BEFORE THE COMISSIONER APPOINTED
BY THE SOUTHLAND REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of resource consents to occupy the Coastal Marine Area with a tide gate and weir and to dam and divert water
AND	
IN THE MATTER	of an application by **SOUTHLAND REGIONAL COUNCIL**

EVIDENCE IN CHIEF OF LAURA ROSE DRUMMOND FOR SOUTHLAND REGIONAL COUNCIL

16 August 2024

FLETCHER VAUTIER MOORE
LAWYERS
PO BOX 3029
RICHMOND 7050

Solicitor(s): CP Thomsen
Telephone: (03) 543 8301
Email: cthomsen@fvm.co.nz

QUALIFICATIONS AND EXPERIENCE

1. My full name is Laura Rose Drummond

2. I provide a summary of my qualifications and experience here and attach a full CV in Appendix 1.

3. I am a Principal Scientist at Instream Consulting Ltd where I specialise in surface water quality and freshwater ecology. Prior to this I was employed by Pattle Delamore Partners as Technical Director – Ecology. Internationally I have held positions in Canada as a Freshwater Ecologist, Fisheries Specialist and Environmental and Regulatory Specialist. Prior to this I was employed by the National Institute of Water and Atmospheric Research (NIWA) as a Freshwater Ecology Technician.

4. I have a Bachelor of Science (2005), Post Graduate Diploma in Science (2006), and Master of Science in Ecology (2012) from the University of Canterbury.

5. I have over 17 years' experience in freshwater ecology research and consulting. I have been involved in a wide range of surface water quality and ecology assessments of effects both within New Zealand and Canada. My particular area of expertise is in mitigating the effects of land use and development on freshwater environments.

6. My project experience covers a range of activities including agricultural, development, landfill, quarry, wastewater, stormwater and water supply projects. My work experience relevant to these applications includes fish passage assessments and remediation, including designing baseline fish surveys to test the success of the Mona Vale weir replacement in the Ōtākaro/Avon River, and fish surveys and passage advice for the Stead Street culvert in Invercargill, which now has two fish-friendly Archimedes screw pumps.

EXPERT WITNESS CODE OF CONDUCT

7. I have read the Code of Conduct for Expert Witnesses set out in the Environment Court Practice Note 2014 and agree to comply with it. This evidence has been prepared in accordance with the Code of Conduct. I

confirm that the opinions I express in this evidence are within my expertise and represent my true and complete professional opinions. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express. The evidence I am giving is within my area of expertise, except where I state that I am relying on the opinion or evidence of others. I understand it is my duty to assist the Court impartially on relevant matters within my area of expertise.

SCOPE OF EVIDENCE

8. Southland Regional Council, known as Environment Southland, has applied for resource consents to re-authorise the location and operation of tide gates and a weir on the Titiroa Stream, 160 m upstream of the Tokanui-Gorge Road Bridge on State Highway 92. I understand the application is to replace lapsed coastal permits.

9. My role is to give ecological evidence on the effects of the tide gates and weir on freshwater ecosystems, including fish passage and inanga spawning.

10. Specifically, I have been asked to address.

    (a) How the tide gates and weir impact fish passage and migration and the works undertaken to determine this.

    (b) How the gates may impact water quality.

    (c) The proposed options to avoid, remedy, mitigate or offset the effects of the tide gates.

    (d) Proposed mitigation and offsetting options.

11. In preparing this evidence I confirm I have read:

    (a) The parts of the application that are relevant to my professional expertise.

    (b) The evidence of:

(i) Ian Dave Connor on behalf of the Southland Regional Council;

(ii) Colin Shen Young on behalf of the Southland Regional Council; and,

(iii) Matthew James Garder on behalf of the Southland Regional Council.

Function & Role of the Gates

12. The Titiroa tide gates were installed to prevent tidal ingress upstream from the tide gates to enable the drainage and use of productive land. The gates are located approximately 8.5 km from the ocean.

13. The morphology of the channel at the tide gate diversion has been modified, with approximately 180 m of the channel narrowed to approximately 10 m wide by the presence of an earthen dam/weir and the gate structure. The mainstem of the Titiroa River upstream and downstream of the gates is approximately 20 and 25-30 m wide, respectively.

14. The Titiroa tide gates are a passive gate design, with three gates hinged at the side. A positive head differential on the downstream side (i.e., higher water level) closes the gates. A positive head difference on the upstream side causes the gates to open and release water downstream (see Attachment 1 for photos).

15. The duration of each tide gate opening depends on the height of the tide and the flow and water level of Titiroa Stream upstream of the gates. When observed[1], the tide gates were open for approximately 380 minutes, i.e., about 51% of the 12.5-hour tidal cycle.

16. Further information on the role of the gates in relation to flood protection and tidal ingress is discussed in the evidence of Mr Connor and Mr Young.

[1] By Pattle Delamore Partners staff during the velocity survey.

TOPIC 1 – Background

Titiroa Stream

17. The Titiroa Stream is located on the eastern bank of the lower Mataura River floodplain and predominately flows through agricultural land, with some remnants of native bush in the tributaries and upper reaches. The location of the tide gate structure is approximately 200 m upstream of the Tokonui-Gorge Road Highway and approximately 6.5 km upstream from the Toetoes (Fortrose) Estuary.

18. Toetoes (Fortrose) Estuary is mapped under the 'Regionally Significant Wetland and Sensitive Waterbodies' layer in the Proposed Water and Land Plan[2]. Long term monitoring sites in the Toetoes Estuary are dominated by sandy sediments and representative of 'good' health[3]. However, high nutrient inputs and nuisance macroalgal growths have previously been identified as key issues[4].

19. The Titiroa Stream is known to support a range of native and introduced fish species (discussed further in paragraphs 27-34). Downstream of the gates is a popular whitebait fishing location during the season (1 September to 30 October), with 92 registered whitebait stands downstream of the Tokonui-Gorge Road Highway[5]. The Titiroa Stream is also known for brown trout fishing, with a fishing season of 1 October – 30 April. No whitebait fishing can occur upstream of the Tokonui-Gorge Road Highway.

20. In addition to the modified reach associated with the gates, approximately 10 linear km upstream from the tide gates a flow diversion is present, referred to as the Titiroa 'cut-off' which connects the Titiroa Stream to the Mataura River. I understand that this channel was put in to divert high flows to the Mataura River and avoid flooding of the lower Titiroa Stream when the tide gates are shut. The Titiroa cut-off therefore has the potential to provide a migration pathway for fish into the upper catchment. A map

---

[2] Beacon (es.govt.nz)
[3] Land, Air, Water Aotearoa (LAWA) - Fortrose Estuary Site B
[4] Stevens, L, M. (2018). Fortrose (Toetoes) Estuary. Broad Scale Habitat Mapping 2018. Prepared for Environment Southland. 46p.
[5] As per the evidence of Mr Connor.

showing the location of the Titiroa Cut in relation to the tide gates is provided in Figure 1.

21. Approximately 444 ha grazed land owned by Environment Southland in the Tititoa catchment has been retired. In the lower reaches the intention is to restore this land to coastal wetlands, with projects currently in progress. The tide gates increase the water level inundation in these lower reaches, which supports the restoration of lowland swamp/wetland habitat.

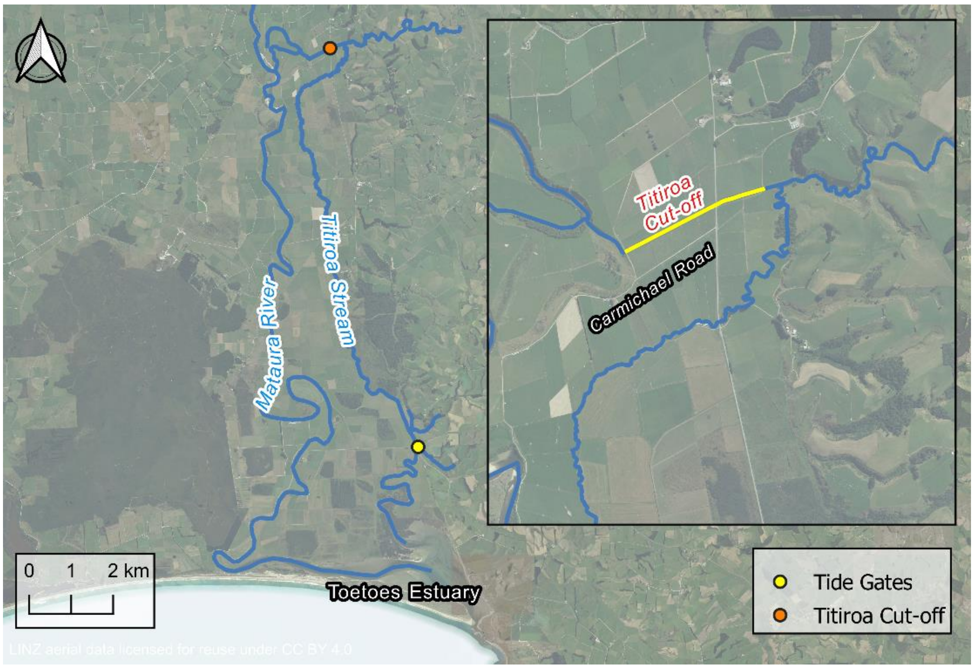

Figure 1: Overview of Titiroa Stream catchment, showing the location of the tide gates and the Titiroa cut-off[6]

Fish Passage Guidelines

22. The New Zealand Fish Passage Guidelines (for structures up to 4 metres) was published in 2018[7] (referred to hereafter as 'the Guidelines'). The intent of the Guidelines is to set the foundation for the improvement of fish passage management in New Zealand. It does this by providing recommended practice for the design of instream infrastructure to provide for fish passage.

23. When considering flood and tide gates, the fish passage guidelines conclude they can significantly disrupt the movements of aquatic organisms

[6] November 2022.
[7] NZ-FishPassageGuidelines-upto4m-NIWA-DOC-NZFPAG.pdf

and alter upstream habitats. However, the guidelines also recognise such infrastructure can be necessary. Best practice where flood or tide gates are required is to install automated gates that operate the gate only when water levels reach a critical elevation.

24. The Guidelines recommend that where operational constraints prevent the use of automated gate systems, self-regulating "fish friendly" gates (FFGs) should be installed. FFGs can increase the duration and aperture that the gate is open, particularly on the incoming tide when juvenile fish are moving upstream.

25. It is noted, that as per the Guidelines, tide and flood gates were historically most often constructed of cast iron or wood. The Guidelines state that newer aluminium and plastic gates are preferred to the old designs because the lighter gates open more easily allowing for better fish passage and drainage. Side-hinged gates, which are the type of gates present at the Titiroa Stream, are also stated in the Guidelines as preferable to top-hung gates as they require a smaller hydraulic head to open them, they open wider and for longer, providing more opportunity for fish to pass through the gate.

TOPIC 2 – Fish Passage Assessment

Fish Community Survey

26. As part of the conditions of consent, a comparison of native fish communities in sites upstream and downstream of the tide gate structure was required. Two fish surveys have been undertaken. The first consisted of six baited fyke nets and six baited gee minnow traps set both upstream and downstream of the dam wall adjacent to the diversion channel, in similar, ponded habitat[8]. This survey was undertaken by PDP in February 2021. The second fish survey was undertaken by Aquatic Ecology Limited (AEL) of behalf of PDP in the main stem of the stream, to address questions raised by Department of Conservation (DOC), Te Ao Marama Incorporated (TAMI) and Fish & Game. Four unbaited fyke nets and four unbaited gee minnow traps were set approximately 200 m upstream and downstream of

[8] Although the area available was relatively small, these two areas provided an excellent "side by side" comparison between upstream and downstream communities. This was primarily because they were of similar area and were static (non-flowing) habitats.

the gates in the main stem of the Titiroa Stream and left to soak overnight. This survey as undertaken in March 2022. Sites in relation to the tide gates are shown in Figure 1.

Figure 1: Tide gates and channel. Image sourced from PDP Titiroa Tide Gate Mitigation Options Report[9]

27. These two surveys provide an overview of the species composition and densities in two differing habitat types. It is recognised that a more intensive fishing survey including sites further upstream and downstream of the gates may have resulting in additional species being recoded, however, habitat conditions downstream of the gates are brackish, compared to freshwater

[9] November 2022.

upstream. Therefore, results would have been skewed by habitat differences. The results gained from both fishing surveys provide evidence that a similar diversity of fish species captured upstream and downstream of the gates, as expected with the gates providing passage for half the tidal cycle. The results show a difference in fish abundance upstream and downstream of the tide gates, with some species affected more than others, as summarised in Table 1.

Table 1: Summary of fish survey results. Data are number of fish caught.

Table 1: Fish Survey Summary (from Table 3, PDP 2022)					
Common name	**Species name**	**January 2021**		**March 2022**	
		U/S	**D/S**	**U/S**	**D/S**
Longfin Eel	*Anguilla dieffenbachii*	66	192	21	66
Shortfin Eel	*Anguilla australis*	3	27	17	39
Inanga	*Galaxias maculatus*	28	303	16	200
Common Bully	*Gobiomorphus cotidianus*	13	29	27	117
Redfin Perch	*Perca fluviatilis*	0	58	2	0
Giant Kokopu	*Galaxias argenteus*	0	0	1	0
Redfin Bully	*Gobiomorphus huttoni*	0	0	10	0
Triplefin[1]	*Forsterygion lapillum*	0	0	0	38
Total		**110**	**609**	**94**	**460**

Notes:

[1.] Marine species that occupies the lower reaches of tidal streams.

28. Six native migratory[10] species were recorded in this investigation, with all but one found both upstream and downstream of the tide gates[11]. Of the species caught, inanga, longfin eel, and giant kokopu are of conservation interest, because they have an 'At-Risk Declining' threat status[12]. The average catch per net, or "catch per unit effort" (CPUE), has been calculated for the 2022 fish survey, which was more representative of mainstem habitat conditions. The CPUE upstream and downstream of the gates was 24 and 115, respectively. This shows higher fish density downstream of the gates,

[10] Scientific term is diadromous, meaning fish that migrate between the sea and fresh water. Referred to in evidence as migratory for simplicity.

[11] Giant kokopu (*Galaxias argenteus*) was only recorded upstream of the gates.

[12] Dunn, N.R.; Allibone, R.M.; Closs, G.P.; Crow, S.K.; David, B.O.; Goodman, J.M.; Griffiths, M.; Jack, D.C.; Ling, N.; Waters, J.M.; Rolfe, J.R. 2018: Conservation status of New Zealand freshwater fishes, 2017. New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 p. Conservation status of New Zealand freshwater fishes, 2017 (doc.govt.nz).

which can be attributed to the presence of the gates restricting fish movement upstream when the gates are closed, which was captured during the overnight net setting.

29. All tide gates influence fish movement, as they impede stream flow for a proportion of the tidal cycle, but some restrict upstream movement of fish more than others. The Titiroa Stream tide gates provide open flow within the diversion channel (three free flowing areas approximately 2 m wide are present between the gates structures) for approximately 6 hours during a 12-hr tidal cycle. Of the species assessed (the six migratory species in Table 1) inanga were determined as the species with the highest impact from the gates. This was because of their life history, which links spawning migration to spring high tides and their weak swimming abilities (discussed further in paragraphs 35-39). Common bullies are also substantially affected, and eels to a lesser extent.

30. Inanga have a catadromous life-cycle, meaning adults migrate from rivers and streams to estuaries to spawn. Inanga are the main whitebait species around New Zealand and they spawn amongst marginal grasses and rushes in areas close to the upstream limit of salt water penetration (the "salt wedge") at the very peak of high spring tides during Autumn. Fertilised eggs remain among the damp vegetation but out of the water until a later high spring tide, when they are re-inundated, hatch, and are washed downstream to the sea (about six months later they migrate back into the rivers as whitebait). The presence and operation of the Titiroa tide gates means that inanga in the river upstream of the tide gates may be prevented or delayed from migrating to spawning areas downstream of the gates (but are able to access spawning areas upstream of the dates). In addition, the tide gates reduce the upstream extent of saltwater egress, meaning the length of spawning habitat is likely truncated.

31. It is recognised that additional species not recorded during the fish survey or in the New Zealand Freshwater Fish database may be present in the Titiroa Stream. TAMI have shared that kanakana (lamprey: *Geotria australis*) were historically harvested in the Titiroa Stream, while review of the New Zealand Freshwater Fish database records the presence of Gollum galaxias (*Galaxias gollumoides*), smelt (*Retropinna retropinna*), flounder

(Rhombosolea) and brown trout (*Salmo trutta*). Gollum galaxias have the threat classification 'Nationally Vulnerable'[13]. I cannot comment on the historical fish diversity of the stream but note there are a range of factors that may have influenced the stream over time. These include agricultural land use, channel modification and the presence of tide gates which alters the hydrological regime.

32. Of the species listed in paragraph 31, Gollum galaxias are non-diadromous (do not migrate to sea), smelt and flounder typically reside in the lower reaches of stream and estuaries, but could be expected to occur upstream of the tide gates given the low channel grade. Brown trout are strong swimmers and expected to be able to migrate past the gates when open, however juveniles may struggle at peak velocities. While there are no known records for kanakana/lamprey presence in the Titiroa Stream, they are known to be in the Mataura River and could therefore be present in the Titiroa Stream.

33. Kanakana, also known as lamprey (*Geotria australis*) are lacking in scientific information on distribution and abundance. NIWA consider this is partially because of the rarity and secretive nature of adults, as well as the lack of projects targeting this species[14]. They have an anadromous life cycle, which means that their larvae rear in freshwater and migrate to the ocean as juveniles. They feed and grow to adulthood in the ocean and then migrate back to freshwater in winter/spring to spawn and die. While little is known about the cues used for migration, literatures suggest upstream migration is triggered by increases in stream discharge[15] and they are known to leave the water when necessary and travel along the river edge[16]. While they are known to use their sucking disc mouth to climb natural and artificial barriers (such as waterfalls and dams)[17] hard edges, as present at the top of the

---

[13] Dunn, N.R.; Allibone, R.M.; Closs, G.P.; Crow, S.K.; David, B.O.; Goodman, J.M.; Griffiths, M.; Jack, D.C.; Ling, N.; Waters, J.M.; Rolfe, J.R. 2018: Conservation status of New Zealand freshwater fishes, 2017. New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 p. Conservation status of New Zealand freshwater fishes, 2017 (doc.govt.nz).

[14] Restoration and enhancement of piharau / kanakana / lamprey | NIWA

[15] Ecology of the New Zealand Lamprey (doc.govt.nz)

[16] McDowall R.M. (1990) New Zealand Freshwater Fishes: A Natural History and Guide. Heinemann Reed, Auckland, New Zealand.

[17] Ecology of the New Zealand Lamprey (doc.govt.nz)

Titiroa tide gates, will likely limit or prevent success in climbing over gates structure as full suction cannot be maintained.

34. As kanakana migration may be triggered by increases in stream discharge, the tidal opening of the gates is not expected to be a major barrier for their migration. This is because the gates are passive by design and will open when high flows occur upstream. They are also open for half of the tidal cycle. It is noted that a nationally significant population of kanakana was discovered in Canal Reserve Drain, a spring-fed timber lined waterway, which discharges to the Styx River in Christchurch[18]. This waterway is upstream of a tide gate structure in the lower reaches of the Styx River.

Velocity Assessment

35. As required by the conditions of consent on the lapsed coastal permits, an assessment of the flow profile immediately downstream of the tide gate structure was undertaken. The purpose being to determine whether water velocities through the gates and diversion channel exceed the known swimming speeds of native fish when the gates are open. If water velocities in the diversion channel are the same or higher than target fish swimming speeds, upstream passage of fish upstream can be limited, causing an adverse effect. Water velocities can be high when flow is restricted at tide or flood gates outlets, in particular if the outflow structure is small in comparison to flows (i.e. piped tide gate outlets with top hinged gates).

36. Flow profile measurements were undertaken approximately 2 m downstream of the Titiroa tide gate structure using a River Surveyor S5. The minimum and maximum water velocities recorded were 0.02 m/s and 1.19 m/s. The average water velocity calculated throughout a series of transects across the Titiroa Stream was 0.36 m/s. Water velocities were measured over a 40-minute period from when the gates opened. Field notes indicate that flows were highest in the thalweg of the channel, with slower flows along the bottom and sides of the channel.

[18] Baker, C., Sinton, A., Reeve, K., & Williams, P. (2017). Canal Reserve Drain Intersection Upgrade - Impacts on Lamprey. Prepared for Christchurch City Council. December 2017. NIWA Client Report No: 2018013HN.

37. The average water velocity of 0.36 m/s has been compared to known swimming speeds of fish species recorded in the Titiroa Stream[19]. Available swimming speed data includes burst swimming (high intensity, short duration), prolonged swimming (between 20 seconds and 200 minutes, typically ending in exhaustion), and sustained swimming (aerobic, maintained for extended periods of time (>200 minutes), and does not end in fatigue). It is noted that as fish get bigger, their swimming speed increases, therefore juvenile fish migrating upstream are at most risk of high velocities through structures.

38. When comparing known prolonged and sustained swimming speed data to velocities measured downstream of the gates, small inanga, smelt and common bully would struggle to swim upstream at the average velocity measured. However, they will be able to move though in the gates when velocities are lower (i.e., the minimum velocity measured of 0.02 m/s). Common bully, eels and brown trout are expected to be able to move through the gates when comparing average velocity to published swimming speed data.

39. When closed, the tide gates prevent passage and result in increased numbers of fish downstream, which leads to predation of smaller fish by larger fish and birds. However, during each tidal cycle there are sustained periods when flow through the gates is low, as well as a period on the rising tide when there is very little downstream flow. During these times there is no barrier to fish movement up or downstream. Measures taken downstream of the gates show that when the gates first open, water velocities will impede upstream movement for weak swimming species like inanga. However, for most of the time when gates are open water velocities will not impede upstream migration of fish. A potential mitigation option for increased velocities within the diversion channel (compared to the mainstem) is to install baffles to provide resting areas for smaller fish moving upstream.

[19] Table D1 in the New Zealand Fish Passage Guidelines.

TOPIC 3 – Water Quality

40. There are studies which show tide gates can reduce salinity and water velocity upstream, as well as increasing sediment deposition, and lower dissolved oxygen and higher water temperatures[20]. As the gates provide free stream flow and drainage when open, no significant adverse effects on water quality are expected. I have queried the catchment group on the frequency of sediment buildup in the Titiroa River upstream of the bund. No dredging has occurred and there have been no issues with increased sedimentation in the river, that I am aware of.

41. The salinity level upstream of the gates is altered during the tidal cycle because of their presence. As shown in the hydraulic modelling (section 3.3 of PDP 2022[21]) flow inundation would extend to Flemings Road if the gates were removed. The current salt wedge has been mapped at approximately 160 m upstream of the gates, whereas previously it was mapped as downstream of the gates (section 3.1 of PDP 2022[22]). If the gates were removed, the salt wedge would extend further upstream during the incoming tide, resulting in more brackish conditions upstream of the gates and an extended salt wedge for inanga spawning. In the consideration of whether FFGs are needed, the effects on the salt wedge need to also be considered. Care would need to be taken with any major changes to the tide gates structure and what effects that could have on the existing salt wedge and associated inanga spawning habitat.

TOPIC 4 – Effects Management Hierarchy Assessment

42. An assessment of the effects management hierarchy was undertaken as part of the fish passage assessment. A summary of this assessment, as well as updates proposed since lodging consent, is discussed in the

[20] Franklin, P.A., Hodges, M. (2015) Modified tide gate management for enhancing instream habitat for native fish upstream of the saline limit. Ecological Engineering, 81(0): 233- 242. http://dx.doi.org/10.1016/j.ecoleng.2015.04.004.
Scott, D.C., Arbeider, M., Gordon, J., Moore, J.W. (2016) Flood control structures in tidal creeks associated with reduction in nursery potential for native fishes and creation of hotspots for invasive species. Canadian Journal of Fisheries and Aquatic Sciences, 73(7): 1138-1148. 10.1139/cjfas-2015-0311.
[21] PDP (2022). Titiroa Tide Gate – Mitigation Options. Prepared for Environment Southand. November 2022.
[22] PDP (2022). Titiroa Tide Gate – Mitigation Options. Prepared for Environment Southand. November 2022.

subsections below. The effects management hierarchy is relevant for certain proposed habitat enhancements, which include the inanga spawning habitat enhancement.

(a) Avoid - There is no way to avoid the effects of the activity without removing the tide gate structure and giving back the land to full tidal inundation and flooding. This was not considered an option by Environment Southland, as per the evidence of Mr Young and Mr Connor.

(b) Minimise or Remedy - There is no way to fully remedy the effects of a tide gate without removing it or providing an alternate bypass. Due to the tidal conditions and landowner restrictions, an effective bypass would be challenging to install. To minimise the potential effects of increased water velocities in the diversion channel downstream and through the tide gate structure when gates are open, baffles (or boulder installations) are proposed. This will provide slow velocity zones and resting places for native fish and enable the use of 'burst' swimming speed to assist native fish movement through the gates.

(c) If the gates cannot be removed, automated or FFGs are the best option available to minimise effects to fish passage. This option would enable a greater period of time for fish movement past the gates. I am aware modelling of small increases in tidal inundation has been undertaken (1 hour at either side of the tide) and showed this increase in gate opening would result in loss of drainage network capacity[23]. FFGs are not a one size fits all model and need to be designed on a site-specific basis.

(d) Aquatic Offsetting and Compensation – As more than minor adverse residual adverse effects on inanga spawning cannot be avoided, minimised, or remedied for functional reasons, aquatic offsetting or compensation is required. It is noted that because of the nature of this application, including the highly modified farmland in the catchment as part of the previously lawful occupation of the gates

[23] As per the evidence of Mr Gardner.

and the changes to the salt wedge, it is very difficult to assess and determine the actual extent of lost inanga spawning habitat.[24] I therefore cannot be confident that no net loss can occur. Therefore, aquatic compensation has been provided.

(e) Aquatic offsetting in the form of habitat enhancements is proposed. A range of restoration and/or enhancement options in nearby environments was proposed for further discussion with stakeholders, with the aim of consulting on the most ecologically beneficial enhancement for the catchment. As this did not happen, options currently put forward for habitat enhancement consist of inanga spawning habitat improvements, enhancement of a tributary immediately downstream of the gates for inanga spawning and native fish habitat, and enhancement of a ring drain downstream of the Tokanui-Gorge Highway. Further discussion with stakeholders is still recommended to achieve positive outcomes.

TOPIC 5 – Aquatic Compensation Options

43. Inanga were targeted for aquatic compensation measures as they were determined to be the species most affected by the tide gates, with adverse effects on spawning and upstream migration. Plus, inanga are also an At Risk species, valued mahinga kai, and part of a recreational fishery. It is acknowledged that inanga spawning enhancement does not compensate for restricted access for all migratory species.

44. Potential lost inanga spawning habitat within the Titiroa Stream due to the presence of the tide gates has been measured as 1.38 ha of riparian land. This is a very conservative assessment considering inundation and potential spawning conditions to Flemming Road; however, actual spawning areas would be depended on the changes to the salt wedge that would occur from the removal of the gates, which is not known. The area was determined by inputting data into GIS to calculate the area of bank. Terrain survey points, which identified the bank slope were digitized as well as the lengths of suitable inanga spawning habitat from the gates to Flemming

[24] The estimate in the Mitigation Report discussed below notwithstanding.

Road. These individual areas were quantified as the potential riparian area lost to inanga spawning.

45. A survey of spawning habitat quality in this area was undertaken by AEL (on behalf of PDP), with low value banks on the Titiroa Stream upstream of the gates mapped[25]. Suitable locations were identified for inanga spawning that currently have unsuitable microclimates that could be enhanced through bank restructuring (increase in slope/area), restricting stock access to allow for bank stability and vegetation growth, as well as riparian planting. It is recommended that enhancement follows the guidelines outlined in Richardson and Taylor (2004)[26].

46. The proposed enhancement would improve the current bank conditions, which would result in betterment and would create improved spawning habitat upstream of the tide gates, where the salt wedge has been mapped and spawning has been observed. For example, reducing the bank angle would optimise the potential spawning area, because the tide gates, in their present form, minimise tidal level fluctuations in proximity to the salt wedge.

47. The riparian area of the true right bank upstream of the tide gates that is owned by Environment Southland (within the 500 m radius of the identified saltwater wedge) is proposed for enhanced inanga spawning habitat. Both banks, as well as a tributary upstream of the gates were initially proposed for enhancement. However, only the true right bank and the island between the diversion channel and weir can now be included due to landowner restrictions. This results in an area of 0.6 ha in the immediate area of the gates, as shown in Figure 3.

48. To provide improved inanga spawning habitat and improved instream conditions for native fish downstream of the gates, including refugia areas from predation for smaller fish, enhancement of the tributary on the true right bank downstream of the gates is proposed. This has been calculated as an area of 0.53 ha (not 5.33 ha as reported in PDP (2022)[27]), as shown in

---

[25] As determined through spawning and habitat assessments undertaken by Aquatic Ecology Limited in the mitigation assessment report (PDP 2022).

[26] Richardson, J., & Taylor, M. J. (2002). *A guide to restoring inanga habitat*. NIWA Science and Technology Series No. 50 (Vol. 2002).

[27] PDP (2022). Titiroa Tide Gate – Mitigation Options. Prepared for Environment Southand. November 2022.

Figure 3. A perched culvert is located under Middleton Road, approximately 50 m upstream from the confluence with the Titiroa Stream. This culvert will be remediated to provide effective fish passage and meet the Guidelines for culverts.

49. This tributary was chosen as previous investigations[28] into potential inanga spawning areas in Southland rivers highlighted the limited spawning habitat available within the Titiroa Stream. The unnamed tributary which enters the Titiroa Stream immediately downstream of the tide gate, was identified as "high priority for enhancement as it may be the only major freshwater-tidal area in the Titiroa system". Enhancement of this tributary will also provide improved habitat for native fish downstream of the gates.

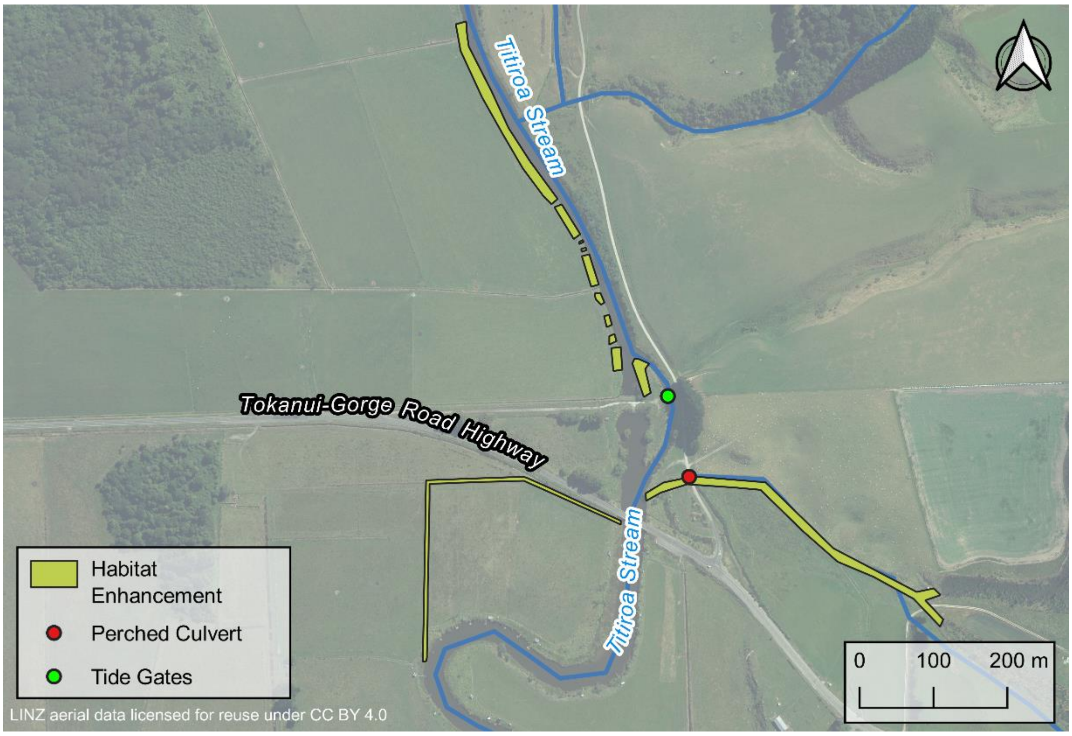

Figure 3: Proposed habitat enhancement locations[29]

50. Additional potential spawning area improvements were identified downstream of the gates, in the drainage network of lease land. However further assessment is considered required to confirm the salinity of water in

[28] Hicks, Andy., Leigh, Bjorn,. & Dare, James,. (2013) *Potential Inanga Spawning Areas in Southland Rivers.* Technical Report. Environment Southland.
[29] November 2022.

this area as high salinity limits fertilization success[30]. The potential for 'spawning islands' in lease land downstream of the gates was proposed as an option, however this has not been progressed as stakeholder engagement did not occur. Further investigation would be required to confirm the viability and cost of enhancement in this area, as salinity levels may be too high.

51. As the potential for inanga spawning improvements is limited and does not address the restricted fish passage upstream, alternative compensation, such as enhancement in the lower reaches, native fish habitat enhancement or riparian planting along the Titiroa Stream is recommended. While this does not address the restricted fish passage, it would result in an improvement to the natural and riparian biodiversity values of the waterway.

52. In addition to the habitat enhancement for native fish and perched culvert remediation in the tributary discussed in paragraphs 48-49, enhancement of the ring drain in the lease land discussed in paragraph 51 is proposed for native fish habitat. This would involve widening and battering of the banks of the drains, creation of pools and riparian planting to provide increased habitat outside of the mainstem of the Titiroa Stream. This has been calculated as an area of 0.27 ha, as shown in Figure 3.

53. This results in a total area of habitat enhancement of 1.4 ha. In the mitigation report[31] there was an option for up to 6.9 ha of enhancement for further discussion with submitters, in understood that these discussions did not occur. Further opportunities for collaboration with existing restoration projects in the lower catchment, as well as engagement with submitters on opportunities for enhancement, it still recommended. To ensure that the proposed enhancement is ecologically meaningful and successful, conditions will be required to ensure the proposed works are undertaken in a collaborative manner with stakeholders, including input into and approval

---

[30] Hicks Andy, Barbee Nicole C., Swearer Stephen E., Downes Barbara J. (2010). *Estuarine geomorphology and low salinity requirement for fertilisation influence spawning site location in the diadromous fish, Galaxias maculatus*. Marine and Freshwater Research.

[31] PDP (2022). Titiroa Tide Gate – Mitigation Options. Prepared for Environment Southand. November 2022.

of proposed works and associated enhancement proposals and monitoring plans.

SUMMARY

54. The Titiroa tide gates restrict the free passage of fish up and downstream of the structure when closed, which can affect the migration of native fish within the catchment. Passage is available when the gates are open, which is half of the tidal cycle. Results from the fishing surveys show that there is a difference in fish abundance upstream and downstream of the tide gates; however, the diversity of fish species captured was similar.

55. From an ecological perspective, the best outcome is to remove the gates to provide unobstructed passage. However, if this is not functionally possible, modifications or replacement with automated or FFGs is the preferred option for new or replacement gates, as per the Guidelines. It is noted that the Guidelines state that where operational constraints prevent the use of automated gate systems, side hinged gates (as are present) are preferable over top hinged gates, as they require a smaller hydraulic head to open them, therefore they stay open for longer. If FFGs are to be investigated further, additional hydraulic modelling will be required to determine what level of opening times could occur without resulting in adverse effects to upgradient land. Modelling has shown an increase in opening time of 1 hr would result in adverse effects upstream.

56. To minimise the level of effect of the gate’s presence on fish passage, baffles are proposed within the diversion channel to reduce water velocities when the gates are open. Aquatic compensation in the form of improved opportunities for inanga spawning, which is highly impacted by the gates, enhanced tributary habitats for native fish and remediation of a perched culvert which forms a fish passage barrier downstream of the gates is proposed. A range of potential enhancement options were provided for further consideration and consultation. These options have been updated in response to landowner restrictions and include improved inanga spawning habitat and tributary enhancement for a total area of approximately 1.4 ha.

57. In my opinion, if the gates cannot be removed or modified, the proposed baffle installation will reduce the level of effect on fish passage when the

gates are open. Aquatic compensation measures can improve the natural values of the Titiroa Stream near the tide gates and go some way to reducing the level of adverse effect of the tide gates. This can be achieved through providing additional inanga spawning habitat, enhanced native fish habitat, remediation of a perched culvert and improved riparian biodiversity values. However, these options will not address the restricted fish passage upstream when the gates are closed. Conditions will be required to ensure that proposed habitat enhancement works are undertaken in a collaborative manner with the Environment Southland science group and stakeholders, including input into and approval of proposed works and associated monitoring plans.

Laura Drummond

16 August 2024

Appendix 1

Site photos

Figure A1: Titiroa tide gates – view of open gates from true right bank.

Figure A2: Titiroa tide gates – drone view of closed gates and diversion channel.

Figure A3: View downstream towards Toetoes (Fortrose Estuary)

Figure A4: Perched culvert to be remediated at proposed tributary enhancement site.

Figure A4: Potential drain for enhancement in Environment Southland lease land downstream of gates