HEARING BEFORE COMMISSIONERS

IN THE MATTER	the Resource Management Act 1991
AND	Otago Regional Council
AND	Plan Change 5A (Lindis Integrated Water Management)

EVIDENCE OF JENS HAAYE REKKER

1. INTRODUCTION

1.1 My name is Jens Haaye Rekker. I hold the qualifications of Bachelor of Science (Geology) and Postgraduate Diploma in Science with Credit (Geology) from Otago University. Since 2014, I have been employed by Lincoln Agritech Ltd as a senior groundwater scientist. In the period February 2008 to October 2013, I was employed as a senior resource scientist by Otago Regional Council in the Resource Science Unit. Prior to this I have worked in the field of groundwater consulting for the firms Aqua-Firma, CM Jewell & Associates, HLA Envirosciences, MWH New Zealand, Liquid Earth Australia, Kingett Mitchell and Golder Associates, primarily in the South Island. Prior to September 1993, I was employed as a geo-hydrologist for the Hydrology – Research & Development section of Amsterdam Water Supply.

1.2 The range of groundwater advice that I provide in the course of my work is wide, including relevant investigations of groundwater basin sustainable yield, hydrologic effects of bore fields in proximity to rivers and the hydrogeology of alluvial aquifers. I have combined scientific investigations with advising resource management professionals and the public on the effects of a range of water management options relating to freshwater, and particularly groundwater resources.

1.3 I have a background of undertaking and assisting water resource investigations in the Upper Clutha, including assisting with the ORC (2008) report, peer reviewing the Houlbrooke (2010) report, consulting with the Tarras community in several ORC public meetings and undertaking extensive investigations of the Cardrona River catchment with hydrological conditions or issues common to those of the Lindis River catchment.

1.4 I have been engaged to assist the hearing with a characterisation of the Lindis Alluvial Ribbon Aquifer, the interactions of the aquifer and the overlying lower Lindis River, and the implications of a range of future minimum flow settings to manage the Lindis River.

1.5 My scope of evidence includes reviewing the most relevant technical publications and reports covering the above subjects in the upper Clutha River / Mata Au catchment. I then examine original hydrological data for the interpretations they provide on river – aquifer modes of interaction. Subsequently, I review a range of minimum flow settings in terms of their effect on river flow conditions throughout river reaches along the lower Lindis River.

1.6 I acknowledge that I have read the Environment Court practice note on the conduct of Expert Witnesses 2014. I have complied with this in preparing my evidence. My evidence contains my own opinion and technical workings, except where I specify another person or organisation as the source of information presented herein.

2. THE LINDIS ALLUVIAL RIBBON AQUIFER

2.1 The Lindis Alluvial Ribbon Aquifer is a halo of recent age schist-derived sand and gravel alluvium associated with modern reworking of river aggregate that is partially saturated with groundwater.

2.2 The Lindis River is couched within this thin veneer of alluvium downstream of the short gorge in the lower river (between Archies Flat and The Point). The alluvium is underlain by Miocene age mudstone at shallow depth beneath the land surface. Supporting this inference, almost all water bores tapping the alluvium are reported to have a total depth in the range of 5 m to 20 m below ground level (Houlbrooke, 2010).

2.3 The alluvium is fringed by glacial till terraces composed of scattered boulders, silt and sand deposited during a glacial advance that terminated further down-valley at Lowburn, near Cromwell. These older terraces (aged between 600,000 to 400,000 years before present) are also underlain by Miocene mudstone and sandy silt.

2.4 Downstream of Lindis Crossing, which is marked by the bridge carrying State Highway 8 (SH8) over the Lindis River, the valley passes out of the gap fringed by glacial till and into glacial outwash gravel deposits associated with the Alberttown Glacial Advance. These glacial outwash terraces north and south of the Lindis River between Lindis Crossing and the Clutha River confluence comprise the Lower Tarras (Maori Point) and Bendigo terrace aquifers, respectively.

2.5 There are multiple lines of evidence that the Lindis Alluvial Ribbon Aquifer is in direct hydraulic communication with the adjoining Lindis River. These will be examined further in subsequent discussion.

2.6 The Lindis River Alluvial Ribbon Aquifer was first proposed in plan change 1C in 2009 as a means of regulating groundwater withdrawals from the aquifer that would otherwise have a strong effect on the flow of the Lindis River. An older mapping of the Lindis River Alluvial Ribbon Aquifer, truncated at SH8 and not including the Lindis Alluvial Fan, was referenced in Schedule 2C of the Regional Plan: Water.

2.7 The corollary to the above water management objective (regulating stream depletion) was that the state of the water table in the aquifer could have an effect on river flow by a process called stream flow depletion (see for example PDP and ECan, 2000).

3. THE LOWER LINDIS RIVER

3.1 The geomorphology of the Lindis River downstream of Archies Flat is dominantly a braided river of low flow volume.

3.2 The lower Lindis River has a mean gradient of 0.5 % or 1:200, consistent with its braided river geomorphology (e.g. Leopold and Wolman, 1957). The development of braiding generally manifests as a main and secondary braid channel.

3.3 The Lindis River drains a diverse catchment that is mountainous with high precipitation totals in its headwaters, and comprising an inter-montane basin in rain shadow, with low precipitation in its lower reaches upstream of its mouth.

3.4 Downstream of the Lindis Peak flow recorder, the median and low flows measured in the river decreases, in contrast to a river's normal tendency to recruit increased flow in the downstream direction.

3.5 Otago Regional Council (ORC) supplied hydrological statistic tables list the long-term seven-day Mean Annual Low Flow (7dMALF) at Lindis Peak recorder at 1,626 litres per second (L/s). The same statistic at the downstream Ardgour Road recorder (i.e. 7dMALF) was 252 L/s. Once the 7dMALF value for Ardgour Road is 'naturalised[1]', the value increases to 1,935 L/s. These tendencies for 7dMALF to decline in actual downstream measurements and increase once naturalised statistics are used, is accentuated once the irrigation season statistics are examined.

3.6 The 7dMALF declines from Lindis Peak to Ardgour Road hydrological sites by 1,186 L/s using the irrigation season (September –May) period and actual values. Examining the same change, but substituting naturalised values for Ardgour Road, the 7dMALF increases by 278 L/s.

3.7 The considerable loss of flow between Lindis Peak and Ardgour Road recorders is the result of diversions of river flow into surface water races (Tarras Race at Cluden, Ardgour Race and Begg–Stackpole Race), direct pumping from the river channel and stream depletion of the river caused by riparian groundwater pumping. The end-use of the water taken is almost

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[1] The flow of the Lindis River is naturalised by adding 50 L/s to the total at Lindis Peak recorder to account for abstraction upstream of it and then adding the flow of each of the six measured tributaries between Lindis Peak and Ardgour Road recorders (Opus International Consultants, 2015).

exclusively the irrigation of pasture with a distinct irrigation season (October to April).

3.8 The taking of Lindis River has proven very difficult to quantify due to the past lack of requirements to measure the taking of water and the twilight period for modern regulations requiring measurement to be implemented. However, 2011 estimates of irrigation abstraction from the Lindis River upstream of Ardgour Road recorder is 2,300 L/s to irrigate 2,000 hectares (ha) of pasture (Opus International Consultants, 2015). Aside from the artificial taking of water from the Lindis River, water infiltrates into its bed and passes into the underlying alluvial ribbon aquifer along reaches of the river where the sub-surface hydraulic gradient is favourable.

3.9 However, the infiltrated water remains largely within the Lindis Alluvial Ribbon Aquifer, at least upstream of Lindis Crossing. So, the water that had infiltrated mostly returns to the river by seepage into the river channel in reaches where the sub-surface hydraulic gradient favours that.

3.10 Between Archies Flat and Lindis Crossing, the net effect of infiltration to the underlying aquifer and seepage from the aquifer back into the river is thought to be approximately neutral. ORC surface water or groundwater science investigations have not found evidence for significant departure of alluvial ribbon aquifer water outside the Lindis Valley. In fact, the 2010 groundwater investigation covering the valley (Houlbrooke, 2010) found groundwater flow to converge towards the Lindis River meaning that aquifer water remained within the valley.

3.11 The above pattern changes at Lindis Crossing, where the pinch in the valley floor imparted by the proximity of the glacial till terraces is released and an alluvial fan associated with the Lindis River has over-printed the Alberttown outwash surface between SH8 bridge and the Clutha / Mata Au counfluence. In this zone, groundwater contours presented in Houlbrooke (2010) show groundwater level contours radiating from Lindis Crossing and leaving the riverine area in the direction of the Lower Tarras and Bendigo aquifers.

4. SUMMARY FOR THE LINDIS RIVER AND ALLUVIAL RIBBON AQUIFER

4.1 Integrating the above characterisation of the river and aquifer, the braided Lindis River obtains the majority of its flow upstream of the Lindis Peak recorder and loses a substantial portion of this to diversion and abstraction for irrigation of pasture.

4.2 The Lindis Alluvial Ribbon Aquifer is narrow, laterally within the lower Lindis Valley, and thin (less than 20 m) vertically between the underlying mudstone basement and land surface. Hence, the aquifer has low pore volume and groundwater storage. Natural recharge is also low due to low rainfall.

4.3 The braided bed of the river adjoins the alluvial aquifer and is partially saturated with infiltrated river water and, to a lesser extent, land surface recharge of excess soil water through the valley floor.

4.4 Compared to the large-scale loss of diverted and abstracted water that leaves the Lindis Valley by evapo-transpiration and inter-catchment export, the losses and gains of the river with the alluvial aquifer are small with almost no net effect on river flow until Lindis Crossing.

4.5 As the Lindis Alluvial Fan crosses the older Alberttown outwash surface, river water is lost to the aquifer in a manner that does not see its return before the Clutha Confluence.

5. RIVER – AQUIFER HYDROLOGIC INTERACTIONS

5.1 Interactions between the Lindis River and the associated alluvial aquifer have documented in ORC (2008) and Houlbrooke (2010). These studies concentrated on the river – aquifer interactions downstream of Ardgour Road recorder towards the Clutha confluence.

5.2 More recent published and other undocumented work on Lindis River low flow hydrology (ORC, 2016; Upper Clutha Fisheries Trust, 2014; Cawthron; and Otago University / Fish and Game surveys) have examined river – aquifer interaction more widely along the lower river, primarily downstream of Archies Flat and including recorder sites such as Rutherfords (near The Point), Ardgour Bridge and *ad hoc* gauging points AA – EE in between.

5.3 Turning firstly to the earlier ORC water resources investigations (ORC, 2008; and Houlbrooke, 2010), these studies note the declines in river flow between the Ardgour Road recorder and either Lindis Crossing and/or the Clutha Confluence. The last two recorder sites were temporary sites whereas Ardgour Road recorder is a State off Environment (SOE) permanent site.

5.4 ORC (2008), page 20, first paragraph: *"…it is clear that flows between 0.3 and 0.4 m^3/s (300 to 400 L/s) at Ardgour Road (recorder) are insufficient to maintain surface flows at Lindis Crossing"*.

5.5 The ORC (2008) report contains a time series hydrograph plot of simultaneous river flow at Lindis Peak, Ardgour Road, Lindis Crossing and Clutha Confluence in the 2007 – 08 irrigation season (Figure 5.4). This hydrograph shows while Ardgour Road recorder flows fell to less than 1,600 L/s in the irrigation season, that flow in each site in the lower river (particularly Lindis Crossing and Clutha Confluence) was markedly lower than the site above, implying loss of river flow to the aquifer. As the 2007-08 summer flows declined, flow ceased firstly at Clutha Confluence and then Lindis Crossing, while the river at Ardgour Road maintained a flow of about 250 L/s throughout the period.

5.6 ORC (2008), page 26, first paragraph referring to Figure 5.11. "*…surface flows at Lindis Crossing ceased on 1 January 2008. The low variation of flow loss indicates that there has been a sharp drop in the water table and this section of the Lindis River has become a disconnected losing reach that is decoupled from the underlying aquifer*."

5.7 ORC (2008), page 26, third paragraph referring to discussion above. "*These data indicate that at low stable flows there is a constant loss of approximately 0.44 m^3/s between Ardgour Rd and the Clutha confluence once the river becomes de-coupled from the water table."*

5.8 ORC (2008) also introduced the concepts of gaining, losing coupled and losing decoupled reaches of an alluvial river within the Lindis River context.

The distinctions were based around the relative levels of saturation in river and water table.

5.8.1 A **gaining reach** of river comprises connected surface water and a water table higher than the river channel, so that groundwater converges towards the river channel and the river gains flow.

5.8.2 A **losing, coupled reach** of river comprises connected surface water and a water table beneath the level of water in the river channel, so river water drains into groundwater and the river loses flow.

5.8.3 A **losing, decoupled reach** of river comprises disconnected surface water and a deeper water table separated vertically by an unsaturated zone, so river water drains by unsaturated flow through its bed. The rate of drainage is governed by the wetted perimeter of the river and unsaturated permeability.

5.9 Houlbrooke (2010) indicates that groundwater can augment the river between Ardgour Road recorder and Lindis Crossing when the water table is high following a period of higher river flow or land surface recharge. In November 2007 with river flow at Ardgour Road recorder being above 3000 L/s, there is evidence in hydrograph differentials of Lindis Crossing recorder flow being augmented by groundwater seepage. Even during such high flow episodes the reach between Lindis Crossing and Clutha Confluence continued to lose up to 1000 L/s out of the river to the alluvial aquifer (ORC, 2010, Figure 4.8).

5.10 Houlbrooke (2010) observed during stable, low flow periods that the loss of river flow downstream of Ardgour Road recorder stabilised to approximately 450 L/s.

5.11 However, following river flows falling below critical thresholds and the river downstream of Ardgour Road recorder failing, the water table was observed to drop sharply by up to 2.2 m over the course of 1½ months (ORC, 2010). This is evidence for the mechanism of desaturation and disconnection between river bed and water table.

5.12 ORC (2016) included simultaneous flow gauging at four recorder sites in the Lindis River downstream of Archies Flat; Rutherfords (The Point), Ardgour Road, Lindis Crossing (SH8) and Clutha Confluence. Analysis of simultaneous daily average flow at Ardgour Road and Clutha Confluence recorders revealed that flow at Clutha Confluence tended to zero when flow at Ardgour Road recorder approached 440 L/s (ORC, 2016).

5.13 Further upstream of Ardgour Road recorder, observations and gaugings of the Lindis River indicate that groundwater seepage inflows sustain this reach of the river during low, irrigation season flows. During the same periods the river flow in the vicinity of the Ardgour Bridge (c.f. Ardgour Road recorder) may taper off and cease flowing (see e.g. Clutha Fisheries Trust, 2014).

5.14 ORC (2016) added hydrological data from a new temporary recorder site at The Point, called Rutherfords; and also temperature logging at Ardgour Bridge for the 2014 – 15 irrigation season. These time series record revealed the presence of a losing – gaining sequence in the Lindis River bed between The Point (Rutherfords) and the Ardgour Road recorder site.

5.15 The evidence of Peter Wilson for the Otago Fish and Game Council includes same-day, multiple site river flow gauging between The Point and Ardgour Bridge at five gauging sites along a section of river 1.9 km long on 9 December 2015. River flow at The Point (EE) was measured at 620 L/s. Downstream measured flows registered falls between 125 L/s and 250 L/s. The net loss immediately upstream of Ardgour Bridge (AA) was 125 L/s.

5.16 Cawthron Institute hydrological data provided in the evidence of Rasmus Gabrielsson is consistent with two sets of infiltrating – seeping sequences between The Point and the Clutha Confluence. The Rutherfords (at The Point) and Ardgour Road recorder sites would appear to be located towards the base of seepage-dominant sections of the Lindis River. The river at Ardgour Bridge and immediately upstream of Clutha Confluence appear to be located at the base of infiltration-dominated sections of their respective sequences, but lacking seepage return of flow to the river.

5.17 The distinguishing differences between the Rutherfords – Ardgour Road sequence and the Ardgour Road – Clutha Confluence sequence is that the downstream sequence water infiltrates into an alluvial fan and it terminates the sequence by infiltration. Thus, water does not return to the river downstream of Lindis Crossing once lost.

5.18 In addition to the spatial river water gain and loss sequences, there are elements of temporal gain and loss cycling for the same reaches in response to changes in river flow and water table height in the adjoining alluvial aquifer. Observations and data that characterise the temporal gain and loss cycles have proved much more difficult to obtain since they rely on direct measurements over the full range of river flow, and knowledge of water table fluctuations in the underlying alluvial aquifer.

5.19 ORC has not obtained systematic measurements of the water table variation in the Lindis Alluvial Ribbon Aquifer, except for two sets of shallow bore hydrographs from the Lindis Crossing – Confluence alluvial fan and over the period 22 May 2009 to 20 April 2010 (see Houlbrooke, 2010). Unfortunately, flow measurements were not made at Lindis Crossing or Clutha Confluence over the same period in a manner that would allow for the correlation of river losses with water table height at the same time.

5.20 Nonetheless, my understanding of the river flow and shallow groundwater dynamics of braided rivers would suggest that there are three distinct states of interaction that can apply along the continuum from high flow, high water table condition to low flow, low water table conditions:

5.20.1 During high flow and water table conditions the river is more likely to be gaining with groundwater flow converging towards the river.

5.20.2 During falling river flow and water flow conditions the river is more likely to be losing to groundwater due to the water table having fallen below the river water level, while the river and aquifer remain in saturated connection. The loss of river water will be governed by the hydraulic gradient and saturated permeability of the river bed and aquifer.

5.20.3 During low river flow and water table conditions the river is highly likely to be losing to groundwater, however the water table may have fallen sufficiently for the river bed and water table to disconnect. The loss of river water will be governed by the wetted perimeter of the river and unsaturated permeability of the river bed and aquifer.

5.21 The significance of the state change from saturated to unsaturated sketched out above is that the loss of river water may go through a significant threshold as the river bed disconnects from the water table.

5.22 An occluding factor in estimating total river losses is that losses are most apparent during low river flows.

6. MODELLING OF RIVER – AQUIFER INTERACTION

6.1 Groundwater computer modelling is a useful in evaluating more cryptic hydrological phenomenon such as river – aquifer interaction. The flow interaction processes of braided alluvium have been codified in the groundwater flow computer model MODFLOW (McDonald and Harbaugh, 1988) and associated MODFLOW modules such as RIV (Harbaugh et al, 2000), STR (Prudic, 1989) and SFR (Niswonger and Prudic, 2005).

6.2 Houlbrooke (2010) included reporting on the development of a MODFLOW model of the Tarras – Ardgour Valley – Bendigo groundwater system. This model used standard groundwater modelling practice, but did not include temporal variation. Hence it was a steady state model. The modelling scenarios assessed included evaluating the effect of river flow and aquifer interaction between The Point and Clutha Confluence with the STR module.

6.3 Scenario 4 of the Houlbrooke (2010) report included a sensitivity analysis of Lindis River flows entering the groundwater basin at The Point, flow at Ardgour Road and remaining flow at the Clutha Confluence. Five input flows were applied as sub-scenarios of Scenario 4; 1,000, 800, 500 and 200 L/s at the basin edge.

6.4 Summarising these simulations, approximately 60 L/s of net river flow was lost between The Point and Adrgour Road recorder. Approximately 440 L/s of flow was lost between Ardgour Road recorder and Clutha Confluence. This quantum of river flow loss was consistent with the later flow differential between these two sites in ORC (2016).

6.5 The sub-scenario of 1,000 L/s Lindis River flow at The Point predicted an intermediate flow of 940 L/s at Ardgour Road and a residual flow in the river at Clutha Confluence of 500 L/s (page 32, Figure 5.6, Houlbrooke, 2010).

6.6 As the MODFLOW model scenarios were steady state, no account was made of time variant factors that potentially lead to higher rates of river flow loss at times of rapid flow decline in the lower river.

6.7 Groundwater modelling within scenarios 1, 2, 3, 5 and 6 examine the effect of a range of groundwater management settings within the Lower Tarras and Bendigo aquifers. The difference between scenario 1 (with no groundwater pumping from these aquifers) and scenario 2 (with 2008 groundwater allocation and typical December low flows in the Lindis River) was reported to be a 88 L/s reduction in river flow at Clutha Confluence under the abstractive regime.

6.8 Scenario 3A envisages removing the depletion effect of two large capacity bores within the Lindis Alluvial Fan (well records G41/0316 and G41/0230 with a combined annual allocation of 1.47 million cubic metres) to assess their effect on Lindis River flow. The finding from scenario 3A was these bores would have a steady state depletion effect on the river of 25 L/s.

7. IMPLICATIONS FOR WATER MANAGEMENT IN THE LINDIS RIVER

7.1 The Section 32A report accompanying the proposed plan change outlines four options for river flow management ("management flows" or sometimes termed "minimum flows"). In addition in relation to groundwater management, the Section 32A report outlines two options for groundwater allocation limits and two options for mapping catchment or alluvial ribbon boundaries. All options outlined have some share of effect on the Lindis River within a surface water – groundwater interaction context.

7.2 Option 1 contains no change to the current water management regime and offers no net improvement in the Lindis River hydrological impacts from abstraction to ameliorate effects on the habitat, fisheries, cultural and recreational values outlined in the evidence of Peter Wilson, Morgan Trotter and Rasmus Gabrielsson.

7.3 Option 2 contains a management flow restriction (measured at Ardgour Road recorder) of 450 L/s in the period December to April of any irrigation season. This management flow regime would have little effect on the drying up of the Lindis River between Lindis Crossing (SH8) and the Clutha Confluence during summer low flows, which coincide with the relaxed 450 L/s management flow. Furthermore, there would be little material improvement in recharging the alluvial ribbon aquifer downstream of Lindis Crossing, which would otherwise buffer the effects of losses to the aquifer.

7.4 Option 3 contains a management flow restriction of 750 L/s from October to May in any irrigation season. This management flow regime would trigger curtailment of surface water and connected groundwater abstraction that should have a material effect in restoring flow to the whole river for fish passage in particular. Furthermore, the maintenance of river flow across the length of the Lindis River between Ardgour Road recorder and the Clutha Confluence would increase the length of time that the water table within the alluvial aquifer is recharged, buffering the tendency for decline and disconnection.

7.5 Option 4 contains a management flow restriction of 900 L/s from October to May in any irrigation season. This management flow regime allow for continuous flow in the Lindis River of at least 250 L/s at Clutha

Confluence under most foreseeable climate and groundwater depletion conditions. Optimised recharge of the alluvial aquifer and maintenance of nominal water table height would be a secondary, but important additional benefit of this management flow regime.

7.6 In addition to management flows, options 2, 3 and 4 envisage a reduction in the surface water allocation from the current over-allocated 4,002 L/s to 1,000 L/s. This would have a beneficial effect as the lower allocation limit would be likely to result in an increase in the total volume of water left to pass through the lower Lindis River. I would consider that a cumulative result of the lower allocation limit would be an overall higher alluvial aquifer water table state and longer periods of gaining or connected losing interaction between river and aquifer.

7.7 In terms of plan change options for catchment or alluvial ribbon boundaries, option 2 for the inclusion of the Lindis alluvial fan within the Lindis Alluvial Ribbon would have a beneficial effect on the maintenance of in-stream values for the lower river, particularly in the area of the fan downstream of Lindis Crossing (SH8). By inclusion of the alluvial fan in the alluvial ribbon, groundwater takes established on the fan would likely be governed by the management flow regime and surface water allocation limits set for the Lindis River rather than double-dipping from the groundwater allocation of the Lower Tarras or Bendigo groundwater allocation zones.

7.8 My professional opinion of the options to be adopted for the eventual management of the Lindis River embodies the following mix:

- Option 4 with a management flow of at least 900 L/s between October and May in any year and annual surface water allocation limit of 1,000 L/s, and

- Option 2 for managing groundwater in the Bendigo – Tarras basin, including an allocation limit of 0.19 million cubic metres per annum for the Ardgour Valley aquifer (outside of the Lindis Alluvial Ribbon Aquifer), and

- Option 2 with the inclusion of the Lindis Alluvial Fan to the Lindis Alluvial Ribbon Aquifer.

7.9 Expected outcomes of a combined surface water – groundwater management regime for the Lindis catchment embodied in item 7.8, include the following:

- Improved river flow and continuity within the SH8 – Clutha Confluence and The Point to Ardgour Bridge drying reaches of the lower Lindis River.
- Improved fish passage.
- Improved fish habitat, particularly in the aforementioned drying reaches.
- Improved recreational values (fishing, swimming and passive).
- Improved aquatic ecological conditions for the lower Lindis River.
- Improved cultural values for the Lindis River, including mauri.

7.10 It is my professional opinion that the mix of water management settings in item 7.8 are required for the expected outcomes to be reliably achieved in any hydrological year. A management flow of 750 L/s would potentially achieve connectivity during some years. But the evidence of Morgan Trotter and Rasmus Gabrielsson will show that the maintenance of fish passage and enhancement of the currently heavily degraded fish habitat would not be achieved.

7.11 The proposed management flow regime, whether 450, 750, or 900 L/s is to be tied to measurements of flow made at the Ardgour Road recorder site. This site does not give a realistic representation of the flow rates the lower Lindis River reaches are experiencing due mainly to infiltration and seepage. It is considered that the Ardgour Road recorder site measures some of the highest instantaneous flows of the lower river, especially during low flows and low water table conditions when significant areas of river bed are dry.

7.12 In view of the uncertainty as whether the Ardgour Road recorder flow is reflected in the flow throughout lower river reaches, a degree of precaution or conservativism is advisable in setting the management flow rate at the recorder site for the maintenance of values along the length of the lower river.

This consideration is another factor in me preferring a management flow of at least 900 L/s over the next lower option of 750 L/s.

7.13 I also note that other than setting maximum aquifer allocation limits for the Ardgour Valley, Lower Tarras and Bendigo groundwater allocation zones, the proposed plan change does not include elements of linking water table fluctuation in the Lindis Alluvial Ribbon Aquifer to Lindis River management flows. While the hydrological characterisation and monitoring infrastructure may not have reached the level of facilitating such a linkage, I consider such to be an opportunity for optimising future flow and groundwater management of the Lindis area.

8. SUMMARY & CONCLUSIONS

8.1 It is my opinion that the water management of the Lindis River and associated groundwater management zones would be optimally arranged under option 4 of the proposed plan change s32 report supporting the proposed plan change, comprising a management flow of at least 900 L/s between October and May in any year and annual surface water allocation limit of 1,000 L/s.

8.2 It is my opinion that the Lindis Alluvial Ribbon Aquifer within Schedule 2C of the Regional Plan: Water should be extended to include the Lindis Alluvial Fan as set out in option 2 of the catchment boundary and mapping section of the s32 report.

8.3 It is my opinion that the Ardgour Valley, Lower Tarras and Bendigo groundwater allocation zones should set allocation limits in accordance with option 2 of the s32A report accompanying the proposed plan change.

8.4 These water management settings comprise a water management approach with the best mix of instruments and limits to achieve flows in the lower Lindis River that recognise the accepted values of fish passage, fishery, recreation, cultural and aquatic ecology.

J H REKKER
17 March 2016.

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