BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991 ("the Act")
AND	
IN THE MATTER	Proposed Plan Change 5A: Lindis Integrated Water Management

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STATEMENT OF MATTHEW AARON HICKEY
EVIDENCE ON BEHALF OF THE LINDIS CATCHMENT GROUP LTD

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Introduction

Qualifications and experience

1. My full name is Matthew Aaron Hickey.

2. I hold a Bachelor of Science Double Major, Geography and Ecology (2000), a Post Graduate Diploma of Science in Ecology (2002) and a Master of Science (MSc) in Ecology (2005) all from the University of Otago. My MSc was focused on comparing two methods for obtaining fish population estimates - electric fishing compared to night spotlight counts. Many of my study sites were situated in the Lindis Catchment.

3. In 2003 I was employed by the Otago Regional Council (ORC) as a resource scientist specialising in water quantity. In April 2006 I moved roles at ORC taking up the position of Manager Resource Science. In this role I was responsible for managing the science program including the delivery of technical information for minimum flow setting across Otago.

4. Over the last 12 years I've made numerous (>50) technical recommendations for residual flows conditions to protect the aquatic values at individual takes points across Otago, worked on setting environmental flows and allocation limits for a number of Otago's rivers, as well as water quantity policy development for the Regional Plan: Water (RPW), specifically around managing the transition from deemed permits to RMA consents.

5. Since 2003, I've presented at public meetings and hearings and been the main author of technical reports, for all the minimum flows that have been set by ORC since 2003. These include:

    - Trotters Creek,
    - The Waianakarua River
    - Luggate Creek

- The Taieri at Tiroiti
- The Pomahaka River
- The Waiwera River

6. As well as working at a Regional level I've worked on national level initiatives. In 2006 I started work on the Sustainable Water Program of Action, specifically the national environmental standard for ecological flows and levels (MfE, 2008). As a member of the working group I applied my allocation knowledge to both policy and technical issues in a limit setting context. Further to this I was also a reviewer of the final science report regarding ecological methods prepared by many of the lead scientists in the field in New Zealand (Becca 2008).

7. I confirm that I have read and agree to comply with the Environment Court Code of Conduct for Expert Witnesses (Consolidated Practice Note 2014). This evidence is within my area of expertise, except where I state that I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Evidence Overview

8. My evidence today will cover the *Proposed National Environmental Standard on Ecological Flows and Water Levels (MfE 2008),* the deficiencies in the S32 Report with respect to ecological effects and the subsequent comparison of the different flow options, particularly options 2 and 3. I will attempt to outline the complex Lindis river hydrology including its distinctly different reaches and comment on this in relation to the ORC's proposal. I will then compare this with what LCG's proposes.

9. I will discuss the significant implication of the temperature information collected by ORC over the 14/15 irrigation season that was left out of the Section 32 analysis. I will discuss and compare the Instream Flow Incremental Methodology (IFIM) data for the Lindis River and its relevance to trout (including spawning and recruitment) and native fish values that are present. I will show a series of photos from representative reaches of the Lindis River which directly compare LCG's proposal with that of the ORC.

10. I will outline LCG's proposal to change its water take infrastructure and the implications of this for flows and in-stream values. Finally, I will endeavour to show what LCG's proposal delivers in terms of outcomes for the values present in the Lindis River.

Proposed National Environmental Standard on Ecological Flows and Water Levels (2008)

11. In 2008 Ministry for the Environment (MfE) published two documents, the *Proposed National Environmental Standard on Ecological Flows and Water Levels discussion document* (Proposed NES) (MfE 2008) and the *Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels* (Becca 2008). The Becca (2008) report is the critical document as it forms the basis of the methods that are recommended for setting ecological flows and water levels in regional plans, as is the case with the Lindis. The following is taken from page 28 of the proposed NES discussion document:

> *……………… It is intended that the document will be referenced in the national environmental standard and form the basis for the selection and application of methods to determine ecological flows and water levels.*

12. The Proposed NES was designed to give guidance on appropriate methods for setting ecological limits, it was confined to the technical aspects for ecological values. It was not to

fulfil the full requirements of an assessment under the RMA (social, cultural and economic aspects) for setting a minimum flow. The following is taken directly from page IX of the proposed NES discussion document.

> *……….The proposals set out in this discussion document do not provide guidance to decision-makers on the weighting to give ecological values, or how to incorporate social and economic values into environmental flow decisions. Neither does the proposal set standards for ecological protection nor does it provide methods for assessing other values (eg, recreational).*

13. The proposed NES discussion document clearly has two preferred approaches and the following two bullet points are taken directly from page IX of the discussion document.

    - *sets interim limits on the alterations to flows and/or water levels in those rivers, wetlands and groundwater systems for which there are no limits set in a proposed or operative regional plan (or other statutory instrument)*
    - *Provides a process for selecting the appropriate technical methods for evaluating the ecological component of environmental flows and water levels.*

14. Essentially the first bullet point was to act as a stop gap to allow regional plans to catch up and set appropriate allocation limits and minimum flows or levels. The second bullet point was to provide guidance on the appropriate method(s) to use when setting an allocation limit or minimum flow or level. The expectation was that eventually interim limits would be replaced by those set using the methods in the Becca (2008) report. The following is taken directly from page 25 of the proposed NES discussion document:

> *……..The proposed national environmental standard establishes interim limits on alterations to flows and water levels that will apply to water bodies for which there are no environmental flows or water levels specified in a*

proposed or operative water plan. The interim limits will apply until an alternative is established through the regional plan process.

15. The proposed NES discusses interim limits of which it recommends allocation limits of 50% MALF and a minimum flow of 80% MALF for rivers with a mean flow of $5m^3/s$ or more. The Lindis would fit this category. However, this component of the NES is not relevant to the Lindis, it is the *Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels* (Becca 2008) that is relevant to setting a minimum flow in a regional plan. The interim limits were essentially a default that could be set if a Regional Plan didn't have limits specific to allocation or a minimum flow, it was conservative and was intended to be temporary.

16. The component of the NES that is relevant to the Lindis is actually Tables 2 and 3 of the *Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels* (Becca 2008). This document provides a matrix for determining the levels of information that should be acquired to make robust effects based decisions for rivers when setting ecological limits in a regional plan. Simply it shows that where values are medium to high, or the degree of hydrological alteration due to abstraction is high then there is an increased demand for information. The Lindis meets this elevated criteria.

17. Using percentages of MALF (e.g. 53% of MALF = 1000 l/s) was not considered robust in catchments such as this Lindis with its values and high demand for water and was only considered acceptable in catchments with low to medium values and/or low to medium abstraction levels (Becca 2008).

18. The assumption that percentage of MALF protects values assumes that flow is directly proportional to available habitat (Becca 2008). This in my experience is rarely the case. For example, the most significant habitat gains for the instream values in the Lindis occurs with

the first 400 l/s of flow, that is 50% or more of the available habitat at MALF for the main values of the Lindis (excluding adult trout) occurs at flows of 400 l/s or less (Jowett and Wilding, 2003). Habitat gains with flows above this flow are disproportionately less as flow increase (Jowett and Wilding, 2003). Thus the assumption that flow and habitat are proportional in the Lindis is incorrect and any argument relying on MALF percentage should be disregarded. Setting a minimum flow on this assumption would lead to opportunities for out of stream use in the Lindis to be lost and would not be technically defensible or consistent with the proposed NES (MfE, 2008; Becca, 2008).

Section 32 Report – Flaws in the Ecological Assessment

19. The Section 32 Report appears to have selectively used components of the information available when making its assessment in support of ORC's preferred option 3. There is a clear lack of understanding of the habitat requirements and the level of habitat protection required to ensure the instream values of the Lindis River are maintained and enhanced well beyond what has historically been the case.

20. The Section 32 Report fails to adequately outline the significant ecological benefits of Option 2 over Option 1. Option 1 results in about 15 Km of dry river bed between the Tarras Race off take and the Clutha Confluence most summers, as a result of this dewatering there is significant fish kills of both trout and native fish on an annual basis in these reaches (Figure 1).

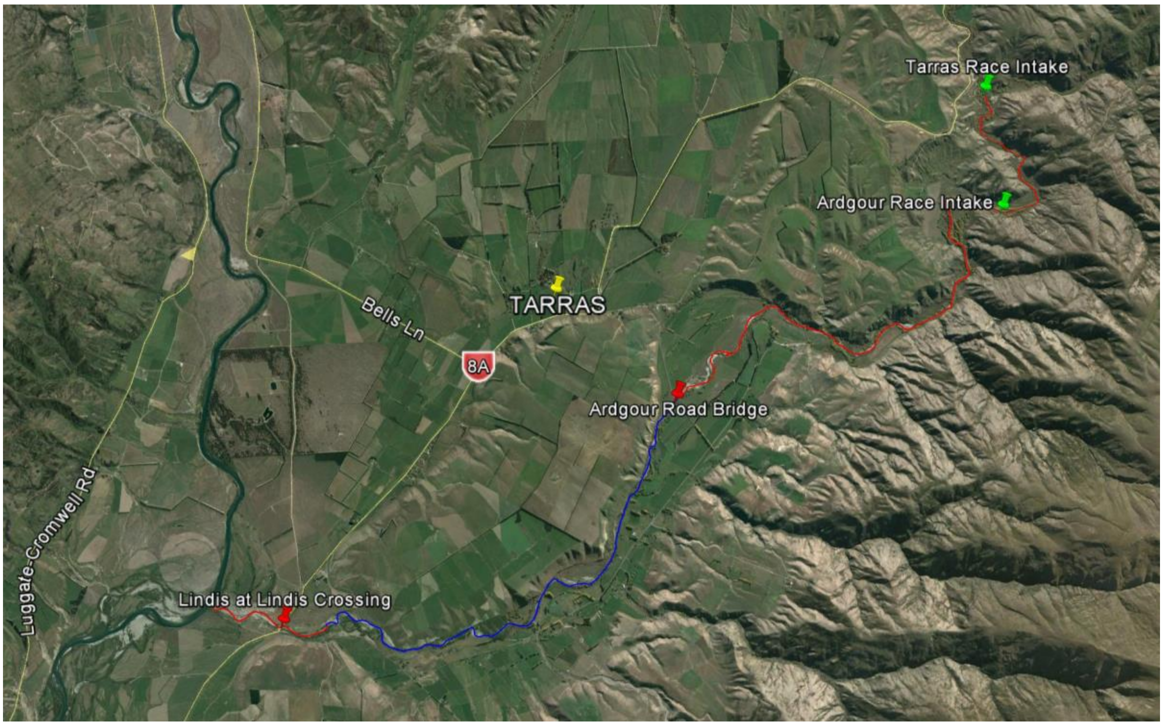


Figure 1. Existing Flow regime during summer downstream of the Tarras Race intake (red is dry, blue is flowing).

21. Option 2's flow regime in combination with LCG's significant infrastructure changes (e.g. shifting and splitting up the big intakes) will ensure that surface flows are continuous to the Clutha, although the improvements made by these infrastructure changes were not acknowledged in the section 32 report. This significant improvement in the flow regime will most likely prevent fish kills due to dewatering from the existing Tarras Race intake to the Clutha Confluence. The change in take infrastructure will mean flows in the Lindis above the Ardgour flow recorder will provide for significant improvements in native and sports fish habitat.

22. The Section 32 Report when comparing the ecological benefits and costs of each flow option appears to paint a full picture of Option 3 (ORC's preferred option), while where things are equally applicable to the lower minimum flow Option 2 they are left out.

23. For example, Option 3 is listed as providing for brown/rainbow trout spawning habitat, while Option 2 does not. Given Option 2 has exactly the same flow regime during the time that both brown and rainbow trout spawn it is inaccurate and misleading to leave out providing for brown/rainbow trout spawning habitat of Option 2. It means Options 2 and 3 cannot be effectively and honestly compared.

24. The Section 32 Report states that Option 3 "sustains the needs of mahika kai, taoka and other species of importance to Kai Tahu" however Option 2 does not. Longfin eel is the only mahika kai species present in the Lindis River. The IFIM data shows that a flow of 750 l/s provides 84% habitat at MALF for this species and a flow of 450 l/s provides 78% habitat at MALF –still a very effective provision of habitat. On this basis it is inaccurate and misleading for Option 2 to state that 450 l/s "does not protect" mahika kai. (Table 4).

25. The Section 32 report has no analysis of the relative effects of the Lindis flow regime to the presence of the Roxburgh and Clyde dam on the population of the key mahinga kai species – longfin eel. The effects of Roxburgh Dam are well documented and the following is taken directly from page 25 of Jellyman (2012), *The status of longfin eels in New Zealand - an overview of stocks and harvest Prepared for Parliamentary Commissioner for the Environment January 2012:*

> *"At the time Roxburgh Dam was being built on the Clutha River in the 1950's, the advice from the fishery managers was that no fish pass was necessary (Jellyman 1984), apparently to "protect upper lake fisheries from contamination by eels or salmon". Lack of recognition of the importance of eels mean that they were effectively excluded from access beyond all hydro dams …*
>
> *Since then, all significant hydro dams that impede upstream eel passage have progressively implemented an upstream passage programme. The major exception is*

Roxburgh Dam, the only major river system where there is no annual monitoring of elvers (although an elver passage facility was installed in 1996, there has been no agreement reached between Contact Energy and the local iwi about monitoring this, hence it has not operated since 2004)."

26. There is ample longfin eel habitat which is relatively unaffected by abstraction in the Lindis catchment but eel densities have gradually reduced to very low densities over time and in many areas are no longer present. This is not a problem specific to the Lindis but is the case for the entire Clutha Catchment upstream of Roxburgh Dam (approximately 33% of Otago).

27. It is important not to confuse the Lindis flow regime with the status of the longfin eel population caused by other factors and therefore inappropriately weight the significance in the benefits of a higher minimum flow as ORC has done. The Section 32 report makes no mention that the limiting factor for Longfin eels in the Lindis (and the entire Upper Clutha) is not flow but is in fact recruitment. Thus it is misleading to say one minimum flow option is better than another or attribute the existing Lindis eel population to the existing Lindis flow regime. Not until elvers are able to pass the two downstream hydropower dams in sufficient densities to re-colonise the Upper Clutha will the longfin eel population reach levels that meets cultural or ecological expectations.

28. Contact energy does have a consent condition to provide both eel passage up and downstream of Roxburgh, Clyde and the Hawea Dams by early 2017. The Section 32 report has not made any mention of what methods will be used, how effective any transfer method will be nor how long it will take the Lindis to be recolonised by Longfin eels. Without this information it is difficult to assess even whether any minimum flow regime will make any

material difference to the Lindis River eel population let alone elevate one minimum flow option above another.

29. Longfin eels are an important native fish species to New Zealand and to local iwi with its taoka status. However, it is fair to seek an acknowledgement that management of the Lindis has not caused the significant decline of this species in the Lindis catchment. Longfin eels should be considered within the Lindis flow regime in the wider context of the Upper Clutha and ORC's IFIM data showing that any minimum flow of 400 l/s or more will provide ample longfin eel habitat where abstraction reduces flows (Table 4).

30. Option 3 states that there is <u>no suitable</u> trout habitat downstream of SH 8 (Lindis Crossing). Again this is wrong. There are three life stages of trout in the Lindis River:

    - Fry being the young of the year from the last winter's spawning, these fish tend to be small (approximately 70mm in length).
    - Yearling trout which are into the second year and tend to be in the 120 -200mm size class.
    - Finally, adult trout are also present and these fish are generally in the 400 – 600mm size class.

31. Generally, fry and yearling trout prefer riffle and run habitat while adult trout will be found in deeper pools or runs with good riparian cover. For this reason, the lower Lindis below Lindis Crossing still holds some physical habitat for juvenile brown trout particularly fry and yearling trout. ORC 2008, provides data showing that good numbers of trout were present when flows are and temperatures are favourable.

32. A minimum flow of 750 l/s will provide significant <u>physical habitat</u> for trout fry and yearling trout in the Lindis River downstream of Lindis Crossing even with continuous losses occurring (Table 1). For example, yearling trout physical habitat reduces from 70% retention of habitat

at MALF to 50 % with distance downstream towards the Clutha as flow loses occur over the reach (Table 1).

Table 1: Relative available habitat at the Clutha Confluence and Lindis Crossing Bridge with a minimum flow of 750 l/s once loses have occurred compared to the amount of habitat that would be available at Naturalised MALF (1860 l/s) for three life stages of brown trout.

	habitat retention as a % of MALF at Lindis Crossing	habitat retention as a % of MALF at the Clutha confluence
Brown trout adult	19	8
Brown trout yearling	70	50
Brown trout fry	66	43

33. This lack of understanding of the relationship between flows and physical habitat in the Lindis River below Lindis Crossing and the habitat needs for different size classes of brown trout present has meant the Section 32 Report is flawed in its assessment of effects on trout in the Lindis River below Lindis Crossing for Option 3. Given this it raises serious doubts on other effects noted by the Section 32 Report for other options relevant to trout.

34. The section 32 Report often refers to the “lower Lindis” or “middle reaches” but these are not defined geographically with any land marks or distance upstream. It makes it very hard to determine where the highlighted effects occur or the length of river they actually affect. For example, Option 2 has listed as an ecosystem cost “no suitable trout habitat in the lower Lindis”. Without defining where the lower Lindis begins, it is very difficult to understand and assess this statement. Is the Lower Lindis River from Lindis Crossing to the Clutha Confluence or is it the lower third of the Lindis River (assuming the upper third is the “upper Lindis” and the middle third is the “mid Lindis”)? Depending on the definition of the “lower Lindis” the length of river affected is dramatically different.

35. At a flow of 450 l/s at the Ardgour flow site surface flows will reduce towards the Clutha Confluence due to losses. Nevertheless, there is significant fry and Juvenile rearing habitat from below Lindis Crossing and upstream of there (ORC, 2011). Accordingly, the statement under Option 2 that there will be "no suitable trout habitat in the lower Lindis" is simplistic and once again, misleading.

36. Option 3 is titled "flow continuity - fish passage", however in ORC's previous Section 32 Consultation Draft (ORC 2014) Option 3 was simply titled "flow continuity". I have not been able to find any assessment of "fish passage" to show why this option provides for fish passage but others don't? I would expect such an assessment to at least cover when fish passage is necessary (e.g. spawning migration) and at what time of year or under which flows fish movements actually occur.

37. Given Option 3 lists one of its ecological benefits is "<u>unimpeded fish passage along the entire river"</u> I have to assume this is for all species and age classes present all of the time. Unfortunately, the Section 32 Report contains <u>no</u> discussion or analysis of fish passage along the two losing reaches of the Lindis River at a flow of 750 l/s.

38. Hudson and Harkness (2010) in carrying out their assessment of fish passage in the Hutt River for Wellington Regional Council recommended the following minimum depth for trout passage:

- 25 cm (0.25 m) minimum depth for large trout
- 20 cm (0.20 m) minimum depth for smaller trout

Hayes (1998) in the Waimea River near Nelson recommends a minimum depth of 18 cm (0.18 m) for adult trout passage.

39. The assertion of unimpeded fish passage along the entire Lindis River in Option 3 in incorrect when comparing to published minimum depths for trout passage. When there is a flow of 750 l/s at the Ardgour flow site, the reach below Lindis Crossing Bridge could be as low as 350 l/s immediately above the Clutha Confluence based on measured losses. Using a representative cross section from a gauging reported in Table 6.1 of ORC's "Management flows for aquatic ecosystems in the Lindis River" carried out in a run at the Lindis Crossing Bridge where the flow gauged was 436 l/s, the average depth is only 12 cm. Given runs are deeper than riffles, and expected flows in the 1.5 Km losing reach from Lindis Crossing Bridge to the confluence under a 750 l/s minimum flow are less than that gauged, it is reasonable to expect long sections of river to be well under 10cm in depth. Therefore, it is unlikely that Option 3 represents unimpeded fish passage for all species that inhabit the river, especially large eels (>1000mm in length), yearling trout (150 -200mm in length) and adult trout (400 -600mm in length) (Hudson and Harkness, 2010; Hayes 1998).

40. In addition, temperatures exceed those tolerable for trout at flows less than 1,400 l/s during December to March (Dale and Olsen, 2015). This means that a statement that 750 l/s will provide unimpeded fish passage along the entire river at all times is simplistic and misleading, as in the losing reaches below Lindis Crossing these higher temperatures are likely to impede trout passage during the warmer months (Dec- Mar) (Dale and Olsen, 2015). The effect of temperature on fish presence should have been covered in the Section 32 Report when attributing fish passage effects to the different options.

41. Option 4 Flow Continuity – Fish Habitat. This is a new Option from the Previous Section 32 Consultation Draft where ORC recommended 450 l/s (ORC 2014). I find this option confusing as it recommends a minimum flow of "900 l/s or more". I've never seen a minimum flow recommendation like this, it provides no surety on what the option delivers for both instream and out of stream use. What does the "or more" component mean, and how is it

reasonably comparable to the other Section 32 Options? By leaving this flow option so open ended it suggest it's not really considered a serious option by ORC and I would have to question why it is even in the Section 32 Report.

42. Furthermore, the difference in "fish habitat" protection by a flow of 900 l/s compared to 750 l/s is minimal (4% – 7% gain in habitat for longfin eel, trout fry, yearling trout, common bully and 3% reduction in habitat for upland bully). Essentially Options 3 would achieve the same outcome for <u>fish habitat</u> as Option 4.

Submission Observations Attributed to the Wrong Flow Option and Wrong Technical Presentations used to Determine Ecological Effects in the S32.

43. Before attributing observations of the effects of flows in public submissions to inform the outcome of any minimum flow option in their Section 32 Report, ORC should have scrutinised the observations (dates, times and location they were made) and the flows they were made at based on "certified" flow data. It is best practice to always use "certified" data for flow comparisons or studies as this data has been through ORC's quality control system and been adjusted for things such as rating changes. Figure 2 below highlights the different daily flows obtained depending on whether flows from ORC's website (telemetry) or ORC's certified data set is used.

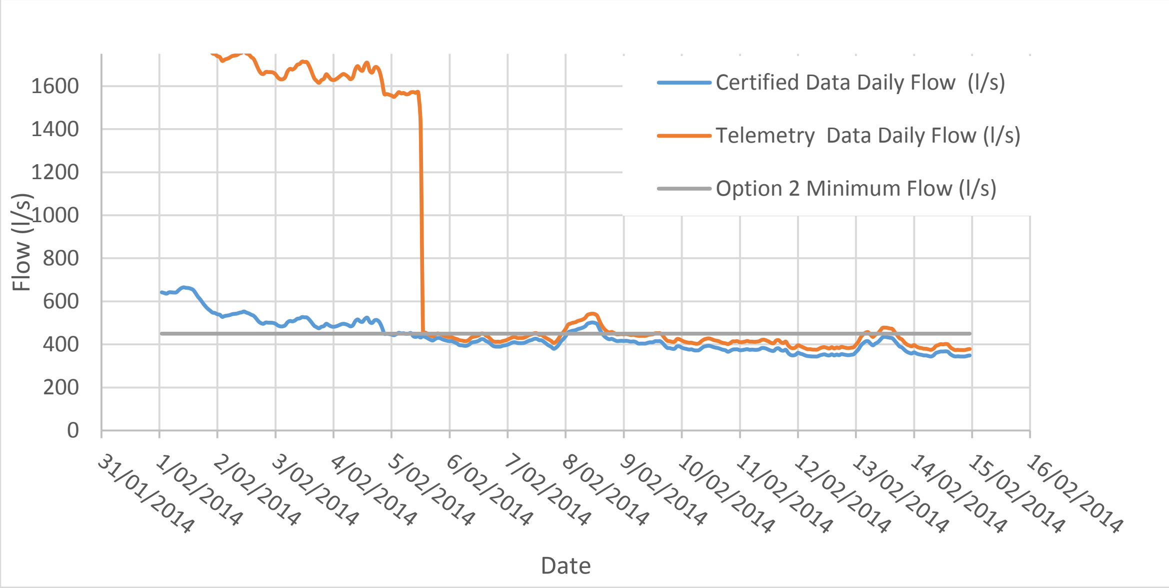


Figure 2. "Telemetry" flow (flows show on ORC website) compared to "Certified" flow (quality assured) for early February 2014.

44. Observations and conclusions made relative to the telemetry flow data are <u>not</u> comparable to any of the technical observation made in ORC's technical reports or presentations prior to 2015. Just as observations of effects at flows less than 450 l/s are <u>not</u> attributable to the Section 32's Option 2.

45. It is worth noting that the telemetered flow information was significantly out for the 2013/14 summer, often by over 1000 l/s (Figure 2). This is unusual and would have made making good observation on the ground of flow effects very difficult.

46. The Section 32 Report states that Option 2 will result in "high mortality rates due to predation". Options 3 and 4 do not mention predation as either a cost or benefit, presumably the inference to be drawn for these options is that there will ***<u>not</u>*** be high mortality rates from predation. On August the 10th this year following notification of proposed plan change 5A, I made an information request to the ORC asking for the flow

related information supporting this assertion, particularly relative to the other options considered in the Section 32 Report.

47. In reply, on the 14th of August 2015, ORC provided me with two submissions (Jolly, 2014 and Wilson, 2014), a Fish and Game research update (Trotter 2015) and the technical presentation that was given at the 2nd community workshop in 2010 by ORC which suggested predation will be an issue below Lindis Crossing (ORC, 2010).

48. The Wilson (2014) submission shows the effects of the current flow regime on fish kills including by predation and stranding, it does not mention anything about predation levels with a minimum flow of 450 l/s.

49. The Jolly (2014) submission actually states that with a flow of 450 l/s there will be less fish predation by birds. The following is taken directly from Jolly (2014).

> *"There will be a negative effect on the balance of the ecosystem as the predator wading bird such as shags and herons will have a feeding resource reduced as the pools they traditionally feed from over summer will not happen at a time they are nesting and needing a larger feed requirement".*

50. The research update (Trotter, 2015) discusses the fish kills and predation at flows of 266 l/s. Again these observations are of the current regime not one with a minimum flow of 450 l/s.

51. None of the submissions (Jolly, 2014 and Wilson, 2014), or the research update (Trotter 2015) provided to me on the 14th of August by ORC support their Section 32 Report claim that "Option 2 will result in high mortality rates due to predation".

52. The further observations in Wilson (2014) for the 06/03/2014 showing a fish kill were for a flow of 230 l/s at the Ardgour flow site based on certified ORC daily flow data for that day - this is close to half the Option 2 flow of 450 l/s.

53. The fly-over observations by Clutha Fisheries Trust (CFT) in WiIson (2014) were done at 278 l/s (based on certified daily flow data), rather than 346 l/s as stated in the pictorial (Wilson, 2014). This resulted in the observations of effects for these flows once again being incorrectly attributed to Option 2's minimum flow of 450 l/s by ORC.

54. The presentation provided to me by ORC from the 2nd community workshop in 2010 was used in the Section 32 Report to attribute predation effects to a flow of 450 l/s (Option 2). However, the presentation conclusions were actually based on a lower flow than the 450 l/s. I then requested the technical presentation given when comparing the effects of 450 l/s to 750 l/s to the community in 2011 (ORC, 2011). This presentation makes no mention of predation as an outcome for the relevant Option 2 flow of 450 l/s.

55. In 2010 ORC recommended 400 l/s as this would guarantee flows under the Lindis Crossing Bridge and would maintain "refuge pools" in the lower river (pools fed by groundwater but with no surface flows entering) immediately above the Clutha Confluence. It was expected these pools would be at risk of predation from birds.

56. Following feedback from the community and Fish and Game that disconnected pools wouldn't maintain the values in the lower river below Lindis Crossing ORC reviewed the 400 l/s option and lifted it to 450 l/s with the intent of maintaining surface flow connection between pools and a connection to the Clutha River, this was based on the measured loss of 440 l/s between Ardgour Road flow site and the Clutha Confluence (ORC 2008). This was presented to the community in 2011.

57. Since the flow losses in the Lower Lindis River were reported as 440 l/s in the 2008 Management Flows Report, ORC's Science update report in 2015 again reported losses of 442 l/s in the 14/15 summer and a further updates for flow loss estimate for the 07/08 and 15/16 summers shows losses of 375 and 352 l/s respectively (Olsen, 2016). These further loss estimates are still consistent with ORC's 2011 Community Workshop presentation outcomes below Lindis Crossing for a minimum flow of 450 l/s.

58. The submission observations by Wilson (2014) of fish kills and the technical presentation from October 2010 are only relevant for flows between 230 l/s – 435 l/s, with the worst effects observed at 230 l/s based on certified daily flows. None of these effects are a fair reflection of a minimum flow which prevents flows falling below 450 l/s and thus do not support the Section 32 Report position that Option 2 results in significant <u>predation</u> effects.

59. I would contend that if flows were maintained above 450 l/s at Ardgour Road, the fish kill observed on the 6th of March in Wilson (2014) at the Lindis Crossing Bridge would not have occurred as there would have been <u>at least 230 l/s</u> flowing into the pool shown based on ORC flow monitoring and recorded losses between the proposed Ardgour minimum flow site and the Lindis Crossing Bridge (Dale and Olsen, 2015).

60. The majority of the "predation" observed under the current flow regime (where flows can get lower than 200 l/s) is "scavenging" of dead fish after flows have ceased and stranded fish or where fish are trapped in isolated pools (Wilson, 2014; ORC, 2008). A flow of 450 l/s prevents pools becoming disconnected, thus should prevent this occurring in the future.

61. Predation is a normal part of a healthy river eco-system, fish eat macroinvertebrates, big fish eat small fish and shags and herons eat fish. To my knowledge there has been no peer reviewed or published assessment done of predation effects on fish in the Lindis when flows

are held at or above 450 l/s, 750 l/s or at any other flow, and thus no valid comparison can be made between predation effects at these varying flows.

62. When understanding the effects of predation on fish it needs to be looked at in the context of would happen under Options 2 and 3 and 4 which provide significant juvenile trout habitat under IFIM (Jowett and Wilding, 2003). Future predation should not be assessed on the existing flow regime and assumed to continue. The following sums up the effect of predation under Options 2, 3 and 4, and is taken directly from pg. 25 Jowett, et al. (2008)

> *"Maintenance of trout habitat ought to favour shags by maintaining trout populations that shags can exploit for food. The feeding habitat requirements of wading birds, terns and gulls should be adequately provided for by the maintenance of adult and juvenile habitat-inasmuch as the habitat of aquatic invertebrates is taken into consideration in the maintenance of the later. Birds and trout rely on aquatic invertebrate production in shallow riffles and runs for food. If the concept of sustaining productivity of trout populations is an integral part of the minimum flow regime then the food requirements of birds ought to be well catered for."*

Use of Best Available Science

63. The NPS-FM (2014) requires councils to use the best available science when making recommendations and decisions on limit setting. The following is taken from the preamble of the NPS-FM (2014).

> *"Setting enforceable quality and quantity limits is a key purpose of this national policy statement.*
>
> *......The process for setting limits should be informed by the best available information and scientific and socio-economic knowledge."*

64. The original assessments of ecological effects for minimum flows of 450 l/s and 750 l/s were based on science reported in ORC (2008). This work was later verified by NIWA (Horrell,

2014) as robust. Unfortunately, ORC then disregarded this work in its Section 32 Report in favour of "observations of an anecdotal nature". The following statement was an ORC response at the April 2015 Lindis Community meeting (ORC 2015).

> *"ORC: Staff has revised the flow loss after considering information provided by Fish and Game (which is more of observational and anecdotal nature) and after more recent observations in January 2015. ORC will make the information supporting the 550 l/s flow loss available."*

65. The failure to relate field observations to certified flow data when drawing conclusions about the effects of flows or using anecdotal observations in preference to per reviewed science reports does not represent the use of best available scientific information.

66. Furthermore, the flow data to determine the 550 l/s flow loss presented by ORC on the 1st of April 2015 to the community workshop and in the subsequent Section 32 report a loss between the Ardgour flow site and Clutha Confluence had not been "certified". It wasn't until the 10th of July 2015 that the flow record from 25/06/14 to 13/02/2015 for the Lindis at Ardgour was actually certified by ORC. Dale and Olsen (2015) using certified data and a better loss estimate method revised the 550 l/s flow loss down to 442 l/s. As mentioned earlier it is best practice to always use "certified" data for flow comparisons or studies as this data has been through ORC's quality control system and been adjusted for things such as rating changes.

67. Other aspects of the Section 32 report also represent a failure to use best available scientific information. Over the 14/15 irrigation season ORC investigated the hydrology of the losing reaches above the Ardgour Road Bridge (identified in March 2014 by Clutha Fisheries Trust) and below Lindis Crossing after Fish and Game staff raised concerns with potential increased

losses in February 2014 (Wilson, 2014). ORC also deployed temperature loggers in these losing reaches to investigate the effects of temperature on the in-stream values of the Lindis River (on investigation I believe Fish and Games observation of increased losses was actually a rating issue at the Ardgour site, refer to Figure 2).

68. The Section 32 Report neglects to discuss or mention the losing reach above Ardgour Road Bridge and the role temperature plays in both the losing reaches of the Lindis River for the instream values. Given the significance of the temperature information in particular and the fact the section 32 Report was notified in August some four months after the field work was completed, this omission is at the very least remiss of ORC and certainly inconsistent with the NPS-FM (2014).

69. Given the Section 32 Report lists high water temperature as an ecosystem cost downstream of Lindis Crossing (SH 8 Bridge) for Option 2 and ORC's technical report (Dale and Olsen, 2015) shows that for flows up to 1400 l/s high water temperature is a risk down stream of Lindis Crossing I can't understand why it's not an ecosystem cost for Options 3 and 4 also. By omitting this fact, it leads the reader to think that options 3 and 4 prevent high temperatures below Lindis Crossing which is factually incorrect. This is another example of failure of the Section 32 Report to make use of the best science available at the time it was produced and it is therefore inconsistent with the NPS-FM (2014).

NIWA Review of ORC's Science

70. In November 2014 NIWA was contracted to complete a review of science information to support 750 l/s minimum flow and in December 2014 a report titled "Review of the science supporting the proposed minimum flow regime for the Lindis River" was provided to ORC.

71. The report focuses on 750 l/s having been clearly directed in November 2014 based on the brief supplied by ORC that 750 l/s was now ORC's preferred option (ORC 2014b). Interestingly ORC had identified its preferred flow option some months prior to the economic assessment being delivered by Becca and Opus and on the same day they withdrew from the previously agreed further science work with LCG and the other relevant stakeholders.

72. Given a minimum flow must balance, the ecological, cultural, economic and social wellbeing it would seem pre-emptive to decide on a minimum flow as the NIWA report shows without the other relevant information. To have credibility in this process the NIWA review should have provided an assessment of the outcomes 450 l/s and 750 l/s would provide for instream values along with any other flow they thought was relevant.

73. Page 9 of The NIWA review surmised the following:

> *"If for any reason a lesser minimum flow of 750 l/s is proposed there would be a need for a more complete concurrent field study in the Lindis River lower reaches to prove: continuous connection with the Clutha; the water temperature did not become too hot for trout; and the habitat for, and the population of, juvenile brown trout was maintained."*

74. Following the 14/15 summer ORC went on to show that flow losses between Ardgour flow site and the Clutha confluence were 442 l/s, and that temperatures at flows of 1400 l/s or less exceed acute levels for trout from December to March (Dale and Olsen 2015). Further loss information supplied by the ORC for the 15/16 irrigation season showed that flow losses between Ardgour flow site and the Clutha confluence were 352 l/s (Olsen, 2016).

75. Effectively the most recent reporting from ORC (Dale and Olsen, 2015 and Olsen, 2016) and hydrological data collected from the lower Lindis during December 2015 shows that 450 l/s would provide connectivity to the Clutha and that for trout neither 450 or 750 l/s will ensure temperatures below Lindis Crossing are conducive to trout during the critical summer period.

Summary

76. These significant inaccuracies in describing the ecological effects of different flows, as highlighted above, leaves significant doubt about the adequacy of all the descriptions of ecological effects for all of the options in the Section 32 Report. One possibility is that the ecological assessment in the Section 32 Report was not reviewed by a suitably qualified technical expert, which given the complicated hydrology and ecology of the Lindis, I would have certainly expected.

77. It is my view that the comparison of relative effects of the flow management options in the Section 32 Report on the in-stream values of the Lindis Rivers are incomplete as the best possible science available at the time was not used in the Section 32 analysis. Nor has an adequate or appropriate cost-benefit analysis been carried out on the environmental outcomes likely to result from any of the minimum flow options. A robust cost – benefit analysis must be underpinned by the most accurate and up to date scientific information available (NPS-FM, 2014). This has not been the case here.

78. I believe that the Section 32 Report is so inadequate with respect to ecological effects it would severely inhibit members of the general public making a fair assessment of the options provided.

LCG'S Flow Regime Proposal

79. LCG proposes the following flow regime to protect the instream values of the Lindis River compared to ORC's preferred option and what currently occurs (Table 2). The key difference is the drop from 750 l/s to 450 l/s from December to April (Table 2). It is the difference between 450 l/s and 750 l/s that will be the focus of the following sections.

Table 2. LCG's flow regime proposal compared to ORC's preferred option and the existing regime.

Status Quo (200 l/s)	***LCG's Proposal (450 l/s)***	***ORC's Proposal***
200 l/s (Oct –May) Primary Allocation is 4002 l/s	750 l/s (May) 1600 l/s (June – September) 750 l/s (Oct – Nov) 450 l/s (Dec – April) Primary Allocation Limit 1900 l/s	750 l/s (Oct -May) 1600 l/s (June – September) Primary Allocation Limit 1000 l/s

Lindis Hydrological Patterns

80. The Lindis River offers one of the most challenging systems ecologically and hydrologically in Otago. It is my view that the river can be broken into three significant hydrological reaches that are either neutral, gaining or losing (Figure 3).

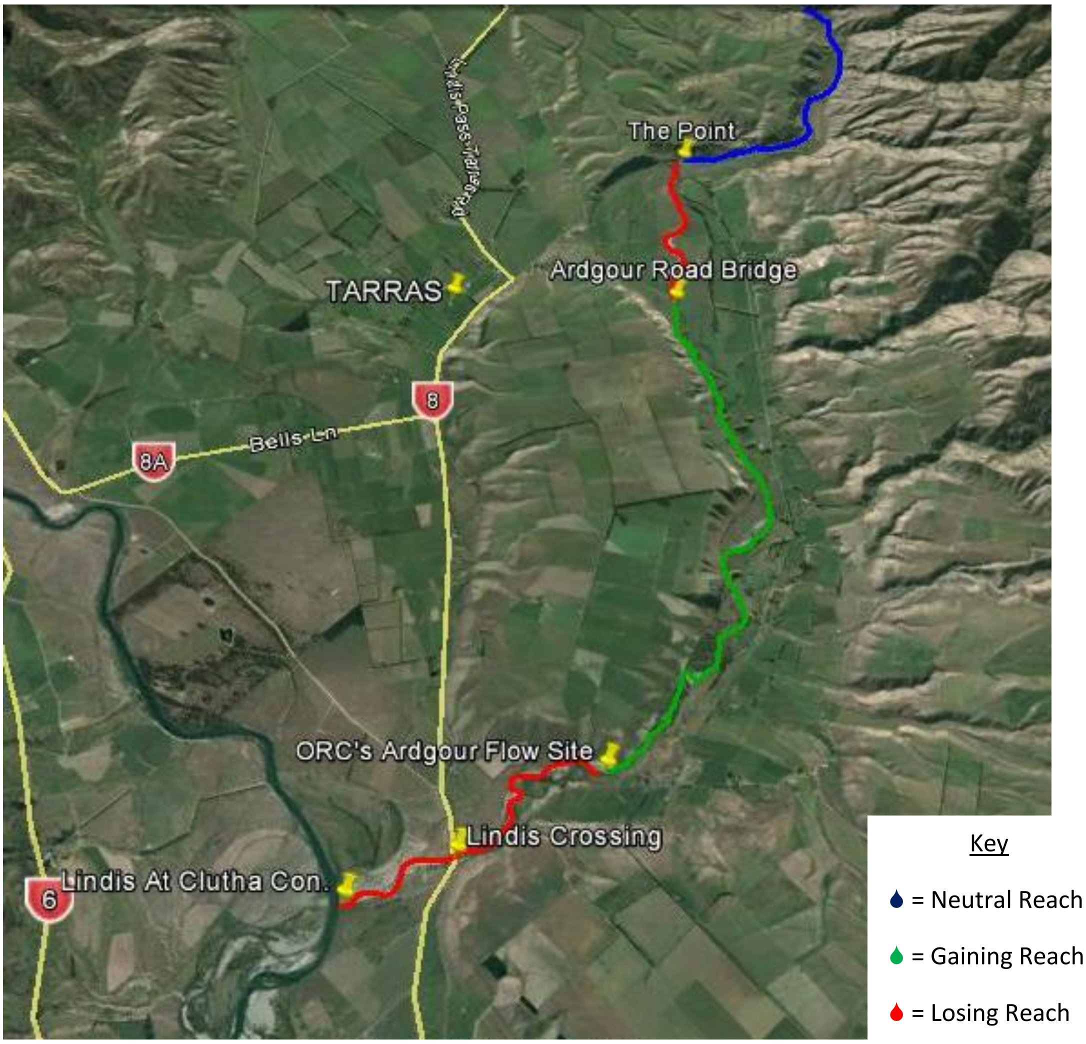


Figure 3. The hydrologically different reaches of the Lindis River. The neutral reach is the whole river upstream of "The Point".

Upstream of "The Point"

81. This section of river is what I'd describe for the most part as behaving like a "normal" river. As you move down the catchment it gains flow as tributaries enter, it has no significant

losing or gaining reaches, it is relatively neutral. Under the current take regime this reach can be dry from the Cluden Stream confluence downstream as observed by CFT in March 2014 (CFT, 2014). This is due to abstraction not natural loses. Upstream of Cluden Stream no issues with low flows due to abstraction have been documented.

"The Point" to Ardgour Road Bridge

82. This reach is a losing reach with surface water lost to the surrounding alluvial aquifer. Losses in this reach have been measured at 500 l/s by ORC (Dale and Olsen, 2015). Most summers under the current regime this reach is completely dry (Figure 3).

Ardgour Road Bridge to ORC's Ardgour Flow Recorder

83. This reach is a gaining reach with surface water increasing with distance downstream. Gains in this reach are approximately 250 l/s (Dale and Olsen, 2015). This reach always flows though in dry summers the extent of the reach can reduce (Figure 3).

ORC's Ardgour Flow Recorder to Clutha Confluence

84. This reach is a losing reach with surface water lost to the surrounding alluvial aquifer. Losses in this reach have been measured as 352 - 442 l/s (Dale and Olsen, 2015; Olsen 2016). Most summers under the current regime this reach is completely dry from about Lindis Crossing to the Clutha Confluence (Figure 3).

85. Figure 4 below attempts to visually show the unusual hydrology of the Lindis River, it is based on a 1 in 10 year low flow ($Q_7 10$) at Lindis Peak (960 l/s) and assumes no significant abstraction occurring in the river below this point. It can be seen that recorded flows at the confluence in summer will always be less than recorded at Lindis Peak, even with no abstraction. This is considered unusual especially relative to other rivers like the Taieri,

Manuherikia or Pomahaka Rivers for example where with no abstraction they will always record higher flows at the bottom of their systems than in the mid reaches. It is very important to understand this hydrological pattern when assessing the effects of a single minimum flow point in a dynamic river like the Lindis.

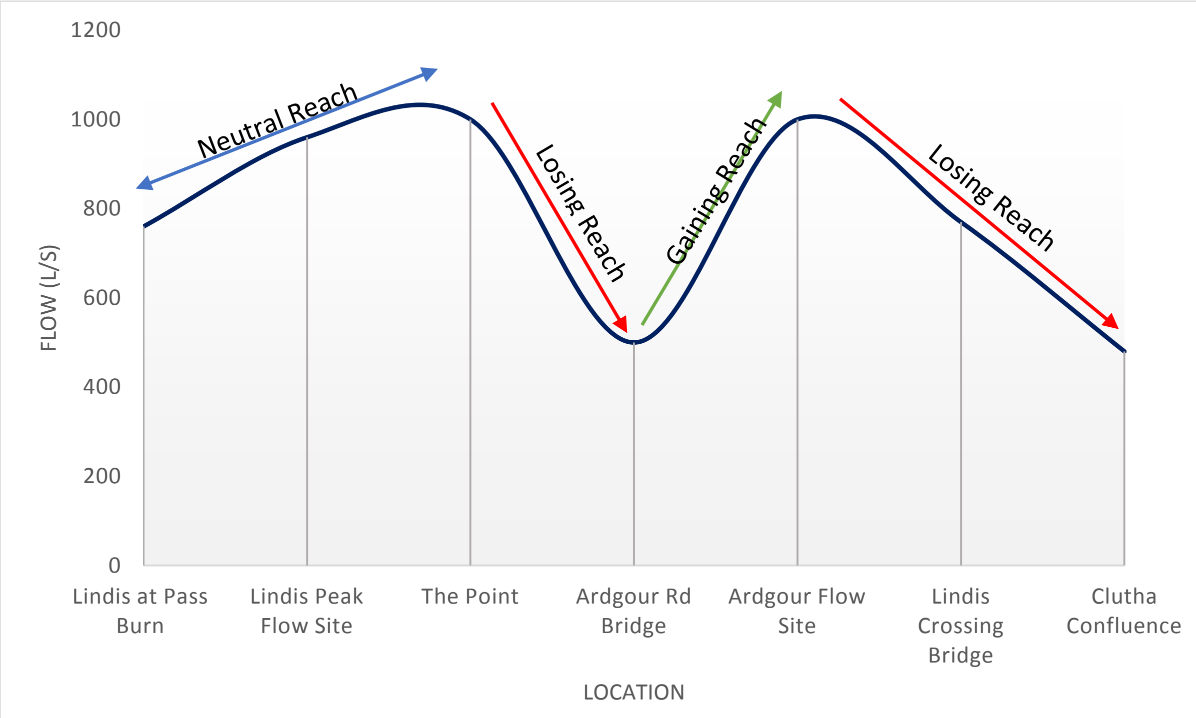


Figure 4. Schematic (not to scale) of the different hydrological reaches in the Lindis River based on 14/15 irrigation season measured flows and a $Q_7$10 flow of 960 l/s at Lindis Peak with no main-stem takes.

86. These distinctly different hydrological reaches means understanding the ecological effects of setting a minimum flow at one place in the catchment can be incredibly complicated without good observations (linked to flow), hydrological, temperature, fish behaviour and ecological information. The following parts of my evidence endeavour to tie this information together to understand the ecological effects of ORC’s and LCG’s proposals.

IFIM and Habitat Retention

87. Habitat quality drives the density of stream biota, not the magnitude of the flow, thus flows less than those naturally occurring are often able to sustain stream ecosystems (Jowett et al. 2008). It is the available physical habitat with different flows that the Instream Flow Incremental Methodology (IFIM) quantifies allowing the assessment of changes in flow on the relative habitat available for different species.

88. The IFIM only considers physical habitat and changes with flow. It does not consider other factors such as temperature or water quality which may impact a fishery (Jowett et al. 2008). That is a flow may provide optimum physical habitat for a fish species but if the temperature or water quality is not suitable the habitat will not be utilised.

89. Levels of habitat retention are conservative, in that a change in habitat does not cause an equal response in population size (Jowett et al, 2008). The theory is that a change in habitat quantity will only have an effect if all the available habitat is being utilised, that is, the stream is at carrying capacity (Jowett et al. 2008). Streams are rarely at carrying capacity for many reasons such as flows are changing all the time, predation, mortality and migration. Jowett et al, (2008) state that in the case of a high density fishery a habitat retention level of 90% would probably result in no change in the population, whereas if the retention levels were dropped to 50% there would be some effect on the population.

90. The IFIM allows an assessment at a reach or river scale to determine the relative amount habitat or weighted useable area (WUA) under different flows for individual fish species or age class of a particular species. The IFIM approach essentially averages the habitat across a reach at a particular flow, in doing this it allows for the natural variation in habitat quality

along a stream reach but it cannot be used to say what the exact habitat quality will be at a single point (Jowett et al. 2008).

91. In order to utilise the IFIM management decision tool appropriately one needs to have a good understanding of the fish species or values present to apply it to (Jowett et al. 2008). The fisheries values as notified by ORC in its section 32 Report and listed in schedule 1A of the Regional Plan: Water relevant to the main stem of the Lindis River are as follows:

- Trout spawning (Schedule 1A)
- Juvenile rearing (Schedule 1A)
- Significant presence of Longfin eel (Schedule 1A)
- Common and upland bully (Section 32)

92. The next step is to attribute a habitat retention level based on the significance of the values present (Jowett et al. 2008, Jowett and Hayes, 2004). Habitat retention is based on maintaining a proportion of the habitat available under a normal low flow conditions (Jowett and Hayes, 2004). For the purpose of my evidence I've used the 7-day mean annual low flow (MALF).

93. To my knowledge the values of the Lindis are not considered to be of "regional" or "national" significance, though the Lindis does provide spawning and juvenile rearing habitat for the nationally significant fisheries of the Upper Clutha River and Lake Dunstan. Jowett and Hayes (2004) clearly recommended a 70% habitat protection level for a "high" value trout spawning or juvenile rearing stream and that 60% for a "low" value trout spawning or juvenile rearing stream is adequate. Jowett and Hayes (2004) also recommend 60% for a "low significance" common bully stream. Table 3 below is taken directly from pg. 20 of

Jowett and Hayes (2004) and highlights the recommended protection levels for trout rearing and bully streams.

Table 3: Suggested significance ranking (from highest (01) to lowest (5)) of critical values and habitat retention.

Critical Value	Fishery Quality	Significance Ranking	% Habitat Retention
Large adult trout – perennial fishery	High	1	90
Diadromous galaxiid	High	1	90
Non – diadromous galaxiid	-	2	80
Trout spawning/juvenile rearing	High	3	70
Large adult trout – perennial fishery	Low	3	70
Diadromous galaxiid	Low	3	70
Trout spawning/juvenile rearing	Low	5	60
Redfin/common bully	-	5	60

94. Given the fisheries values of the Lindis a habitat retention level of 60 -70 % of the habitat available at MALF is appropriate. The LCG proposal (450 l/s) delivers the following habitat retention levels for the fisheries values of the Lindis:

- Trout spawning – Near optimum flow (maximum protection).
- Juvenile rearing – 63% for fry and 67% for yearling habitat retention.
- Significant presence of Longfin eel - 75% habitat retention.
- Common and upland bully – 76% and 132% habitat retention respectively. Optimum flow for upland bullies is less than MALF, thus the high percentage.

95. Table 4 below provides a full comparison of the existing habitat available under the current Lindis regime and ORC's 750 l/s minimum relative to what LCG proposes in the future for the entire suite of values that are present during the irrigation season. LCG's proposal is entirely

consistent with habitat protection levels in (Table 3) suggested by leading experts Jowett and Hayes (2004).

Table 4: Relative available habitat at several flows compared to the amount of habitat that would be available at Naturalised MALF (1860 l/s) for the values relevant during the irrigation season (summer – autumn).

	Status Quo (200 l/s)	Option 2 (450 l/s)	Option 3 (750 l/s)
Longfin eel	64	75	84
Flathead galaxiid[#]	114	125	122
Common bully	55	76	87
Upland bully	131	132	126
Brown trout adult	5	17	33
Brown trout yearling	45	67	83
Brown trout fry	38	63	84

[#] Due to trout predation Flathead G. are only found in small headwater streams with barriers or water takes preventing trout access.

96. Table 4 clearly shows that LCG's proposed flow of 450 l/s almost doubles the available habitat for trout fry and yearlings compared to what has historically occurred. Furthermore, an increase in flow of 40% or 300 l/s in minimum flow level to the 750 l/s the ORC has proposed only results in a moderate increase in habitat for brown trout fry or yearlings, 21% and 16% respectively (Table 4). Adult brown trout habitat is severely restricted by available habitat under the current regime and that proposed by either LCG or ORC. This reflects the lack of deep pool habitat due to the rivers morphology (Table 4).

97. The LCG proposed flow has marginally more available habitat for upland bullies (6%) than the ORC proposed minimum flow of 750 l/s, while the ORC proposal provides a marginal increase in habitat for Longfin eel and common bully relative to that of LCG, with an extra 9% and 11% habitat respectively (Table 4). These increases in habitat are considered minimal as LCG's proposal already provides more than 75% of the available habitat at MALF for all native fish species.

98. Flathead galaxiids are incredibly susceptible to trout predation and as a result they are rarely found together (Leprieur et al. 2006). In the Lindis, non-migratory galaxiid populations are only found in headwater streams with trout barriers in place. Given their restricted distribution, it is not considered necessary to consider the effects of the main stem minimum flow on the Lindis on flathead galaxiid habitat.

99. Trout spawning is considered a significant value for the Lindis River with the IFIM data suggesting the following optimum flows for brown and rainbow trout spawning in the Lindis River (Table 5) (Jowett and Wilding 2003).

Table 5: Relevant habitat protection levels for trout spawning during the non - irrigation season (winter).

Ecological Value	Optimum Flow (m^3/s)
Brown trout spawning	1.4
Rainbow trout spawning	2.4

100. Both ORC's and LCG's flow proposal suggest a winter primary minimum flow of 1.6 m^3/s which is considered near optimum for brown trout spawning based on the IFIM (Jowett and Wilding, 2003). Although both brown and rainbow trout spawn in the Lindis, brown trout are by far and away the most dominant species (Jellyman and Bonnett, 1992; ORC, 2008). It is expected that the 1.6 m^3/s will provide for both brown and rainbow trout spawning (Jowett and Wilding, 2003).

Water Temperature

101. Water temperature, particularly high water temperature, directly affects fish populations, by impacting on their growth, spawning, and migration and in a worst case their survival (Elliot,

1994). New Zealand's native fish tend to be more temperature tolerant than the introduced sports fish, thus brown and rainbow trout are the most susceptible to high temperatures in the Lindis River (Dale and Olsen, 2015).

102. Significant mortality of brown trout occurs at temperatures above 24^{o}C relatively quickly, while their growth is impaired at temperatures greater than 19^{o}C (Elliot and Hurley, 1998). Todd et al. (2008) calculated both acute and chronic thermal for brown and rainbow trout and Olsen et al. (2012) estimated thermal thresholds for longfin eel and common bully using the same criteria. Acute thermal threshold is calculated as the highest two-hour average water temperature measured within a 24 hr period. Acute thermal threshold is the point at which thermal stress occurs after short-term exposure and substantial mortality is likely to be observed if those temperatures persist, whereas the chronic threshold is expressed as the maximum weekly average temperature and is intended to protect species from sub-lethal effects of elevated temperatures (Todd et al. 2008).

103. The following Table is taken directly from Dale and Olsen (2015), it shows the exceedances of the acute and chronic criteria for the species present in the Lindis River. The table clearly shows the Lindis between Lindis Crossing and the Clutha Confluence is not suitable for trout due to temperature from December to March.

Summary of the number of days exceeding acute and chronic thermal criteria for the protection of rainbow and brown trout at five sites in the Lindis River between 1 October 2014 – 30 April 2015.

Site	Total record (d)	Total number of dry days (d)	Number of days exceeding thermal criteria						
			Acute (max. 2-h average)		Chronic (weekly average)				
			Rainbow trout	Brown trout	Rainbow trout	Brown trout	Longfin eel (adult)	Longfin eel (elver)	Common bully
			23.8°C	24.6°C	18.2°C	19.6°C	30°C	28°C	24°C
Rutherford's	205	6	0	0	0	0	0	0	0
Ardgour Road Bridge	135	>52	3	2	5	0	0	0	0
Ardgour Road hydro	212	0	0	0	0	0	0	0	0
Lindis Crossing	212	93	0	0	2	0	0	0	0
Clutha confluence	212	103	16	13	17	9	0	1	1

Chronic Temperature Impacts

104. Dale and Olsen (2015) report that chronic temperature thresholds were exceeded for longfin eel elvers, common bully, brown and rainbow trout in the Lindis between Lindis Crossing and Clutha confluence and for rainbow trout at Ardgour Rd Bridge (see table above).

Acute Temperature Impacts

105. Dale and Olsen (2015) found that water temperature in the Lindis between Lindis Crossing and the Clutha confluence was likely to limit trout with temperature often exceeding 24.6 °C for periods longer than 2 hours. In fact, Dale and Olsen (2015) found that even at flows of 1,400 l/s at the proposed minimum flow site, temperatures can reach levels acute to brown and rainbow trout below Lindis Crossing. Furthermore, at flows of 1,300 l/s to 1,400 l/s the acute temperature threshold for brown trout was exceeded for 4 hours continuously, this could result in fish kills if trout aren't able to retreat to more favourable temperatures.

106. Observations made by Fish and Game Staff on the 29th of December 2014 when the Lindis River was still connected to the Clutha River show that although bullies were present from 600m below Lindis Crossing no trout were observed (Fish and Game, 2015). Given there was

still flow and physical habitat available for juvenile trout it supports the temperature findings in Dale and Olsen (2015) that as high temperatures occur in this reach at relatively high flows they more than likely force trout to leave this reach well in advance of the lowest flows.

107. Observations in ORC (2008) made by Fish and Game and ORC staff show trout moving upstream as the river downstream of Lindis Crossing dried. It isn't known whether this was in response to elevated temperatures or a reduction in flow, however it is consistent with the findings of Davey et al (2006) and Armstrong et al (1998) that most fish exhibit a strong tendency for upstream migration when faced with extreme flow reductions.

108. The observation in ORC (2008) and Fish and Game (2015) along with the temperature data in Dale and Olsen (2015) suggest that the lowest kilometre of the Lindis River is inhospitable to trout when flows are below 1400 l/ as measured at the Ardgour flow site During December to March.

109. If flows are held at or above 450 l/s at the Ardgour flow site ORC reports shows there should still be a connection to the Clutha (ORC 2008; Dale and Olsen 2015). Figure 5 (taken from ORC 2011) shows that with a flow of 370 l/s recorded at Ardgour the lower 260m of the Lindis River dried. It is fair to conclude that with a higher flow the extent of dry river bed would be less if at all.

Figure 5. Aerial photograph of Lindis River between Lindis Crossing and the Clutha Confluence showing the extent of surface flows when Ardgour flow site was at 370 l/s (ORC, 2011).

110. The observations and fisheries data in (ORC, 2008) suggest trout will be able to move in advance of drying if it occurred to the permanently flowing reach. By preventing the sudden drops in flows as historically occurred and documented in ORC (2008) the risk of stranding fish and causing fish kills is significantly reduced (Davey et al. 2006).

111. Water temperature at the Ardgour flow site and Lindis Crossing Bridge showed no exceedances of the acute threshold for brown or rainbow trout (Dale and Olsen, 2015). This is more than likely due to the reach around the Ardgour flow site being a gaining reach from groundwater which usually is much cooler, combined with shading from the riparian willow cover (Dale and Olsen, 2015).

112. Water temperature at Ardgour Road Bridge exceeded the acute levels for both brown and rainbow trout on 2 and 3 occasions respectively in late December 2014 and early January

2015 (Dale and Olsen, 2015). However, these exceedances occurred at flows close to 500 l/s as recorded at the Ardgour flow site, much lower than the flows when acute temperatures for trout where reached in the lower Lindis downstream of Lindis Crossing (Dale and Olsen, 2015).

113. Table 6 provides an indicative summary of the flows as recorded at the proposed minimum flow site for when acute temperatures for trout where reached, it shows that even at flows almost double the minimum flow proposed by ORC (750 l/s) temperature will prevent trout safely inhabiting the Lindis below Lindis Crossing during December-March.

Table 6: Acute temperature thresholds for brown and rainbow trout (Todd et al. 2008) Compared to temperatures and flows at the Ardgour flow site (Dec-Mar).

	Acute Criteria (°C)	Date and flows at which acute Criteria was exceeded (l/s) at Ardgour Rd Bridge (Dec-March).	Flows at which acute Criteria is exceeded (l/s) at ORC's Ardgour flow site (Dec-March).	Flows at which acute Criteria is exceeded (l/s) at Lindis Crossing Bridge (Dec-March).	Date and examples of flows at which acute Criteria is exceeded (l/s) at Clutha Confluence (Dec-March).
Brown trout	24.6	504 (28/12/14) 513 (29/12/14)	No exceedances, lowest hourly flow 206 l/s.	No exceedances while flow was present.	1357 (23/12/14) 1068 (24/12/14) 837 (25/12/14) 807 (26/12/14) 546 (28/12/14)
Rainbow Trout	23.8	807 (26/12/14) 519 (28/12/14) 513 (29/12/14) 444 (05/01/15)	No exceedances, lowest hourly flow 206 l/s.	No exceedance while flow was present.	1357 (23/12/14) 1106 (24/12/14) 853 (25/12/14) 807 (26/12/14) 546 (28/12/14)

Specific Ecological Effects in the Losing Reaches

114. It is important to understand the relative impact in each reach when making a decision on a minimum flow regime. However, while assessing specific effects on a reach the over-all picture of the river must be kept in mind.

115. Rivers which lose and gain flow along their length can look dramatically different a few kilometres apart even with no abstraction. This is natural. Losing reaches are not something that need to be fixed, rather they should be simply acknowledged for what they are, or even embraced for the unique ecological values they can hold. In the case of the Lindis it is likely the upper (neutral) reach offers the most favourable conditions for trout and as such provides a small adult fishery. The gaining reach between Ardgour Road Bridge and the Ardgour flow recorder would provide good yearling and fry habitat with a minimum flow of 450 l/s.

116. The two losing reaches, "The Point to Ardgour Road Bridge" and "Ardgour flow recorder to the Clutha confluence" are likely to contain relatively good levels of physical habitat for trout at the top of each reach, reducing with distance downstream until flows return from groundwater or the Clutha River. However, temperature will severely impact trout in the Lindis downstream of Lindis Crossing even at flows well above those proposed by ORC (see Table 6).

Comparison of Lindis River Flowing Reaches under the Existing Regime to those under the LCG Proposal.

117. Figure 6 below shows where surface flows occur during Summer in the Linids River below the Tarras Race intake. It shows under the existing regime that significant lengths (14-15 Km) of river bed can be dry during summer.

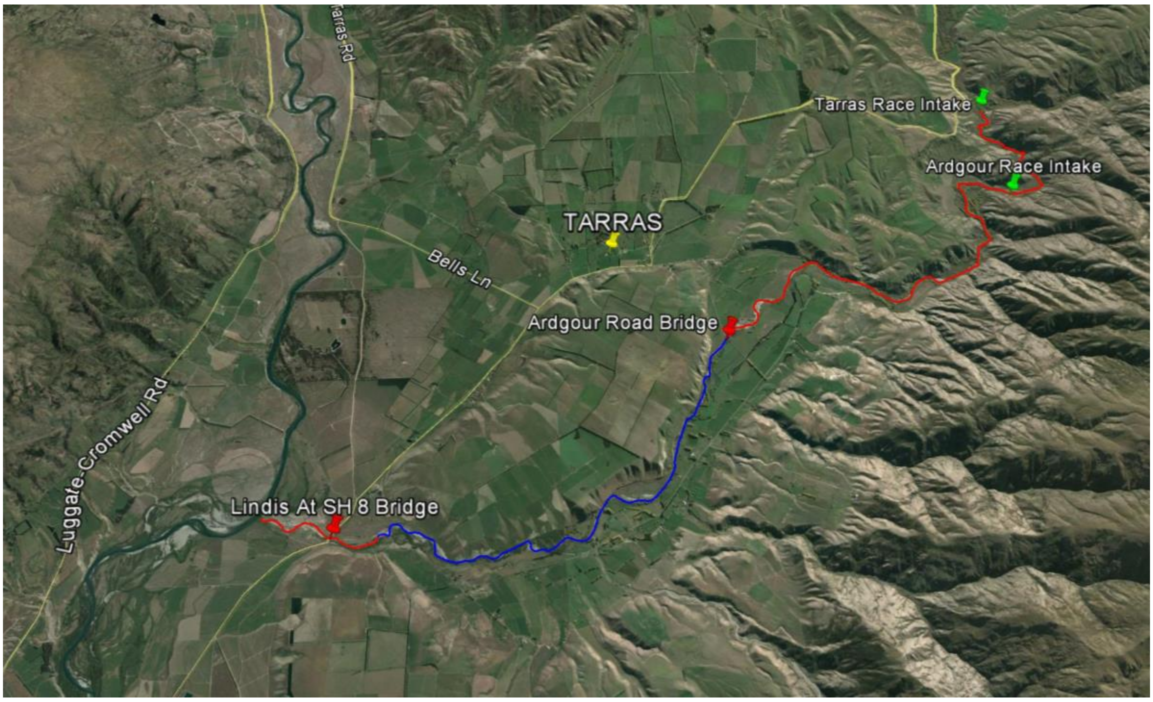


Figure 6. Existing Flow regime during summer downstream of the Tarras Race intake (red is potentially dry, blue is flowing).

118. Under LCG's proposal there will be continuous flow to the Clutha River, with no dry reaches above Lindis Crossing Bridge.

Direct Comparison of LCG's and ORC's Minimum Flows Using Photos

119. It is all very well to talk flows and % Habitat but it is important to be able to see what a particular flow will deliver. Between December 2014 and January 2016 the LCG took photos of the Lindis River at numerous points in the Lindis River between "The Point" and the Clutha Confluence, allowing them to be compared to certified flows at the proposed minimum flow site (Figure 7 and Figure 8).

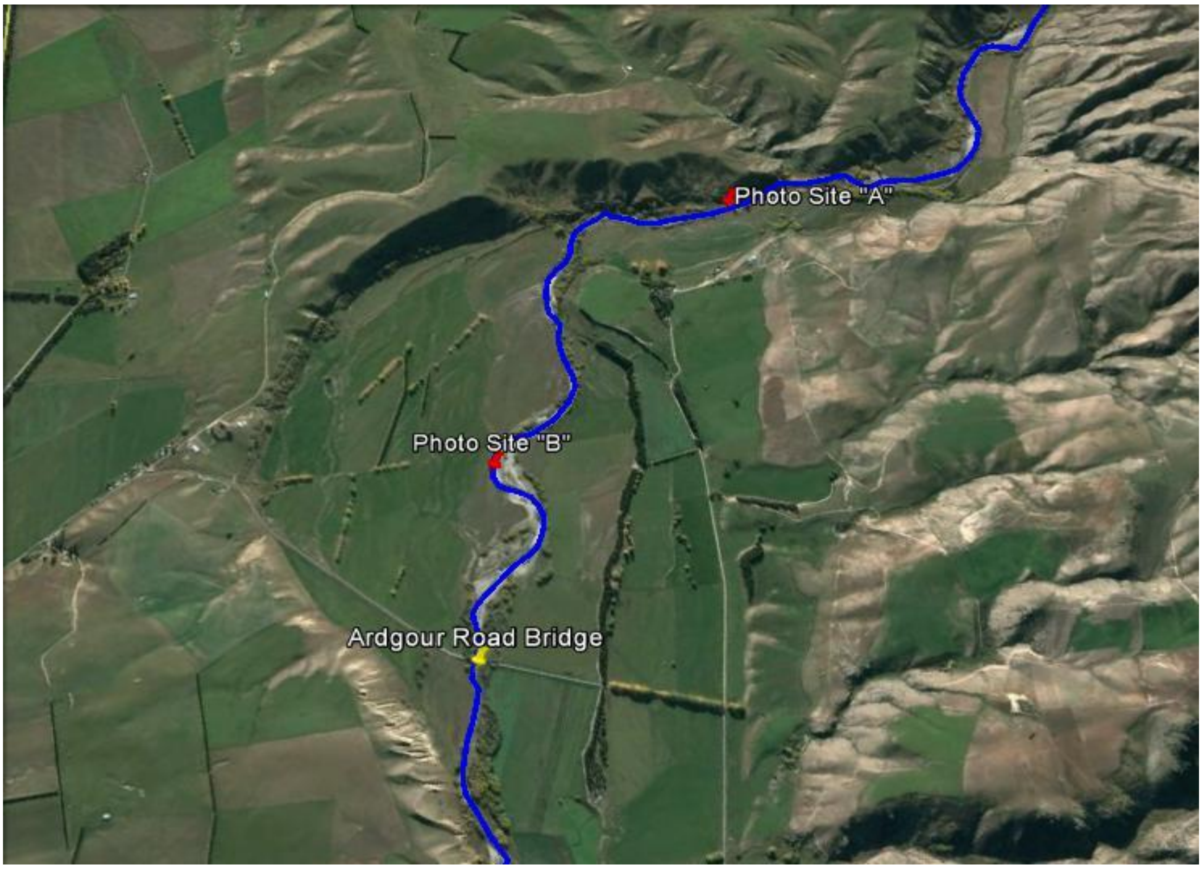


Figure 7. Map of where flow comparison photos were taken above the Ardgour Rd Bridge in December and January.

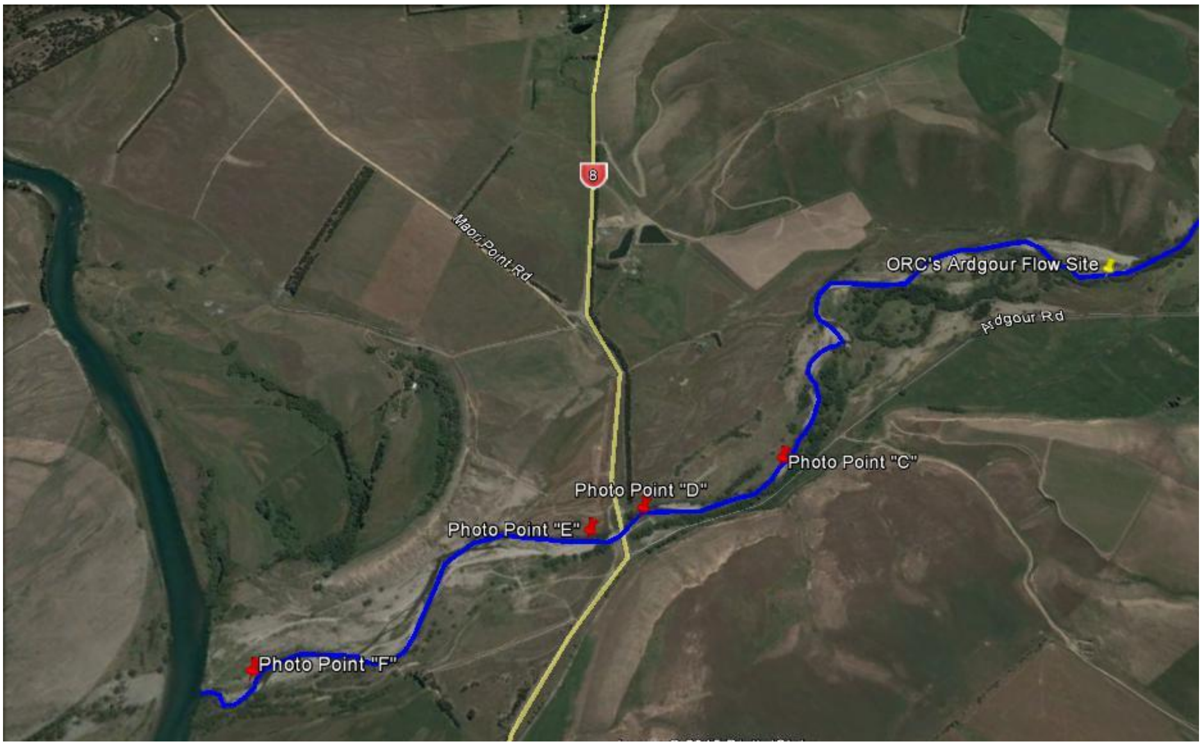
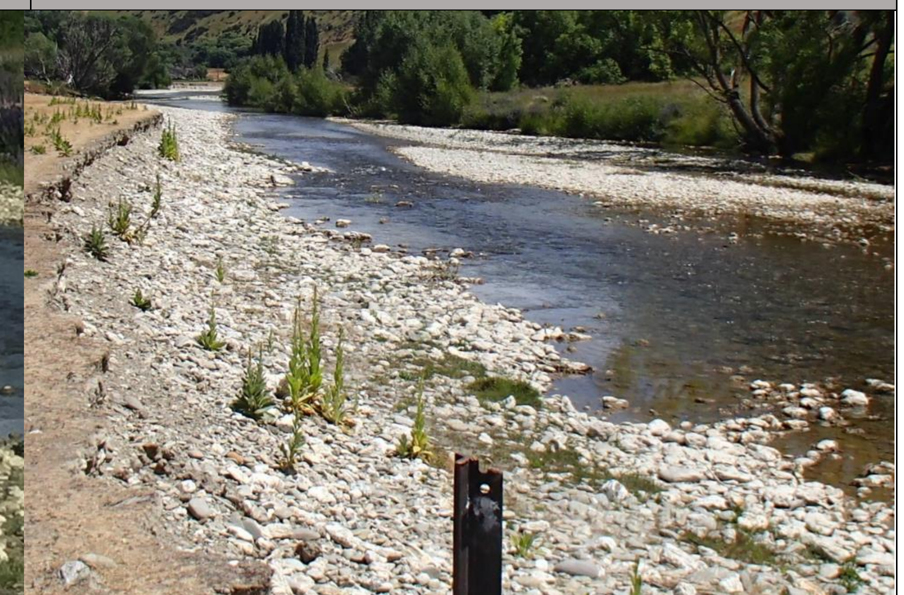
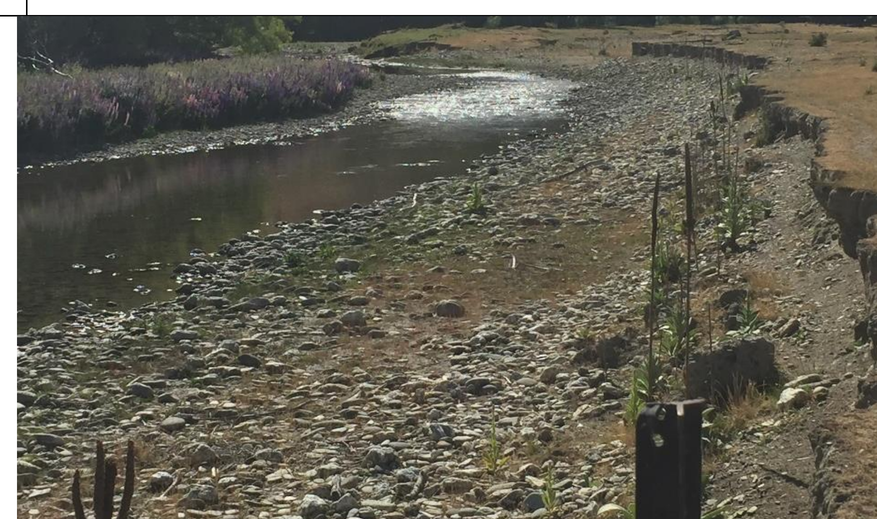
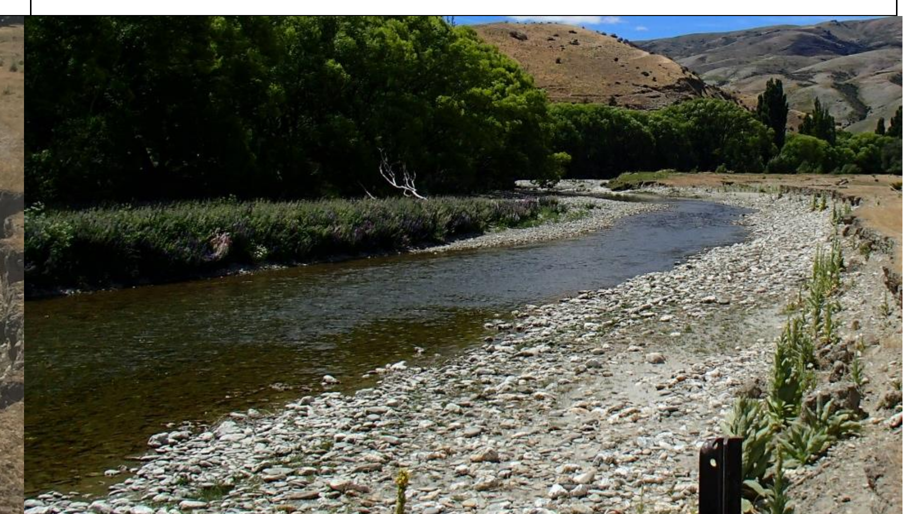


Figure 8. Map of where flow comparison photos were taken below the Ardgour flow site in December and January.

120. Table 7 allows a visual comparison of what 450 l/s and 750 l/s will deliver aesthetically based on the photos taken by LCG. The relatively minor difference in the appearance of the flows supports the IFIM data which shows the extra 300 l/s (between 450 l/s and 750 l/s) only marginally increases physical habitat (Table 4).

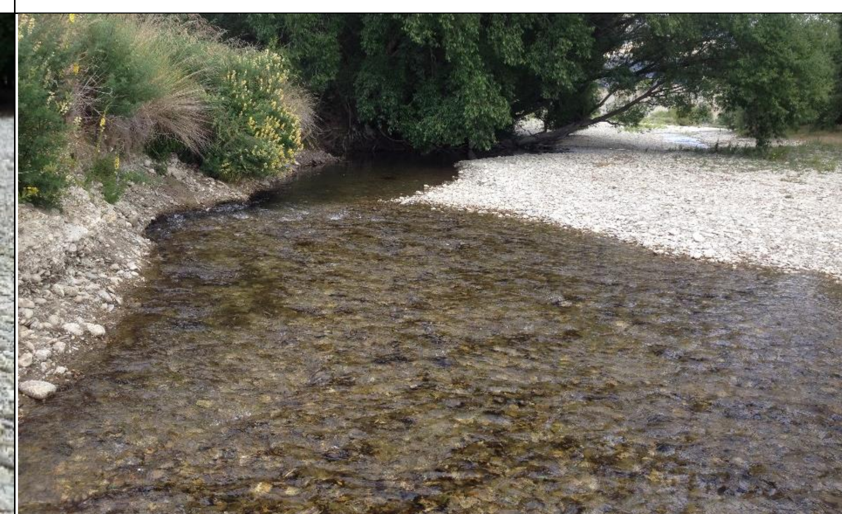
121. Furthermore, it should be noted that for the photos taken from points A and B in Table 7 below the LCG proposal to disestablish 3 races and shift them to below the Ardgour Road Bridge are likely to result in flows of at least 1000 l/s at these points, rather than 486 l/s as depicted.

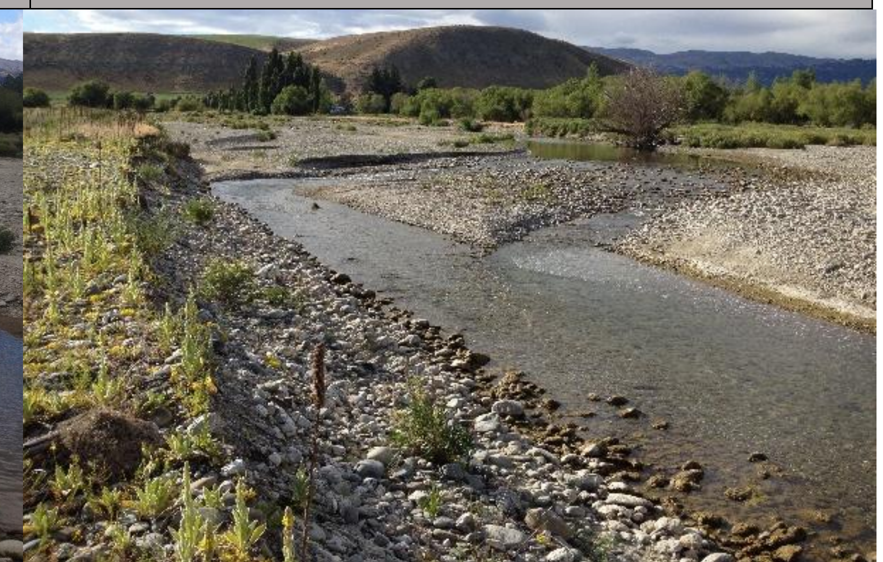
Table 7. Comparison of Status Quo flow (200 l/s), LCG's proposal of 450 l/s and ORC's proposal of 750 l/s.

	Status Quo	**486 l/s (expect at least 1000 l/s at this point with infrastructure changes)**	**784l/s**
Photo Point "A" Lindis River above the Ardgour Rd Bridge at "the Point", looking downstream.			
Photo Point "A" Lindis River above the Ardgour Rd Bridge at "the Point", looking upstream.			

	Status Quo	486 l/s (expect at least 600 - 1100 l/s at this point with infrastructure changes)	784 l/s
Photo Point "B" Lindis River upstream of the Ardgour Road Bridge, looking downstream.			
Photo Point "B" Lindis River upstream of the Ardgour Road Bridge, looking upstream.			

	Status Quo	537 l/s	784 l/s
Photo Point "C" Lindis River between ORC's Ardgour flow site and Lindis Crossing.			
Photo Point "C" Lindis River between ORC's Ardgour flow site and Lindis Crossing.			

	Status Quo	436 l/s	784 l/s
Photo Point "D" Lindis River immediately above the Lindis Crossing Bridge			
Photo Point "E" Lindis River immediately below the Lindis Crossing Bridge			

	Status Quo	436 l/s	784 l/s
Photo Point "F" Lindis River immediately above the Clutha confluence.			
Photo Point "F" Lindis at Clutha confluence. Clutha can be seen in the distance. Pisa Range is in the Background.			

LCG's Proposed Infrastructure Change

122. LCG proposes to disestablish the three major water races in the catchment, Tarras Race, Ardgour Race and Begg's Race and take water from piped and screened intakes mostly below Ardgour Road Bridge (the exception being one existing take above Ardgour Rd Bridge) (Figure 9).

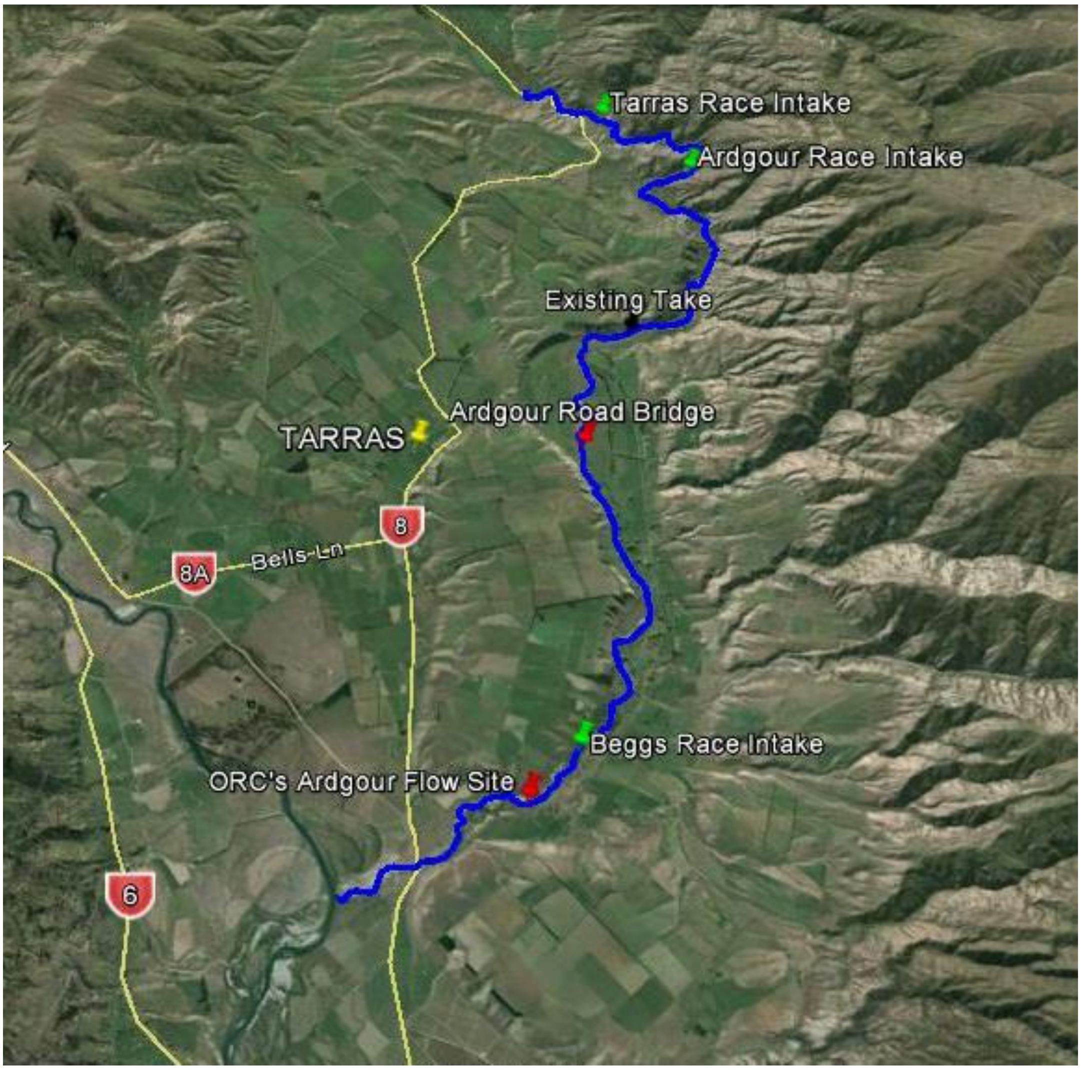


Figure 9. Relevant sites for LCG's proposal of changed water take locations.

123. This shift in take infrastructure will dramatically alter flows in the Lower Lindis. Table 8 below attempts to provide a comparison of the current regime to what LCG proposes with its changes to infrastructure.

Table 8. Comparison of expected flows for December to April at specific points in the Lindis River following LCG's proposed infrastructure upgrades.

Location	Status Quo Flow (l/s)	LCG Proposed Flows (l/s)
Lindis at Cluden Stream confluence (immediately above the existing Tarras and Ardgour races).	1500	1500
Lindis at "The Point"	100	1500
Lindis at Ardgour Bridge	0	600 - 1100 (depending on rate of loss to GW and 400 l/s proposed takes)
Lindis at Ardgour flow Site	200	450
Lindis at SH 8	0	220 – 250
Lindis at Clutha Confluence	0	8 - 98

124. This change in infrastructure will have significant benefits to the Lindis River most notably the reach from the Cluden Stream confluence to the Ardgour Road Bridge which historically can be completely dry due to either the water taken at the Tarras and Ardgour Race intakes, losses to groundwater or a combination of the two. This change offers the very real possibility of there being a significant adult trout fishery upstream of "The Point" to the Cluden Stream confluence as this reach would offer significant habitat at flows of 900 l/s or more (Personal Obs.).

125. With the takes below the Ardgour Road Bridge being smaller and dispersed along the reach to the Ardgour flow site, combined with a minimum flow of 450 l/s the effects of the change in water take infrastructure will be a significant improvement for ecological values upstream of Lindis Crossing Bridge.

Existing Flow Regime Effects on Brown Trout

Spawning

126. Trout spawning occurs over winter, with brown trout entering the Lindis from the Clutha from late April if flows allow. Brown trout tend to make up the majority of the spawning in the Lindis although there is a small run of rainbow trout (Jellyman and Bonnett 1992). Brown trout spawning occurs between May and July with rainbow trout later (Jellyman and Bonnett 1992). Historically there has been little if any impact on trout spawning in the Lindis due to spawning occurring at the time of least water demand and greatest flow.

Rearing

127. Under the current regime the best rearing habitat in the Lindis Catchment is found in the main stem and tributaries above the existing Ardgour and Tarras Race off-takes. Some rearing occurs in the Lindis downstream of the existing Ardgour and Tarras Race off-takes but this is sporadic and limited by the severity of the summer and resultant abstraction of water. Most summers will see flows and thus rearing habitat restricted to the gaining reach between Ardgour Road Bridge and the Ardgour flow recorder. The historic flow regime usually provides about 40% habitat retention relative to MALF (Table 4).

128. Overall the existing flow regime is having significant adverse effects on trout rearing habitat in the Lindis River.

Recruitment to the Upper Clutha and Lake Dunstan

129. Most out migration of trout in the Lindis to the Clutha and Lake Dunstan occurs over the months from May to December, with 67.6 % of fry and 91.6% of yearling trout leaving in this period (Jellyman and Bonnett, 1992). This is consistent with other studies showing juvenile

trout migration tends to occur in spring and autumn with higher flows (Hayes, 1988; Holmes et al. 2014).

130. Recruitment is hindered most summers from the end of December to end of April due to abstraction drying the Lindis River, preventing out migration. Jellyman and Bonnett (1992) note that delaying the summer migration of trout does not seem to affect their condition.

131. Holmes et al. (2014) recently found through pit tagging 1000 fish and tracking their movements that the majority of trout movement was during higher flows. Holmes et al. (2014) show that out-migration tends to be triggered by either outgrowing the available habitat and/or the available food resource. Out-migration in autumn-spring most likely results in densities well below carrying capacity in early summer and that out-migration over corrects for food and space limits significantly reducing densities before summer when habitat is most likely to be constrained (Holmes et al. 2014).

132. Current race off takes have been estimated to entrain between 23- 63% of the juvenile fish leaving the Lindis River, thus losing them from the system and reducing recruitment to the Clutha River and Lake Dunstan (Jellyman and Bonnett,1992). Holmes et al. (2014) specifically raise race off-takes that are not screened as a potential risk to juvenile trout out-migration.

133. Clearly the existing flow regime combined with the existing take configuration has significant adverse effects on trout recruitment from the Lindis River to the Clutha River and Lake Dunstan.

Nationally Significant Lake Dunstan and Upper Clutha Fisheries

134. The Lindis River is recognised as a rearing and recruitment river for the nationally significant fisheries of both Lake Dunstan and the Upper Clutha River. Both theses fisheries sustain high amounts of angling pressure in excess of 40,000 angler days per annum between them (Unwin, 2009), and are second only to Lake Onslow for the highest bag limits for trout in the region with six fish per person per day (Fish and Game fishing regulation for 15/16 season). Both fisheries have never been shown to be recruitment limited and the proposed hatchery that was part of the conditions imposed by the government when Clyde Dam was built was deemed unnecessary for that reason (Jellyman (A), 2011).

135. The Clutha Fisheries Trust (CFT) website (www.cluthafisheries.co.nz/the_trust.html) states the following:

> *"However, the need (or otherwise) for a sports fish hatchery became the subject of debate. The general consensus among fisheries managers was that natural recruitment would be* sufficient to maintain a satisfactory sports fishery."

136. I note that Fish and Game Otago's latest 10 year management plan lists increased angling pressure as an issue for the Upper Clutha but makes no mention of juvenile recruitment (Otago Fish and Game Council, 2015).

137. Furthermore, the CFT reports that up to 30% of the Lake Dunstan brown trout population uses the Lindis River as their preferred spawning stream (CFT, 2011). Thus it is possible to infer a significant proportion of the 30% of Lake Dunstan's trout population have come from the Lindis Catchment as they tend to return to their natal streams to spawn (McDowall, 2001; Jellyman (B), 2011; and Frank, 2012). This supports that significant recruitment is occurring under the present Lindis River flow regime (probably mostly from above the

Cluden Stream confluence) and that there are relatively good levels of Lindis River trout surviving to maturity.

138. Lake Dunstan and the Upper Clutha Fisheries are not recruitment limited despite the existing flow regime and take configuration in the Lindis River.

Existing Flow Regime Effects on Native Fish

139. Under the current regime the best native fish habitat in the Lindis Catchment is found in the main stem and tributaries above the existing Ardgour and Tarras Race off-takes and the gaining reach between Ardgour Road Bridge and the Ardgour flow recorder.

140. Many native fish species prefer low flows, thus the historic flow regime usually provides about 64% habitat retention relative to MALF for longfin eels, 55% for common bullies and 131% for upland bullies (Table 4).

141. Some common and upland bullies inhabit the losing reaches but this is a high risk strategy heavily dependent on the severity of the summer and resultant abstraction of water. Fortunately, bully species are very prolific breeders and their populations recover quickly.

142. Extensive fish kills of native fish have historically occurred in the two losing reaches (Figure 3) and these have been well documented (ORC, 2008).

143. Non migratory galaxiids are confined to tributary streams where barriers prevent trout predation which has resulted in local extinctions in other catchments in Otago (Ravenscroft, 2014).

144. Although the Lindis Catchment as a whole provides ample longfin eel habitat their numbers are relatively low due to recruitment issues caused by the Roxburgh and Clyde Dams (elver recruitment is a fraction of pre dam levels) and commercial harvest. Sadly, although some longfin eels do reach maturity in the Lindis, they are unlikely to reach their oceanic breeding grounds with two sets of turbines to negotiate on their downstream migration to the sea.

145. The existing flow regime in combination with the Roxburgh and Clyde Dam, commercial fishing and trout predation is having significant adverse effects on native fish in the Lindis River.

LCG's Proposed Flow Regime Effects on Brown Trout

Spawning

146. LCG proposes a winter minimum flow from June to September of 1,600 l/s. This flow provides near optimum spawning habitat for brown and rainbow trout (Jowett and Wilding, 2003). This flow recognises the significance of the trout spawning in the Lindis to the nationally significant adult fishery values of the Upper Clutha River and Lake Dunstan.

Rearing

147. LCG proposes a summer (Dec – April) minimum flow of 450 l/s, this provides 63% and 67% retention of habitat at MALF for fry and yearling brown trout, this is consistent with habitat retention levels for low value trout rearing streams (Jowett and Hayes, 2004). Given under LCG's proposal the proposed minimum flow is really only relevant to the reach below the Ardgour flow site and the significant gains in fish habitat upstream due to infrastructure changes mean these habitat protection values are a worst case scenario for this short reach of river.

148. The temperature data from the 14/15 summer shows that the Lindis River downstream of Lindis Crossing is not suitable habitat for brown trout during the summer months (Dec-Mar) even with flows up to 1400 l/s (Dale and Olsen, 2015). Fish and Game observations support that trout leave the Lower Lindis River before it reaches its lowest flows and while the river is connected to the Clutha (Fish and Game 2015). For this reason, the LCG proposes to maintain a habitat level that encourages fish to either move up or downstream to reaches more favourable to trout.

149. LCG's proposed flow regime will enhance the rearing habitat in the Lindis River to levels consistent with recommended levels by experts (Jowett and Hayes, 2004).

Recruitment to the Upper Clutha and Lake Dunstan

150. By significantly improving the rearing habitat (see above) and maintaining surface connection year round it will allow juvenile trout to out-migrate at the peak times they migrate. This is consistent with Holmes et al. (2014) and Jellyman and Bonnett (1992) which showed out migration was often tied to flow increases which aided downstream migration and most migration occurs between autumn and spring. In addition, the findings of Hayes et al. (2010) show that flows much lower than MALF are not a significant concern for young trout. These findings all support the LCG proposal of providing 63 – 67 % available habitat for the juvenile trout that chose to stay in the lower Lindis over summer.

151. Based on the juvenile trout losses to the large irrigation races reported by Jellyman and Bonnett (1992) where between 23- 63% of the juvenile trout population were lost, there will be a significant improvement to recruitment levels as LCG proposes to decommission these

races and shift to screened pumped takes from the Lindis River. Effectively this removes this historical juvenile trout loss from occurring in the future.

152. LCG's proposed flow regime and change in water take infrastructure will significantly enhance trout recruitment from the Lindis to Lake Dunstan and the Upper Clutha.

Nationally Significant Lake Dunstan and Upper Clutha Fisheries.

153. LCG's proposal through its significant enhancement of trout rearing and recruitment is likely to further enhance the nationally significant fisheries of both Lake Dunstan and the Upper Clutha River. The improved recruitment may be able to offset the increased angling pressure identified as an issue for the Upper Clutha in Fish and Game Otago's latest 10 year management plan by increasing fish stocks. There may even be potential to increase daily bag limits for trout in the upper Clutha.

154. Finally, under LCG's proposal it is entirely plausible that the percentage of Lake Dunstan brown trout using the Lindis for spawning will one day far exceed the previously reported 30% once the improved regime has been in place for several years (CFT, 2011).

155. Lake Dunstan and the Upper Clutha River fisheries are likely to be significantly enhanced under LCG's proposal.

LCG's Proposed Flow Regime Effects on Native Fish

156. LCG's proposed minimum flow will ensure habitat retention levels of 75% of MALF for Longfin eels. This is based on the expectation that ORC will enforce Contact Energy's consent condition relevant to longfin eel recruitment above Roxburgh and Clyde Dams and

in future this species will again inhabit the available habitat in the Lindis Catchment. LCG also recognises the significance of this species to Kai Tahu.

157. 76% and 132% of habitat retention at MALF will occur as a result of LCG's proposal for the common and upland bullies respectively. This enhances the existing situation for these species.

158. LCG's proposed minimum flow (particularly in combination with its proposed changes to intake infrastructure) should maintain a continuous connection with the Clutha. It is likely that due to losses the lowest flows will be immediately above the Clutha confluence and the rate of reduction in flow will be slow enough for fish to move upstream or downstream to more favourable habitat if needed. Trout should have left the reach well before any drying due to temperatures not being suitable for them with flows below 1400 l/s (Dale and Olsen 2015; Fish and Game 2015).

159. LCG's proposed flow regime will significantly enhance the native fish values of the Lindis River.

Conclusion

160. The LCG proposal ensure the ecological values of the Lindis River are maintained and enhanced by providing the following habitat protection levels relative to what would be available at MALF:

- Trout spawning - Near optimum flow (maximum protection).
- Juvenile rearing – At least 63% for fry and 67% for yearling habitat retention.
- Significant presence of Longfin eel - 75% habitat retention.

- Common and upland bully – 76% and 132% habitat retention respectively. Optimum flow for upland bullies is less than MALF, thus the high percentage.

161. A minimum flow of 450 l/s should prevent the historic fish kills of native fish. A minimum flow of 450 l/s will provide significant habitat for longfin eel (75% habitat retention at MALF) common bully (76% habitat retention at MALF) and upland bully (132% habitat retention at MALF).

162. High water temperatures in the Lindis River downstream of Lindis Crossing shows that neither the ORC proposal nor LCG's proposal will be able to provide for trout in this reach during Summer (Dec – March).

163. Trout spawning will be protected by the winter minimum flow of 1600 l/s which provides near optimum spawning habitat for both brown and rainbow trout based on the IFIM (Jowett and Wilding, 2003).

164. Aesthetically a flow of 450 l/s in combination with the changes in take location proposed by LCG achieves the same as a flow of 750 l/s does (Table 7).

165. LCG proposes that for trout the lower river below Lindis Crossing should be managed for ensuring recruitment to the Clutha and Lake Dunstan. By maintaining continuous flows and ensuring freshes can reach the Clutha in combination with less than favourable habitat below immediately above the Clutha confluence for trout will encourage trout to pass through the reach rather than take up residence when flows allow. The temperature signal occurring at much higher flows (beginning at 1400 l/s) should encourage trout to leave the reach well in advance of the minimum flow of 450 l/s being reached.

166. By maintaining connection with the Clutha it ensures that when freshes do occur they will make it through to the Clutha River rather than being lost to ground due to the significant reaches of dry river bed as occurs at present. These freshes are the most likely time for trout to out-migrate from the Lindis to the Clutha if they are still present over summer (Holmes et al. 2014).

167. LCG's intent is to disestablish the existing race configuration and move to screened pump systems from the river below Ardgour Road Bridge. This dramatically improves flows in the Lindis below the Cluden Stream Confluence (Table 8). This significant change in take infrastructure will also remove the annual loss of juvenile trout to entrainment in the races and potentially create a further 9 km of adult trout habitat compared to what occurs now.

168. The combination of maintaining at least 63% - 67% juvenile trout retention of habitat at MALF, continuous flow, and removal of the current race infrastructure should dramatically enhance juvenile trout recruitment to the Clutha River and Lake Dunstan.

Dated this 18 day of March 2016

Matthew Hickey

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