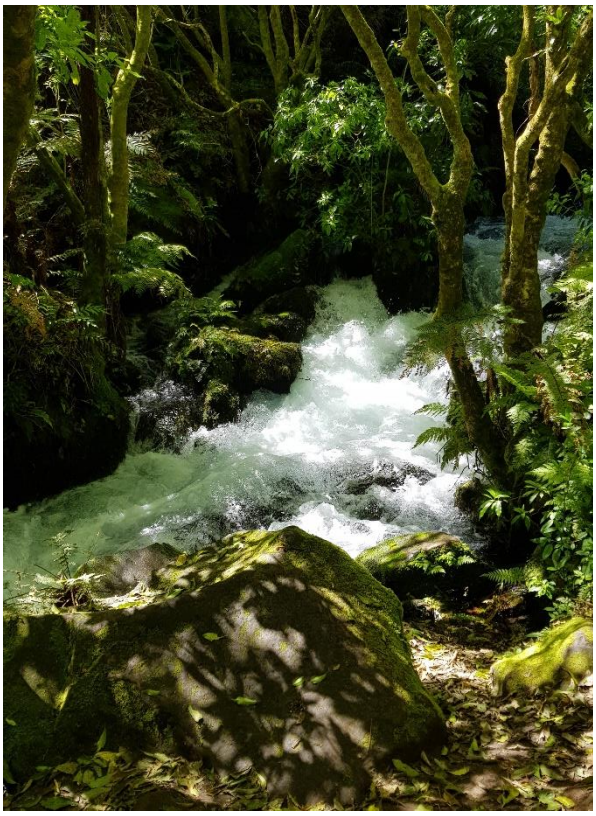


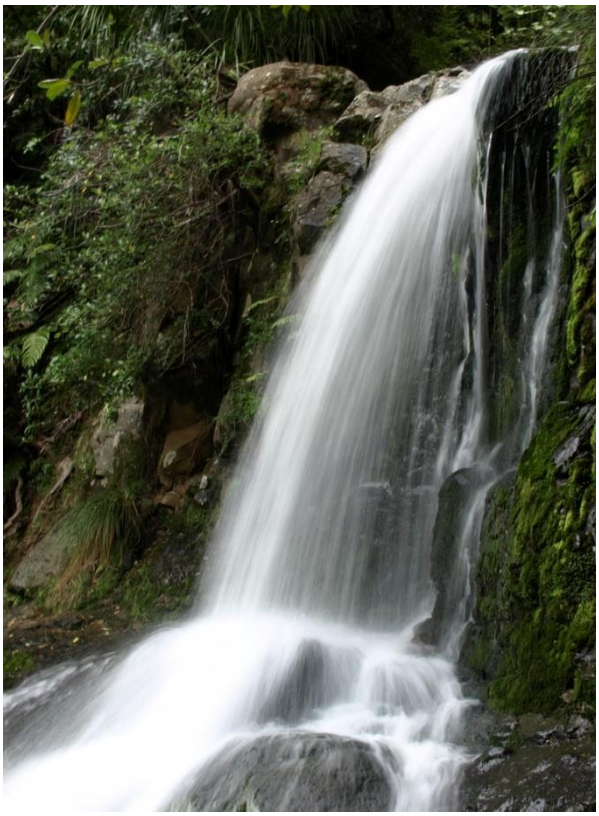

Dams

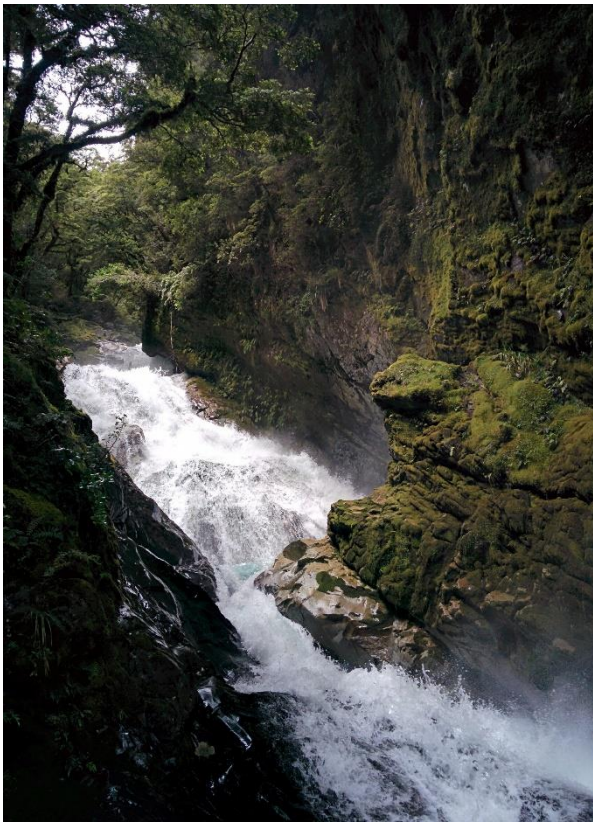

Flap gates

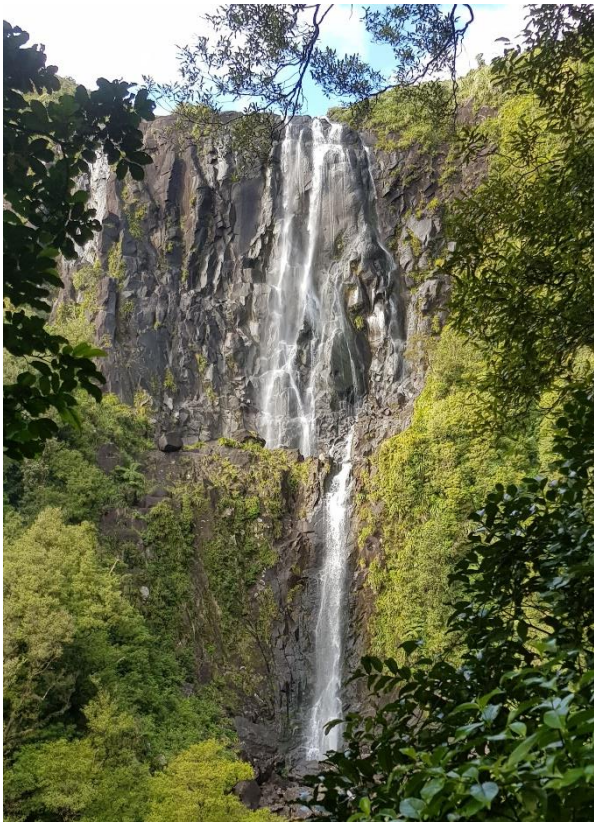
Pump stations

Natural barriers









Bridges

Multi-span bridges

Single-span bridges

Appendix C What do I measure for culverts and how?

Figure C-1 illustrates the key characteristics of a culvert barrel to be measured during a culvert assessment.

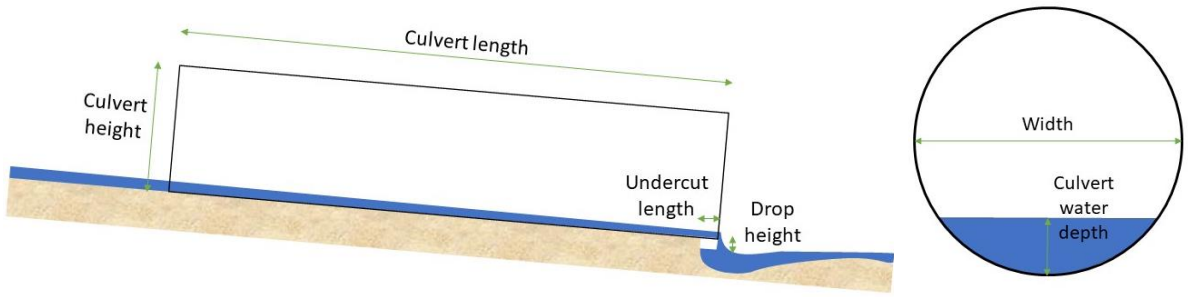


Figure C-1: Where to measure key dimensions of a culvert.

Figure C-2 illustrates how to use the float method for measuring average water velocity inside the culvert. The time it takes for a float to pass from the upstream end of the culvert and out the downstream end is measured using a stopwatch. The average water velocity through the culvert is then calculated as follows:

Water velocity (metres per second) = Culvert length (metres) ÷ time taken for float to pass through culvert (seconds)

Repeating the measurement (or using several floats) to get an average water velocity can be useful for getting a more reliable estimate of the water velocity. Mandarins or golf balls are good floats, but a small stick can also work. Having a hand net to catch the floats at the downstream end is useful. If access to the culvert is safe, it may be possible to measure a maximum water velocity that could be entered in the field instead.

Figure C-2: Illustration of how to use the float method of measuring water velocity. The floats are released upstream of the culvert. A stopwatch is started as the floats enter the culvert. The time taken for each float to reach the other end of the culvert is recorded. This is used to calculate water velocity.

Culvert slope is determined relative to the stream. A good culvert from a fish passage perspective should have a similar slope to the adjacent stream. The three different options are shown in Figure C-3. Culvert alignment is also judged relative to the line of the stream or river. This is illustrated in Figure C-4.

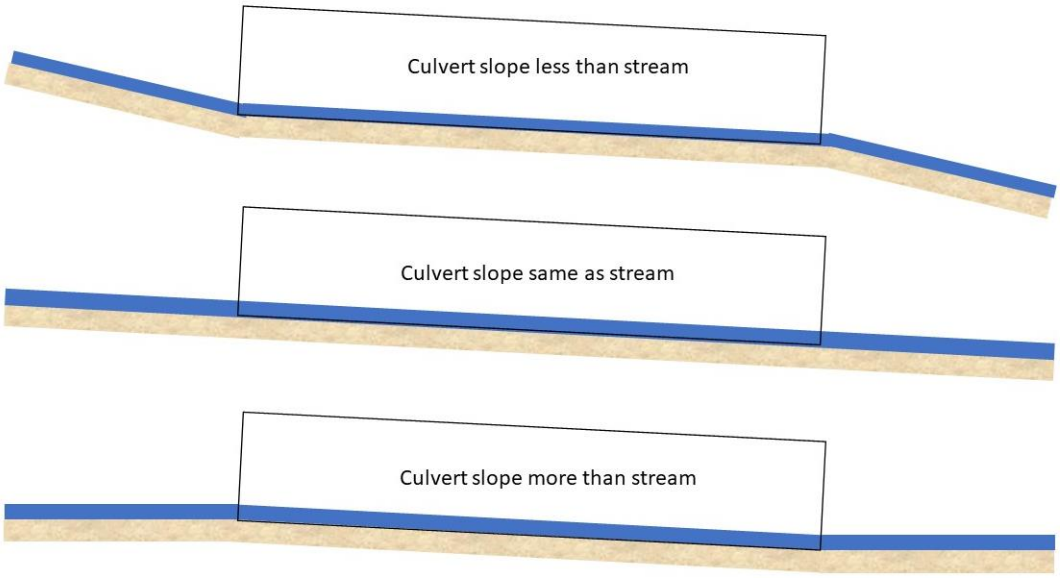


Figure C-3: Illustration of the different culvert slope options.

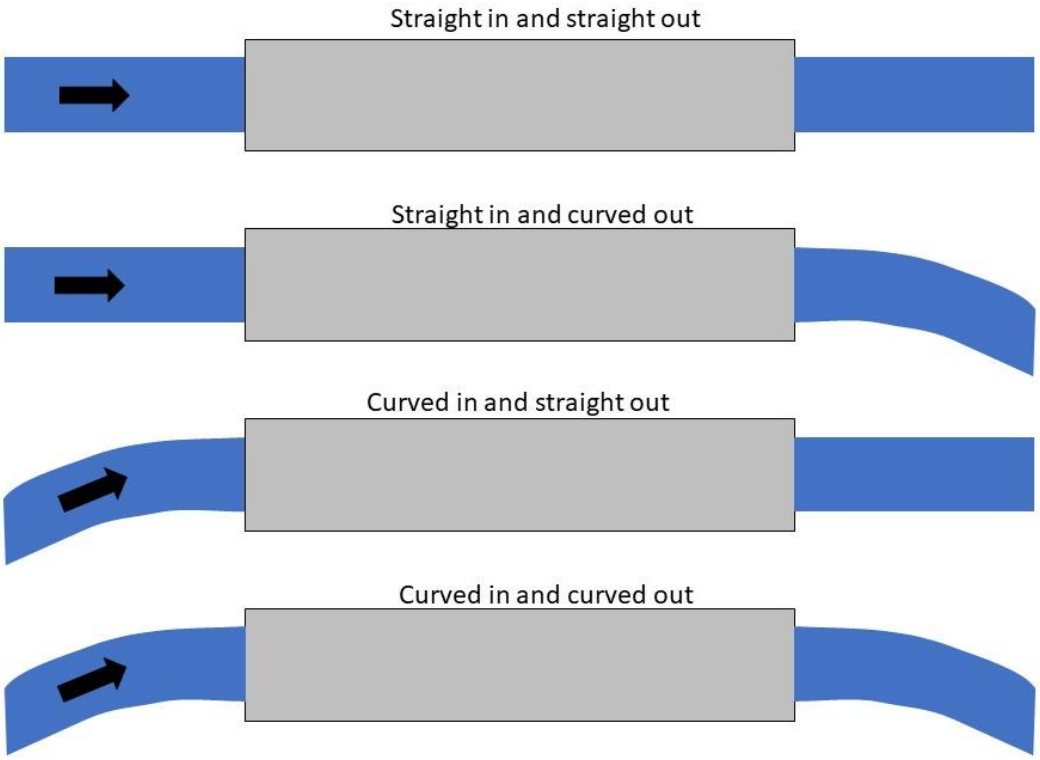


Figure C-4: Illustration of the different culvert versus stream alignment options.

Figure C-5: Example of where low velocity recirculation zones are present, but wetted climbing margins are absent.

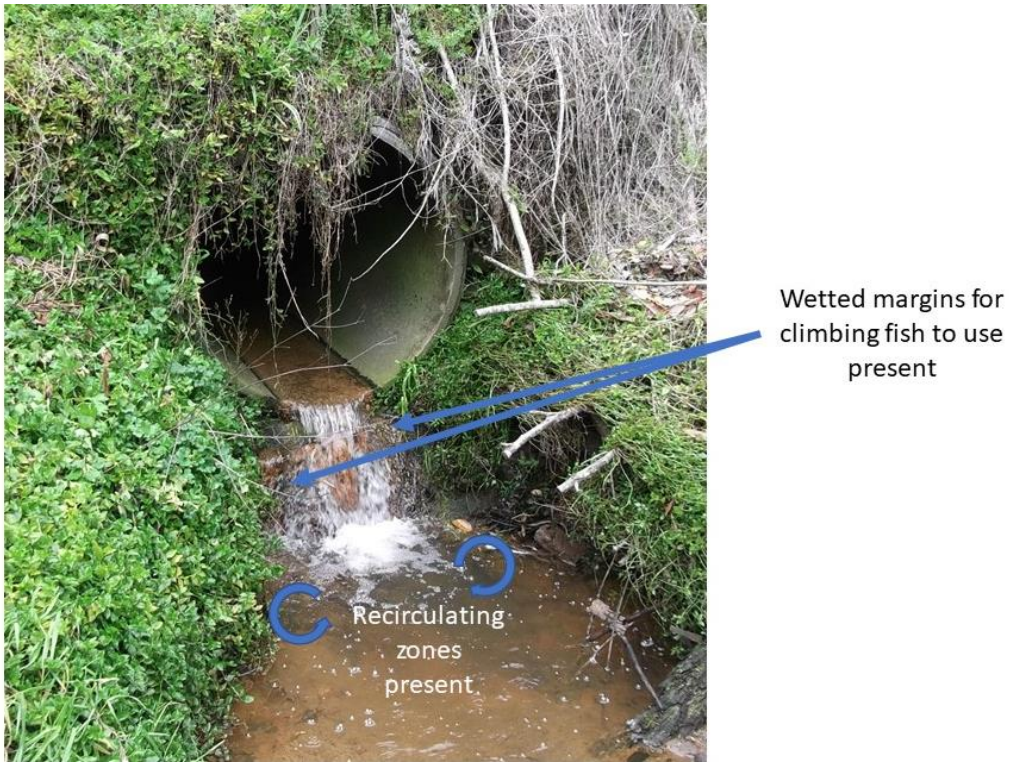


Figure C-6: Example of where wetted climbing margins and low velocity recirculation zones are present.

Appendix D What do I measure for weirs and how?

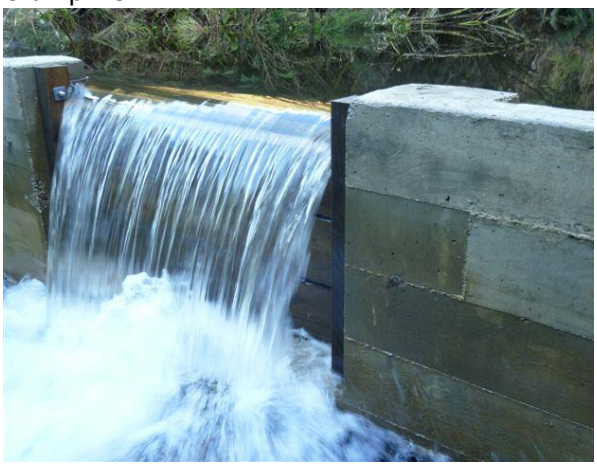
Weir types

Broad-crested

V-notch

Crump weir

Stepped



Sharp-crested weir

Figure D-1: Examples of different weir types.

Crest types

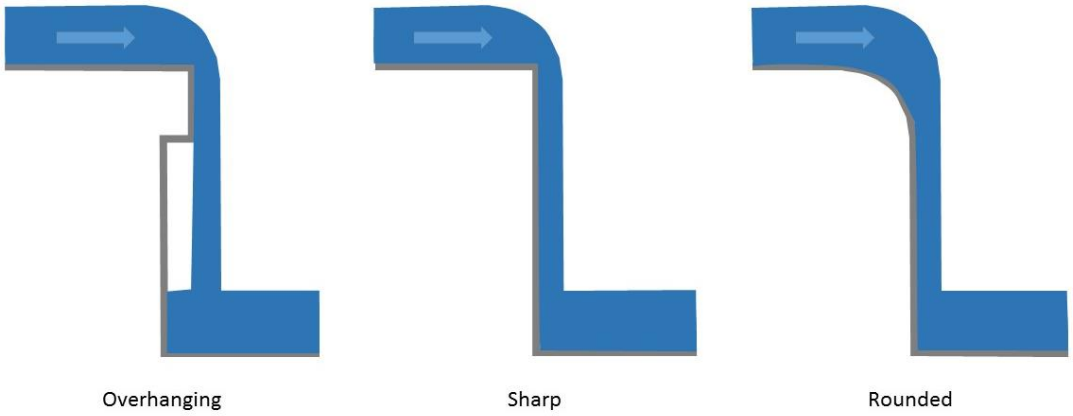


Figure D-2: Examples of different weir crest shapes.

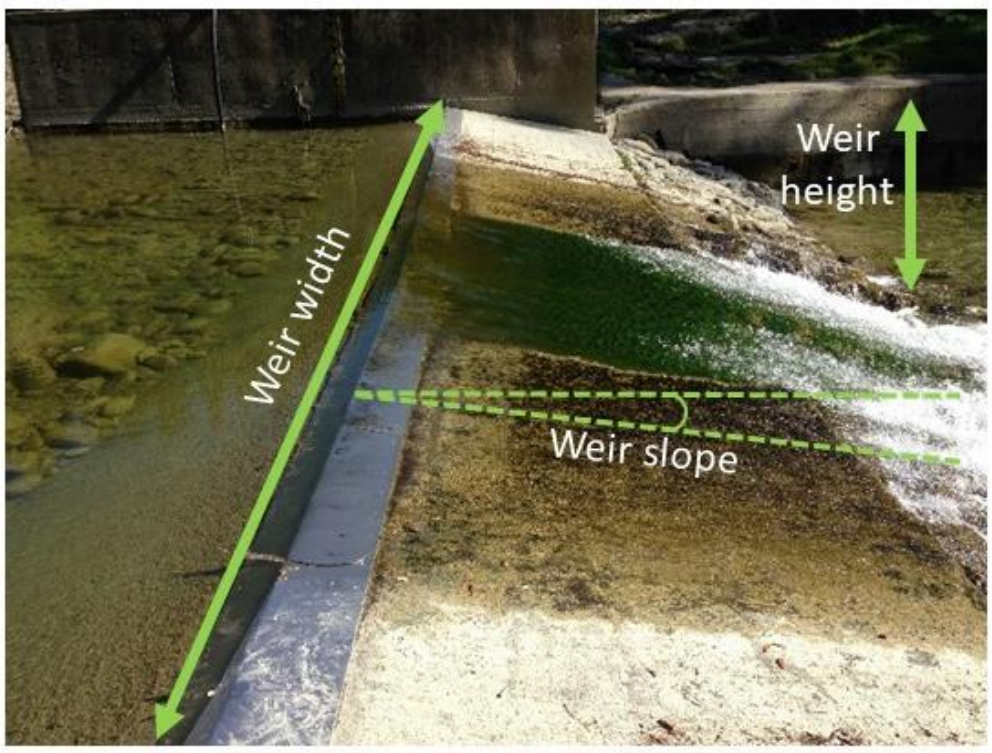


Figure D-3: Illustration of where to take key measurements for weirs.

Identifying wetted margins

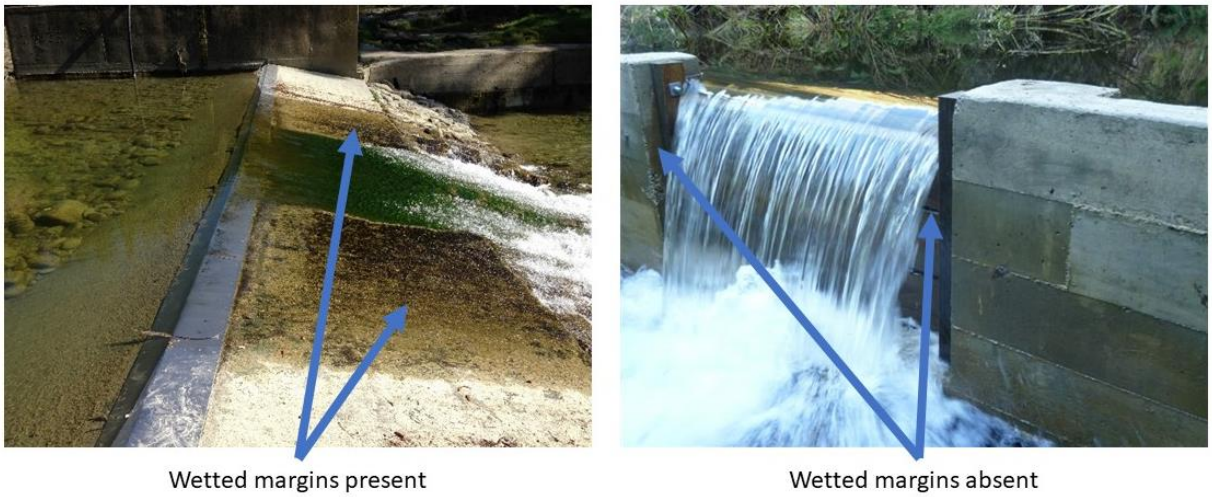


Figure D-4: Examples of weirs with and without wetted margins present.

Measuring backwater distance

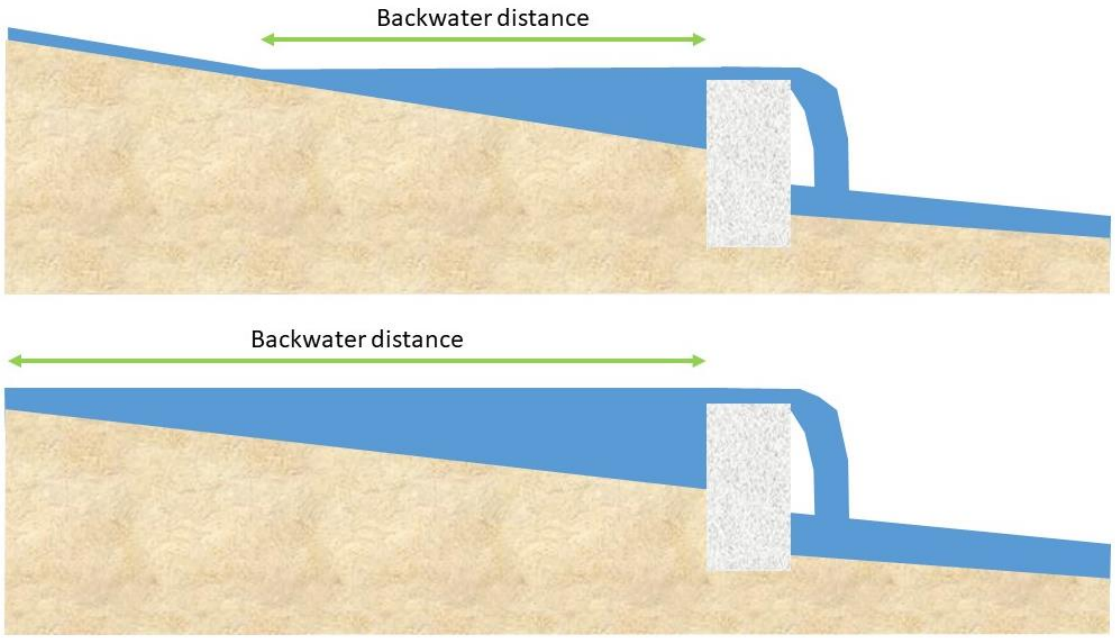


Figure D-5: Illustration of how to identify and measure backwatering distance. The weir holds back the water upstream and raises the water level. This is known as backwatering. The distance upstream that the weir influences water depth is dependent on the height of the weir and the slope of the stream above the weir.

Appendix E What are structure add-ons?

Structure add-ons are ancillary structural elements that are part of the overall structure. Commonly encountered examples include headwalls, wingwalls and aprons (Figure E-1). Screens can also be present to minimise the entry of debris into structures, or for safety reasons. Ramps are increasingly being used to restore fish passage by eliminating drops at the outlet or downstream side of the structure (Figure E-2).

Figure E-1: Example of a culvert with an integrated headwall, wingwalls and apron.

Figure E-2: Example of a fish ramp installed downstream of a culvert.

Appendix F How is fish passage risk calculated?

Introduction

Different structures can impede the movements of fish to a greater or lesser degree depending on their characteristics. For managing river connectivity, it is important to understand the extent to which fish passage may be impeded by a structure. Two approaches to evaluating the risk to fish passage have been implemented in the fish passage assessment tool: 1. Rule-based assessment, and 2. Visual assessment. These methods are outlined below.

Rule-based assessment

Rule-based approaches to evaluating fish passage risk are preferred because they provide an objective assessment of risk. That is, for a given set of structure characteristics, the fish passage risk will always be the same. In contrast, visual assessments can vary between surveyors, even for the same structure, because they are reliant on the experience and knowledge of the surveyor, which varies between individual surveyors.

The development of rule-based assessments is reliant on sufficient knowledge being available to define appropriate rules. Rule-based methods can be relatively simplistic, e.g., if a dam is greater than 50 m high there is a very high risk that it will prevent migration of most fish species, or more complex, incorporating multiple characteristics to determine the likelihood of passage, e.g., if a culvert is more than 50 m long, has a smooth substrate, has water velocities higher than 1 m/s and is perched, then there is a very high risk that it will prevent migration of most fish species.

For the purpose of this project, a combination of simple and more complex rules were developed for different structure types. For bridges, pump stations, dams and flap gates, simple rules were established (Table F-1).

Table F-1: Rule-based risk assessments for bridges, pump stations, dams and flap gates.

Structure type	Rule	Risk class
Bridge	Any bridge	Very low
Pump station	Any pump station	Very high
Dam	Dam without a fish pass and/or trap and transfer scheme	Very high
Dam	Dam with a fish pass and/or trap and transfer scheme	High
Flap gate	Flap gate without fish friendly flap design	Very high
Flap gate	Flap gate with fish friendly flap design	High

For culverts, weirs and fords a formal expert elicitation process was used to collate knowledge about how different characteristics of the structures combine to influence fish passage success. Bayesian network models were developed to implement more complex rule-based assessments for these structures (Figure F-2 to Figure F-4). Further information on these models can be obtained from NIWA.

The output of the model is a probability distribution that describes the expected likelihood of passage based on different combinations of structure characteristics. The risk class allocated to a structure is determined by calculating the probability of the expected likelihood of passage falling in to each class and then selecting the class with the highest probability (Figure F-1).

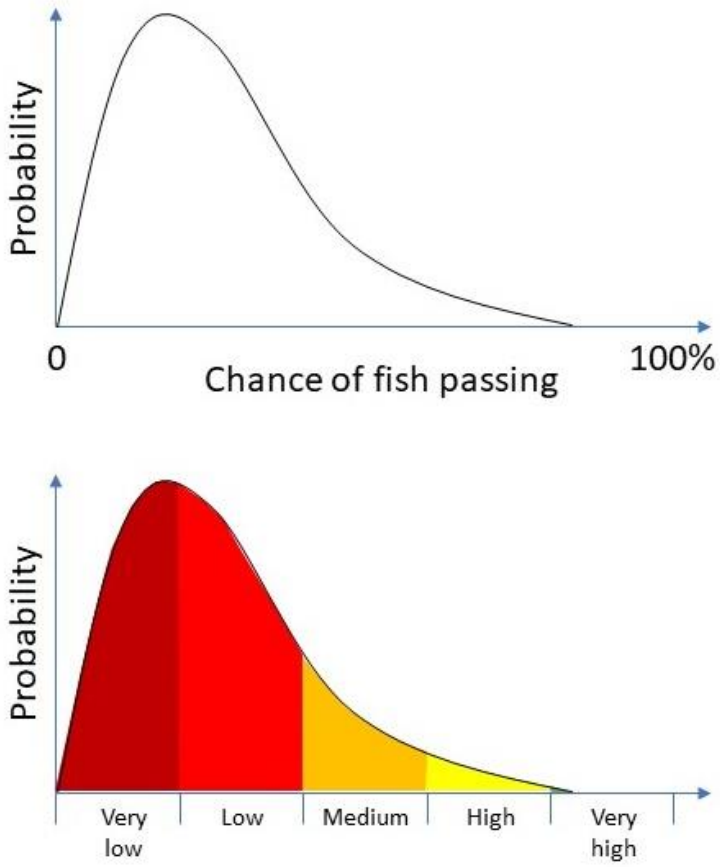


Figure F-1: Illustration of how the risk class is calculated from the Bayesian model outputs. The model output is a probability distribution (top). The area under the curve is equal to one and so the area under the curve in each class is equal to the probability of fish passage risk being in that class.

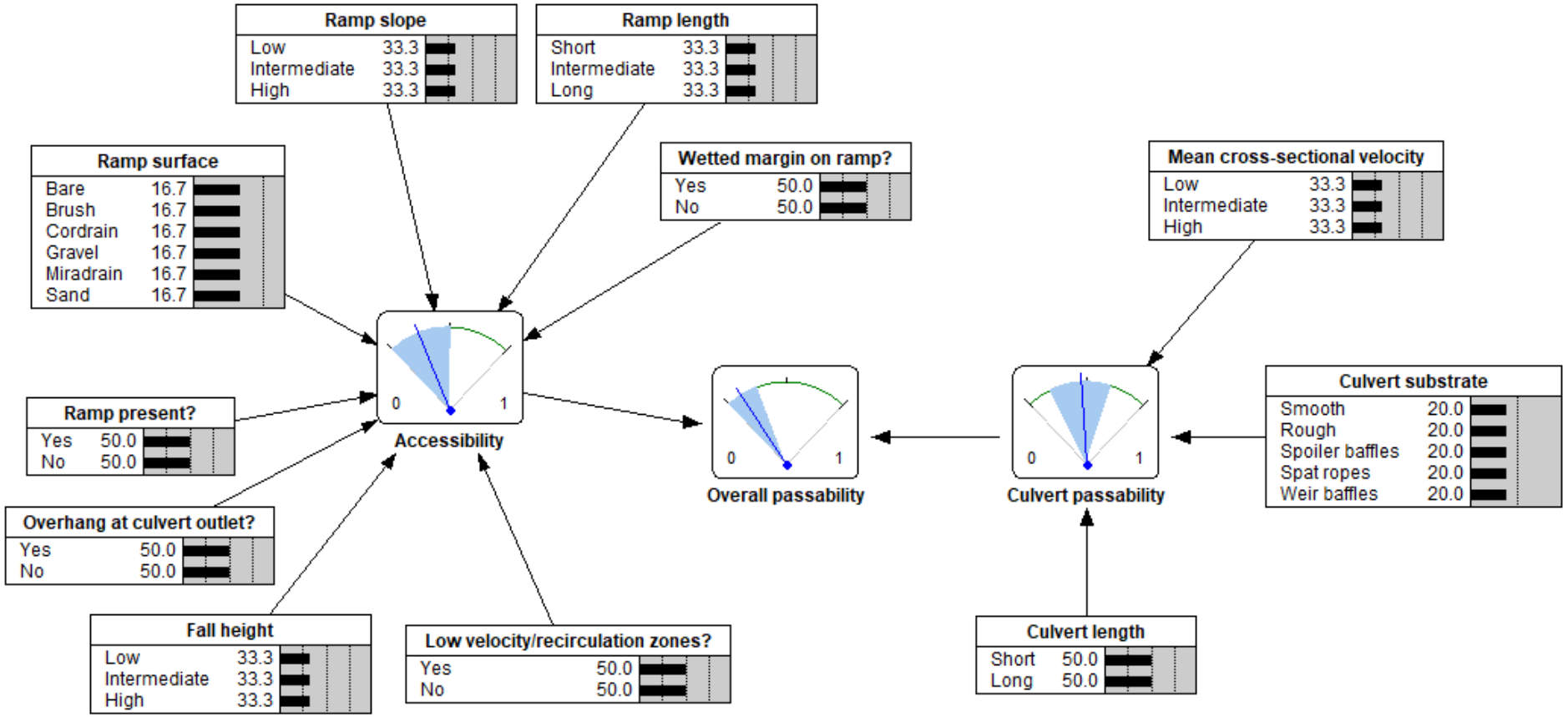


Figure F-2: Structure of the Bayesian network model used to implement rule-based assessment of fish passage at culverts.

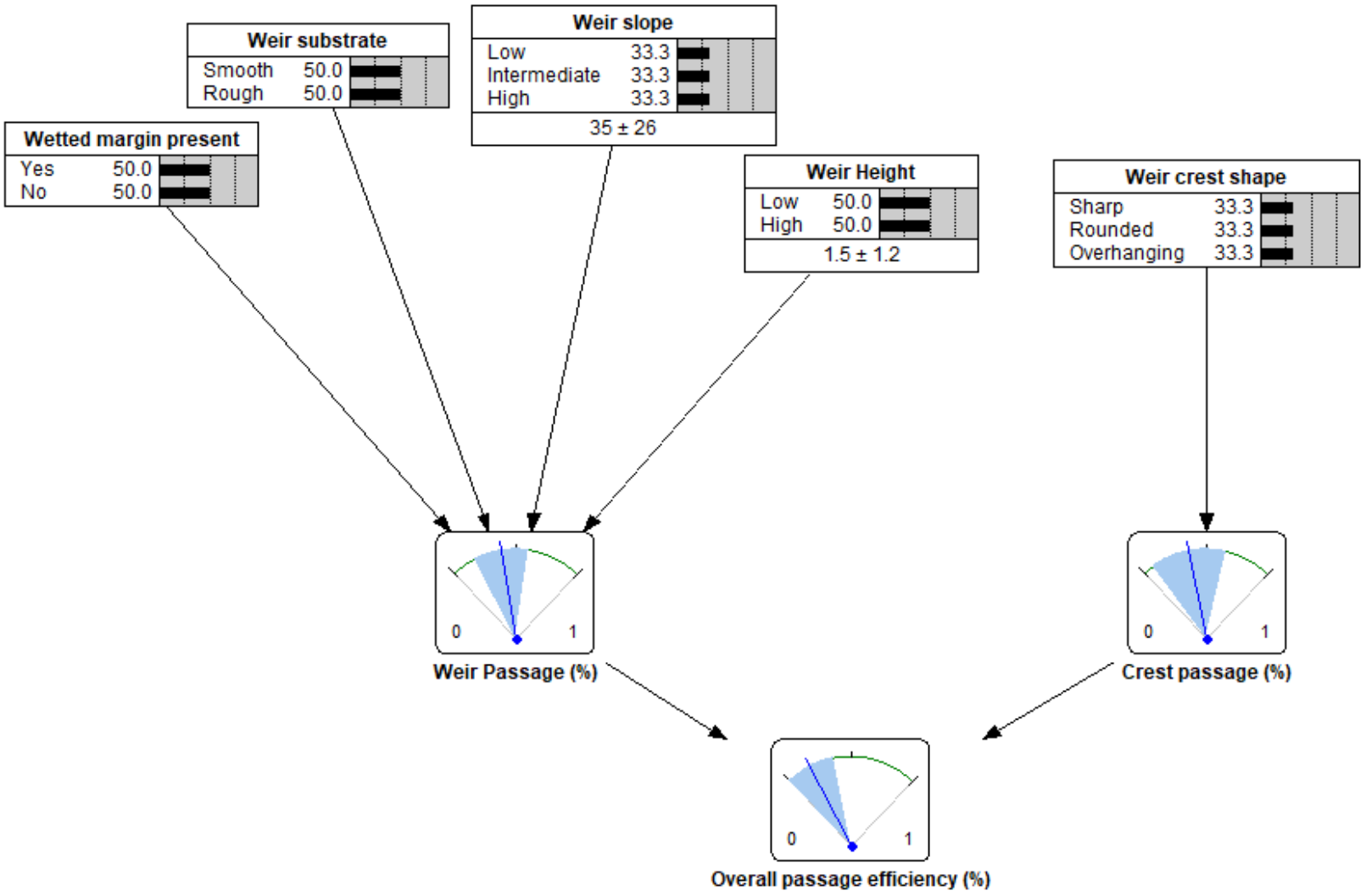


Figure F-3: Structure of the Bayesian network model used to implement rule-based assessment of fish passage at weirs.

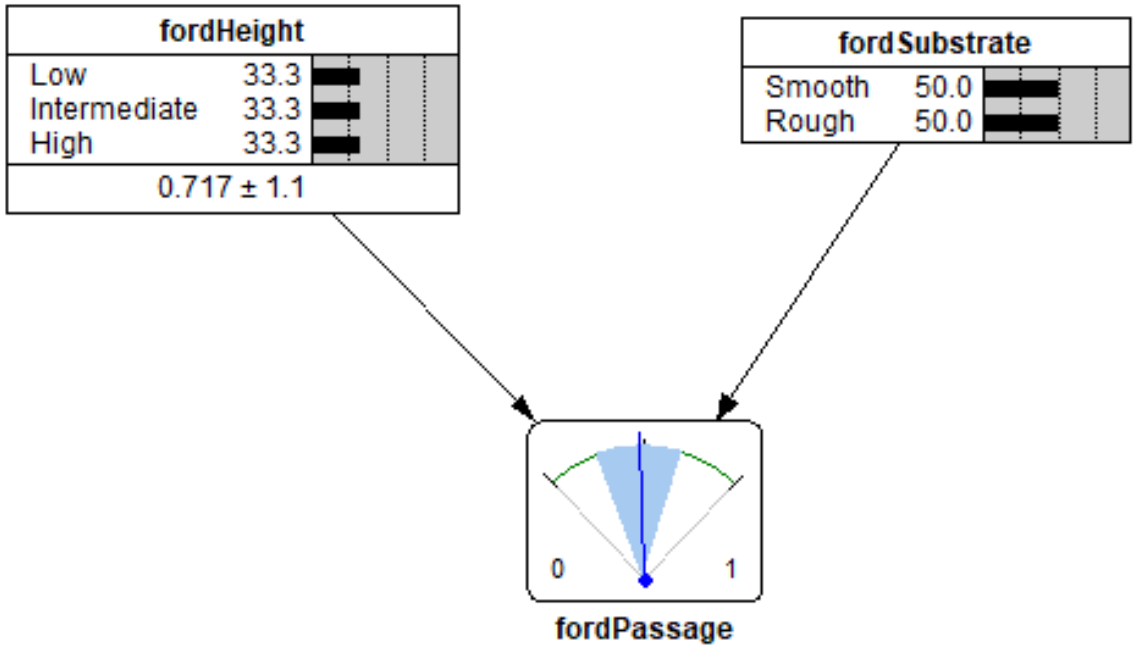


Figure F-4: Structure of the Bayesian network model used to implement rule-based assessment of fish passage at fords. Note that where a ford incorporates culverts, the culvert Bayesian network model is applied.

Visual assessment

Visual assessment of fish passage risk is reliant on the surveyor making a judgement call on the likelihood that fish movements will be impeded by a structure they are assessing. It is subjective and varies between individuals based on their experience and knowledge of fish passage and fish movement capabilities and behaviour. However, it can be a useful guide and for some structure types there is no default risk class and insufficient knowledge to develop a model. Qualitative descriptors of the different fish passage risk classes are provided in Table F-2

Table F-2: Qualitative descriptions of the different fish passage risk classes.

Risk class	Description
Very high	Very high chance that most or all fish species will be blocked most or all the time.
High	High chance that the movements of many fish species and life stages will be restricted for much of the time.
Moderate	Moderate chance that movements of some fish species and life stages are commonly restricted.
Low	Some chance that movements of weaker swimming species are restricted some of the time.
Very low	Movements are unimpeded for most or all fish species and life stages for most or all the time.
Not assessed	Select this if you are not confident or do not have the right knowledge to determine the likely risk.

Appendix G Environmental reporting

The Environmental Reporting Act 2015 requires the Ministry for the Environment and Stats NZ to report on the state of our environment, the pressures that affect that state, and how that state influences aspects of the environment and well-being (MfE & Stats NZ 2017). Instream structures, such as weirs and culverts, are a pressure on the state of our freshwaters. However, the extent of this pressure, and the potential impacts on freshwater ecosystems, are poorly known in New Zealand (MfE & Stats NZ 2017). The 2020 National Policy Statement for Freshwater Management (NPS-FM; MfE 2020) and National Environmental Standards for Freshwater (NES-F; New Zealand Government 2020) introduced new requirements to identify, survey and assess all new and existing instream structures across the New Zealand river network.

Data collected using the Fish Passage Assessment Tool app will fulfil the fish passage information requirements of the NPS-FM and NES-F and improve our knowledge of the extent of the pressure caused by instream structures, enhancing our ability to quantify the current state of river connectivity. The data can also be used to assist with prioritising efforts to reconnect waterways as required under the NPS-FM 2020. As part of the Fish Passage Assessment Tool project, a number of environmental reporting metrics have been derived and implemented in the Fish Passage Assessment Tool web resource. These metrics and their rationale are described in the following sections.

Pressure-state-impact framework

New Zealand's environmental reporting series published by the Ministry for the Environment and Stats NZ uses a pressure-state-impact framework for presenting information. A ***pressure*** is defined as something that influences and can explain change in the state of the environment. The presence of instream structures within waterways can be considered a pressure as they influence the state of river connectivity. ***State*** is a measure of the condition of the environment. River connectivity is an example of a measure of the state of freshwater environments. The consequences of changes in the state or condition of the environment are known as ***impacts***. Disruptions to river connectivity caused by the presence of instream structures alter fish abundance and distributions in streams and rivers. This is an example of an impact. The metrics that have been implemented within the Fish Passage Assessment Tool are designed to be consistent with this framework.

Fish passage pressure metric

One of the main objectives of the Fish Passage Assessment Tool is to capture the information required to quantify the magnitude of the pressure on freshwater ecosystems that results from instream structures. This requires information on the location of structures and the likelihood that they impede fish movements.

The Fish Passage Assessment Tool uses a risk-based framework for characterising the likelihood that fish movements are impeded at a structure. This categorisation is based on information on the features of the structure that is collected using the Fish Passage Assessment Tool mobile app. All structures are rated on a five-point scale from 'Very low risk' to 'Very high risk' of impeding fish movements. Structures that are assessed as 'Very low risk' are likely to provide good passage for all fish species and life stages for most or all of the time. Structures that are assessed as 'Very high risk' are highly likely to prevent the movement of most fish species and life stages for most (or all) of the time.

The fish passage pressure metric quantifies the number of different structure types in each of the five passage risk classes (Figure G-1; Table G-1). The larger the number of structures present, and the greater the proportion of those structures in the higher risk classes, the greater the pressure on the fish communities. The metric is generally calculated at a catchment scale, but can also be aggregated at larger regional or national scales.

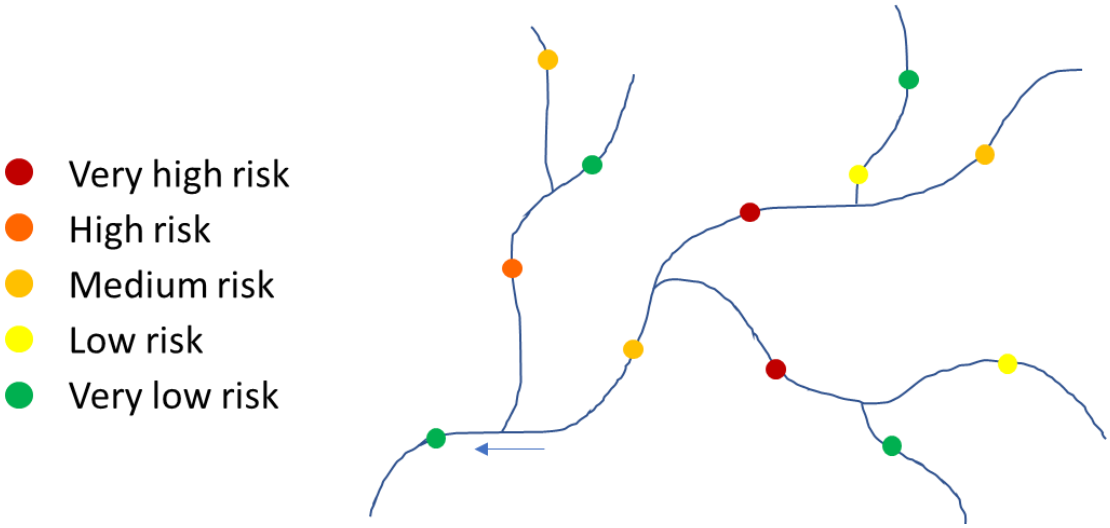


Figure G-1: Illustration of a theoretical catchment showing the location of instream structures that have been assessed for fish passage. Structures are colour coded according to the likelihood that they impede fish passage.

Table G-1: Example of the fish passage pressure metrics calculated for the theoretical catchment in Figure G-1.

Risk of impeding fish movements	Number of structures	Proportion of structures
Very low risk	4	33%
Low risk	2	17%
Medium risk	3	25%
High risk	1	8%
Very high risk	2	17%
Not assessed	0	0

A key limitation of the fish passage pressure metric is that only structures that have been identified and assessed can be incorporated in the calculations. Where a full census of structures has not been carried out, the number of structures will be underestimated. However, as the sample size increases it is increasingly likely that the proportion of barriers that occur in each risk class may be representative of the catchment (or larger spatial unit) as a whole.

River connectivity state metric

Fish and other aquatic organisms move between different habitats to undertake different activities, such as breeding, feeding or seeking refuge. Instream structures can disrupt the connectivity of rivers by limiting the movement of aquatic organisms. When connectivity between critical habitats is

disrupted, organisms can no longer complete their life-cycle, resulting in reduced abundance and/or changes in distribution of these organisms.

Many of New Zealand's most well-known and widespread fish species, e.g., whitebait and eels, migrate between marine and freshwater habitats during their life and so are highly susceptible to disrupted river connectivity. Connectivity is, therefore, a critical measure of environmental state for freshwater environments.

A range of methods of differing complexity are available for quantifying river connectivity at different scales (e.g., Cote et al. 2009, Segurado et al. 2013). For the purposes of this project, a metric that could be easily computed and scaled from the catchment, to regional or national levels was required. It must also be easily understood and straightforward to communicate to the public. The approach taken was to classify all river reaches according to the barrier with the highest fish passage risk class that occurred downstream, and then calculate the total stream length within each risk class (Figure G-2; Table G-2).

In the example illustrated in Figure G-2, access to the stream reaches in Zone A has a very low risk of being impeded, as structure #1 (the only downstream barrier) was assessed as having a very low risk of impeding fish movements. In contrast, stream reaches in Zones D and E are located upstream of barriers (#6 and #10) that have been assessed as presenting a very high risk of impeding upstream fish movements. Consequently, these reaches have a very high risk of having restricted connectivity. Once the stream network has been classified into the different risk groups, total stream length in each risk class is calculated and the proportion of the stream network in each class derived (Table G-2). The greater the proportion of the river network in the higher risk classes, the poorer the state of river connectivity, and the greater the risk of impacts on instream values.

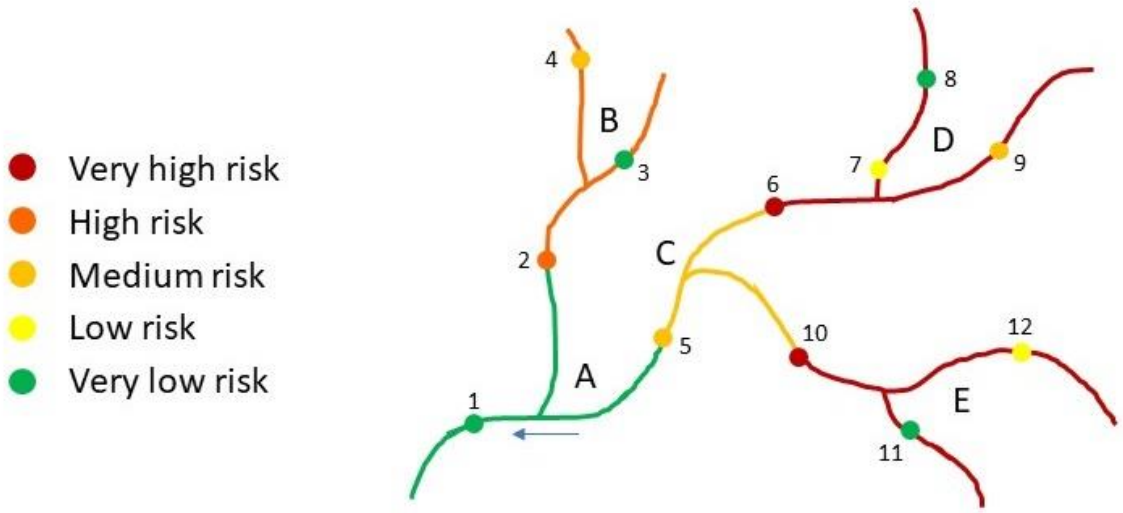


Figure G-2: River connectivity state metric. The connectivity of each stream reach is classified to match that of the worst barrier downstream of it on the river network.

Table G-2: River connectivity state metrics calculated for a theoretical example catchment. The higher the proportion of the stream network with medium to very high risk of connectivity being restricted, the greater the probability of impacts on fish communities.

Risk that connectivity is restricted	Length of stream network (km)	Proportion of stream network
Very low risk	40	23%
Low risk	0	0%
Medium risk	15	9%
High risk	25	15%
Very high risk	90	53%

As with the fish passage pressure metric, a key limitation of the river connectivity state metric is that only structures that have been identified and assessed can be incorporated in the calculations. Where an unidentified or unassessed structure is located upstream of an existing 'Very high risk' structure, it will have no impact on the connectivity metric for those stream reaches as it is determined by the downstream structure. However, where an unidentified or unassessed structure is located in a stream reach currently classified as very low to high risk, there is the potential for the connectivity metric to change.

Appendix H Barrier prioritisation scores

Introduction

Barrier removal or remediation can be a cost-effective means of restoring aquatic biodiversity. Factors such as where in the catchment a barrier is situated, whether there are other barriers upstream and/or downstream, and the location of critical habitats, all influence the potential ecological benefits that can be achieved from barrier removal or remediation. To help understand the relative potential ecological benefits of improving passage at different barriers, a simple ecological prioritisation score has been developed. The score ranges from 0 (low priority) to 20 (high priority). The score for any barrier can be viewed by clicking on a structure in the web portal, or by downloading the data.

How is the score calculated?

The prioritisation score is calculated by adding together four separate scores that each reflect different aspects of how a structure can influence river connectivity:

Barrier score

The higher the risk that a barrier is restricting fish passage, the greater the impact it is having on the upstream catchment. Consequently, the higher the fish passage risk class for a structure, the greater the potential ecological value in remediating it. The barrier score is based on the risk class allocated within the fish passage assessment tool and is shown in Table H-1.

Table H-1: Barrier score. Structures that have not been assessed are allocated a score of 3 because their potential impact is unknown.

Risk class	Score
Very high risk	5
High risk	4
Medium risk	3
Low risk	2
Very low risk	1
Not assessed	3

Downstream connectivity score

The value of remediating a barrier is diminished if there are further downstream barriers that limit the number of fish able to reach a site from the sea. The downstream connectivity score reflects the cumulative effects of downstream barriers on the number of fish potentially arriving at a site. The lower the downstream connectivity score, the lower the value of remediating a site. The score is allocated based on the cumulative probability of passage at downstream barriers:

$$P_{DS} = \prod_{i=1}^{n} p_i \quad (1)$$

Where P_{DS} = cumulative probability of passage at downstream barriers and p_i is the probability of passage (defined as the median probability for each risk class; Table H-2) at barrier *i*, where barriers *i* to *n* are in sequence starting from the barrier closest to the sea. The downstream connectivity score is based on the value of P_{DS} (Table H-3).

Table H-2: Median probability of passage for each passage risk class. Structures that have not been assessed are given an arbitrary score of 0.5 to reflect that they may have a potential impact on upstream passage.

Risk class	p
Very high risk	0.1
High risk	0.3
Medium risk	0.5
Low risk	0.7
Very low risk	0.9
Not assessed	0.5

Table H-3: Downstream connectivity score.

P_{DS}	Score
≤0.2	0
>0.2 & ≤0.4	1
>0.4 & ≤0.6	3
>0.6 & ≤0.8	4
>0.8	5

Catchment position score

The larger the proportion of a catchment that is upstream of a barrier, the greater the potential value in remediating the structure. The proportion of the catchment, rather than simply the distance inland or total stream length upstream is used because it scales relative to catchment size. It is calculated as the total stream length in the catchment upstream of the barrier divided by the total stream length in the catchment downstream of the barrier, with higher scores allocated the greater the proportion of the catchment that is upstream of the structure (i.e., the closer the structure is to the sea; Table H-4).

Table H-4: Catchment position score.

Proportion of the catchment upstream of the barrier (%)	Score
≤5	0
>5 & ≤25	1
>25 & ≤50	3
>50 & ≤75	4
>75	5

Accessible upstream habitat score

Access to habitats upstream of a barrier may be limited by the presence of further barriers. The greater the proportion of the upstream catchment that is accessible (i.e., access is not impeded by other barriers), the higher the potential ecological value in remediating the structure. It is calculated as the total stream length upstream of the barrier that is not upstream of another barrier with a risk class of 'Low', 'Medium', 'High', 'Very high' or 'Not assessed', divided by the total length of stream upstream of the barrier. Differences in stream size are not currently accounted for. Higher scores are allocated the greater the proportion of the catchment upstream of the structure where access is not impeded by other structures (Table H-5).

Table H-5: Accessible upstream habitat score.

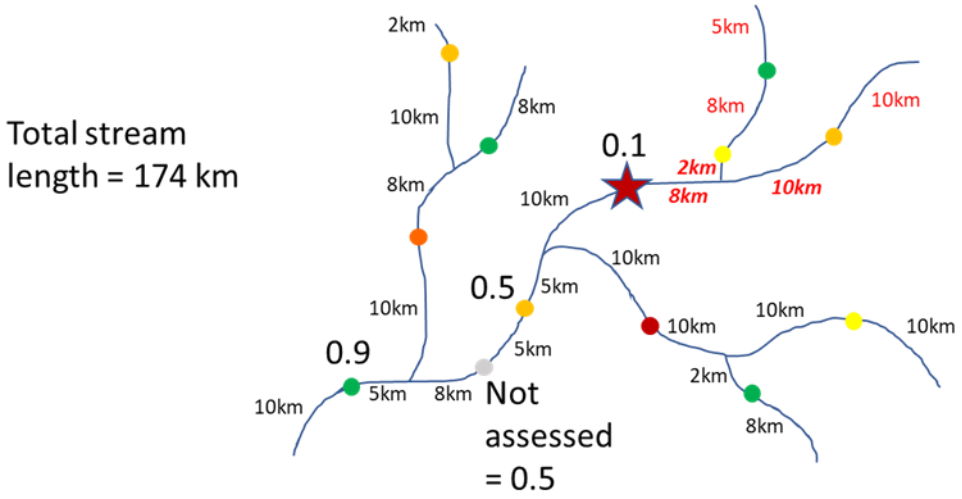
Proportion of the catchment upstream of the barrier that is accessible (%)	Score
≤5	0
>5 & ≤25	1
>25 & ≤50	3
>50 & ≤75	4
>75	5

Barrier prioritisation score

The overall barrier prioritisation score is calculated by adding together each of the component scores:

Prioritisation score = Barrier score + Downstream connectivity score + Catchment position score + Accessible upstream habitat score

The calculation of the metric is illustrated in Figure H-1.



Barrier score = 5
Downstream connectivity score = 1 (0.9*0.5*0.5 = 0.225)
Catchment position score = 1 (100*(***8***+***2***+8+5+***10***+10/174) = 24.7)
Upstream habitat quantity score = 3 (100*(***8***+***2***+***10***/***8***+***2***+8+5+***10***+10) = 46.5)

Total priority score = 5+1+1+3 = 10

Figure H-1: Illustration of how the barrier prioritisation score is calculated for a structure in an example catchment.

What do the scores mean?

The prioritisation score is intended to provide a simplistic indicator of the potential ecological value that may result from remediating a structure. The higher the score, the greater the potential ecological benefits of remediating the structure. The score for any structure is influenced by the location and passability of other structures in the same catchment, and so can vary as more structures are identified and assessed, or as other barriers are removed or remediated. Because of this, there is some uncertainty in the score if all barriers in a catchment have not been identified or assessed.

At present, the score does not take account of the suitability of upstream habitats for supporting fish communities, instead assuming that more accessible stream length, regardless of its quality, is equally beneficial. In reality, habitat suitability varies between reaches for different species. Metrics incorporating habitat suitability may be added in future.

It should also be recognised that a multitude of other factors may also influence the decision to remediate one structure ahead of another. For example, the cost of the fix required, the age and condition of the structure, whether the catchment is conservation land or is heavily modified, cultural or recreational values, accessibility and structure ownership, amongst other factors, could all contribute to determining the relative value of remediating a structure.

Appendix I Threatened species upstream

Threatened species flag

Some barriers can offer ecological benefits by preventing the spread of undesirable species and protecting important populations of native fish. To assist with identifying barriers that may protect important native fish populations, a threatened species flag will be appear on the record for any structure where any of the species in Table I-1 are recorded in the New Zealand Freshwater Fish Database as being present upstream.

Table I-1: List of key non-migratory galaxias that may benefit from protection by instream barriers that exclude invasive fish. [1]Kakanui. [2]Waitaki. [3]Manuherikia River. [4]Southland. Modified from Franklin et al. (2018) and updated to reflect 2017 threat rankings for freshwater fish (Dunn et al. 2018).

Common Name	Scientific Name	Threat status
Central Otago roundhead galaxias	*G. anomalus*	Nationally endangered
Lowland longjaw galaxias	*G. cobitinis*	Nationally Critical[1]/ Nationally endangered[2]
Taieri Flathead galaxias	*G. depressiceps*	Nationally vulnerable
Dwarf galaxias	*G. divergens*	Declining
Eldon's galaxias	*G. eldoni*	Nationally endangered
Gollum galaxias	*G. gollumoides*	Nationally vulnerable
Bignose galaxias	*G. macronasus*	Nationally vulnerable
Alpine galaxias	*G. paucispondylus*	Nationally endangered[3]/ Nationally vulnerable[4]
Pomahaka galaxias	*G. 'Pomahaka'*	Nationally vulnerable
Upland longjaw galaxias	*G. prognathus*	Nationally vulnerable
Dusky galaxias	*G. pullus*	Nationally endangered
Clutha flathead galaxias	*G. 'species D'*	Nationally critical
Northern flathead galaxias	*G. 'northern'*	Nationally vulnerable
Canterbury galaxias	*G. vulgaris*	Declining
Southern flathead galaxias	*G. 'southern'*	Nationally vulnerable
Teviot flathead galaxias	*G. 'Teviot'*	Nationally critical
Nevis galaxias	*G. 'Nevis'*	Nationally endangered
Canterbury mudfish	*N. burrowsius*	Nationally critical
Brown mudfish	*N. apoda*	Declining
Black mudfish	*N. diversus*	Declining
Northland mudfish	*N. heleios*	Nationally vulnerable