**BEFORE COMMISSIONERS ON BEHALF OF ENVIRONMENT SOUTHLAND**

**REF APP-20181750**

| | |
|---|---|
| **UNDER** | the Resource Management Act 1991 |
| **IN THE MATTER OF** | an application for resource consent |
| **BY** | M & C Adams as trustees of the MJ Adams Trust to:<br>- use land for farming;<br>- discharge agricultural effluent to land;<br>- take and use groundwater for dairy shed operations and stock drinking water. |

STATEMENT OF EVIDENCE OF MICHAEL CONRAD FREEMAN

29 April 2019

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# 1. QUALIFICATIONS AND EXPERTISE

1.1 My full name is Michael Conrad Freeman and I am a Senior Scientist/Planner at Landpro Limited, a firm of consulting planners, scientists, surveyors and engineers. I hold the qualification of BSc (Environmental Science, University of Warwick) and PhD (Periphyton and Water Quality, Massey University). I have worked as a research scientist, water quality scientist, regional council director, environmental consultant, Soil and Water Impact Leader, and Commissioner during the past 35 years. I have both the Intermediate and Advanced Sustainable Nutrient Management Certificates from Massey University.

1.2 I also have specific expertise in the use of Overseer Nutrient Budgets (Overseer) in planning and regulatory settings having worked with the Overseer team at AgReseach for 2.5 years. I have co-authored and reviewed various technical papers on Overseer, including a major project that resulted in the publication of the report: "Using Overseer in regulation - Technical resources and guidance for the appropriate and consistent use of Overseer by regional councils."[1]

1.3 I hold professional membership with the Resource Management Law Association (RMLA), and the Environmental Institute of Australia and New Zealand.

1.4 I have been employed by Landpro since January 2018 and have undertaken a wide variety of resource management related work for various clients, including preparing resource consent applications, providing policy and regulatory advice, and consent management services. A significant proportion of my work relates to resource consents relating to dairy farms in Southland. I have prepared a significant number of reports on water quality and related contaminant loss mitigation in Southland.

1.5 I am familiar with these resource consent applications subject to this hearing. I have not yet personally visited the site. However, I have studied a considerable amount of information on the landholding and will visit the site prior to the hearing.

# 2. CODE OF CONDUCT FOR EXPERT WITNESSES

2.1 I have read the Code of Conduct for Expert Witnesses within the Environment Court Consolidated Practice Note 2014 and I agree to comply with that Code. This evidence is within my area of

[1] Freeman, M, Robson, M, Lilburne L, McCallum-Clark, M, Cooke, A, & McNae, D. (2016) Using OVERSEER in regulation - technical resources and guidance for the appropriate and consistent use of OVERSEER by regional councils, August 2016. Report prepared by Freeman Environmental Ltd for the OVERSEER Guidance Project Board.

expertise, except where I state I am relying on what I have been told by another person. To the best of my knowledge I have not omitted to consider any material facts known to me that might alter or detract from the opinions I express. In addition, I go further than this expert witness code of conduct requires in that I make "… clear the sources and extent of uncertainty, including assumptions, and alternative scenarios and data interpretation[2]."

# 3. SCOPE OF EVIDENCE

3.1 My evidence covers the following matters:

- The current state of surface water quality in the general location and downstream of the property.
- Summary of the evidence regarding implementation of good management practices (GMPs) and mitigation beyond GMPs and estimates of contaminant loss to water, and;
- The effects of the proposed changes to land use and management of farm dairy effluent on groundwater quality and surface water quality.

# 4. BACKGROUND

4.1 The detailed background to the application is covered in detail in the original resource consent applications, in the planning evidence of Ms Copeland and in the technical evidence of Ms Hunter. I am familiar with the details of the application and do not repeat that information here.

# 5. Soil and physiographic environment

5.1 The soils and physiographic zones have been described in detail in the main Assessment of Environmental Effects (AEE), the s.42A report, and the planning evidence together with the implications for contaminant loss and are not repeated here.

# 6. Receiving water bodies

6.1 The Adams property is spread across the upper catchment of the Wairio Stream, the Waikoura Stream and the Opio Stream that feed the main Otautau Stream that subsequently feeds into the Aparima River as indicated in the following figure. There is a long-term water quality monitoring

[2] United Kingdom Office of Science and Technology's "Code of Practice for Scientific Advisory Committees, December 2007. Refer: Freeman (2011) The resource consent process: Environmental models and uncertainty, RMLA, August 2011.

site for the Otautau Stream at the Otautau-Tuatapere Road (note Environment Southland's GIS system's labelling of the Waikoura as the Waicola Stream sub-catchment).

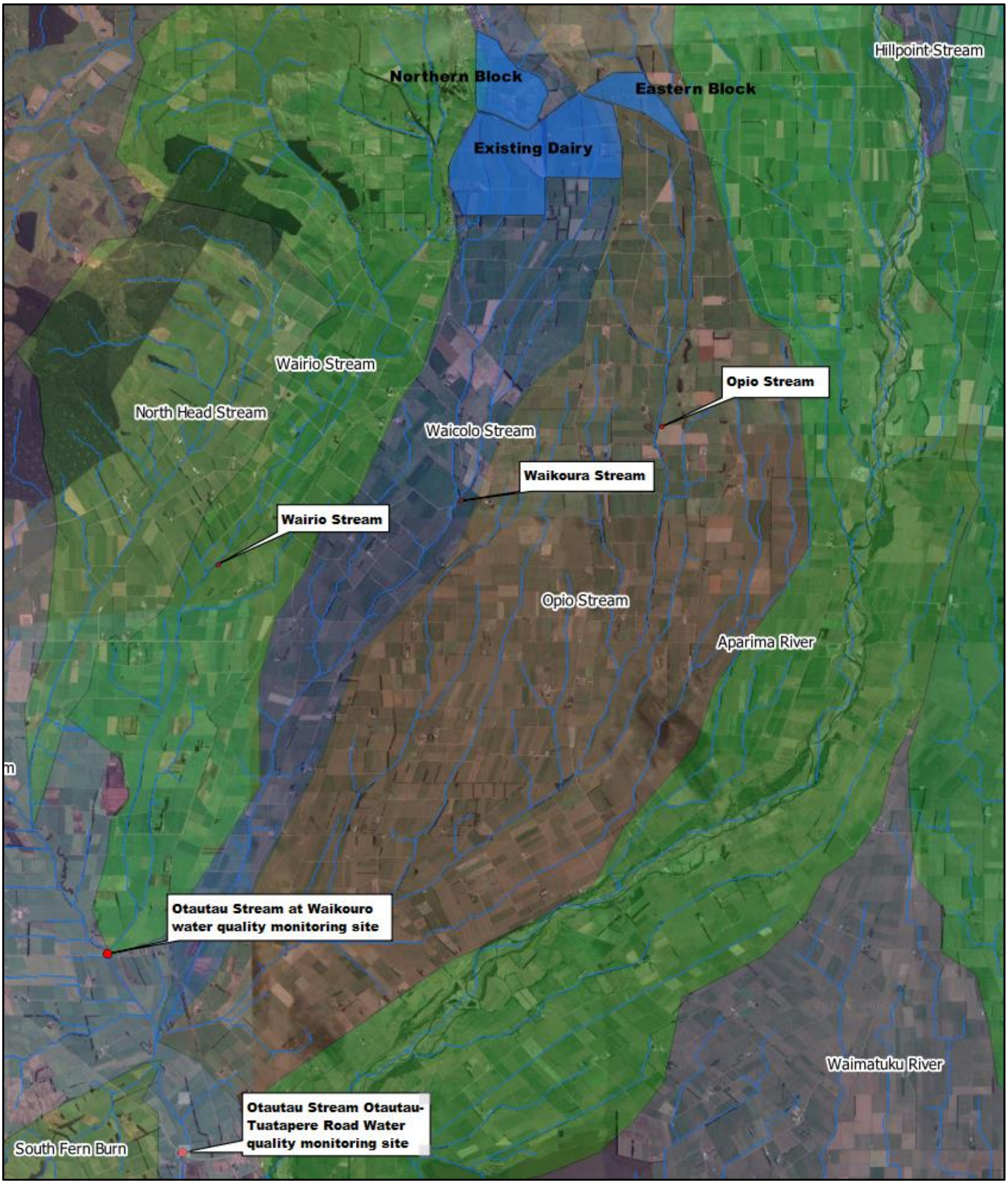


**Figure 1: Location of property and catchment above the Otautau Stream monitoring site, shaded areas showing Environment Southland GIS catchment areas (with labelled Waicola Stream)**

6.2 The land use in the catchment is predominantly sheep and beef, dairying and some grain growing. The soils in the catchment are mainly heavy soils that are not naturally well drained and provide for significant run-off during rainfall events and artificial drainage provides an important transport route. The settlement of Nightcaps and the Takitimu mine are located in the upper catchment. The Nightcaps settlement discharges sewage treated via an oxidation pond and stormwater to the Wairio Stream and the Takitimu mine also discharges treated site water to the Wairio Stream. All of these discharges occur upstream of the Adams property.

6.3 The implications of the soils in the catchment for the loss of contaminants to water are explained in the original AEE, s.42A report and in the planning evidence. Those conclusions also apply generally to the majority of the catchment.

6.4 The Adams property is identified on Beacon (Environment Southland's public GIS system) as spread over the Waicola and Opio stream catchments. However, the labelling of the Waicola appears to be an error because the catchment is for the Waikouro Stream. The topographic map and NIWA/MfE stream flow information also show a small part of the Northern Block in the Wairio catchment. At least one creek from the Eastern Block leaves the 'Waicola' catchment and drains into the Wairio Stream. This is illustrated in Figure 1.

6.5 The minor catchment designation errors in the Environment Southland GIS layers are not critical but given the comments in the s.42A about contaminant loss in the Opio Stream, it is important to have an accurate understanding of drainage direction and catchment boundaries.

6.6 There are two relatively long-term water quality monitoring sites downstream of the Adams property. The Otautau Stream at Waikouro[3] site which is in the Wairio Stream catchment which drains a very small part of the Existing Dairy Block, and the Otautau Stream at the Otautau-Tuatapere Road site which receives the Waikoura and Opio streams and is downstream of the Adams property.

6.7 The Adams property is underlain by groundwater that is part of the Upper Aparima groundwater management zone (as specified in the PSWLP). There does not appear to be any specific technical reports on groundwater hydrogeology in this area. However, information used to inform the PSWLP process (LWP 2017[4]) strongly indicates that the groundwater in this general area is primarily recharged via rainfall and some infiltration of runoff from surrounding hills.

[3] The site is referred to as Waikouro. However, the primary stream that joins the Otautau Stream just downstream of this site is the Waikoura Stream.

[4] Landwaterpeople (2017) Groundwater Provisions of the Proposed Southland Water and Land Plan, Technical Background, Report for Environment Southland

Groundwater discharge is primarily to drains and streams in the area, and the general direction of groundwater flow is southerly.

# 7. Statutory water quality objectives and standards

7.1 The most directly relevant planning documents are the Regional Water Plan for Southland (RWPS) and the Proposed Southland Water and Land Plan (PSWLP). These describe the values, objectives, policies and 'standards' for water in the Southland region.

7.2 Under the RWPS and the PSWLP, surface water bodies on the property and at downstream monitoring sites appear to be classified as lowland hard streams. Table 1 summarises the values associated with this water body type as specified in the RWPS. The PSWLP does not establish values for rivers and streams. However, the relevant regional objectives in the PSWLP are also provided in Table 1.

7.3 The relevant numerical water quality standards and guidelines are included in Section 8 of this evidence along with the results from water quality monitoring.

7.4 The Southland Regional Coastal Plan also contains a diverse suite of objectives and values that apply to the Jacobs River Estuary. Those are not repeated here but it is important to appreciate that there is a relationship between regional plans and the overarching Southland Regional Policy Statement.

**Table 1: Summary of key regional plan surface water values & objectives for water in this location**

| Regional Plan | Classification | Values/objectives specified in the relevant plan |
|---|---|---|
| Southland Regional Water Plan 2010 Objective 3 | Lowland hard bed | - Bathing in those sites where bathing is popular;<br>- Trout where present, otherwise native fish;<br>- Stock drinking water;<br>- Ngāi Tahu cultural values, including mahinga kai;<br>- Natural character including aesthetics. |
| Proposed Southland Water and Land Plan Objectives 3, 6, 7, & 8 | Lowland hard bed | 3 The mauri (inherent health) of waterbodies provide for te hauora o te tangata (health of the people), te hauora o te taiao (health of the environment) and te hauora o te wai (health of the waterbody).<br>6 There is no reduction in the quality of freshwater and water in estuaries and coastal lagoons by,<br>(a) maintaining the quality of water in waterbodies, estuaries and coastal lagoons, where the water quality is not degraded; and<br>(b) improving the quality of water in waterbodies, estuaries and coastal lagoons, that have been degraded by human activities.<br>7 Any further over-allocation of freshwater (water quality and quantity) is avoided and any existing over-allocation is phased out in accordance with freshwater objectives, freshwater quality limits |

| Regional Plan | Classification | Values/objectives specified in the relevant plan |
|---|---|---|
| | | and timeframes established under Freshwater Management Unit processes.<br>8 (a) The quality of groundwater that meets both the Drinking Water Standards for New Zealand 2005 (revised 2008) and any freshwater objectives, including for connected surface waterbodies, established under Freshwater Management Unit processes is maintained; and<br>(b) The quality of groundwater that does not meet Objective 8(a) because of the effects of land use or discharge activities is progressively improved so that:<br>(1) groundwater (excluding aquifers where the ambient water quality is naturally less than the Drinking Water Standards for New Zealand 2005 (revised 2008)) meets the Drinking Water Standards for New Zealand 2005 (revised 2008); and<br>(2) groundwater meets any freshwater objectives and freshwater quality limits established under Freshwater Management Unit processes |

7.5 These values and objectives are relevant reference points here to understand the implications of existing water quality particularly where that quality is not consistent with relevant objective and values specified in relevant regional plans.

7.6 The detailed policy assessment is contained in the AEE and in the planning evidence.

# 8. Existing water quality in the vicinity and downstream of the property

**Surface water quality**

8.1 The following tables and figures provide summary information on the quality of surface water and groundwater in the vicinity of the Adams property. The water quality data has been provided by Environment Southland via the LAWA (Land Air Water Aotearoa) website[5] or more recent data directly. This water quality information is compared to the most relevant guidelines, specifically the National Objective Framework (NOF) attributes (e.g., *E. coli*, clarity (black disc), dissolved reactive phosphorus, ammonia, etc.) contained within the National Policy Statement Freshwater Management (2017)(NPSFM), the PSWLP Appendix E Water Quality 'Standards' (referenced

[5] https://www.lawa.org.nz/

primarily via Policy 16 of the PSWLP), and the Australia New Zealand Environment and Conservation Council (ANZECC) water quality 'trigger values'[6].

8.2 The stream definitions (Lowland Hard Bed) appear[7] to provide direction for both the PSWLP water quality standards and also provide some indication of the likely natural background water quality.

[6] Water quality that exceeds an ANZECC trigger value indicates marginal water quality for supporting ecosystem health. If the median value of a water quality variable for a particular site exceeds the trigger value, then it is intended to 'trigger' an investigation response to identify the cause and significance of the degraded water quality. (Hart, B.T., Maher, B., & Lawrence, I. (1999) New generation water quality guidelines for ecosystem protection. Freshwater biology 41: 347-359).

[7] It is difficult to find an explicit linkage from all the PSWLP Appendix E water quality standards to the maps contained in the separate Maps volume of the PSWLP.

**Table 2: Summary of State and Trend of the Otautau Stream at the Otautau-Tuatapere Road Stream water quality monitoring site, (LAWA/Environment Southland data)**

| **Primary WQ indicators** | **State** | **National Objective Framework (NOF) Band Annual Median (2008 – 2017)**<br>**PSWLP Maximum (2018)** | **Trend identified by LAWA** | **PSWLP water quality standard (Lowland Hard Bed), ANZECC∞ trigger values and comments** |
|---|---|---|---|---|
| *E. Coli* | In the worst 25% of all lowland rural sites | E – For more than 30% of the time, estimated risk is >5% and average infection risk is >7%<br>5-year median = **850 n/100ml**<br>Maximum 2018 = **13,400 cfu/ 100ml** | Likely Improving | ≤1,000/100ml Faecal coliforms#<br>Comment - Highly unlikely to meet standard |
| Clarity (Black Disc) | In the worst 25% of all lowland rural sites | No NOF attribute set<br>5-year median = **0.77 m**<br>Median 2018 **= 0.95** | Not Assessed | ≥ 1.6 m when flow below median flow,<br>Comment - Unlikely to meet standard (flows not recorded at time of sampling) |
| Total Oxidised N | In the worst 50% of all lowland rural sites | B – Some growth effect on up to 5% of species.<br>5-year median = **0.705 g/m$^3$**<br>Maximum 2018 = **4.2 g/m$^3$** | Very likely Improving | ≤0.444 g/m$^3$ (ANZECC, 2000)*<br>Comment - Greater than this trigger value |
| Ammoniacal N | In the worst 25% of all lowland rural sites | A – 99% species protection level. No observed effect on any species tested.<br>5-year median = **0.026 g/m$^3$**<br>Maximum 2018= **0.09 g/m$^3$** | Indeterminate | <2.5-0.9 (pH 6.0-8.0)<br>Comment - Meets standard |
| Dissolved Reactive P | In the worst 25% of all lowland rural sites | No NOF attribute set<br>5-year median = **0.0235 g/m$^3$**<br>Maximum 2018= **0.01 g/m$^3$** | Likely degrading | ≤0.01 g/m$^3$ (ANZECC, 2000)*<br>Comment - Greater than this trigger value |
| Macroinvertebrate Community Index | Fair | LAWA not assessed.<br>Medians 97 – 2018 & 2016 – 2018 = 95 | Not assessed | >90<br>Comment – Likely to meet standard |
| **Appendix E PSWLP Water Quality stds.** | | **Observed WQ range for 2018** | | **PSWLP water quality standard (Lowland Hard Bed)** |
| Temperature | | Not sampled/assessed by ESπ | | ≤23°C |
| pH | | Not sampled/assessed by ESπ | | 6.5 – 9.0 |
| Sediment cover | | Not sampled/assessed by ES | | ≤10% |
| Dissolved oxygen | | Not sampled/assessed by ESπ | | > 80 % sat. |
| Bacterial/fungal slime | | Not sampled/assessed by ES | | Not visible to the naked eye. |
| Filamentous algae | | Not sampled/assessed by ES | | ≤35 g/m$^2$ |
| Fish | | Not sampled/assessed by ES | | Not rendered unsuitable for human consumption |

∞Australian and New Zealand Environment and Conservation Council, 2000, Australian and New Zealand guidelines for fresh and marine water quality.

# PSWLP standard is ≤1,000 faecal coliforms/100 ml. However, *E. coli* is monitored. *E coli* are a subset of faecal coliforms.

* ANZECC trigger values for investigation. These have no legal status in NZ and are included as a reference point only.

π I understand that these variables may have been assessed but were not provided to me as part of the Excel file of water quality data.

**Table 3 Summary of State and Trend of the Otautau Stream at the Waikouro water quality monitoring site (recent data not made available prior to finalisation of evidence)**

| Primary WQ indicators | State | National Objective Framework (NOF) Band Annual Median (2008 – 2017)<br>PSWLP Maximum (2018) | Trend identified by LAWA | PSWLP water quality standard (Lowland Hard Bed), ANZECC[∞] trigger values and comments |
|---|---|---|---|---|
| *E. Coli* | In the worst 25% of all lowland rural sites | E – For more than 30% of the time, estimated risk is >5% and average infection risk is >7%<br>5-year median = **1,300 n/100ml** | Likely Improving | ≤1,000/100ml Faecal coliforms[#]<br>Comment - Unlikely to meet standard |
| Clarity (Black Disc) | In the worst 25% of all lowland rural sites | No NOF attribute set<br>5-year median = **0.71 m** | Not Assessed | ≥ 1.6 m when flow below median flow,<br>Comment - Unlikely to meet standard (flows not measured) |
| Total Oxidised N | In the worst 50% of all lowland rural sites | B – Some growth effect on up to 5% of species.<br>5-year median = **0.79 g/m³** | Very likely Improving | ≤0.444 g/m³ (ANZECC, 2000)*<br>Comment - Greater than this trigger value |
| Ammoniacal N | In the worst 25% of all lowland rural sites | A – 99% species protection level. No observed effect on any species tested.<br>5-year median = **0.0225 g/m³** | Very likely improving | <2.5-0.9 (pH 6.0-8.0)<br>Comment - Meets standard |
| Dissolved Reactive P | In the worst 25% of all lowland rural sites | No NOF attribute set<br>5-year median = **0.021 g/m³** | Likely Improving | ≤0.01 g/m³ (ANZECC, 2000)*<br>Comment - Greater than this trigger value |
| Macroinvertebrate Community Index | Good | Good<br>5-year median = 100 | Not assessed | >90<br>Comment - Meets standard |
| **Appendix E PSWLP Water Quality stds.** | | **Observed WQ range for 2018** | | **PSWLP water quality standard (Lowland Hard Bed)** |
| Temperature | | Not sampled/assessed by ES [π] | | ≤23°C |
| pH | | Not sampled/assessed by ES [π] | | 6.5 – 9.0 |
| Sediment cover | | Not sampled/assessed by ES | | ≤10% |
| Dissolved oxygen | | Not sampled/assessed by ES [π] | | > 80 % sat. |
| Bacterial/fungal slime | | Not sampled/assessed by ES | | Not visible to the naked eye. |
| Filamentous algae | | Not sampled/assessed by ES | | ≤35 g/m2 |
| Fish | | Not sampled/assessed by ES | | Not rendered unsuitable for human consumption |

[∞]Australian and New Zealand Environment and Conservation Council, 2000, Australian and New Zealand guidelines for fresh and marine water quality.

[#] PSWLP standard is ≤1,000 faecal coliforms/100 ml. However, *E. coli* is monitored. *E coli* are a subset of faecal coliforms.

* ANZECC trigger values for investigation. These have no legal status in NZ and are included as a reference point only.

[π] I understand that these variables may have been assessed but were not provided to me as part of the Excel file of water quality data.

8.3 These data indicate that water quality in the Otautau Stream is degraded and does not meet all the relevant numerical standards or guidelines. It is not possible to provide a comprehensive interpretation of water quality in the context of the PSWLP water quality standards because not all the water quality standards are monitored and determining compliance with the water clarity standard requires concurrent flow gauging. There is a permanent stream flow monitoring site at the Otautau-Tuatapere Road site but not at the Waikouro site. My understanding is that flow measurements have not been recorded at the time that water clarity measurements were taken, and I have not attempted to develop a synthetic suite of data to estimate flows at the time of sampling. In addition, there are notes that accompany the sampling results that state that clarity measurements have not been taken at high flows.

8.4 A brief memorandum dated 16 April 2019 provided by Environment Southland has assessed water quality in this general location. That memo refers to water quality data that has not been made available to me and also assesses compliance with PSWLP water quality standards in terms of five-year median values. I have compared water quality with these standards on the basis of simple maximum because those standards are specified as maximum values not medians.

8.5 The three most significant water quality related issues in Otautau Stream from an assessment of these data appear to be:

1. High concentrations of faecal indicator microorganisms;
2. Raised nutrient concentrations leading to plant growth in the stream and further downstream; and
3. Apparent relatively poor water clarity.

8.6 The LAWA water quality monitoring information only goes up to December 2017 (as at mid-April 2019). Additional information was provided separately from Environment Southland for the Otautau-Tuatapere Road site in an Excel file. A comprehensive statistical comparison of this dataset with the LAWA statistical summaries has not been undertaken. However, more recent data has been compiled and presented along with the older data dataset.

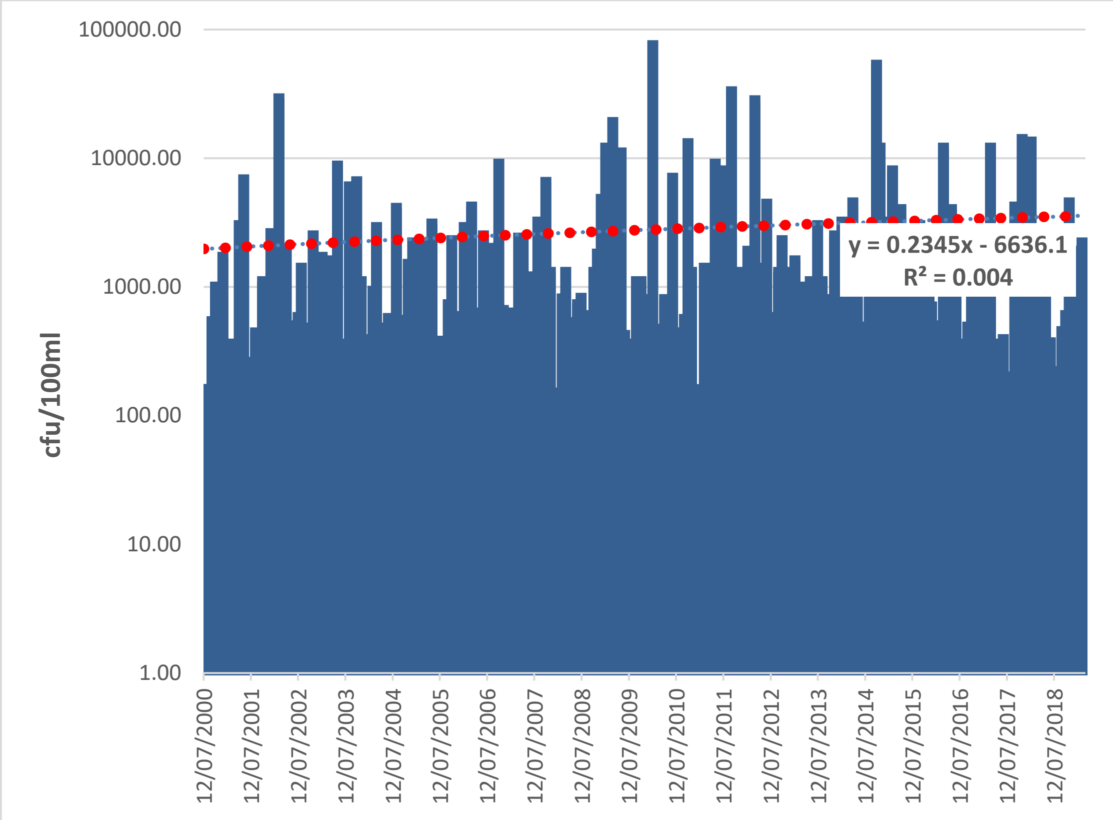


**Figure 2: *E coli* results (2000 – 2018) for the Otautau Stream at the Otautau-Tuatapere Road monitoring site (logarithmic scale)**

8.7 The relatively frequent high concentrations of faecal indicator microorganisms mean that this location would generally not be suitable for swimming or other similar water contact recreation (i.e., LAWA explanation is that this means that "for more than 30% of the time, estimated risk is >5% and average infection risk is >7%") and would also generally have implications for microbiological quality further downstream. My understanding is that the relatively small streams in this catchment are not generally used for contact recreation.

8.8 While the long-term trend line indicates a possible very small long-term increase in *E. coli* concentrations the $R^2$ value of 0.004 means that there is little confidence that this indicates a real trend. The short-term trend data (LAWA assessment) indicate that microbiological quality is improving. The data indicates that the PSWLP water quality standard of ≤1,000 faecal coliform bacteria[8] per 100 ml is unlikely to be met.

[8] *E. coli* are a subset of faecal coliforms and were historically used as the primary microbiological water quality standard. *E coli* have replaced faecal coliform bacteria as the most commonly used indicator, and are specified in the NPSFM NOF.

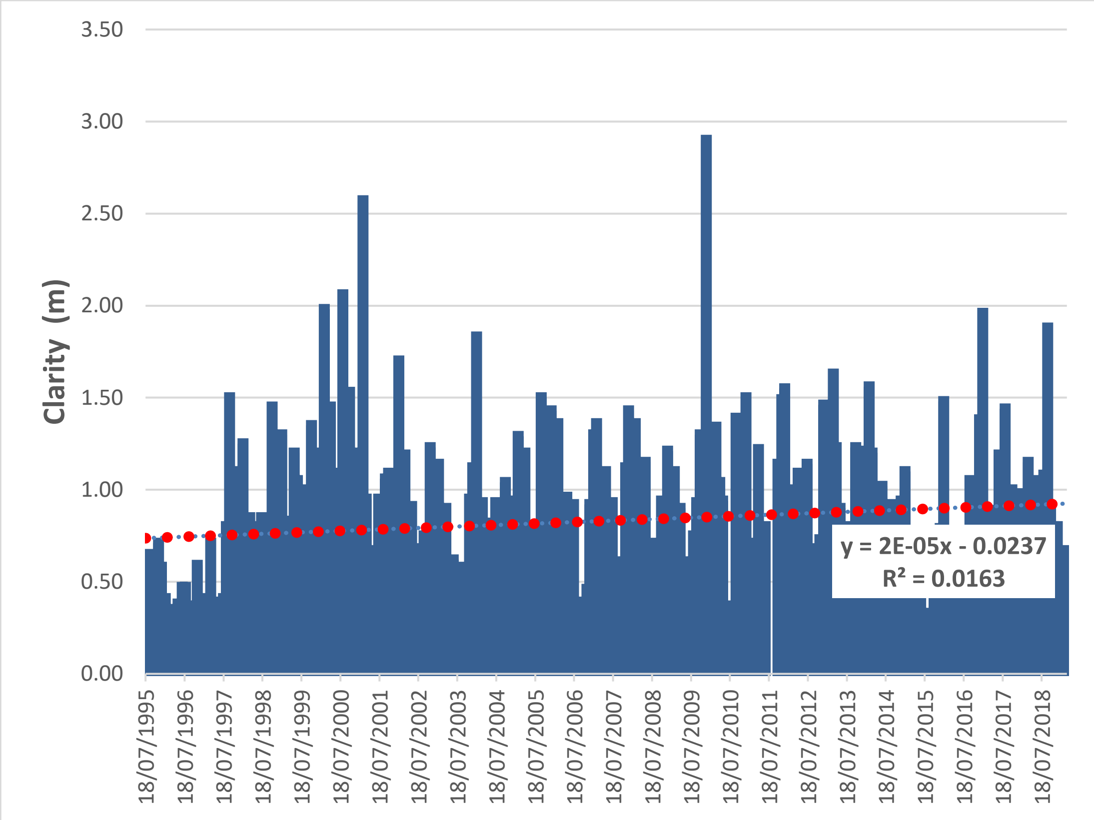


**Figure 3: Clarity (Black Disc) results (1995 – 2018) for the Otautau Stream at the Otautau-Tuatapere Road monitoring site**

8.9 The long-term clarity results appear to indicate a very small increase but the $R^2$ value of 0.0163 indicates that there is little confidence that that reflects a real trend. However, while stream flow data has not been recorded at the time of clarity measurements, the data does tend to indicate that the PSWLP water quality standard of ≥1.6 m at flows less than the median flow, is unlikely to be met.

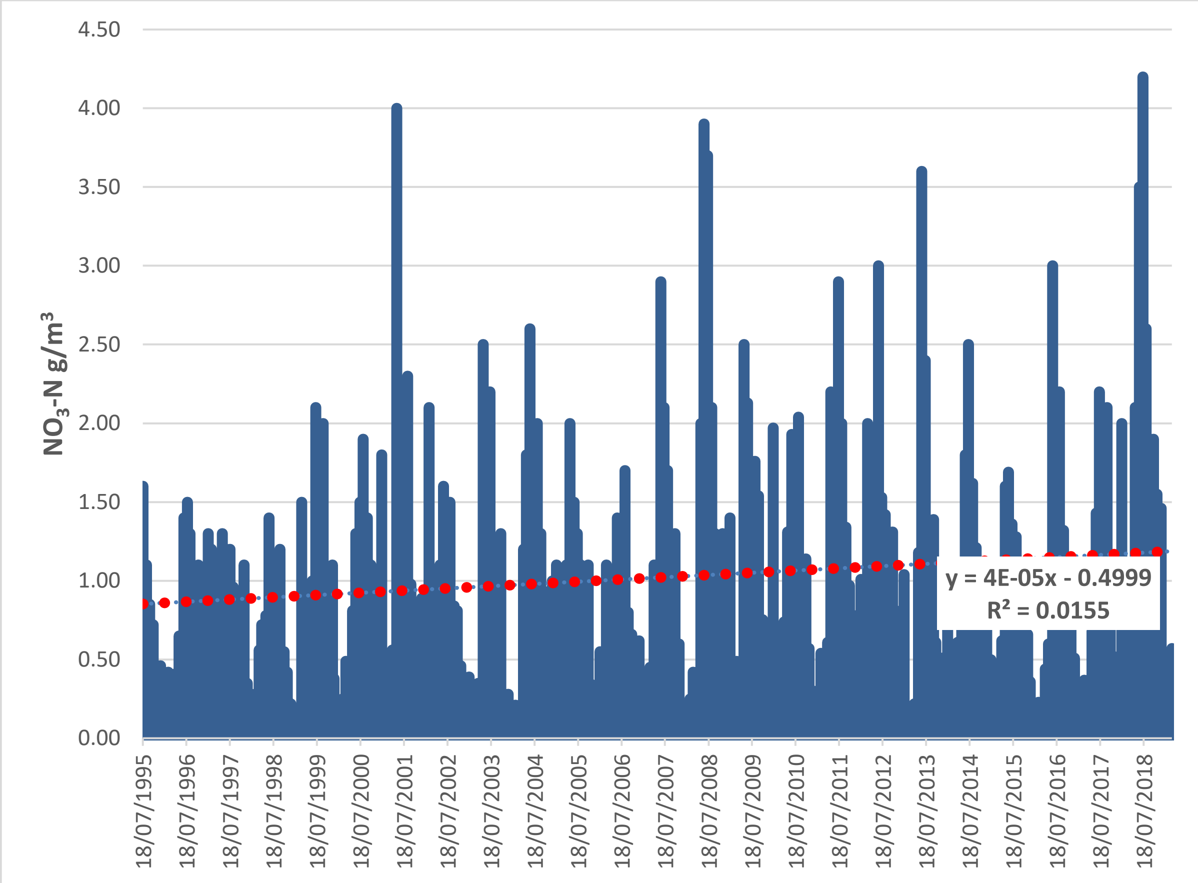


**Figure 4: Nitrate nitrogen results (1995 – 2018) for the Otautau Stream at the Otautau-Tuatapere Road monitoring site**

8.10 While nitrate nitrogen concentrations in the Otautau Stream have been rated as 'B' under the NOF attribute, this value has been set on the basis of nitrate toxicity rather than for nitrogen (N) as a nutrient. In the context of nitrate N as a nutrient both it and dissolved reactive phosphorus concentrations are elevated (using ANZECC trigger values as a guide. See tables 2 & 3). This has the potential to accelerate the growth of macrophytes, periphyton and, lower down in the catchment, in the Jacobs River Estuary, phytoplankton and macroalgae.

8.11 The LAWA data summarised in Table 2 is reported with a five-year trend of "very likely" decreasing concentrations of dissolved inorganic nitrogen. However, the most recent data with a peak of 4.2 g $NO_3$-N/$m^3$ indicates that that conclusion may not be appropriate now.

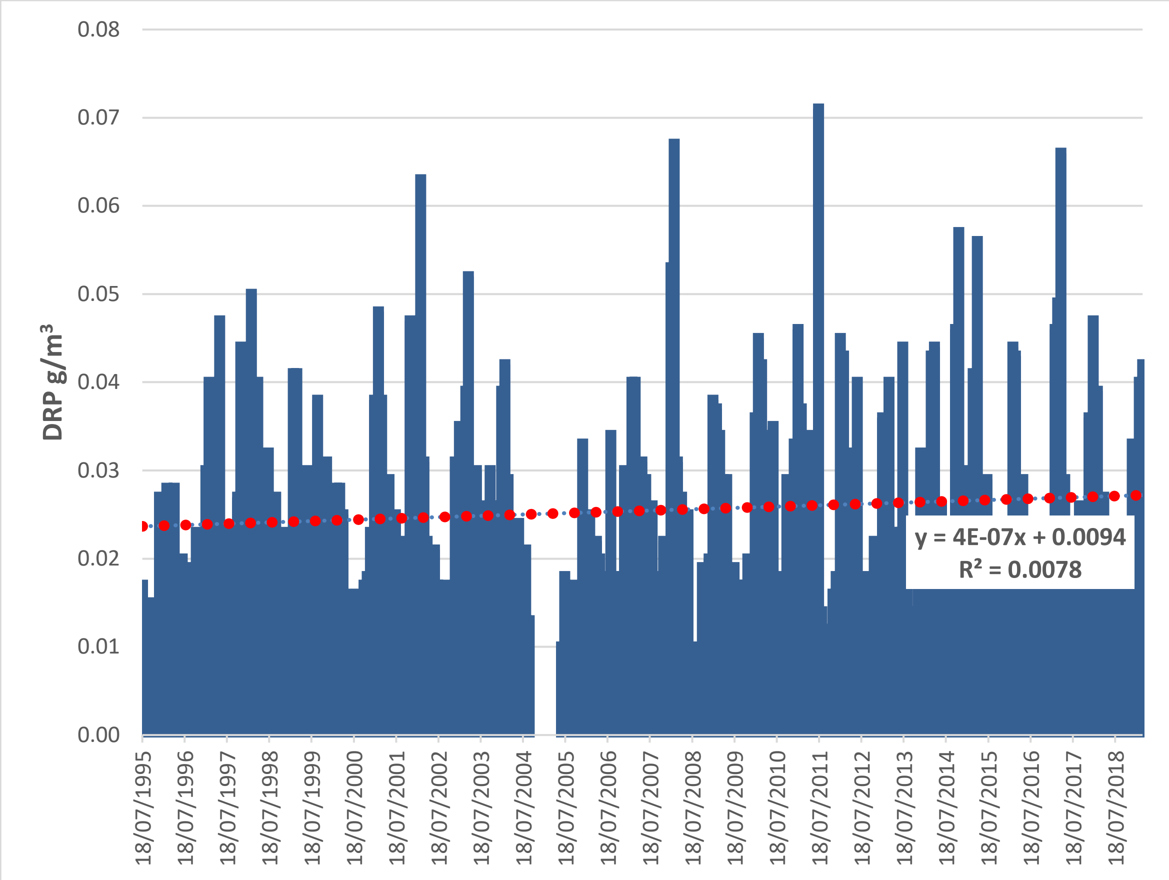


**Figure 5: Dissolved reactive phosphorus results (1995 – 2018) for the Otautau Stream at the Otautau-Tuatapere Road monitoring site**

8.12 The results of monitoring of dissolved reactive phosphorus (DRP) are similar to the nitrate nitrogen results in that the concentrations are generally above the ANZECC trigger value with a long-term trend line with a very low $R^2$ value indicating that we can't make any robust conclusions about trends over time. The LAWA short-term trend reported for the data up to the end of 2017 was a trend of "likely degrading". However, more recent data may result in this being updated.

**Periphyton**

8.13 It has not been possible to provide a definitive assessment of the status of periphyton in the Otautau Stream because at the time of preparing this report, I am waiting for Environment Southland to provide periphyton data from the Otautau Stream Otautau-Tuatapere Road monitoring site. I may be able to provide an addendum to this report if information on periphyton is provided. In the interim, results of annual and 'monthly' periphyton sampling have been provided for the Aparima River at the Thornbury Site, downstream of the confluence with the Otautau Stream. These results are summarised in the following two figures.

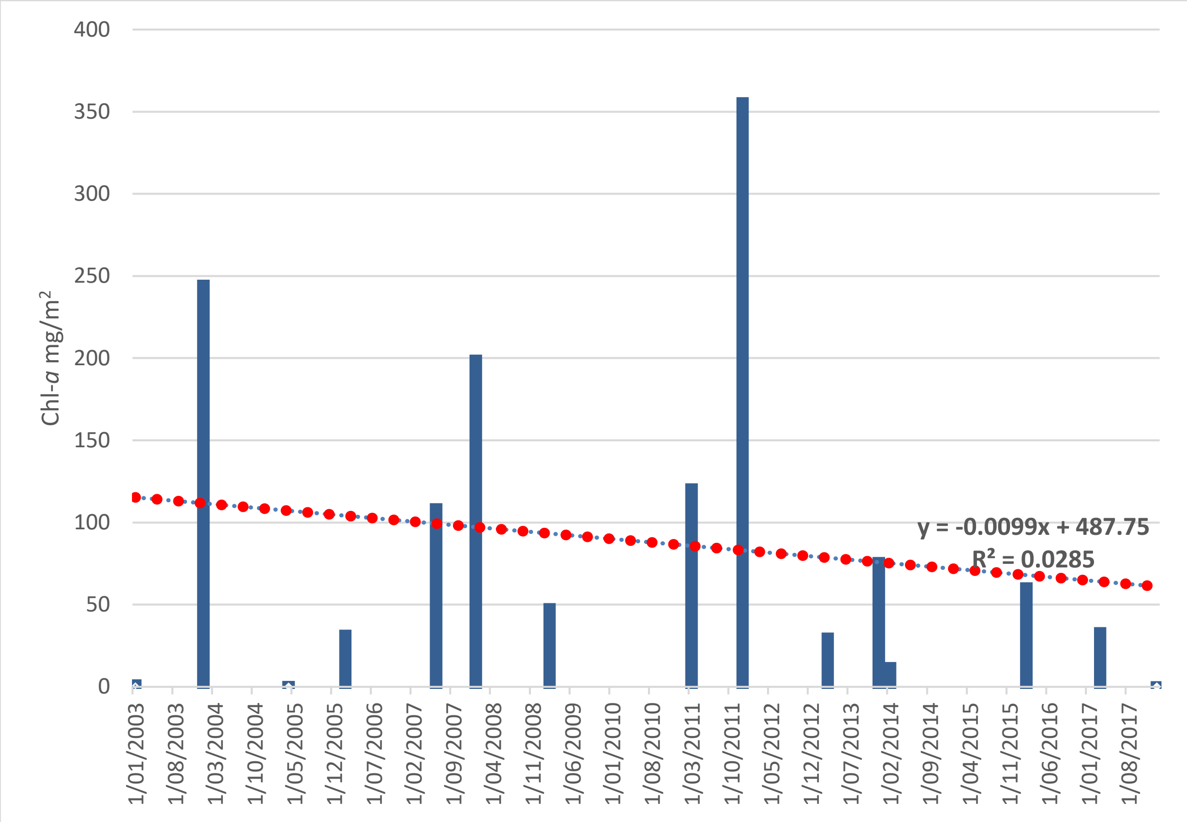


**Figure 6: Annual sampling results of periphyton chlorophyll-a at the Thornbury site in the Aparima River, 2004 - 2018.**

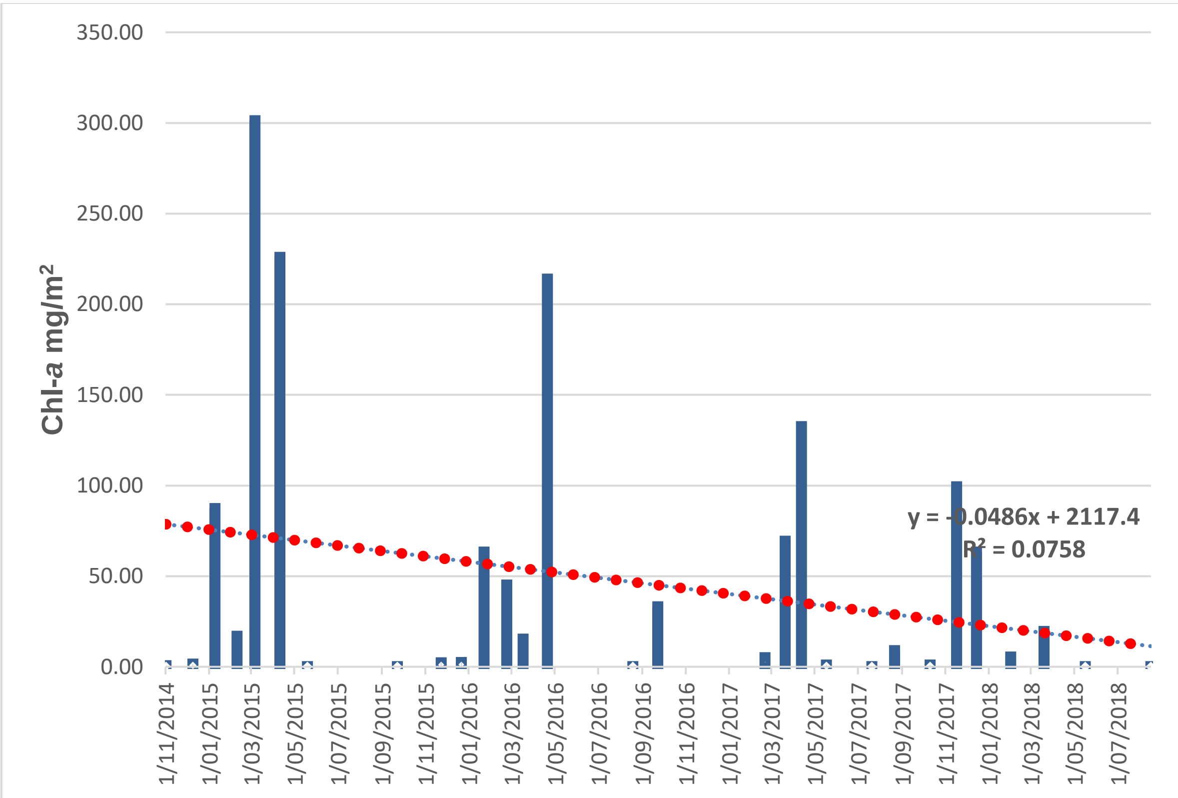


**Figure 7: Summer monthly sampling results of periphyton chlorophyll-a at the Thornbury site in the Aparima River, 2014 - 2018.**

8.14 It is challenging to interpret periphyton data in terms of the NPSFM NOF attribute because of the methodology (including sampling frequency required) used in the NPSFM to define attribute state and the sampling frequency adopted by Environment Southland. The NPSFM indicates that monthly sampling for a minimum of three years is needed. However, Environment Southland have generally sampled approximately seven to nine times per year (Figure 7). Environment Southland also have an annual periphyton sampling programme with those results summarised in Figure 6.

8.15 The NPSFM requires that the River Environment Classification (REC) be used to distinguish between a "Productive" and "Default" category. In this situation the Otautau Stream is defined as "Default" (Geology is "AL" or Alluvium). Similarly, the Aparima River at the Thornbury site has a REC geology class of "HS" or Hard Sedimentary Rock. This means that the State is defined in terms of a "Default" (rather than "Productive") category using a percentile assuming monthly sampling for a minimum of three years. Using the available data for the past three full years, that does not conform with this requirement, indicates a 92%ile of 104 mg chl-*a*/$m^2$ or an Attribute State of "B". I emphasise that this calculation has been done to give an indication of the extent of periphyton coverage and is not intended to be a proper assessment against the NPSFM periphyton attributes.

8.16 The long-term trends shown in figures 6 and 7 indicate a decline in the extent of periphyton chlorophyll coverage. However, the $R^2$ values for both sets of data is very low indicating that this may not reflect a real trend.

**Conclusions on current Otautau Stream water quality**

8.17 The available data indicate that streams in this area have raised concentrations of faecal indicator bacteria, reduced clarity and raised concentrations of dissolved N and P, and are likely to not comply with some PSWLP water quality standards, specifically the faecal coliform and water clarity standards. The primary cause of reduced water quality is most likely agricultural land use with minor contributions from other sources e.g., Nightcaps treated sewage and stormwater, septic tank effluent discharges, and roading run-off.

8.18 The Environment Southland memo referred to earlier concluded the following "*In contrast, majority of the water quality parameters measured from the Otautau tributary sites have failed to meet the pSWLP and ANZECC guidelines, which reflects deteriorating environmental conditions in* *the Otautau Stream. Overall, the observed high levels of nutrients and filamentous algae (> 2 cm) in both waterbodies and high levels of faecal coliform in the Otatau [sic] are a strong indication of nutrient and animal waste contamination of those monitoring sites*."

8.19 I agree that the water quality in the streams in the vicinity of the property do not comply with all relevant water quality guidelines/standards. However, I have some reservations about the Environment Southland staff conclusions about "deteriorating environmental conditions" and "animal waste contamination of those monitoring sites". No data is provided in the memo to explain the basis for the latter two conclusions or what time scale is being applied. However, I do acknowledge the difficulties in obtaining statistically meaningful conclusions about trends, and that the concentrations of key contaminants are almost certainly greater than they were 35 years ago prior to the significant expansion of dairying in Southland[9].

8.20 The long-term water quality monitoring data indicate that agricultural land use activities in the catchment are having adverse effects on water quality and that long-term catchment-scale mitigation of a broad range of land uses and discharges is needed to reduce the concentrations of contaminants in surface waters to levels consistent with national and regional statutory standards and relevant guidelines.

**Groundwater Quality**

8.21 The results of Environment Southland's survey of regional nitrate nitrogen concentrations are provided as a layer within the Beacon public GIS system (Figure 8) and indicates that the property is in an area where the underlying unconfined groundwater was likely to have been primarily between 0.4 – 1.0 mg/l of nitrate nitrogen between 2007 – 2012, or indicative of "modern day background". However, the amount of information that supports this contour map may not always be sufficient to justify making significant conclusions about the differences in groundwater quality in different locations.

[9] Hamil K & McBride K (2003) River water quality trends and increased dairying in Southland, New Zealand, New Zealand Journal of Marine and Freshwater Research, 2003, Vol. 37: 323-332.

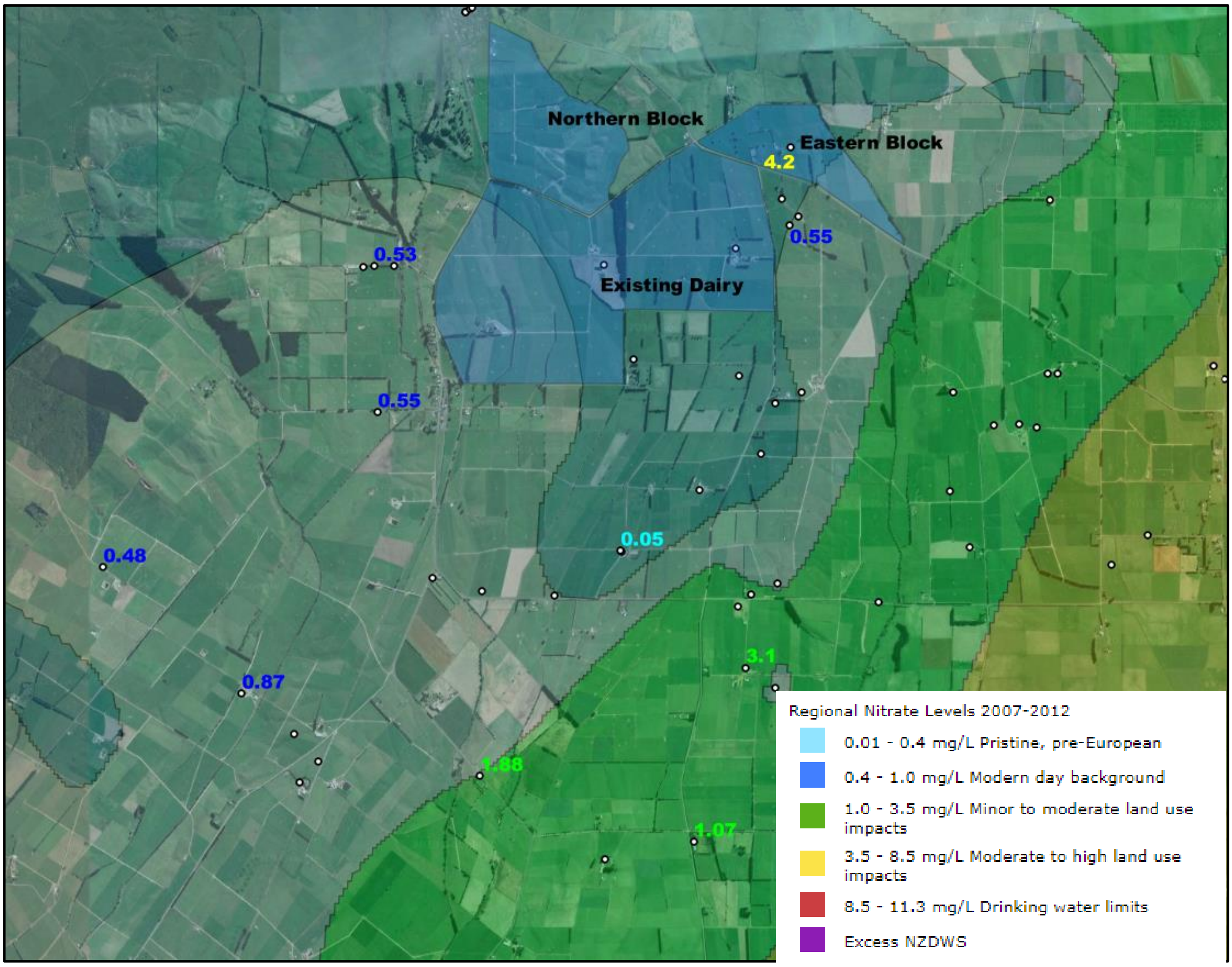


**Figure 8: Environment Southland groundwater nitrate nitrogen contour estimates for the period 2007 – 2012 with location of property overlaid, and more recent peak nitrate nitrogen results**

8.22 Interpretation of the contour data should be done with great care because there are a limited number of results that have been used as the basis for developing these groundwater quality contours, and the source data includes results from a very wide range of bores. Some of these bores are relatively shallow (<10 m depth) and may represent a significant proportion of drainage water quality rather than being representative of unconfined saturated groundwater in the area (majority of water supply bores in the area are between 5 – 50 m depth). It is also not clear what extent of wellhead protection exists for these bores, so for example, it is possible that some of these bores do not have adequate well head protection and some surface water with contaminants can move down the bore casing. In addition, there is some indication from the reported measurements of water levels that some bores in this area may be tapping a lower confined or semi-confined aquifer that may be separated in part from the overlying unconfined groundwater.

8.23 Some more recent groundwater quality data has been obtained from Environment Southland and while very little recent groundwater nitrate nitrogen data is available for this specific area, what is available indicates that the general pattern of nitrate nitrogen concentrations in the area hasn't changed significantly from the situation illustrated in the contours in Figure 8 (2007-2012). The highest nitrate nitrogen results for groundwater samples taken from each bore post 2012 is indicated for the area. One result for the bore on the Eastern Block (4.2 g $NO_3$-N/$m^3$) indicated an increase compared to the 2007-2012 survey period. However, given the limitations outlined above it would be inappropriate to compare one result with the 2007-2012 contour. For example, a sample from the same bore in 1998 had a nitrate nitrogen result of 6.3 g $NO_3$-N/$m^3$.

8.24 In addition to the data interpretation issues identified above, neither the contour diagram nor the compilation of more recent groundwater quality data in Figure 8 indicate what trends if any exist in the area. There are only two bores in the general area that have had nitrate nitrogen monitored over a significant period of time, D45/0004 (2000 – 2018, reported 12 m deep, no information on screen depth) and D45/0186 (2009 – 2018, reported 16.5 m deep, no information on screen depth), both relatively close and down-gradient from the property. Nitrate nitrogen concentrations of groundwater from these bores is illustrated in the following figures.

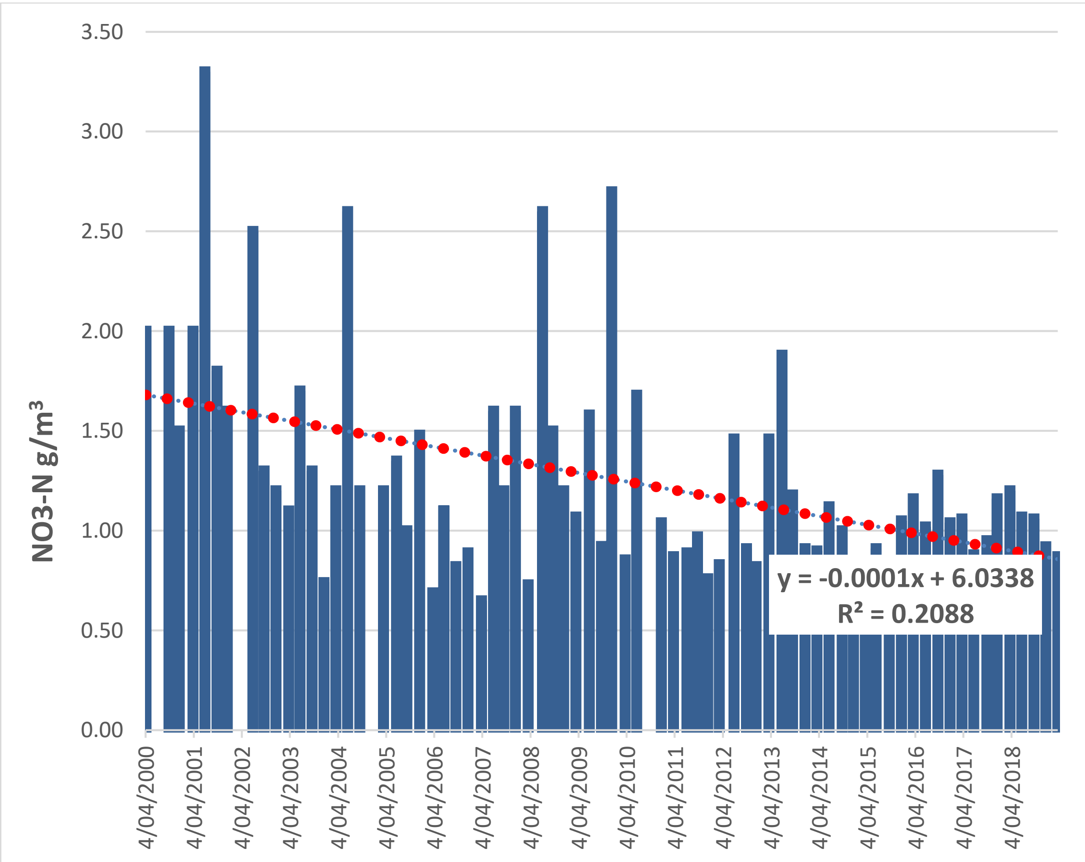


**Figure 9: Nitrate nitrogen concentrations in groundwater from bore D45/0004, 2000-2018 (showing as a green '1.88' south of the property on Figure 6)**

8.25 The results from this bore (D45/0004) indicate a long-term trend of reducing nitrate nitrogen in groundwater. The $R^2$ value of 0.2088, while still relatively low, does indicate the possibility that this reflects a real long-term trend. The fact that this trend does not appear to be reflected in local streams may highlight the complex relationship between groundwater and local and more distant surface water bodies, e.g., this groundwater may be recharging surface water more distant down-gradient or alternatively artificial drainage may be removing some shallower groundwater with higher nitrate nitrogen concentrations. However, the more recent years do tend to indicate a flattening out of this apparent trend.

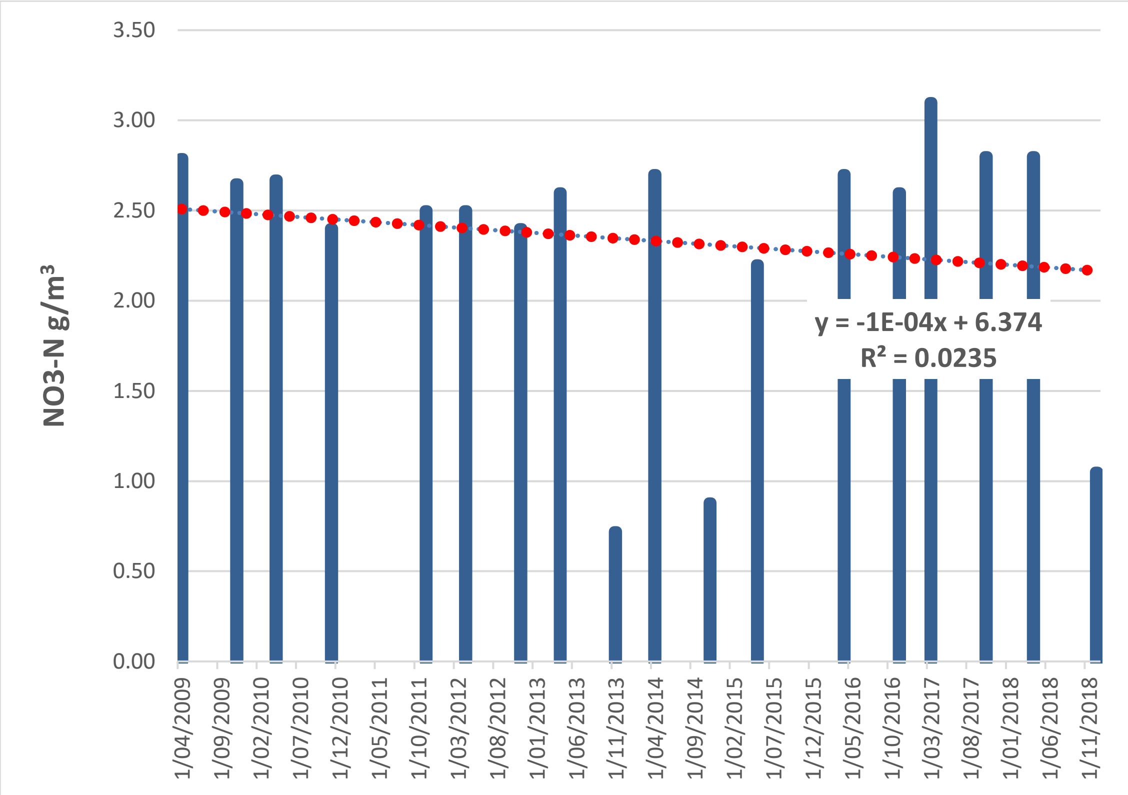


**Figure 10: Nitrate nitrogen concentrations in groundwater from bore D45/0186, 2009-2018 (showing as a green '3.1' south of the property on Figure 6)**

8.26 The long-term data from bore D45.0186 indicate no trend in groundwater nitrate nitrogen concentrations. However, there does appear to be two distinct sets of results – perhaps low nitrate nitrogen at around 1 g $NO_3$-N/m$^3$ and higher nitrate nitrogen at around 2.5 g $NO_3$-N/m$^{3.}$ This may reflect the timing of sampling in terms of peaks and troughs in soil nitrate nitrogen and the timing of drainage.

8.27 In general, the groundwater quality data reflects the predominant rural land use in the catchment contributing to nitrate nitrogen leaching through to groundwater. The key issue is the discharge of groundwater with elevated nitrate nitrogen concentrations to surface waters rather than as a significant issue for the use of groundwater as a source of drinking water (drinking water nitrate nitrogen standard (maximum acceptable value) is 11.3 g/m$^3$), i.e., the contribution of nitrogen to surface waters contributes to plant growth in streams, and the subsequent rivers, and at the bottom of the catchment in the Jacobs River Estuary.

**Jacobs River Estuary water quality**

8.28 The key water quality issue in the Jacobs River Estuary are eutrophication and sedimentation that appears to be driven by N, P and sediment loads to the estuary from the main surface water inputs. Nutrients enter the estuary primarily via the major source of the Aparima River, to a lesser extent the Pourakino River and a number of relatively small creeks. Broad scale mapping has been undertaken by Wriggle Coastal Management from 2003 to 2018[10]. These studies have highlighted a trend from 2003 to 2018 of increased eutrophication with increased coverage by opportunistic macroalgae, combined with soft, poorly oxygenated mud, and decreasing seagrass and saltmarsh. The estuary is currently defined as in a "Poor" condition overall in relation to eutrophication and muddiness, and "Moderate" in relation to habitat loss. Table 4 below summarises the eutrophic status of the Jacobs River Estuary.

**Table 4: Primary and supporting indicator values used to calculate an Estuary Trophic Index score for the Jacobs River Estuary, February 2018[11]**

| PRIMARY SYMPTOM INDICATORS FOR SHALLOW INTERTIDAL DOMINATED ESTUARIES (AT LEAST 1 PRIMARY SYMPTOM INDICATOR REQUIRED) | | | | Primary Symptom Value | Primary Symptom Score |
|---|---|---|---|---|---|
| Required | Opportunistic Macroalgae | OMBT EQR | shallow intertidal | 0.245 | 13 |
| Required | Macroalgal GEZ % | % Gross Eutrophic Zone (GEZ)/Estuary Area | shallow intertidal | 30 | 14 |
| Required | Macroalgal GEZ Ha | Ha Gross Eutrophic Zone (GEZ) | shallow intertidal | 144 | 15 |
| Optional | Phytoplankton biomass | Chl- a (summer 90 pctl, $mg/m^3$) | water column | - | |
| Optional | Cyanobacteria (if issue identified) NOTE ETI rating not yet developed | | water column | - | |
| **SUPPORTING INDICATORS FOR SHALLOW INTERTIDAL DOMINATED ESTUARIES (MUST INCLUDE A MINIMUM OF 1 REQUIRED INDICATOR)** | | | | **Supporting Indicator Value** | **Supporting Indicator Score** |
| Required Indicators | Sediment Oxygenation | Mean Redox Potential (mV) at 1cm depth in most impacted sediments and representing at least 10% of estuary area | shallow intertidal | -317 | 14 |
| Required Indicators | Sediment Oxygenation | % of estuary with Redox Potential <-150mV at 3cm or aRPD <1cm | shallow intertidal | 29 | 14 |
| Required Indicators | Sediment Oxygenation | Ha of estuary with Redox Potential <-150mV at 3cm or aRPD <1cm | shallow intertidal | 143.5 | 15 |
| Required Indicators | Sediment Total Organic Carbon | Mean TOC (%) measured at 0-2cm depth in most impacted sediments and representing at least 10% of estuary area | shallow intertidal | 1.3 | 10 |
| Required Indicators | Sediment Total Nitrogen | Mean TN (mg/kg) measured at 0-2cm depth in most impacted sediments and representing at least 10% of estuary area | shallow intertidal | 1333 | 10 |
| Required Indicators | Macroinvertebrates | Mean AMBI score measured at 0-15cm depth in most impacted sediments and representing at least 10% of estuary area | shallow intertidal | 4.74 | 14 |
| Optional Indicators | Muddy sediment | Proportion of estuary area with >25% mud content | shallow intertidal | 28 | 16 |
| Optional Indicators | Sedimentation Rate | Ratio of mean annual Current State Sediment Load (CSSL) relative to mean annual Natural State (NSSL) | shallow intertidal | - | |
| Optional Indicators | Dissolved oxygen | 1 day instantaneous minimum of water column measured from representative areas of estuary water column (including likely worst case conditions) ($mg.m^3$) | water column | - | |
| NZ ETI Score | | **Final Primary Indicator Score** | | | 15.0 |
| | | **Final Supporting Indicator Score** | | | 13.3 |
| | | | **ETI SCORE** | **0.88** | |
| | | | **ETI BAND** | **POOR** | |

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[10] Stevens, L.M. 2018. Jacobs River Estuary: Broad Scale Habitat mapping 2018. Report prepared by Wriggle Coastal Management for Environment Southland.

8.29 Nutrient loads to the Jacobs River Estuary have been estimated by Aqualinc[12]. These are outlined in the following table.

**Table 5: Summary of estimated N and P loads to eight Southland catchments**

| Catchment | Current catchment agricultural source loads (t/year) | | Total catchment source nitrogen load (t/yr) | Estimated realised nitrogen loads (t/yr) | Estimated attenuation (%) |
|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | | | |
| Bluff_Harbour | 19 | 1 | 36 | 29 | 20 |
| Haldane_Estuary | 23 | 0 | 39 | 26 | 33 |
| Jacobs_River_Estuary | 1958 | 53 | 2133 | 1300 | 39 |
| Lake_Brunton | 20 | 0 | 20 | 14 | 30 |
| New_River_Estuary | 4969 | 139 | 5513 | 3718 | 33 |
| Toetoes_Harbour | 6256 | 142 | 6617 | 4392 | 34 |
| Waiau_River | 2714 | 35 | 4970 | 1864 | 62 |
| Waikawa_Harbour | 144 | 4 | 176 | 180 | -2 |
| Total/average | 16,102 | 374 | 19, 404 | 11,524 | 31 (average) |

8.30 The Aqualinc report further identified the potential nutrient load reductions that could result from various levels of mitigation. These are summarised in the following two tables.

**Table 6 Estimated reductions in the agricultural source loads under three levels of mitigation for all dairy farms in each Southland catchment**

| Catchment | M1 | | | M2 | | | M3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | Overall[1] | N | P | Overall[1] | N | P | Overall[1] |
| Bluff_Harbour | 4 | 26 | 2 | 4 | 29 | 2 | 12 | 29 | 6 |
| Haldane_Estuary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jacobs_River_Estuary | 6 | 28 | 5 | 8 | 31 | 6 | 18 | 31 | 15 |
| Lake_Brunton | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New_River_Estuary | 6 | 29 | 5 | 8 | 32 | 7 | 18 | 32 | 15 |
| Toetoes_Harbour | 3 | 17 | 3 | 4 | 19 | 4 | 10 | 18 | 9 |
| Waiau_River | 1 | 9 | 0 | 1 | 9 | 1 | 4 | 9 | 2 |
| Waikawa_Harbour | 1 | 4 | 1 | 1 | 5 | 1 | 2 | 5 | 2 |

8.31 The full suite of mitigations assessed by Aqualinc includes the following measures.

[12] Aqualinc, Assessment of farm mitigation options and land use change on catchment nutrient contamination loads in the Southland region, 2014

**Table 7:Description of mitigations assumed to apply under each mitigation level**

| Mitigation level | Name | Sheep & Beef | Dairy |
|---|---|---|---|
| Mitigation level 1 | M1 | • Optimised nutrient inputs<br>• Low solubility P<br>• Wetlands | • Stock exclusion from streams<br>• Improved nutrient management<br>• Improved farm dairy effluent (FDE) management |
| Mitigation level 2 | M2 | • Stock exclusion from streams<br>• Reduced stocking rates, improved productivity | • Wetlands<br>• Improved FDE management<br>• Reduced stocking rates, improved per animal productivity. |
| Mitigation level 3 | M3 | • Grass buffer strips<br>• Feed pad for beef cattle | • Restricted grazing strategies<br>• Grass buffer strips<br>• Improved FDE management |

8.32 The proposal provides for all the relevant mitigation measures suggested by the Aqualinc report, with the exception of wetlands. It has not been possible to determine exactly what stocking rate was envisaged in the Aqualinc report or the NZIER report that it was partly based. However, the proposed stocking rate of 2.4 cows/ha is reduced from the original stocking rate of 3.0 cows/ha and appears likely to line up with what was anticipated in the Aqualinc/NZIER reports.

# 9. Implications of water quality for targeting of mitigation

9.1 The water quality results indicate that priorities for contaminant loss mitigation should be faecal indicator organisms, sediment, N, and P. This is largely reflected in the assessment of the physiographic zones (see main AEE) that indicate risks from both artificial drainage and surface runoff because of the generally heavy soils in both areas.

9.2 The primary contribution to the observed water quality issues presented earlier in this report will be from land use activities further upstream in the catchment, with only a relatively tiny contribution from the individual property.

# 10. Contaminant loss mitigation proposals, modelling and water quality

**Existing and proposed good management practices and mitigation**

10.1 The AEE, the Farm Environmental Management Plan (FEMP) and the evidence of Ms Hunter detail the existing good management practices (GMPs) that are currently being implemented on the property and the additional mitigation practices that will be implemented to mitigate nutrient losses over the entire property including the Eastern Block. The following assessments build on those assessments, particularly the estimates of contaminant losses to water to estimate the effects on water quality.

**Overseer and uncertainty**

10.2 The s.42A report raises a significant number of concerns about the use of Overseer as a tool to assist in understanding the potential changes in farm systems on estimates of N and P losses to water. Among other statements, the s.42A report states "*As Overseer uses annual averages, it also does not account for climate variation such as overly wet, or in contrast overly dry, years. Overseer provides an overarching view at block (and farm) scale, and does not account for the variation of landscape, soil and topography types within that block (and/or farm). This simplifies the complex processes that can be occurring within this block. The applicants' site has several soil types, and physiographic zones with different variants which may not be accurately accounted for on a wider scale. Uncertainty within the model itself is also unavoidable. On average, this uncertainty for nutrient losses can equate to up to 30% over and above what is calculated*".

10.3 The s.42A report also includes some statements from, and references to, the recent Parliamentary Commissioner for the Environment report on the use of Overseer[13](PCE report on Overseer). The s.42A report did not acknowledge the full range of conclusions of that report. These are repeated in full in Appendix 1 to this report to ensure that all the conclusions of that report are available. A more complete summary of the PCE report on Overseer, is contained in the key Chapter 5 of the report.

> "It appears from this investigation that most, if not all, of the regional councils currently using Overseer for determining compliance with nitrogen limits do so in this context – i.e. the

[13]Overseer and regulatory oversight; Models, uncertainty and cleaning up our waterways, Parliamentary Commissioner for the Environment (December 2018)

severity of the nitrogen problem they face has led them to Overseer. Council staff acknowledge the tool is far from perfect, but blunter tools would be required if Overseer was not available.

This investigation has identified some important gaps and shortcomings in transparency, peer review, corroboration, uncertainty and sensitivity analyses, and the way the model has been documented. If Overseer is to continue to be used in a regulatory setting, these shortcomings need to be speedily addressed to provide confidence to the regulators and regulated alike. This is essential to building trust in its application and in the nutrient limits that are being set.

It should also be recalled that Overseer assumes good management practices are occurring on farms. To be able to have confidence in a regulatory framework using Overseer-derived nitrogen loss limits, regional councils must be satisfied that these practices are occurring. Regional councils therefore would do well to spend effort monitoring farms for compliance with these practices alongside any Overseer-based framework."

10.4 These considerations are taken into account in the assessment of the proposal, the role that Overseer has in this application and the proposed conditions, as set out in the planning evidence of Ms Copeland The Overseer estimates and effects on water quality have all been undertaken in the light of the inherent uncertainties involved in the application of Overseer.

**Overseer modelling and water quality effects**

10.5 The evidence prepared by Ms Hunter details the Overseer and other modelling undertaken to estimate the N and P loss to water associated with the proposed development. The following two tables provides a summary of current and estimated N and P losses to water.

**Table 8a and 8b Summary of the N and P loss estimates for the current and proposed dairy farm**

| | Current Total Farm System | Proposed Total Farm system | Reduction |
|---|---|---|---|
| N (kg/yr) | 24,684 | 22,870 | -1,814 |
| P (kg/yr) | 560 | 528 | -32 |

| | Current Eastern Block | Proposed Eastern Block | Reduction/increase |
|---|---|---|---|
| N (kg/yr) | 1,395 | 1,361 | -34 |
| P (kg/yr) | 36 | 36 | +1 |

10.6 A critical consideration in the context of the application of Overseer under the PSWLP policy framework is that Overseer is not being used to assess compliance with a catchment-based N loss property target. Overseer is being used to establish a comparative baseline for one farm system. Many of the concerns about uncertainties involved in Overseer estimates are focused particularly on the former situation, not this situation. Where the reference point is one existing property, particularly one that is located in a situation that is similar to those used to calibrate key components (or sub-models) of Overseer, the uncertainties are significantly reduced[14]. Indeed, comparisons of modelled and measured nitrate losses for dairy farms in Southland found[15]:

- *"Given the inherent uncertainty associated with measuring and modelling N leaching, there was good agreement between Overseer estimates and measured values reported for 3 key experimental sites in Southland.*
- *Estimates of drainage volumes, based on annual rainfall inputs to the model also agreed reasonably well with those derived from a daily soil water balance model.*
- *The agreement between measured and modelled values indicates that the Overseer model is performing well for this combination of soil-climate-management factors."*

10.7 This investigation was done with Overseer version 6.1 in 2013 prior to a major change to the hydrological model that would likely have significantly improved drainage estimates.

10.8 Therefore, given that the Overseer N and P loss estimates are being used to compare losses for one property on a relative and not absolute basis, there will be a very low level of uncertainty about the extent to which estimated reductions or increases reflect real reductions or increases.

10.9 The s.42A report specifically identifies effects on water quality on the Opio Stream as the reason why the reporting officer recommends that the application be declined. The s.42A report states (page 14): "*In my view the environmental effects arising from this change will be more than minor effect when compared to the effects of the current land use. The application does not assess what these effects are likely to be in detail, especially at block detail. The application does not provide adequate measures to avoid, remedy or mitigate these effects, rather the application relies on 'offsetting' these effects over the entire landholding*." Later in the s.42A report (page 34): "*I also consider the application to be contrary to Section 7(f), as the assessment of effects concludes that*

[14] Shepherd M *et al* (2013) Overseer: accuracy, precision, error and uncertainty, FLRC workshop proceedings
[15] Smith, C & Monaghan R (2013) Comparing OVERSEER estimates of N leaching from grazed winter forage crops with results from Southland trial sites, Report for Environment Southland, RE500/2013/123

*the proposed activities, especially when cumulative is likely to result in adverse effects on water quality*."

10.10 Further significant mitigation has been proposed since the s.42A report was written and the predicted change to P losses to the Opio Stream is now an increase of 1 kg/yr. It is still possible that there may still be concerns about the modelling undertaken and the inherent uncertainties involved in modelling nutrient losses to water. Therefore, this section examines the effects on water quality in more detail in conjunction with taking account of modelling uncertainty.

10.11 All modelling of long-term annual average estimates of N and P loss to water involve uncertainties, i.e., limitations in parts of the modelling process that is a result of incomplete knowledge. Uncertainty is the most relevant term to use for annual average estimates of N and P loss from a whole farm system[16]. However, the uncertainties involved in Overseer modelling are not currently able to be quantified. They are probably greater than 30% for both N and P modelling[17].

10.12 There are two significant implications of this:

- The estimated differences between the current and proposed farm system nutrient loss estimates is significantly less than the likely uncertainties involved in Overseer modelling.
- Overseer modelling should be considered in conjunction with the specific farm systems and mitigation measures that are proposed, to provide a reasonable level of certainty about the relativities of nutrient loss estimates.

10.13 This means that while there may be a relatively high level of uncertainty about nutrient loss estimates, if there are clear, measurable and verifiable changes to one farm system there will be a high level of certainty about the relative changes to long-tern annual average nutrient loss estimates[18]. Therefore, provided that there is assurance that the farm system changes have occurred there will be a high level of certainty there will be relative reduction in long-term annual average N and P losses to water.

10.14 It is difficult of course to model the resultant changes in water quality that would result from decreased or increased nutrient losses to water. However, given the concerns outlined in the

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[16] Shepherd M *et al* (2013) Overseer: accuracy, precision, error and uncertainty, FLRC workshop proceedings
[17] Wheeler D & Shepherd M (2013) Overseer: Answers to commonly asked questions, RE500/2012/027
[18] Freeman, M, Robson, M, Lilburne L, McCallum-Clark, M, Cooke, A, & McNae, D. (2016) Using OVERSEER in regulation - technical resources and guidance for the appropriate and consistent use of OVERSEER by regional councils, August 2016. Report prepared by Freeman Environmental Ltd for the OVERSEER Guidance Project Board.

s.42A report an effort has been made to assess potential adverse effects in the Opio Stream, the Otautau Stream and at a catchment scale, the Jacobs River Estuary. The approach taken is crude but in this context is considered an appropriate endeavour.

**Water quality effects on the Opio Stream**

10.15 The Overseer and additional modelling detailed in Ms Hunter's evidence estimates the increase in P loss to be approximately 1 kg P/yr. If it is assumed that there is an unreasonably high level of uncertainty about this figure and it is actually three times larger and results in one year increasing by 3 kg P. And it is further assumed that all this P is discharged over the approximately 12 high flow ($FRE_3$[19]) events that occur in the Opio Stream and each discharge is spread over a six hour period and the flows in the stream are up at twice the flow rate, 660 L/s, of the average estimated flow (NIWA River Maps modelling[20]) of approximately 330 L/s. If it is assumed that the Opio Stream has an average DRP concentration of approximately 0.03 $g/m^3$ (based on the long-term average for the Otautau Stream at the Otautau-Tuatapere Road site). The 250g of P would result in 0.0116 g/s being discharged into the Opio Stream which (without any increase in flow) would increase the concentration for a six-hour period up from 0.030 to 0.048 $g/m^3$ for 12 times per year. While this is a theoretical increase the biological significance of this level of increase over the length of the approximate 17 km of Opio Stream also needs to be considered. In reality, the discharges would be happening when many other more significant discharges of run-off are happening from farms, and or other land uses with significantly fewer mitigation measures in place. I consider that in the context of other discharges that would be occurring in the Opio Stream the biological effects would be insignificant.

10.16 Conversely, the nutrient loss modelling for the Eastern Block estimates that N losses would decrease by 34 kg/yr. The effects of reducing N losses needs to be assessed differently from P because N will be primarily lost to groundwater and enter the Opio Stream more slowly. The majority of N loss will occur during significant drainage events but the movement of groundwater and artificial drainage to streams will occur over relatively long periods of time. Therefore, for the purpose of estimating effects it is probably reasonable and conservative to average this out over a 12-month period. This will almost certainly under-estimate the potential benefits from reducing N loss. Averaging 34 kg N over a whole year results in approximately 0.0011 g/s and taking a

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[19] FRE3 = the number of events on average that flows that exceed three times the median flow.
https://shiny.niwa.co.nz/nzrivermaps/

[20] https://shiny.niwa.co.nz/nzrivermaps/

similar approach to the P calculations if this was discharged into the stream at the long-term average flow of 0.33 m/s this would result in a reduction of approximately 0.0033 g/m$^3$.

10.17 If it is assumed that the long-term mean nitrate N concentration in the Opio Stream is similar to that for the Otautau Stream, which is 1.06 g/m$^3$. This reduction could potentially reduce the nitrate N concentrations from 1.06 to 1.05 g/m$^3$. This would not be measurable and would not be of any biological significance in isolation. However, it does indicate what could be achieved at a catchment scale.

**Water quality effects on the Otautau Stream**

10.18 Taking a similar approach to the Otautau Stream the modelling indicates an overall reduction of 1,814 kg N/yr and a reduction of 32 kg P/yr. If a common simplistic approach is taken and reductions are applied evenly throughout the year and the measured, rather than modelled, mean flow is used for the Otautau Stream at the Otautau-Tuatapere Road monitoring site of 4.305 m$^3$/s. The results are illustrated in the following table.

**Table 9 Summary of a simplistic assessment of effects of N and P loss reductions on the nitrate nitrogen and dissolved reactive P**

| | Reduction (kg/yr) | Reduction (g/s) | Reduced concentration in 4.305 (m$^3$/s) | Long-term average (g/m$^3$) | Resultant improved long-term average |
|---|---|---|---|---|---|
| N | 1,814 | 0.0575 | 0.0130 | 1.06 | 1.05 |
| P | 32 | 0.0010 | 0.0002 | 0.03 | Not measurable |

10.19 This assessment is very simplistic and makes a number of significant assumptions including that all the N loss reduction occurs as nitrate N and similarly assumes that all the P loss reduction occurs as dissolved reactivepPhosphorus (DRP). However, this assessment does serve to provide a crude indication that the reductions could result in a theoretically measurable reduction in nitrate N concentrations but not a measurable reduction in DRP concentrations.

**Water quality effects on the Jacobs River Estuary**

10.20 As a proportion of the estimated catchment loads for the Jacobs River Estuary, the overall loads from this property are understandably relatively very small. On a modelled catchment source load basis, using the 2014 Aqualinc data (which is highly likely to need updating) the overall current loads would amount to currently approximately 24.6/1,958 or 1.2% (N) and 0.56/53 or 1.0% (P) of the modelled catchment loads. These figures should be treated with great caution because the catchment load estimates look low based on current dairy farm nutrient loss estimates.

10.21 This calculation is useful to get a rough appreciation of the potential scale of the overall current contributions to N and P catchment loads. However, it can't be used in any meaningful way to estimate contributions to concentrations to the Jacobs River Estuary because of the complex hydrogeological, physical, chemical and biological processes that operate in the contributing catchments.

10.22 The data does highlight the potential importance of targeted catchment wide implementation of contaminant loss measures to address water quality issues. Specifically, it indicates the potential catchment nutrient load reductions that are achievable. For example, if 100 similar dairy farms in the Jacobs River Estuary catchment made similar reductions in N loss this could amount to a catchment reduction of 100 x 1.8 tonnes = 1,800 tonnes/yr. However, the scale of this potential reduction does indicate that the Aqualinc figures may significantly underestimate catchment source loads.

# 11. Estimates of faecal indicator organisms and sediment losses before and after development

11.1 It is very difficult to develop quantitative estimates of the loss of faecal indicator organisms or sediment loss. There are no equivalent readily available farm-scale models that can be used. Some sediment loss models such as SedNetNZ, NZeem and HEL have been tested and applied in New Zealand[21]. However, none are currently widely used in RMA planning or regulatory processes. One common current approach[22] is to use Overseer modelled P loss as a surrogate for both. This is because a key component of Overseer P loss modelling is based on an assessment of soil loss which will include faecal indicator organisms as well as sediment. Therefore, a combination of the Overseer modelled P loss indicating an overall small reduction in P loss and the good management practices and additional mitigation being and proposed to be implemented and outlined in the AEE, provide a clear indication that there is highly likely to be similar small

[21] Palmer D, Dymond J & Basher L (2013) Assessing erosion in the Waipa catchment using the New Zealand Empirical Erosion Model (NZeem®), Highly Erodible Land (HEL), and SedNetNZ models David Palmer, John Dymond, and Les Basher, Landcare Research Report LCR1685.

[22] It was accepted at a 2018 ES consultant meeting that phosphorus loss modelling can be used as an approximate proxy for sediment and microbiological contaminant losses.

reductions in both sediment and faecal indicator loss to water as a consequence of the proposed development.

11.2 Although Overseer phosphorus loss modelling can be used as an approximate proxy for sediment and microbiological loss to water, Overseer does not currently model many of the possible farm management techniques that can be employed to manage P loss partly because the model is not spatially explicit.

11.3 Ms Hunter's evidence summarises the proposed good management practices and additional mitigations which will result in less phosphorus, and generally less sediment and microbiological contaminant loss to water. Therefore, there is a very high level of certainty that there will be very small improvements in sediment and microbiological water quality. However, these changes are unlikely to be measurable unless they are accompanied by similar catchment wide mitigation measures.

# 12. Water quality issues raised by submitters

12.1 The specific issues raised by submitters that relate to water quality are summarised in the following table together with specific responses.

**Table 10 Summary of specific issues/concerns relating to water quality raised by submitters and responses**

| Submitter & issue or concern raised | Response |
|---|---|
| **Lawrence J Cameron (opposed)** | |
| Concerned that there are too many cows in Southland | The number of cows is not the primary driver of water quality effects. The effects of increased cow numbers can be controlled with appropriate land use management practices and effluent management.<br>The proposed application includes a comprehensive suite of management proposals and consent conditions. |
| **Public Health South (neutral)** | |
| Concerned about the proposed increase in cow numbers and potential adverse effects given the existing degraded surface water quality. The following specific concerns are raised:<br>a) Eutrophication of the Jacobs River Estuary<br>b) Increase microbiological contamination of water<br>c) Antibiotic drug resistance<br>d) Risks to water quality from overland flow or artificial drainage<br>e) Water quality risks associated with intensive winter grazing<br>f) Eastern block nutrient losses<br>g) Overseer uncertainty | a) The proposed mitigation will result in a significant reduction in N and P loads to the Otautau Stream catchment and if similar reductions are applied across the Jacobs River catchment there will be a reduction in eutrophication of the Jacobs River Estuary.<br>b) Loss of microorganisms of sanitary significance will be reduced as a consequence of the proposed mitigation.<br>c) Antibiotic drug resistance is beyond the scope of this evidence. MPI is the primary agency responsible for setting controls on the use of antibiotics and antimicrobial compounds.<br>Concerns (d)-(h) have been addressed in other parts of this evidence.<br>i) I am not aware of ozone being used to treat farm dairy effluent discharges in New Zealand. The primary |

| Submitter & issue or concern raised | Response |
|---|---|
| h) If consent is granted wants to see specific conditions to address concerns<br>i) Ozone treatment of effluent<br>j) Compliance monitoring bores<br>k) FEMP conditions including hard stand, cut and carry, not discharging effluent when soils saturated or cracked. | methods used to treat farm dairy effluent in New Zealand are a combination of secondary treatment and deferred land application when there is an appropriate soil moisture deficit.<br>j) Compliance monitoring bores are not supported. Unless large arrays of up-gradient and down-gradient bores are installed, the results from a small number of such bores can be misleading. More meaningful information on groundwater quality can be obtained by the regional council developing a large number of long-term appropriately sited groundwater monitoring bores.<br>k) The proposed conditions will ensure that the predicted mitigation of contaminant loss will occur and there will be a very small improvement in water quality in the Otautau Stream. |
| **Te Ao Marama (Te Rūnanga o Ōraka Aparima) (Opposed)** | |
| Concerned about the current state of water quality in Southland.<br>Wants to avoid the risk of further water quality deterioration and adverse effects on Ngai Tahu values and cultural wellbeing. | The proposed mitigation measures and conditions will ensure that the proposal will not cause any deterioration of water quality. Instead it will make a very small contribution to improving water quality. |

# 13. Conclusions on the effects of the proposal on water quality

**Local and cumulative surface water quality**

13.1 The information outlined in this evidence on the existing quality of surface water downstream of this property combined with the estimates of the current and likely futures losses of sediment, faecal indicator organisms, N and P from the proposed property development provide strong evidence for a real but very small overall improvement in the quality of the Otautau Stream and Waikoura Stream. It is estimated that there will be a negligible increase in P loading to the Opio Stream. However, this would not result in any adverse effects.

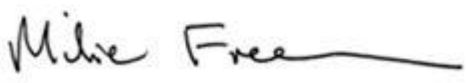
13.2 The improvements in water quality are unlikely to be measurable with the current Environment Southland surface water quality monitoring programmes. However, if other properties in the wider catchment implemented equivalent good management practices/mitigation measures there would be significant and measurable improvements particularly for the water quality variables that currently do not comply with the relevant standards or guidelines. The nature of some water quality issues such as deposition of sediment in slow flowing reaches (which may take many years to move downstream) means that some water quality improvements would take a long time to be realised.

**Local and cumulative groundwater quality**

13.3 The information from the Overseer and additional modelling combined with the specific good management practices/mitigation measures provide strong evidence for a real but small reduction in the N loading to groundwater and associated artificial drainage. If this occurs across enough properties in the wider area there will be an improvement in both the underlying groundwater nitrate N concentrations and the concentrations in drainage water discharging to streams. Because of the complexity of groundwater systems including the inherent heterogeneity of alluvial aquifers, and travel times for drainage water and groundwater it may be many years before reductions in N concentrations are observed in bores used to monitor groundwater quality and in surface water recharged by that groundwater/drainage water.

**Jacobs River Estuary quality**

13.4 The key water quality issues in the Jacobs River Estuary appear to be sediment and nutrient loading. Contaminant losses from this property will be making an almost negligible contribution to these loadings. The good management practices/additional mitigation measures that would be implemented will reduce this contribution by relatively small amounts. By itself this would be insignificant but combined with similar initiatives across the whole Jacobs River Estuary catchment would result in significant reductions in the nutrient and sediment loadings to the estuary which has the potential to contribute to a significant improvement to the significant eutrophication issues in the estuary.



Mike Freeman, BSc, PhD
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Landpro Limited
29 April 2019

## Appendix 1 A full listing of the conclusions of the Parliamentary Commissioner for the Environment report "Overseer and regulatory oversight; Models, uncertainty and cleaning up our waterways", (December 2018)

"Overseer provides farmers with valuable information in making judgments about farm management. This is the purpose for which it was initially designed, and for which it has been managed and resourced. But using Overseer's output is also useful to regional councils who are required, under the National Policy Statement for Freshwater Management, to do something about farm nutrient losses, which are seriously compromising water quality. The same model that optimises nutrient use for farmers, mechanically estimates nutrient loss from the root zone of a paddock.

Of course, there are plenty of practices councils can specify that are known to be beneficial in terms of reduced nutrient losses. And in some cases, ensuring that farms are following good management practices through monitored and enforced farm plans will be sufficient to achieve water quality outcomes. But where nutrient loadings in a catchment are well beyond anything that is consistent with safeguarding the life-supporting capacity of receiving waterbodies, councils need to know that specific, quantifiable reductions are being achieved. There is a need for a tool capable of quantifying nutrients loss from farms.

It is scarcely surprising that some regional councils, grappling with unsustainably high nutrient leaching, have turned to Overseer, since it provides estimates of the very environmental pressure they are charged with managing. But using the tool privately and using it to estimate limits and enforce compliance are two very different things. Farmers may be happy enough with the model as a decision support tool for farming purposes, but demand a much higher level of assurance when the consequences can be used to compel legal compliance. The level of trust placed in modelled outputs is crucially dependent on how those outputs are being used.

Although Overseer's farm and user-based focus make it attractive for use in regulatory decision making, it has not been subjected to the rigorous formal scrutiny that those who are being regulated might expect. The assessment contained in this report has revealed that a significant amount of information needed to confirm Overseer's use in a regulatory setting is lacking. For this reason, a comprehensive and well-resourced evaluation of Overseer needs to be undertaken, if both councils and farmers are going to be able to feel confident that the model is fit for purpose. Initiating this will inevitably require access to the engine of the model, which in turn raises important questions about the proprietary nature of Overseer.

This conclusion raises an immediate question: what should happen in the meantime? As this report has described, Overseer currently underwrites a number of regulatory approaches that are either in force or in the process of being implemented. The approaches of some regional councils represent a considerable amount of 'learning by doing'.

It appears to me that most if not all the regional councils currently using Overseer to determine compliance with nitrogen limits do so because of the nature of the challenge they face. Overseer, in conjunction with catchment-scale modelling, provides a defensible quantitative basis for charting a pathway towards a lower environmental nutrient burden. And Overseer, by itself, provides a defensible basis for engaging land users on how they can, in a quantifiable way, reduce their share of that burden. I should also observe that in these heavily over-allocated settings, if councils were to step back from trying to quantify limits, they would have to turn to much more aggressive input or land-use controls. I am not sure farmers would be any happier with that. They have consistently resisted input controls, such as limits to stocking rates, fertiliser application, cropping practices, and the amount of imported feed, on the basis that these sorts of regulations would be inflexible and stifle innovation on the farm.

Those concerns have and should continue to be taken seriously. Land-use controls will have a role in some situations, but trying to make an effects-based regime work, in which farming activity is limited by its environmental impact, is in my view worth the effort. After all, it focuses everyone on the issue we are trying to address: degraded water quality.

The best way forward is to speedily address important gaps and the shortcomings in transparency, peer review, corroboration, uncertainty and sensitivity analysis, and model documentation raised in this investigation. This will provide confidence both to regulators and farmers that uncertainties associated with the model are within acceptable bounds. This is essential to building trust in its application and in the nutrient limits being set.

It should also be recalled that Overseer assumes that good management practices are occurring on all farms. To have confidence in a regulatory framework using Overseer derived nitrogen-loss limits, regional councils must be satisfied that these practices are occurring on all farms. Key instances where farms may not be compliant with these practices, based on our interviews, relate to storage and application of effluent on farms, and irrigation practices. Regional councils would therefore do well to ensure they are monitoring farms for compliance with these practices alongside any Overseer based framework."