

To: Otago Regional Council  
Attention: Andrew MacLennan

From: Paul Morgan  
River and Fish Engineering  
Solutions

Date: 20 January 2026

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Otago Regional Council requested I review the following documents provided within the substantive application:

B.07 - SLR Aquatic (2025) - Ecological Assessment - Aquatic Ecology  
B.11a - Riley (2025) - Civil Engineering Assessment\_Part1  
B.11b - Riley (2025) - Civil Engineering Assessment\_Part2  
C.01 - Riley (2025) - Environmental Construction Management Plan (ECMP)  
E.03 Otago Regional Consent Conditions Final

The following Memo is a response to this information and issues of concern still remaining with what is proposed.

## **1 Summary of Qualifications and Experience of Author**

My qualifications are a Bachelor of Engineering (hon) in civil engineering from University of Auckland 1997 and a Bachelor of Science (Biological sciences) from University of Otago 1990. I am a Chartered Professional Engineer CPEng (civil) and Fellow of IPENZ (FIPENZ). Prior to working independently since November 2025, I was the Technical Leader and Practice Lead in Water Resources at Stantec for 2.5 years and previously was a Project Director at Riley from 2010 to 2023. I have over 29 years' experience in the assessment, design, and development of water infrastructure, particularly in hydropower, irrigation, river engineering and freshwater fish protection.

My expertise includes concept development, consent applications, design, construction, and operation. I also have experience in hydraulic modelling, flood assessments, river engineering, and hydrology. I have 19 years' experience in fish passage and fish screen facilities at river intakes and am a leading engineer in New Zealand in this field. I was a member of the Canterbury-based Fish Screen Working Group for several years providing engineering advice and supporting the development of assessment tools and design guidelines for fish screen facilities. I was a co-author of the NIWA Fish Screen Facility Guidelines (2023).

Over the last 19 years, I have successfully combined technical engineering skills related to hydraulics, river engineering, and structures with an understanding of aquatic ecology, particularly freshwater fish.

By understanding freshwater fish needs and behaviour around structures, I have integrated ecological knowledge with hydraulic design to assess and develop solutions that improve fish protection during both upstream and downstream movement. I have attended international conferences related to fish and fish passage, presented at several conferences on freshwater fish protection, and been on study tours to the USA and Australia focused on fish screen facilities. I have worked on over 50 fish related projects in New Zealand and I have also worked on projects in Australia, USA, Canada, and the UK.

## **2 Summary of review**

I have reviewed the information provided and considered issues raised in initial review. In general, the main issue of concern is the proposed design to achieve fish passage at the culvert. A review of the proposed changes to original design show there has been a clear attempt to provide for an improved design and a number of these changes have merit but overall, what is proposed has some significant concerns which are explained in detail below. The change to a single large box culvert is an improvement from previous design. The analysis of the fish passage at the culvert presented is still incomplete. The velocities within the culvert have been modelled but they have not been compared to fish swimming speeds and culvert length as detailed in Fish Passage Guidelines. This analysis should be undertaken for both a low and high design flow and also include details of the upstream and downstream apron of the structures to show how fish passage will be maintained in as wide as possible range of flow conditions.

## **3 Proposed design for culvert at stream**

A key issue is that for small fish the sustained swimming speeds are likely to be only in the order 0.1 to 0.3m/s. The two Tables below are from the 2018 (Appendix F) and 2024 (Table 4-1) Fish Passage guidelines which show the sustained swimming speeds for several native fish and also the relationship between culvert length and what velocity of flow. Although Eldon's Galaxias are not specifically included in general swimming speeds relate to length for swimming fish and it would be expected the fish present will be within the range of fish lengths shown in this Table of 40 to 120mm (maximum length reported (NIWA) is 150mm but more common up to 110mm). The average velocity within the natural stream is likely to be greater than this velocity for most conditions and therefore highlights that it is the variation in velocity that occurs, along with areas that fish can rest that enables fish to move upstream so the culvert needs to not only be consistent with the average velocity of the stream but also provide for that variation. In practice it is usually not possible within a culvert to provide the same variability in velocity and therefore a lower average velocity than the stream at least for low to moderate flow conditions is a potential approach to help address that issue.

## Appendix F Fish swimming speed look-up tables

**Table F-1: Maximum allowable water velocity ( $U_w$ ;  $m\ s^{-1}$ ) for a range of fish ( $L_f$ ) and culvert sizes ( $L$ ) for inanga.** These values are derived using the method described in Section 4.2.2 and are based on the relationship provided by Nikora et al. (2003). Grey areas are outside the range of the published relationship ( $t > 400\ s$  and  $4 < U_f/L_f < 18$ ). Maximum allowable water velocity should be calculated as the mean cross-sectional water velocity in the culvert.

		Fish length (mm)								
		40	50	60	70	80	90	100	110	120
Culvert length (m)	5	0.16	0.20	0.24	0.28	0.32	0.36	0.39	0.43	0.47
	10	0.13	0.16	0.20	0.23	0.26	0.29	0.32	0.36	0.39
	15	0.12	0.15	0.18	0.20	0.23	0.26	0.29	0.32	0.34
	20	0.11	0.14	0.16	0.19	0.21	0.24	0.27	0.29	0.32
	50	0.08	0.10	0.12	0.15	0.17	0.19	0.21	0.23	0.25
	75		0.09	0.11	0.13	0.15	0.17	0.18	0.20	0.22
	100			0.10	0.12	0.14	0.15	0.17	0.19	0.20
	150							0.15	0.17	0.18
	200									

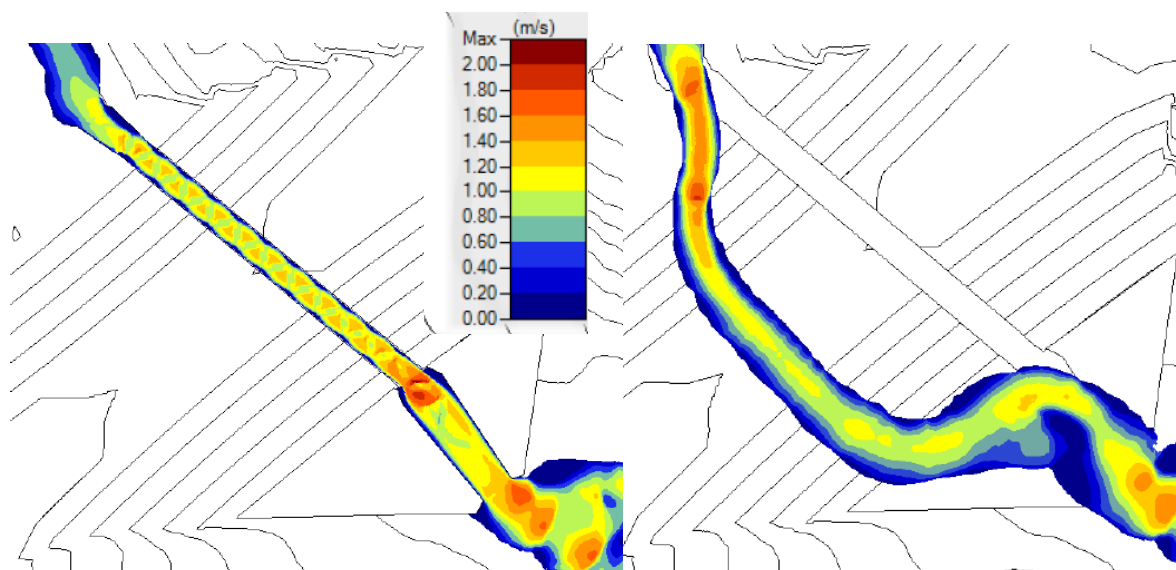
From 2018 Fish Passage Guidelines

**Table 4-1: Mean critical swimming speeds for a range of native fishes during their primary upstream migratory life stage.** Source: Crawford et al. (In review).

Species	Mean maximum sustained swimming speed ( $m\ s^{-1}$ )	Mean critical swimming speed ( $m\ s^{-1}$ )	Mean size (cm)
Banded kōkopu ( <i>Galaxias fasciatus</i> )	0.25	0.36	4.2
Common bully ( <i>Gobiomorphus cotidianus</i> )	0.24	0.34	3.2
Giant kōkopu ( <i>Galaxias fasciatus</i> )	0.44	0.63	4.9
Īnanga ( <i>Galaxias maculatus</i> )	0.20	0.28	4.4
Kōaro ( <i>Galaxias brevipinnis</i> )	0.40	0.57	5.2
Longfin elver ( <i>Anguilla dieffenbachii</i> )	0.22	0.32	11.0
Redfin bully ( <i>Gobiomorphus huttoni</i> )	0.29	0.41	4.1

From 2024 Fish Passage Guidelines

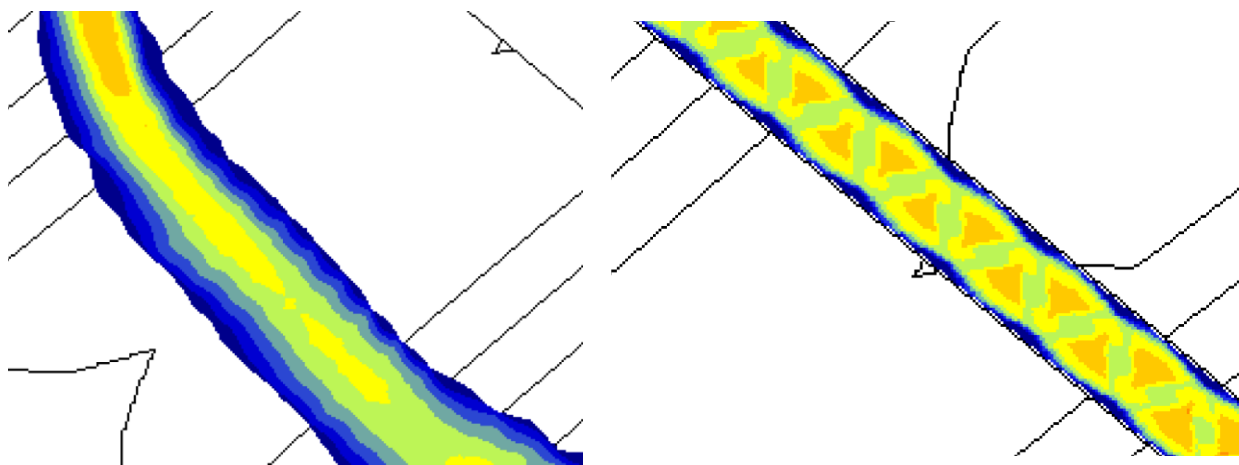
There are concerns with what is proposed for the culvert regarding fish passage. The figures below are from the RILEY report - Civil Engineering Assessment Puke Kapo Hau Mahinerangi Wind Farm Stage 2, Otago dated 15 October 2025. These figures show the velocity profile in the natural channel versus the proposed culvert.



Part of Figure 18 (left) design with culvert and Figure 19 (right) the existing stream.

These figures highlight some of the concerns with the effect of the proposed culvert for the velocity profiles from the hydraulic modelling results. The results show that the margin where there are much lower velocities (darker blue colours) is a lot larger in the natural channel in comparison to the culvert where it is only right against the vertical sides. These results are indicated as being for high flow design condition, but it is expected that the general patterns shown will be the same for low flow conditions just with a reduction in overall velocity.

Below is the velocity profiles in a larger scale to highlight the much larger band of lower flows in the existing stream.



The velocities in the culvert show that the proposed “meandering low flow channel” has all velocities above 0.8m/s, whereas the natural channel has continuous pathways of flow down to 0.2m/s. In this example there is flow that extends across the whole width of the culvert but in lower flow conditions the flow will remain within this channel which although meandering in plan view has a very similar profile along the length. The culvert is 35m long, but this channel appears to be in the order of 50% longer so

in that condition is making the length in the order of 50m long for fish to travel that follow that low flow channel. There are no resting areas or areas of low velocity in that condition for the fish to rest in. The velocity profiles above show that the complex velocity environment in the natural channel is not present in the culvert.

The modelling of the velocity is a good indication of what the velocities are, but it is important to note that this is a 2d model and therefore does not account for the vertical variations that occur within a channel. For a culvert this variation will not be significant as there is consistency in shape and no other objects impacting velocity. The hard vertical edge of a culvert is a significant limitation for higher flows whereas in a stream that has sloping sides means even at higher flows there will be a band of much lower velocity on the edges. In a natural channel there is variation in bed and general channel profile, rocks and other effects on the velocity including vegetation. So, the issues highlighted above show a lack of variation in flow patterns if they were modelled in 3d would expect an even larger difference between the natural channel and the culvert. In 3d there would be much more variability in the edges of the natural stream than what is being shown especially in lower flow conditions. This is what creates the ability for small fish to swim upstream utilising low velocity areas and areas to rest between the need for burst speed needs in some sections.

This means that the complex and variable flow velocity condition that occurs in the stream is not accounted for in the culvert and based on the swimming speeds for fish it seems unlikely that fish will be able to successfully swim upstream through the culvert.

In the initial review we commented that the analysis of fish passage was incomplete as the velocity within the culvert had been calculated but was not then compared to swimming velocity of fish and related to culvert length to show fish passage is achievable. In the recent information presented this is still incomplete.

In the Fish Passage Guidelines 2024 there is a methodology show to compare the calculated velocity within the culvert with fish swimming speeds. Figure 4-9 from the Guideline (seen below) provides for a methodology to account for swimming speeds sustainable for a given time. This comparison does not appear to have been undertaken for the design flows for both high and low conditions and therefore the analysis is incomplete.

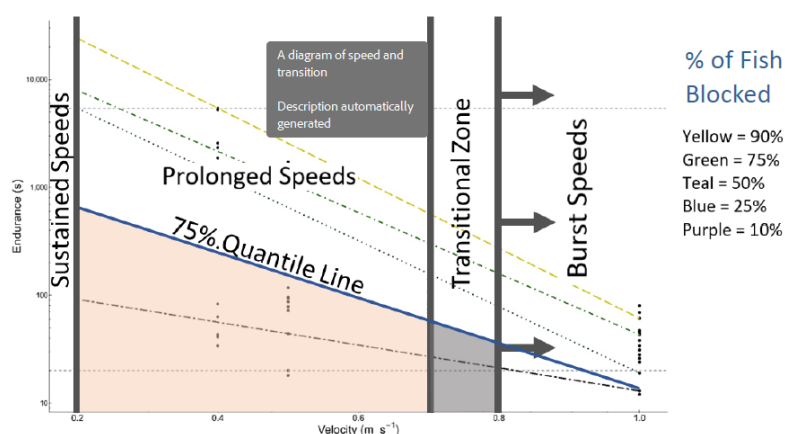


Figure 4-9: Swimming speeds and endurance for inanga. Quantile regression was used to establish relationships between swimming speed and endurance for different percentages of individuals. Adapted from Crawford et al. (In review).

The RILEY report includes the following in Section 5.6 Fish Passage Design Criteria  
*(a) The culvert must provide for the same passage of fish upstream and downstream as*

*would exist without the culvert...*

Even if the other criteria in Section 5.6 can be shown to be met the current design does not provide for (a) as explained above and confirmed from the modelling results presented.

The inclusion of the meander shape on its own is ineffective in improving fish passage for the culvert and in some flow conditions due to the increased length of the channel created through the culvert may reduce the effectiveness for fish passage. A meander in a channel that was formed with a various other geometry created along the length to provide suitable areas for resting and greater variation in velocity may have merit. It is unclear how the meander will be formed and maintained as there is indication of using similar infill material as occurs in the stream. For any material used it is important to use means to fill voids and reduce the risk of flow through this material as in low flow conditions that will impact on how much flow is above that material. The shape of the meander within the culvert is also not found anywhere else within the local natural parts of the stream, where there are meanders they are spread over a much greater distance and is therefore not copying a natural geometry of this stream.

For the culvert aprons a meander channel constructed for low flow has some merit as the issue with the aprons can be they spread flow across a very wide width and in low flows that becomes an issue with depth of flow. However, the sudden change in profile is a concern when flows exceed the meander channel capacity as they then are onto a flat surface and will have shallow depths (so an issue for both upstream but also downstream fish passage). It is better to have an apron that slopes towards a central low flow channel so there are no sudden changes and for the use of rocks embedded to provide for the variability in flows and velocity needed. The alternative is back water effects that create a deeper and lower velocity area, but they are challenging to achieve without creating new issue for fish passage at the structure creating backwater unless it is a rock ramp.

A more proven means internally within the culvert to provide for complex flow conditions are baffle blocks or other baffles. A recent and on-going study by DOC on the West coast where different options for culverts were tested with studies of fish passage found mixed results. In general baffle block culverts performed best where the blocks were trapping some sediment, blocks that stayed clean over time without sediment deposit around them were found to have poor results. So, the baffle system does need to ensure it achieves some sediment deposition for it to be effective. This study has also highlighted again that poorly designed culverts or features within culverts for fish passage can result in a complete barrier to upstream fish passage.

The design of the culvert for effective fish passage needs not only input from suitably qualified and experienced freshwater ecologist but most importantly an engineer with the skills and experience with designing for effective fish passage to ensure the design will enable fish passage over as wide a range of flows as possible.

The questions and comments from this review are:

1. The proposed culvert design does not provide for a solution that will ensure fish passage upstream through the culvert is possible. Regulation 70 (2)(a) is not met by this proposed design and highlights that simply meeting specified criteria about average velocity, embedment, widths on their own are not sufficient to achieve this regulation. The assessment presented had not compared modelled velocities with fish swimming speeds and culvert length to prove this design works for both low and high design flows.
2. The current culvert design does not ensure fish passage is possible and some of this relates to the long length of the culvert as well as lack of any significant means to provide velocity variance. As shown in the Tables from both 2018 and 2024 guidelines small native fish can

only sustain very low velocities which means a 35m culvert will not provide suitable conditions for fish passage unless there are means to provide a wide variety of velocities and resting areas. The proposed meander in the channel does not provide that as indicated by the velocity modelling results presented.

3. If a culvert option remains the approach the design needs to include proven techniques for addressing fish passage needs and accounting for as wide a variety of flow conditions as possible to maintain fish passage. The very low swimming speeds of the size of the fish present at this site highlights the importance of an understanding of the variability in flow conditions required to ensure upstream passage is feasible for a 35m long culvert.
4. Given the large size of the culvert proposed it should be possible to create a bed level with rock features and other more natural conditions that will create the complexity of flow and velocity conditions to enable fish passage. This needs to be robust so that it is not washed out in a flood and therefore just placing rock will not be sufficient on a concrete base so would need to be some constructed baffles combined with rock and other material placed in the invert.

## 4 Site Visit on Thursday 15 January 2026

The site visit included the proposed site for the culvert. What that highlighted is that what is proposed will include a significant filling of the stream gully and is the reason for a very long culvert. In the reports presented it indicates that a bridge option was discounted due to a bridge in excess of 60m long being required. That would be true if the bridge was constructed high above the stream connecting the two sides of the gully. I am not convinced that there is not a potential option for a much lower bridge which would include some earthworks and reshaping down to the lower level and with a much shorter span required. A bridge would be a higher cost option but removes all the risks associated with a culvert creating a barrier to fish passage.

## 5 Consent Conditions

### ***Fish Passage***

I recommend there is a consent condition requiring monitoring after the installation of the culvert to prove that fish passage is not impacted. This is especially important given the proposed culvert is 35m long and the fish species of concern is Eldon's Galaxias. It is worth noting that many fish passage structures constructed to provide fish passage have been found to be ineffective and in general the longer the culvert the less likely fish passage will not be impacted even with a good design when required for small native fish. This should also be repeated after significant flood events if there have been changes to the materials within the culvert or work done to ensure the design conditions are maintained.

### ***Water quality / sediment discharge Monitoring***

The various plans we have now been able to review include various monitoring during construction and note there are consent conditions relating to monitoring of the stream and stormwater during construction and until site conditions have settled.

I recommend ORC consider whether future periodic testing is maintained to ensure water quality in the stream and wetlands is maintained. This may be covered within management plans already.