BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	Plan Change 5A Lindis catchment & Bendigo Tarris Basin Integrated Water Management

---

STATEMENT OF EVIDENCE OF MATTHEW JOHN DALE FOR TE RŪNANGA O MOERAKI, KĀTI HUIRAPA RŪNAKA KI PUKETERAKI, &TE RŪNANGA O ŌTĀKOU (KĀI TAHU)

Dated 18 March 2016

Matt Dale

Senior Environmental Advisor –
Freshwater Management
Te Ao Tūroa – Mauri Team
Te Rūnanga o Ngāi Tahu

Level 1,
258 Stuart Street,
PO Box 799,
DUNEDIN 9054
Tel: 021 85 4648
Email: matthew.dale@ngaitahu.iwi.nz

QUALIFICATIONS AND EXPERIENCE

1. My full name is Matthew John Dale.

2. I am a Senior Environmental Advisor for Freshwater Management with Te Rūnanga o Ngāi Tahu.

3. I hold a Bachelor of Biological Science (Ecology) from La Trobe University, and a Post Graduate Diploma in Ecology from the University of Otago.

4. I have 14 years experience as a freshwater ecologist, specialising in fish ecology, environmental monitoring, hydrology, environmental flow setting, freshwater quantity policy development and implementation, and water resource management. My previous roles include River Ecosystems Technician for the National Institute for Water and Atmospheric Research (two years) and nine years as a Water Resource Scientist with the Otago Regional Council (ORC).

5. I have worked extensively in the Lindis catchment since 2006; undertaking several water quantity and fisheries studies as well as authoring two technical reports (*Management flow for Aquatic Ecosystems in the Lindis River* (2008), and *Update of scientific work in the Lindis catchment: 2008-2015* (2016)). I have undertaken electrofishing surveys at the Lindis at Ardgour Rd Bridge and Lindis Crossing (SH8) from 2006 to 2015 as the project leader for the ORC's State of the Environment fish monitoring programme. I have also worked with Lindis irrigators on Plan Change 1C implementation and have a sound understanding of irrigation practices and infrastructure in the catchment.

6. In preparing this evidence I have reviewed:

   a. The relevant technical reports and information provided by ORC

   b. The ORC's Section 32 Evaluation Report and Section 42A Report

   c. Further information provided by the Lindis Catchment Group

7. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

8. I have been asked by Kāi Tahu to prepare relevant background information on the Lindis catchment and technical evidence in relation to the flows required to maintain Kāi Tahu values in the Lindis River, including the maintenance of a culturally meaningful connection with the Clutha River/Mata Au.

9. This includes:

   a. Hydrology of the Lindis River, including groundwater/surface water interactions

   b. Taonga species of the Lindis catchment

   c. Water quality

   d. Suitability of proposed minimum flows and allocation limits

Background

10. The Lindis River has a catchment area of 1,055 km^2, and flows 70km in a south-west direction from its headwaters in the Dunstan Mountains to its confluence with the Clutha River/Mata Au approximately 6km upstream of Lake Dunstan.

11. It is the largest tributary of the main stem of the upper Clutha River/Mata Au and has a naturalised 7-day Mean Annual Low Flow (MALF) of 1,864 l/s. The catchment is well known for its dry summers and low flows, including dewatering in its lower and middle reaches.

Hydrology

12. Between 2006 and 2016, two hydrological studies have been undertaken in the Lindis River (ORC, 2008; Dale & Olsen 2016). ORC 2008 focussed largely on the hydrology of the catchment downstream of the Ardgour Rd flow recorder, while Dale and Olsen (2016) investigated naturalised flows, as well as the hydrology of the middle and lower reaches of the catchment.

13. The naturalised flow modelling undertaken by Dale & Olsen (2016) suggests that the river would not run dry under natural flow conditions, with the lowest naturalised daily average flow being 841 l/s since records began in 1976.

Upper drying reach

14. On-going collaboration between various stakeholders (Lindis community, Fish & Game, Kāi Tahu, Clutha Fisheries Trust and ORC) between 2008 and 2014 identified an additional reach upstream of the Ardgour Rd bridge was also subject to dewatering. This was due to the operation of large irrigation takes and losses into the Lindis Alluvial Aquifer of approximately 500 l/s (Dale & Olsen, 2016)

15. This was further supported in 2014 by a flyover undertaken by the Clutha Fisheries Trust which identified a 10km reach of intermittent flow and dewatered sections upstream of the Ardgour Rd Bridge (**Appendix 1**).

16. These observed flow patterns are largely driven by a combination of groundwater/surface water interactions, water abstraction and by-wash from irrigation races (Dale & Olsen, 2016).

17. There are 4 large main stem takes that contribute to the flow patterns observed in the upper losing reach; Tarras and Ardgour races (both run by the Lindis Irrigation Company), Rutherford's race and Beggs-Stackpol race. The combined rate of take from these takes varies between approximately 1,000 l/s and 1,600 l/s depending on water availability (Dale & Olsen 2016).

18. A series of by-wash points is used to ration water between the four main takes in the catchment. Instead of reducing the rate of take for the top race (Tarras), a portion of the water from the race is by-

washed back into the river immediately above the next race downstream, with a similar method being used for all of the subsequent downstream races (**Appendix 2**). In this way, the main water users manage water distribution without the need to take into account the travel time and losses to groundwater if the water were to remain in the river (Dale & Olsen 2016; McKeague, 2015).

19. Although this management regime is an efficient method for rostering water amongst open race systems, it means that much of the water is abstracted from the Lindis River well upstream of where it is actually used. Notwithstanding the effect of any future minimum flow, an upgrade of irrigation infrastructure that includes the decommissioning of the Lindis Irrigation Company (LIC) races and abstracting closer to the point of use will contribute significantly to maintaining continuous flows in the upper drying reach.

Lower Lindis River

20. The lower Lindis has a well-known “losing reach” between the Ardgour Rd flow recorder and the Clutha/ Mata Au confluence. ORC (2008) and Dale & Olsen (2016) estimated flow losses in the lower reach by measuring flow differences between three sites; Ardgour Rd, Lindis Crossing, and Clutha confluence (Figure 1).

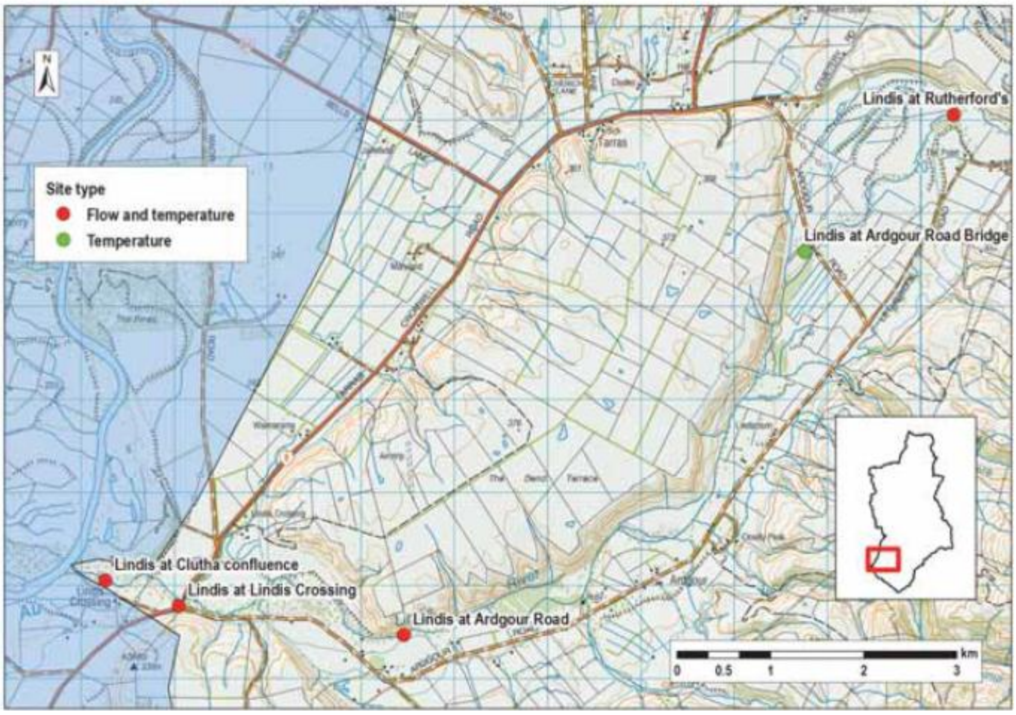


Figure 1: **Flow and temperature sites in the lower and middle reaches of the Lindis River used in the 2014/15 flow study (Dale & Olsen, 2016).**

21. Using these three sites, flow loss estimates were made by directly comparing time series data (ORC 2008; ORC unpublished data 2015) and regression analysis (Olsen & Dale 2016; Olsen 2016). Over the two seasons of flow record encompassed by these studies, it has been shown that flow losses in this reach can vary between 322 and 335 l/s (regression analysis) and 450 and 523 l/s (time series comparison).

22. Unfortunately, neither of these studies were able to estimate losses at stable low flows, and most measurements were taken while flows were receding from spring high flows or after freshes. This creates a degree of uncertainty, as it is likely that flow losses at base flows would differ from those occurring during receding flows.

23. Groundwater surface water interactions such as those observed in the lower Lindis River are largely influenced by channel morphology, pressure head of overlying surface water and the permeability of riverbed sediments (summarised in Arntzen *et al.*, 2006).

24. The influence of surface flows and groundwater levels was illustrated by work undertaken in 2006/07 (ORC, 2008), which indicated that the rate of surface water loss in the lower Lindis River is somewhat

dependant on antecedent groundwater levels in the Lindis Alluvial Aquifer. When flows were moderate and the aquifer was connected to the river via a saturated zone, losses were relatively high, but varied significantly both spatially and temporally depending on flow rates and aquifer levels.

25. Once aquifer levels drop and become disconnected from surface flows, loss of surface water to the aquifer has been shown to be relatively stable within a single irrigation season (ORC, 2008 - Figure 2)

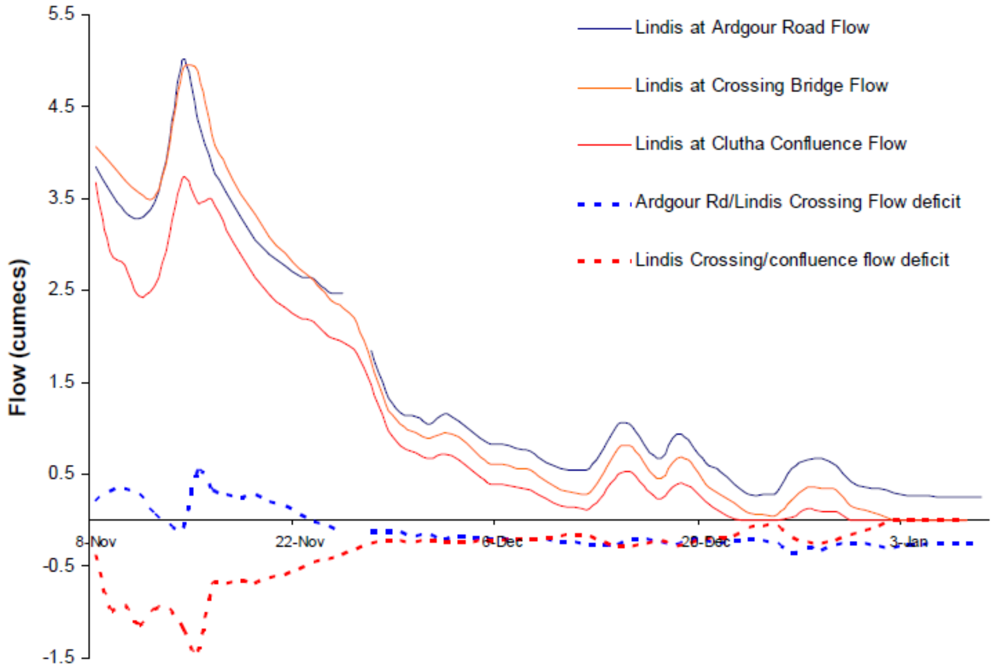


Figure 2: Average daily flows and flow losses in the lower Lindis River during the 2006/07 irrigation season (ORC, 2008).

26. Unfortunately, groundwater monitoring in the lower Lindis catchment is limited to sporadic data from a nearby private bore, and there is insufficient information to reliably estimate critical groundwater thresholds that may influence flow losses in this reach.

27. In addition to groundwater conditions, channel morphology also plays an important role in the rates of surface flow loss in the lower Lindis River. As illustrated by Winter *et al.* (1998), narrow confined channels have a smaller surface area and will have a lower rate of loss than more open unconfined channels that have a greater surface area. In addition to the influence of groundwater described above, changes in

channel morphology and bed composition associated with flood events are likely to be significant drivers in spatial and temporal patterns of flow loss in the lower Lindis River.

28. Due to the level of uncertainty and variation surrounding the rates of flow loss downstream of the proposed minimum flow site, in my opinion a precautionary approach is required when setting a flow to maintain continuity through to the Clutha River/Mata Au.

29. This approach should aim to give reasonable certainty that physical connection can be maintained over the full range of antecedent groundwater conditions, substrate conditions and channel morphology. Furthermore, it should be acknowledged that what constitutes a meaningful connection for Kāi Tahu (as opposed to simple physical connection) is dependent on the flow requirements of the specific values addressed in the evidence of Mr Higgins and Mr Vial.

Tuna/Longfin eel

30. Tuna (longfin eel) are considered a taonga (treasured) species by Kāi Tahu; honoured for their spiritual and mythological significance, as well as their ecological importance and value as a mahinga kai species.

31. Recruitment of tuna into the Lindis River is currently restricted by migration barriers at the Roxburgh and Clyde Dams. However consent conditions for the Roxburgh and Clyde Dams specify that tuna and kanakana (lamprey) passage must be provided by March 2017, so it is expected that tuna will be present in significantly higher numbers in the future.

32. Instream habitat modelling commissioned by ORC (Jowett and Wilding, 2003) found that optimum habitat for tuna was provided at a flow of 3,800 l/s, and that the physical habitat available for tuna at MALF was 7.94 m^2/m Weighted Usable Area (WUA) .

33. The Lindis River below SH8 provides little habitat for adult tuna, due to its unconfined and unstable nature and the absence of deep pools and riparian cover. However this reach may provide habitat for juvenile

tuna moving up from Lake Dunstan if a regular trap and transfer program is implemented at Roxburgh Dam.

34. Recent surveys undertaken by Fish & Game NZ have shown that adult tuna are present in low numbers in the reach between SH8 and the Ardgour Rd Bridge (Dale. M., 2014, *per obs*). This population is likely composed of a combination of individuals that pre-date the construction of the dams, sporadic trap and transfers from the Roxburgh Dam, and unauthorised releases from other locations.

35. The population upstream of SH8 highlights the importance of continuous flow through the upper drying reach described in Paragraphs 14 and 15, where suitable tuna habitat exists but is currently restricted by low flows and dewatering.

36. Although most of the suitable habitat for adult tuna is located above the minimum flow site, it is important that connection is maintained throughout the lower reaches to ensure that any juvenile tuna located within the lower reach are able to move into refuge habitats if conditions become unsuitable due to low flows or high temperature.

37. Minimum flows are unlikely to have an effect on downstream migration of adult tuna, or upstream migration by juveniles, as this behaviour is generally associated with high flow events (Boubee *et al*, 2001, Jellyman, 1977).

Primary allocation limits

38. The proposed primary allocation limit of 1,000 l/s will ensure that any allocation that is surrendered, lapses, expires or is reduced through the Plan Change 1C process is returned to the river and not re-allocated. Maintaining the “sinking lid” approach down to this limit will increase surety of supply for remaining users and contribute to meeting the values of tangata whenua.

Supplementary minimum flow

39. The proposed supplementary minimum flow and allocation regime or the Lindis River is;

    a. Supplementary Block 1 (allocation = 500 l/s)

        i. December to April minimum flow: 1,600 l/s

ii. May to November minimum flow: 2,200 l/s

b. Supplementary Block 2 (allocation = 500 l/s)

i. December to April minimum flow: 2,100l/s

ii. May to November minimum flow: 2,700 l/s

40. The minimum flows and allocation limits described above provide 91% of the optimum flow for adult tuna (longfin eel) between December and April, and 97% of optimum habitat between May and November.

Water quality

41. A recent study by Olsen (2016b) found that nitrate-nitrite nitrogen (NNN) was elevated in the reach between the Ardgour Rd bridge and SH8. Olsen (2016b) states that the high NNN concentrations are likely derived from shallow groundwater that enters the river in the reach at and below the Ardgour Rd Bridge.

42. Schedule 15 of the Regional Plan: Water (RPW) sets a NNN limit of 0.075 mg/l for the Lindis River (80^{th} percentile over 5 a year moving average) which comes into effect in 2025 and is intended to manage the risk of algal proliferation and its associated native effects. The current NNN concentration of 0.212 l/s is three times the Schedule 15 limit.

43. Although the invasive diatom *Didymosphenia germinata* (Didymo) is present in the Lindis catchment, it is also common for significant accrual of filamentous algae to occur during periods of low flow as shown in Figure 3.

Figure 3: Filamentous algae in the Lindis River at the Argour Rd Bridge (upper drying reach).

44. Initial evidence also suggests that the potentially toxic and common benthic cyanobacteria *Phormidium autumnale* may respond well to waters with high measured nitrogen and low phosphorus (Excerpt from evidence from Kathryn Jane McArthur, Tukituki Catchment Proposal Board of Enquiry).

45. *Phormidium* is a benthic cyanobacteria that under certain circumstances has the ability to produce powerful neuromuscular blocking agents that can cause convulsions, coma, limb twitching, hypersalivation, and/or death (Heath *et al*, 2011). In Otago, there have been several instances of dog deaths related to the ingestion of *Phormidium* (ORC media release, 2008).

46. State of the Environment monitoring undertaken by the Otago Regional Council (ORC 2008) has shown that *Phormidium* is present in the Lindis River at Ardgour Rd and it has also been observed further downstream at Lindis Crossing (Dale, *pers obs*). While it is present in many Otago rivers, elevated concentrations of NNN in the Lindis River may increase the risk of *Phormidium* blooms which may have negative impacts on the ability of Kāi Tahu to utilise the river in the future.

47. Olsen (2016b) highlights that a minimum flow can reduce NNN concentrations in the river through dilution, thus the minimum flow may have an important role in reducing the risk of algal blooms caused by high NNN concentrations.

Primary minimum flow

48. Kāi Tahu is seeking a primary minimum flow of 1,000 l/s at the Ardgour Rd flow recorder.

49. This flow will provide 91% of the habitat available at MALF for tuna, and 89% of the optimum flow for this species, ensuring that this taonga species will not be significantly impacted by habitat limitation once upstream migration is restored.

50. Although difficult to quantify within the range of flows that are being considered, a higher minimum flow is likely to reduce the rate of algal accrual through a combination of increased water depth (therefore less light), higher water velocities (increased sloughing) lower water temperatures, and lower nutrient concentrations (Biggs, 2000). The processes described above are likely to reduce the risk high biomass of filamentous algae persisting in the Lindis River.

51. In my opinion, the minimum flow of 1,000 l/s sought by Kāi Tahu will provide connection through both the upper and lower losing reaches, and will provide high surety that flows at the Clutha River/Mata Au confluence will not drop below 400 l/s.

CONCLUSION

52. The reach upstream of the Ardgour Rd Bridge is subject to dewatering due to current water transport infrastructure and water sharing practices. To address this issue an integrated catchment management approach may need to be considered that goes beyond the current scope of the minimum flow.

53. Tuna (longfin eel) are an important taonga species that are currently found in the Lindis River upstream of SH8. Upcoming improvements to fish passage in the Clutha/Mata Au will further increase the significance of the Lindis River for tuna habitat and underscore the

need for a minimum flow that allows tuna to move within the lower catchment as required if conditions become unsuitable.

54. The proposed supplementary minimum flows provide sufficient habitat for adult tuna and are unlikely to have any significant adverse effect on instream values.

55. The lower Lindis River currently experiences NNN concentrations approximately 3 times the Schedule 15 limit as outlined in the Regional Plan: Water.

56. A minimum flow of 1,000 l/s as submitted by Kāi Tahu will reduce NNN concentrations in the lower Lindis River, and with the associated increases in depth and water velocities, and reductions in temperature, will reduce the risk of algal blooms.

57. It is clear that there is spatial and temporal variation in the amount of surface water lost to the alluvial aquifer in the lower Lindis, therefore a precautionary approach should be used when considering minimum flows to ensure that the Kāi Tahu values in the Lindis River are recognised and provided for.

DATED this 18th day of March 2016

Matthew John Dale

REFERENCES

Arntzen. E. V., Geist. D. R., Dresel. P. E., 2006, Effects of fluctuating river flow on groundwater/surface water mixing in the hyporheic zone of a regulated, large cobble bed river, *River Research and Applications*, **22**: 937-946.

Biggs. B. J. F., 2000, New Zealand Periphyton Guidelines: Detecting, Monitoring and Managing Enrichment of Streams.

Boubée. J.A , Mitchell. C.P., Chisnall. B. L., West. D. W., Bowman. E. J., & Haro. A., 2001, Factors regulating the downstream migration of mature eels (Anguilla spp.) at Aniwhenua Dam, Bay of Plenty, New Zealand, New Zealand *Journal of Marine and Freshwater Research*, **35:1**, 121-134

Dale. M. & Olsen. D., 2016, Update of Scientific work in the Lindis catchment: 2008-2015, Otago Regional Council, *ISBN: 978-0-908324-23-1*

Heath. M. W., Wood. S. A., & Ryan. C. G., 2011 Spatial and temporal variability in *Phormidium* mats and associated anatoxin-a and homoanatoxin-a in two New Zealand rivers, Aquatic Microbial Ecology, 64: 69-79.

McKeague. S., 2015, Flow sharing in the lower Lindis River, File note provided to the Otago Regional Council.

Jowett. I. G. & Wilding. T. K., 2003, Flow Requirements for fish habitat in the Chatto, Lindis, Manuherikia, Pomahaka and Waianakarua Rivers, *National Institute of Water & Atmospheric Research Ltd*, NIWA Client Report: HAM2003.052.

Olsen. D. 2016(a). Analysis of flow loss between the Ardgour Rd hydrological site and Clutha confluence on the Lindis River in 2015/16, ORC File Note, *Document ID: A883040*.

Olsen. D. 2016(b). Water quality in the Lindis River catchment 2015, Otago Regional Council, ISBN: 978-0-908324-26-2

Otago Regional Council, 2008, Management Flow for Aquatic Ecosystems in the Lindis River, *ISBN: 1-877265-63-2*

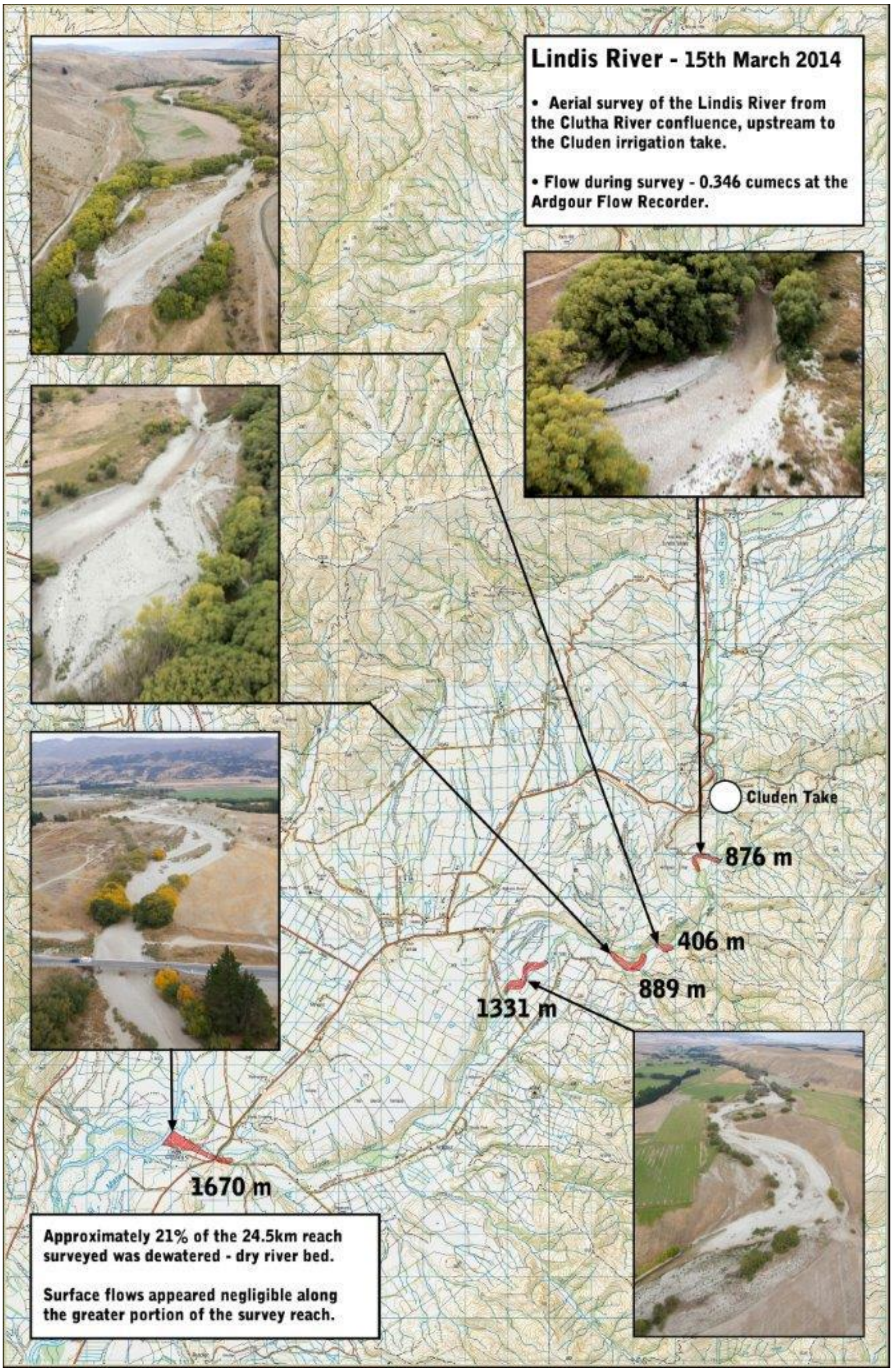
Otago Regional Council, 2008, Media Release 24 January 2008, Toxic algae found in Shag and Wainakarua Rivers

Otago Regional Council, 2015, Water quality and ecosystem health in Otago – July 2010 to June 2015

Winter. T.C., Harvey. J.W., Franke. O.L., & Alley. W.M. 1998. Ground Water and Surface Water: A Single Resource. *U.S. Geological Survey Circular 1139*.

Appendix 1

Drying reaches mapped by the Clutha Fisheries Trust during the 2013/14 irrigation season at a flow of 346 l/s at the Ardgour Rd flow recorder



Appendix 2

Map of major race intakes and bywash points in the Lindis River