BEFORE THE SOUTHLAND REGIONAL COUNCIL

In the matter of sections 88 to 115 of the Resource Management Act 1991

And

In the matter of applications for resource consents by:

CASHMERE BAY DAIRY LIMITED

Applicant

Evidence of Michael Conrad Freeman

6 May 2022

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Qualifications and expertise

1. My full name is Michael Conrad Freeman. I am a senior scientist/planner at Landpro Limited, a firm of consulting planners, scientists, surveyors and engineers. I hold the qualifications of BSc (Hons) (Environmental Science, University of Warwick) and PhD (Periphyton and Water Quality, Massey University). I have both the Intermediate and Advanced Sustainable Nutrient Management Certificates from Massey University. I am a current Ministry for the Environment Certified RMA decision-maker with a chairing endorsement.

2. I have approximately 37 years' experience in environmental science and regulatory processes. My previous relevant work experience includes roles as a water quality research scientist, groundwater quality scientist, pollution control manager, regional council director, environmental consultant, and soil and water impact leader. A significant proportion of my current work relates to providing technical input to the preparation of applications for land use consents, discharge permits and water permits relating to farms in Southland. I have prepared a significant number of reports on water quality and related contaminant loss mitigation in Southland.

3. I have authored or co-authored scientific and technical papers on the role of nutrients in the growth of periphyton. 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] I have also published on the topic of environmental models, uncertainty and the resource consent process.[2]

4. I am a member of the New Zealand Freshwater Sciences Society, the Resource Management Law Association, and the Environmental Institute of Australia and New Zealand. I am also an associate member of the New Zealand Planning Institute.

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[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.

[2] Freeman M (2011) The resource consent process: Environmental models and uncertainty, RM Journal, August 2011, pp 1-8.

5. 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.

Code of conduct for expert witnesses

6. 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 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.

Scope of evidence

7. I will provide information on the following matters:

- Existing groundwater quality in the vicinity of the Cashmere Bay Dairy property.
- Existing surface water quality downstream of the property.
- Effects of the proposal on groundwater and surface water quality.

Background

8. Cashmere Bay Dairy is in the process of applying for resource consents associated with proposed modifications of the dairy farm, including increasing the number of dairy cows and reducing the number of beef cattle. This report assumes a significant level of information about those applications.

Nitrate 'hotspots'

9. The farm is close to an area known to have high nitrate nitrogen concentrations. Two bores in this area have historically had elevated concentrations of nitrate nitrogen that have risen in recent years to 24 g/m^3. This is over twice the NZ Drinking Water Standard Maximum Acceptable Value (MAV) for nitrate nitrogen[3] of 11.3 g/m^3. For example, bore F45/0343 (1.5 km west of the property) has been monitored for nearly 20 years and has been known since 2005[4] to return

[3] The MAV is expressed as nitrate (50 mg/l). However, technical reports refer to nitrate nitrogen, usually using SI units, i.e., equivalent to 11.3 g/m^3 nitrate nitrogen.
[4] Knapdale Groundwater Zone Technical Report (2012) Report for Environment Southland, Liquid Earth.

results that exceed the MAV. Bore F45/0172 on the property was monitored from 2009 to 2019 and regularly exceeded the nitrate nitrogen MAV.

10. I have investigated many examples of reported high concentrations of nitrate nitrogen in bores in Southland. From this and other experiences monitoring and investigating groundwater quality, I have found that reported high nitrate nitrogen concentrations in Southland have several (not mutually exclusive) probable causes and contributing factors. These are briefly outlined below:

- High loadings/high concentrations of nitrogen in drainage water from a wide range of intensive land uses, e.g., dairy grazing, dairy support, arable farming, effluent application, etc.
- Many dairy effluent discharge monitoring bores are poorly located, poorly installed & poorly maintained with sometimes highly inadequate wellhead protection that allows surface water with high concentrations of contaminants to drain into the bore/aquifer.
- Some areas of unconfined groundwater are shallow, thin and have low permeability with little or no river recharge which results in that groundwater being heavily influenced by drainage from intensive land uses (e.g., the Balfour high nitrate nitrogen hot spot area).

Hydrogeological background

11. A thorough review[1] of the hydrogeology of the Knapdale area was undertaken in 2012. Key conclusions of that report are summarised below:

- The Knapdale aquifer away from the Mataura River is recharged predominantly from local soil moisture infiltration.
- The aquifer is shallow and thin.
- This combination of factors means that the aquifer is vulnerable to contamination from nitrate nitrogen in drainage from local land use.

12. Soils underlying the southern half of the farm's effluent discharge area (where effluent is currently discharged via a travelling irrigator) are Oreti soils (Old Mataura Physiographic Zone).

13. The Old Mataura and small Oxidising zones are indicative of free draining soils that allow for significant nitrification of organic nitrogen to nitrate nitrogen. In this hydrogeological situation, this provides the potential for significant nitrate loading to the relatively shallow thin underlying unconfined groundwater.

14. The farm boundary and physiographic zones are illustrated in the following figure. The physiographics indicate a high potential in the area for nitrate nitrogen leaching.

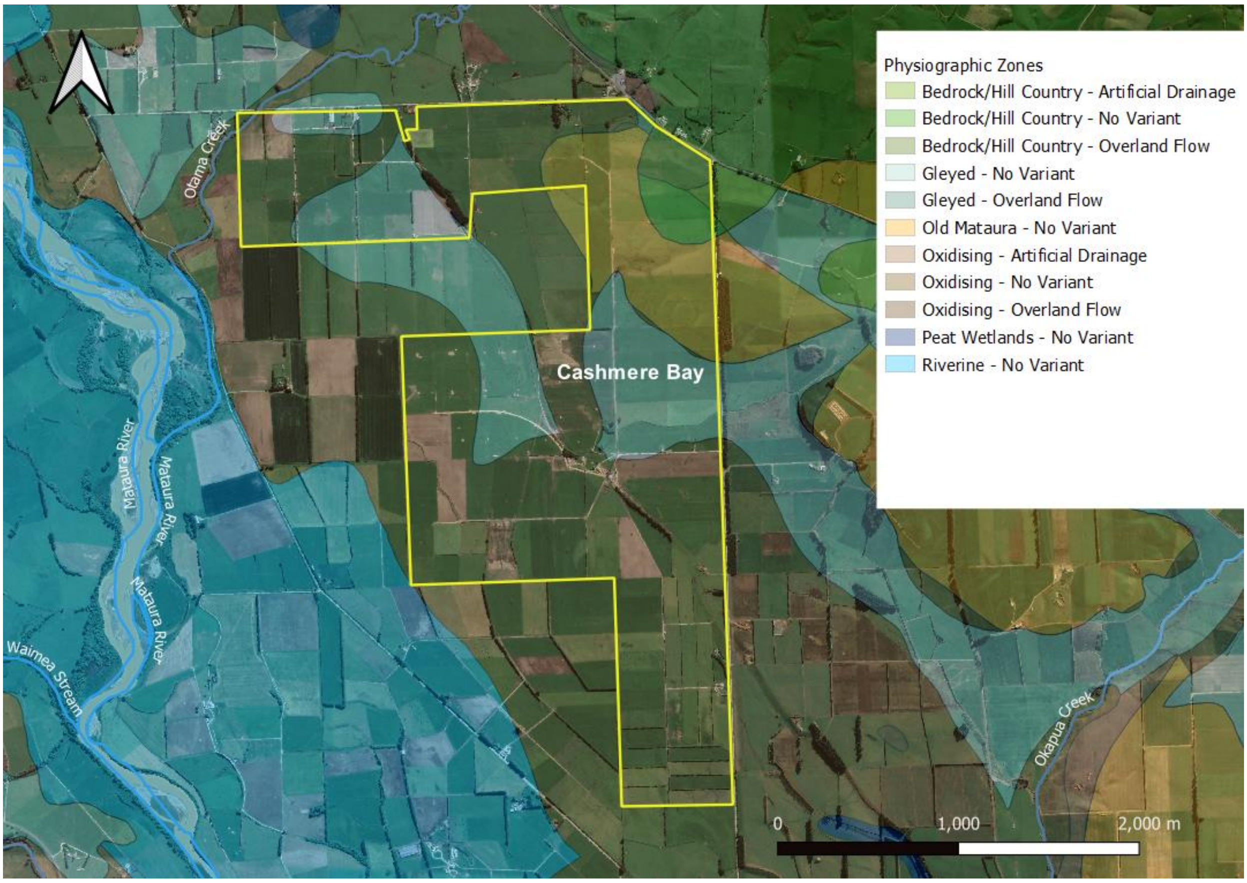

Figure 1: Farm location and physiographic zones

Groundwater flow direction

15. Piezometric contour information from the Knapdale Groundwater Zone Technical Report[1] has been georeferenced and transferred to a GIS layer to illustrate the likely direction of groundwater flow in this area. This data strongly indicates that groundwater flow is towards the Mataura River in a general south-south westerly direction. This is illustrated in the following figure. The flow direction is only a general indication of the likely overall flow direction. It is not clear from the original report how many bores were used to develop the piezometric contours. In addition, there will almost certainly be preferential flow paths that can result in groundwater moving in a direction up to 25° or more away from the general direction of flow for short distances[5].

[5] Close M, Nobes D & Pang L (2012) Presence of preferential flow paths in shallow groundwater systems as indicated by tracer experiments and geophysical surveys.

Robb C, Fenemor A, Morris R, Fernandes R, Hadfield J, Thomas J, Tidswell S, (2021) Guiding groundwater resource management: Groundwater Forum (SIG) Science and Technology Strategy 2021. Prepared for GW-SIG. 36 pages

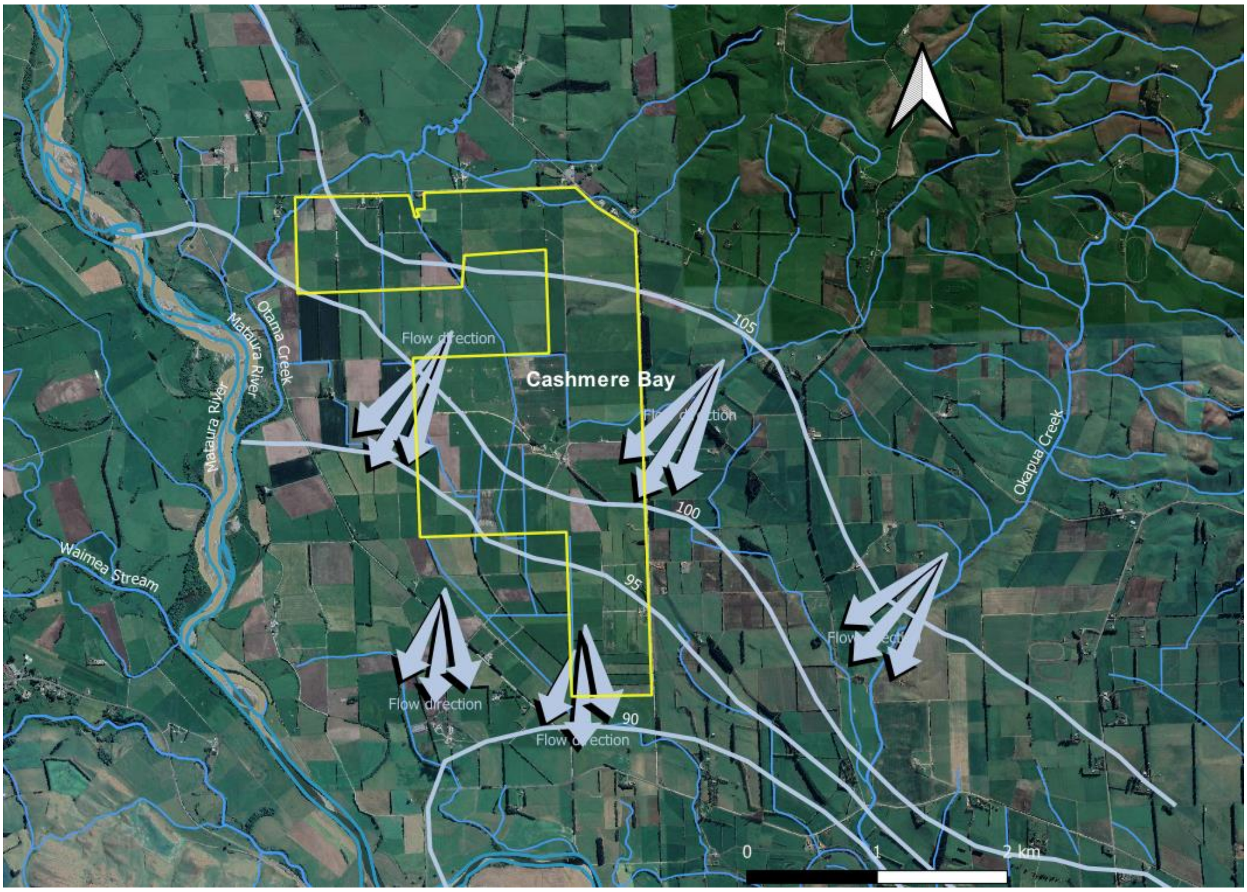

Figure 2: Piezometric contours from the Knapdale Technical Report, bores in the area and associated approximate groundwater flow direction.

Nitrate nitrogen in the wider area

16. Environment Southland samples water quality twice-yearly from various bores in the area. Bore F45/0172 was sampled from 2009 to 2019 and bore F45/0343 has been sampled since 2002. Recorded nitrate nitrogen concentrations in groundwater from bore F45/0343 since 2005 have generally exceeded the MAV and there is a clear trend of increasing nitrate nitrogen concentrations. Elevated nitrate nitrogen concentrations have also been detected in many bores in this wider area. The peak nitrate nitrogen concentrations that have been identified in the area since 2010 are illustrated in the following figure.

17. Figure 3 illustrates the many bores in this wider area with significantly elevated concentrations of nitrate nitrogen, many above the MAV. This information reinforces the conclusions of the 2012 technical report that the area is particularly vulnerable to nitrate contamination. Since the 2012 technical report, it is likely that there has been further intensification of land use in the wider area.

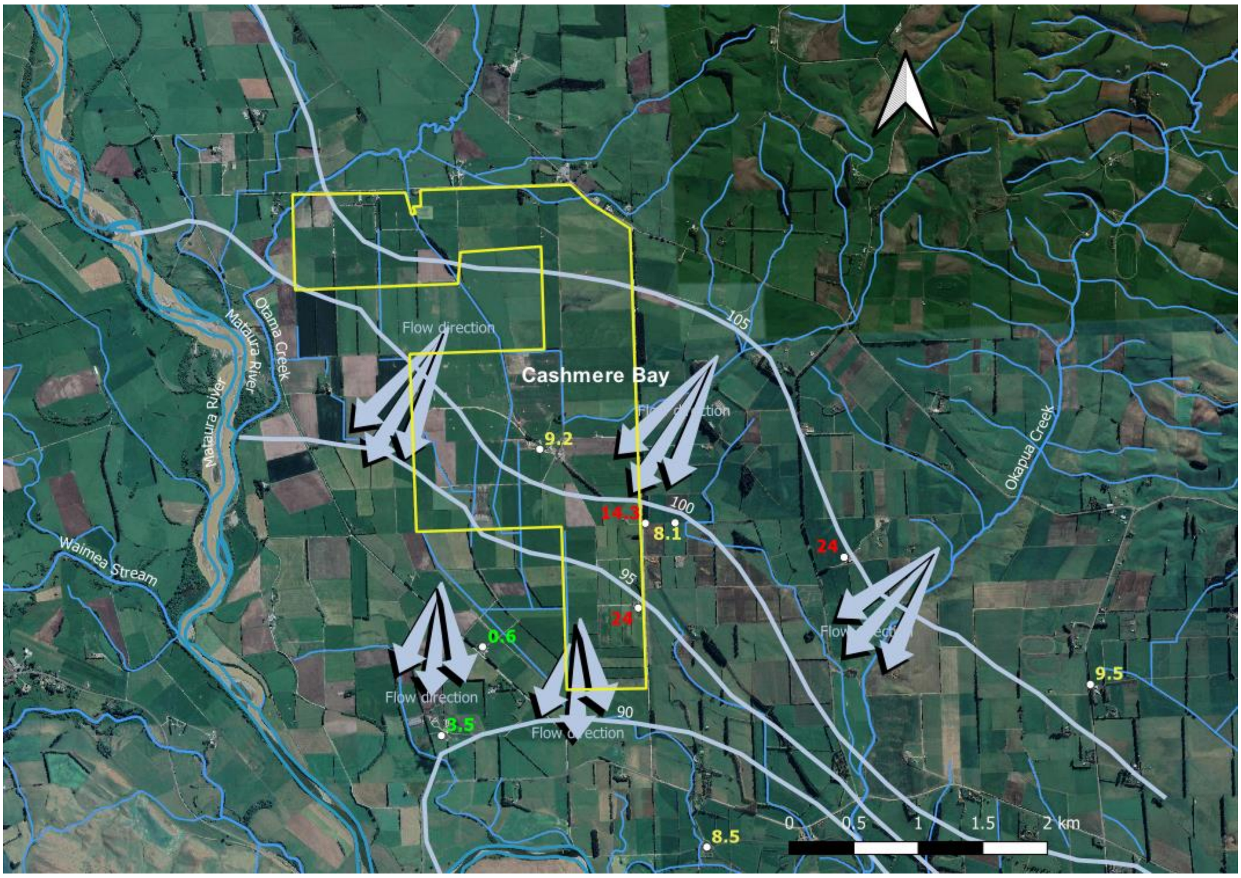

Figure 3: Peak groundwater nitrate nitrogen concentrations in the wider area and approximate groundwater flow direction (bore F45/0172 (on farm) and bore F45/0343 both show (red) peak nitrate nitrogen of 24 g/m³).

18. The concentrations of nitrate nitrogen found in bores F45/0172 and F45/0343 are illustrated in the following figures.

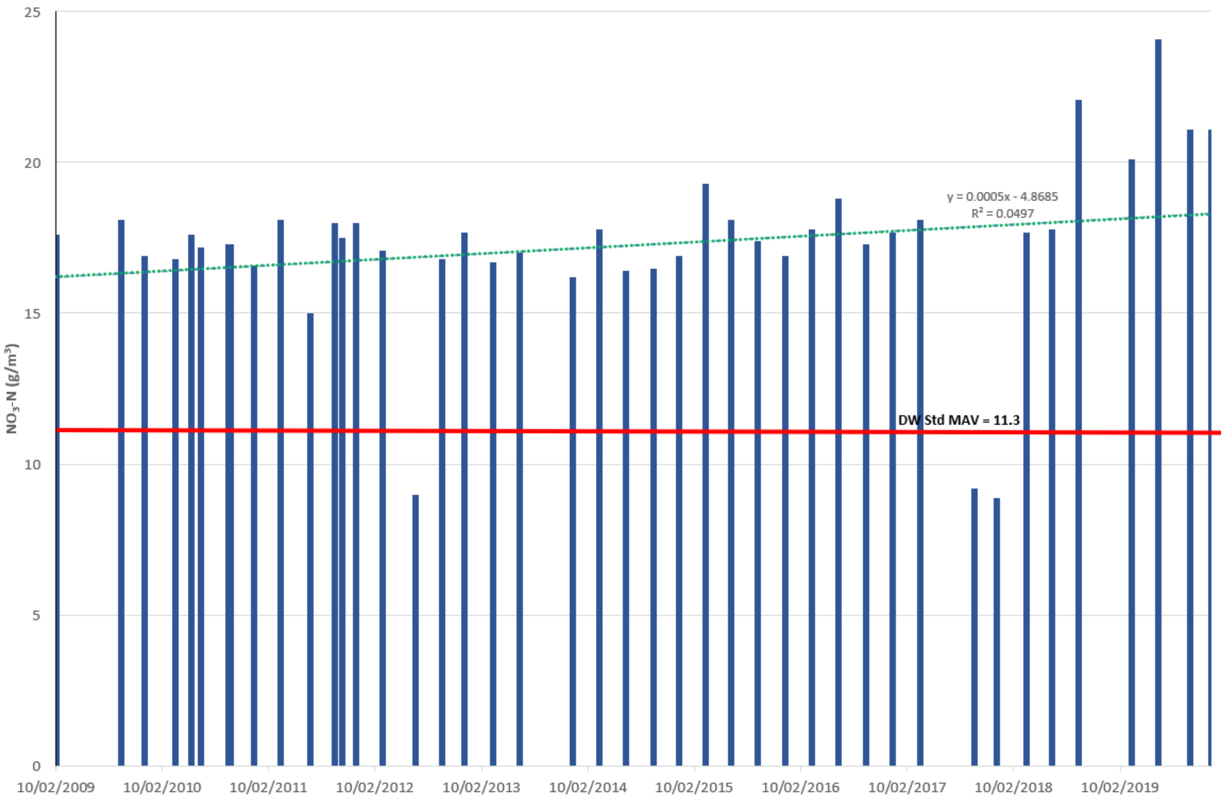

Figure 4: Nitrate nitrogen concentrations from bore F45/0172, 2009 – 2019

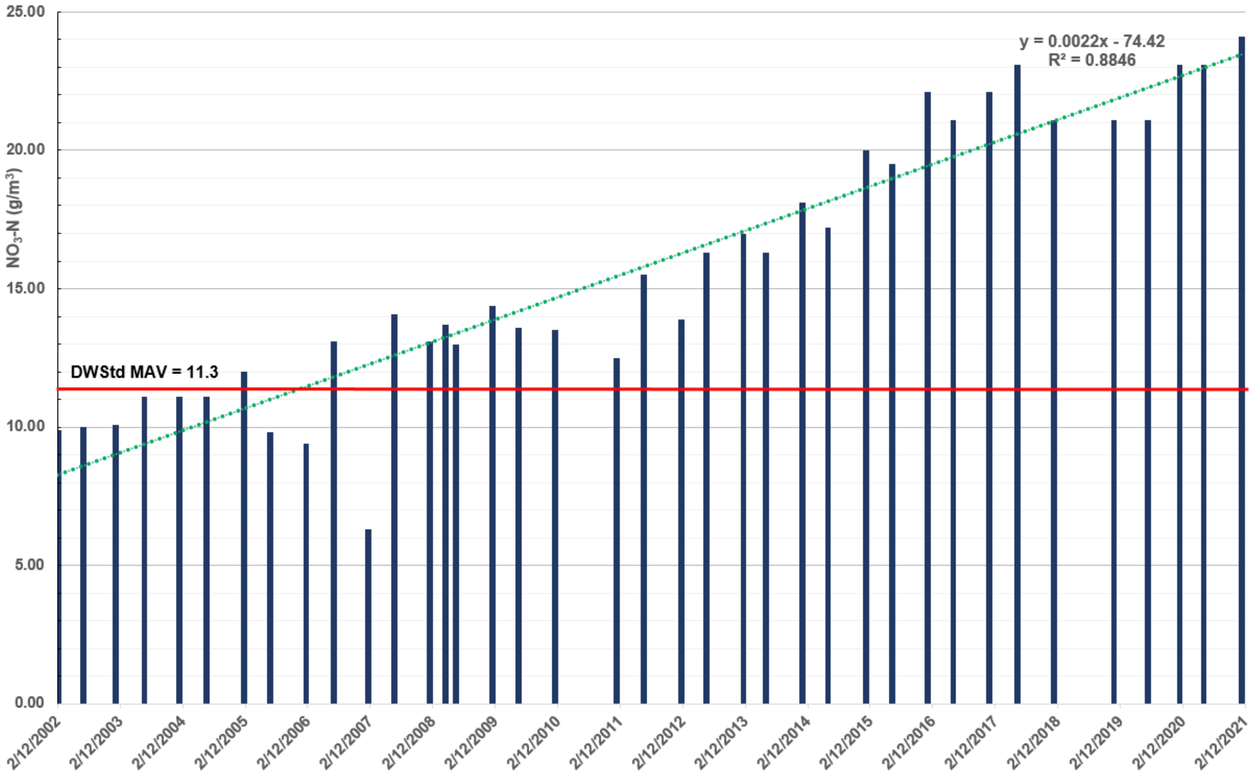

Figure 5: Nitrate nitrogen concentrations from bore F45/0343, 2002 – 2021

19. The wider context of the farm location relative to wider upgradient land use and physiographic zones is illustrated in the following figure.

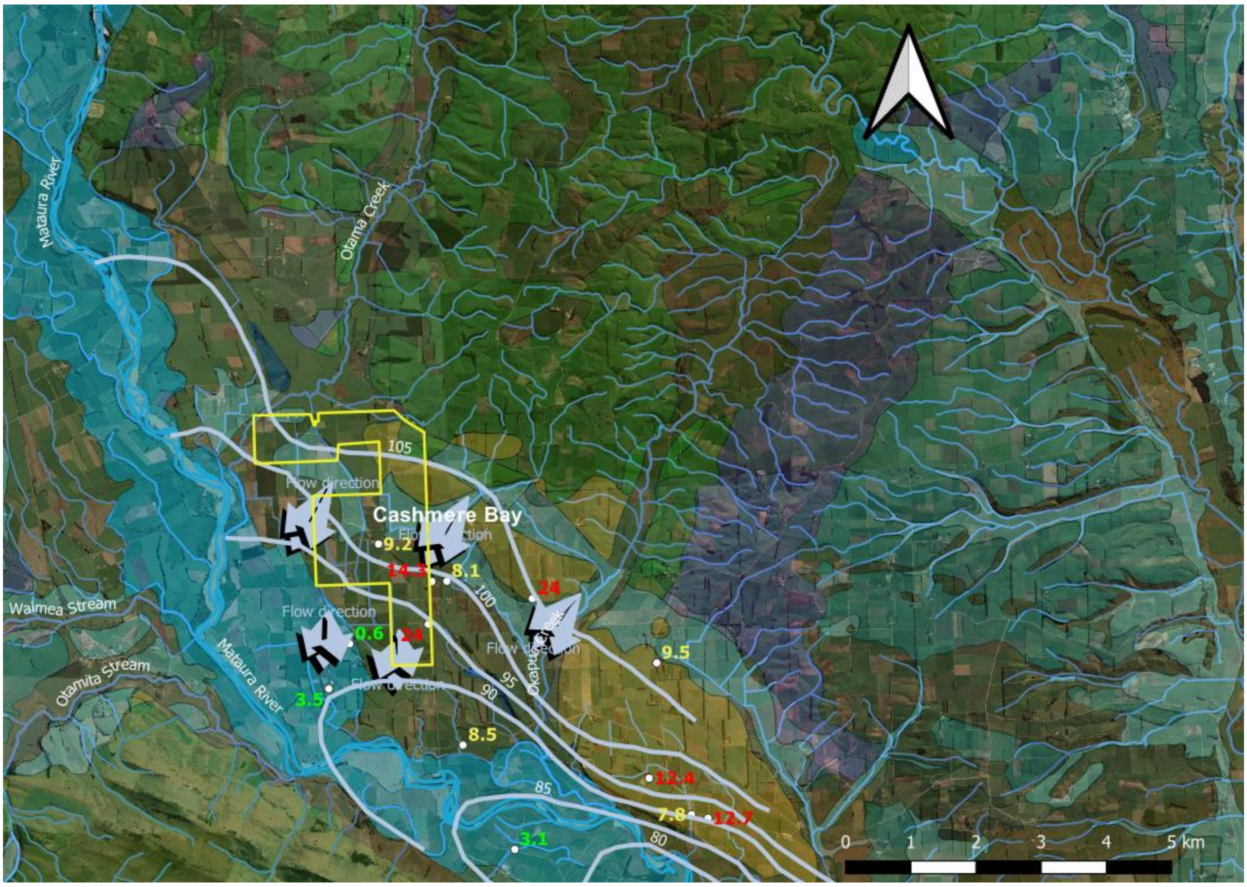

Figure 6: Location of the property showing the wider up-gradient context.

20. Figure 6 illustrates that there are some free-draining soils (Old Mataura and Oxidising) up-gradient from parts of the property and the following figure highlights the potential extent of

intensive winter grazing (summer bare soil is assumed to be indicative of preparation for winter crop planting) that could at times be occurring upgradient from the property.

21. North of Otama Road there is no S-map or Topoclimate soil data for assisting with the derivation of physiographic zones. Therefore, the physiographic zones would have been based on relatively low-resolution knowledge of bedrock, topography and other variables as detailed in Hughes et al[6]. Therefore, there will be more uncertainty about the extent and location of physiographic zones north of Otama Road. The implications of this are discussed in more detail later in this report.

22. The data illustrated in Figure 3 highlight that there are high concentrations of nitrate nitrogen in many bores in this general area with the evidence strongly indicating that a significant component of this is a result of: the relatively intensive land use, the hydrogeology of the area, and a significant proportion of free-draining soils.

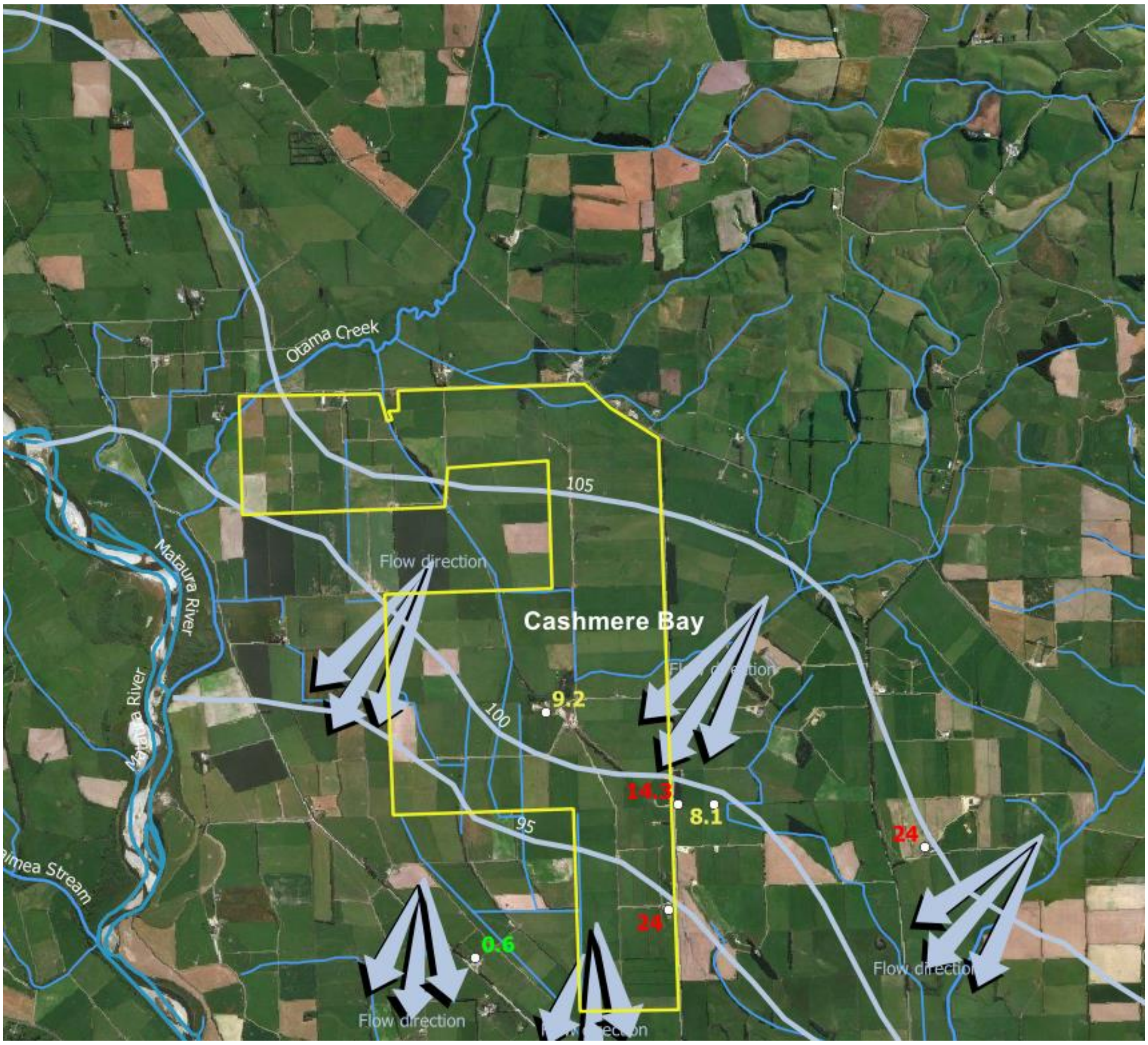

Figure 7: illustration of cultivation of land upgradient of the property, potentially in preparation for intensive winter grazing (undated Bing image https://www.bing.com/maps/aerial)

[6] Hughes B, Wilson K, Rissmann C & Rodway E (2016) Physiographics of Southland: Development and application of a classification system for managing land use effects on water quality in Southland, Technical Report

Likely causes of the high nitrate nitrogen concentrations in the Cashmere Bay farm area

23. The groundwater quality monitoring, general land use and hydrogeology in this area indicate that background nitrate nitrogen concentrations could readily be between 8 - >10 g/m^3. Activities that are likely to have contributed to the elevated nitrate nitrogen concentrations in the area including at bore F45/0172 include:

    - Upgradient intensive land use such as intensive winter grazing, dairy grazing, cereal growing, silage storage, dairy shed effluent disposal, dairy factory effluent disposal, etc., particularly over free-draining soils such as those found in Old Mataura and Oxidising physiographic zones.
    - Overland flow of contaminants into a bore and/or down the bore casing.
    - On property intensive winter grazing, dairy grazing, and effluent application to land particularly in Oxidising and Old Mataura physiographic zone areas.
    - Septic tank effluent discharges.
    - Potential historical sources that are not obvious today.

24. Given the proximity of bore F45/0172 to the eastern boundary of the property and the evidence that indicates that the likely primary recharge direction is from the northeast, it is likely that the high concentrations observed at this bore have been caused primarily by activities on the adjacent land to the northeast.

25. It is important to appreciate that there will be significant lag periods (weeks to years) involved between some upgradient activities and observed increases in nitrate nitrogen in groundwater. This can complicate the interpretation of the relationship between activities and groundwater quality.

Overland flow of contaminants into a bore and/or down the bore casing.

26. My experience of observing bores installed in Southland is that a majority have not been installed in accordance with established good practice. This is particularly the case with bores that have been installed to meet dairy shed effluent discharge permit conditions. I have not personally sighted all the bores in this general area. However, based on my observations and reports from other areas I have no reason to conclude that bores in this location would have better well head protection than in other parts of Southland.

27. Well/bore head should be protected as illustrated in the following figure.

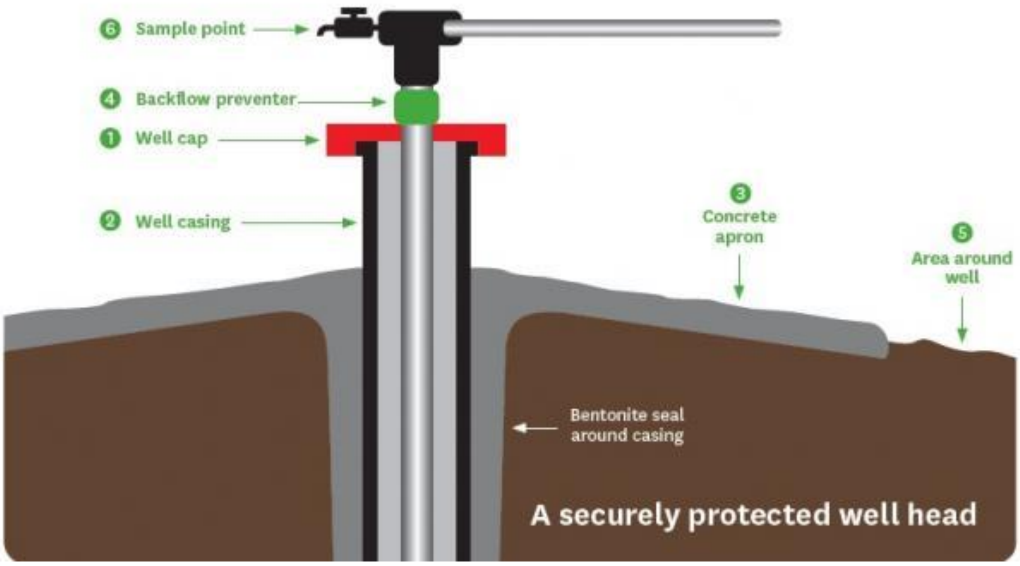

Figure 8: Appropriate wellhead protection to prevent runoff contaminants entering a bore/bore casing (diagram courtesy of HBRC)

Upgradient intensive land use such as intensive winter grazing, dairy grazing, cereal growing, effluent disposal, etc., over free-draining soils such as those found in the physiographic zones Old Mataura and Oxidising.

28. As figures1, 6 and 9 indicate, there are areas of land upgradient where intensive land use occurs on land identified as Old Mataura or Oxidising. However, there is also an extensive area of land upgradient that has been assigned a physiographic zone of Bedrock/Hill Country. Based on this designation the assumption is that this land is "*bedrock or glacial till* found near the surface, located below 800m above sea level. There are no significant areas of groundwater. Glacial till is a mixture of rock debris and sediment that has been deposited by a glacier. It is relatively impermeable, allowing little water to get through*."[7]

29. As noted earlier there does not appear to be any published soil map information for land just north of Otama Road. However, notwithstanding the lack of soil information, specific areas of Old Mataura zones have been identified north of Otama Road and significant areas identified as Bedrock/Hill Country. It is not clear what information was used to derive some of the specific boundaries.

30. The adjacent land north-east and upgradient of this property is authorised to discharge various effluents including dairy factory effluents under the authority of discharge permit AUTH-20202259-V1 and dairy shed/feedlot effluent under AUTH-20146816-01-V1.

31. An understanding of upgradient land use is relevant to understanding the drivers that result in significant concentrations of nitrate nitrogen in groundwater in this wider area where the

[7] Environment Southland Factsheet

physiographic and hydrogeological information indicates a very limited recharge area upgradient of relatively high nitrate nitrogen concentrations. For example, as well as the very high concentrations (24 g N/m^3) found in bores F45/0172 and F45/0343 other bores in this area a similar distance downgradient from Otama Road have relatively high nitrate nitrogen concentrations (> 6 g N/m^3).

32. Groundwater in this area is shallow (5 – 10 m deep), thin (2 – 5 m), and slow moving (0.5 to 1 m/day seepage velocity[8]) and even a relatively small upgradient recharge area of intensive land use appears to result in relatively high nitrate nitrogen concentrations in the underlying groundwater. It is also quite possible that the recharge area extends some distance further north of Otama Road and has a somewhat larger catchment area than the physiographic zones indicate. The topography of the area clearly indicates that the groundwater basin is highly likely to extend further north of Otama Road to the base of the hill country and include some land that is otherwise physiographically zoned as Bedrock/Hill Country. This is illustrated below.

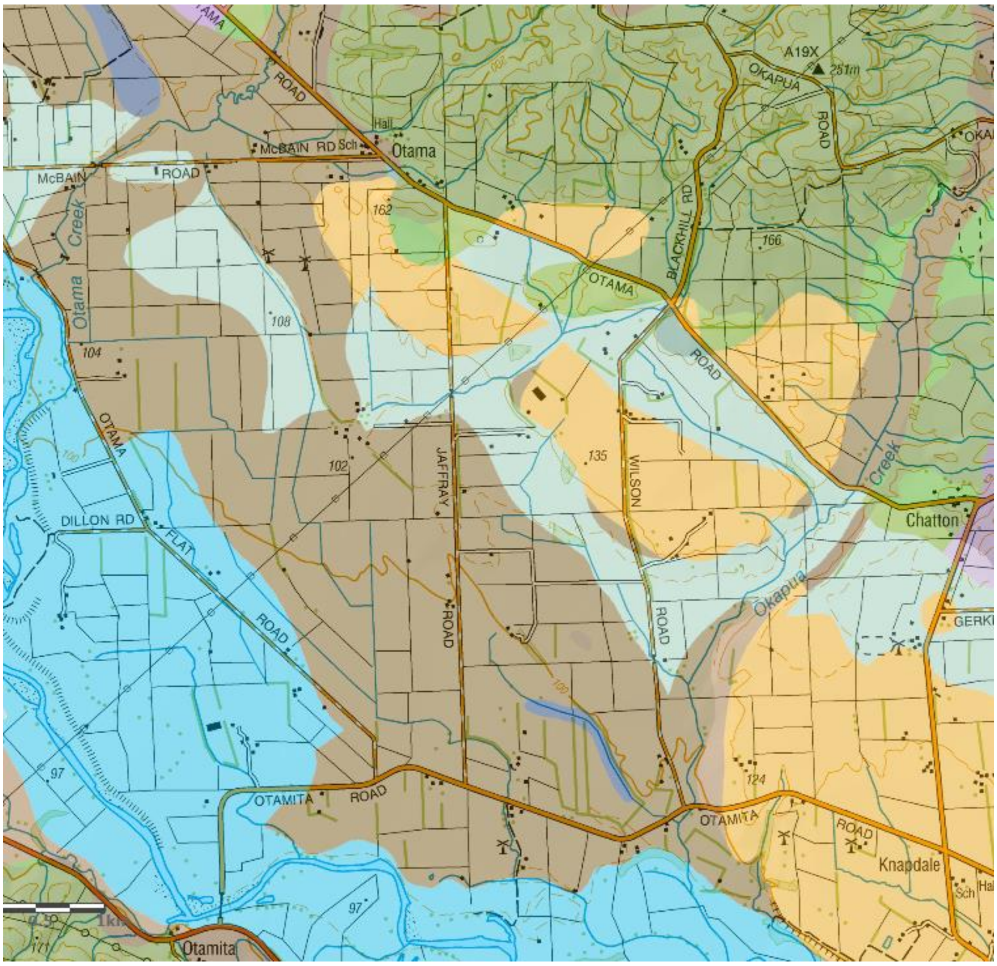

Figure 9: Beacon map showing physiographic zones and topography in the area

[8] Estimated from hydraulic conductivity, hydraulic gradient, and porosity reported in Knapdale Groundwater Zone Technical Report (2012) Report for Environment Southland, Liquid Earth.

On property intensive winter grazing, dairy grazing, and effluent disposal particularly in the Old Mataura/Oxidising physiographic zone area.

33. Even though the piezometric contours for the area indicate that the most likely catchment for the high nitrate nitrogen observed at bore F45/0172 is the adjacent upgradient property, drainage from the property will be contributing some nitrogen to the wider groundwater catchment. That land use includes dairy grazing, intensive winter grazing and dairy shed effluent disposal.

34. Overseer modelling has been undertaken for both the current farm system and for a suite of farm system changes to assess the potential to reduce nitrogen loading to groundwater.

35. The Overseer modelling[9] indicates that the current estimated:

- N loading would be reduced from 24,970 to 22,512 kg N/ha/yr, a nearly 10% reduction.
- P loading would be reduced from 405 to 384 kg P/ha/yr, an approximately 5% reduction.

36. The reductions in nutrient losses would be achieved by the application of the following key strategies:

(i) Increase in milking cow numbers
(ii) Reducing nitrogen fertiliser use
(iii) Removal of beef animals
(iv) Reducing the farm Olsen P to 30

37. These changes will result in a reduction in the amounts of nitrogen leaching to groundwater and phosphorus and other contaminants running off the property. However, by themselves, they are highly unlikely to result in significant reductions in nitrate nitrogen concentrations in groundwater. And because of the likely direction of groundwater flow unlikely to contribute to improving nitrate nitrogen concentrations in the vicinity of bore F45/0172. To achieve significant reductions in nitrate nitrogen concentrations in groundwater in this area would require a new catchment-scale approach to water quality management.

Septic tank effluent discharge.

38. A septic tank effluent discharge field is located approximately 150 m north of bore F45/0172. This is in a general upgradient direction from the bore (although the piezometric contours indicate that it is not directly upgradient) and it is possible that the bore will be at some risk of contamination, particularly microbiological. However, the distance does comply with the Proposed Southland Water and Land Plan permitted activity separation distance of 50 m.

39. To assess whether the septic tank effluent could represent a significant proportion of the elevated nitrogen found in bore F45/0172 it is useful to assess the normal concentration of

[9] Roslin Consultancy Ltd report dated 20 August 2021.

nitrogen in septic tank effluent. The most comprehensive recent assessment done in New Zealand of the risks of on-site domestic wastewater discharges to groundwater quality was undertaken by Dr Lee Burberry in 2014[10]. This study concluded that total nitrogen loading into the ground from an average NZ septic tank system would be 60 g N/m^3 and at the generally accepted maximum daily amount of effluent generated of approximately 1.25 m^3 (included in various regional plans including the Proposed Southland Water and Land Plan) results in a total daily loading of approximately 0.06 x 1.25 = 0.075 kg/day or 27 kg N/yr. While this input of nitrogen is small compared to the range of nitrogen loss from dairy and dairy support land use (30 – 110 kg N/ha/yr[11]), the proximity of the discharge and the potential for a local preferential flow channel means that it is possible that this discharge is providing a small proportion of the observed nitrate nitrogen found in groundwater from bore F45/0172.

40. I have assumed that the septic tank effluent disposal field is a modern disposal field installed in accordance with recognised current good practice. However, it is quite possible that the final discharge is via a boulder pit. Images from Retrolens (www.retrolens.co.nz) show that the house was built between 1980 and 1997 when septic tank boulder pit installations were relatively common in Southland. An upgrade to a modern system that involved discharge into dripline soil irrigation would reduce the nitrogen losses to water. However, it is beyond the scope of this report to endeavour to quantify the reduction of current farm N losses to water that such an upgrade would provide.

Mataura River Water Quality

41. The nearest downstream surface water quality monitoring site is the Gore monitoring site on the Mataura River. The summary data is illustrated in the following figure reproduced from the LAWA website.

42. This information strongly indicates that the quality of the Mataura River at this location is significantly affected by upstream agricultural land use. Noteworthy points are that the microbiological quality and water clarity are particularly poor, nitrogen species concentrations are relatively high but compared to the national water quality bands are classed in the A band. Similarly, phosphorus concentrations score relatively well, in the B band. Trends in water quality are variable with ten year trends showing improvements for surface runoff contaminants (sediment, *E. coli* and phosphorus) while nitrogen concentrations are generally declining.

[10] Burberry (2014) The Potential Hazard On-Site Wastewater Treatment Systems in Darfield and Kirwee Present to Local Groundwater Quality and Critique of Current Assessment Methods, Report prepared for the Ministry of Health.

[11] Ledgard, G. A. (2013). Land Use Change in the Southland Region. Environment Southland Technical Report.

Figure 10: LAWA water quality data for the Mataura River at Gore (Link)

Potential for localised effects on streams

43. A concern raised in relation to the 2019 withdrawn resource consent application made was that more intensive land use on one block of land, even in the context of significant overall property nutrient loss reductions, could result in a localised increase in nitrogen drainage that may not disperse or be mixed with other drainage water from the property with lower nitrate nitrogen drainage water, and could theoretically represent a risk that groundwater with a very localised increased concentration of nitrogen could recharge a small down-gradient stream.

44. This proposal is significantly different from that earlier proposal both in terms of the proposed farm system changes and the baseline reference. Therefore, even if the previous concern had any technical substance, it is not relevant now.

45. The overall reductions in N and P losses that would result from the current proposed changes would not provide measurable changes in local groundwater or surface waters. However, if they were combined with equivalent changes elsewhere in the catchment, it is highly likely that there would be measurable improvements in water quality. The layout of the property, groundwater flow direction and approximate location of significant drains/creeks are illustrated in the following figure.

Figure 12: Approximate locations of local drains/streams relative to the property and groundwater flow direction

Potential for effects on the Otama School groundwater supply

46. The Ministry of Education has lodged a submission that expresses concern about the potential for adverse effects on the quality of groundwater abstracted from bore F45/0351. The submission states:

> "*The Ministry has concerns about the actual and potential adverse effects on the quality of the drinking water supply of the school given that past groundwater sampling has shown elevated contaminant concentrations from bore F45/0172 located at the southeast of the existing dairy platform. The proposed activity has potential to increase the discharge of contaminants, including nitrogen and E.coli, which will affect the health and safety of pupils and staff.*
> *While it appears the school water supply is not affected at present the application does not appear to address potential future adverse effects on the water quality of the school bore, including any detailed monitoring of groundwater quality.*"

47. The location of this bore relative to Cashmere Dairy is shown in the following figure.

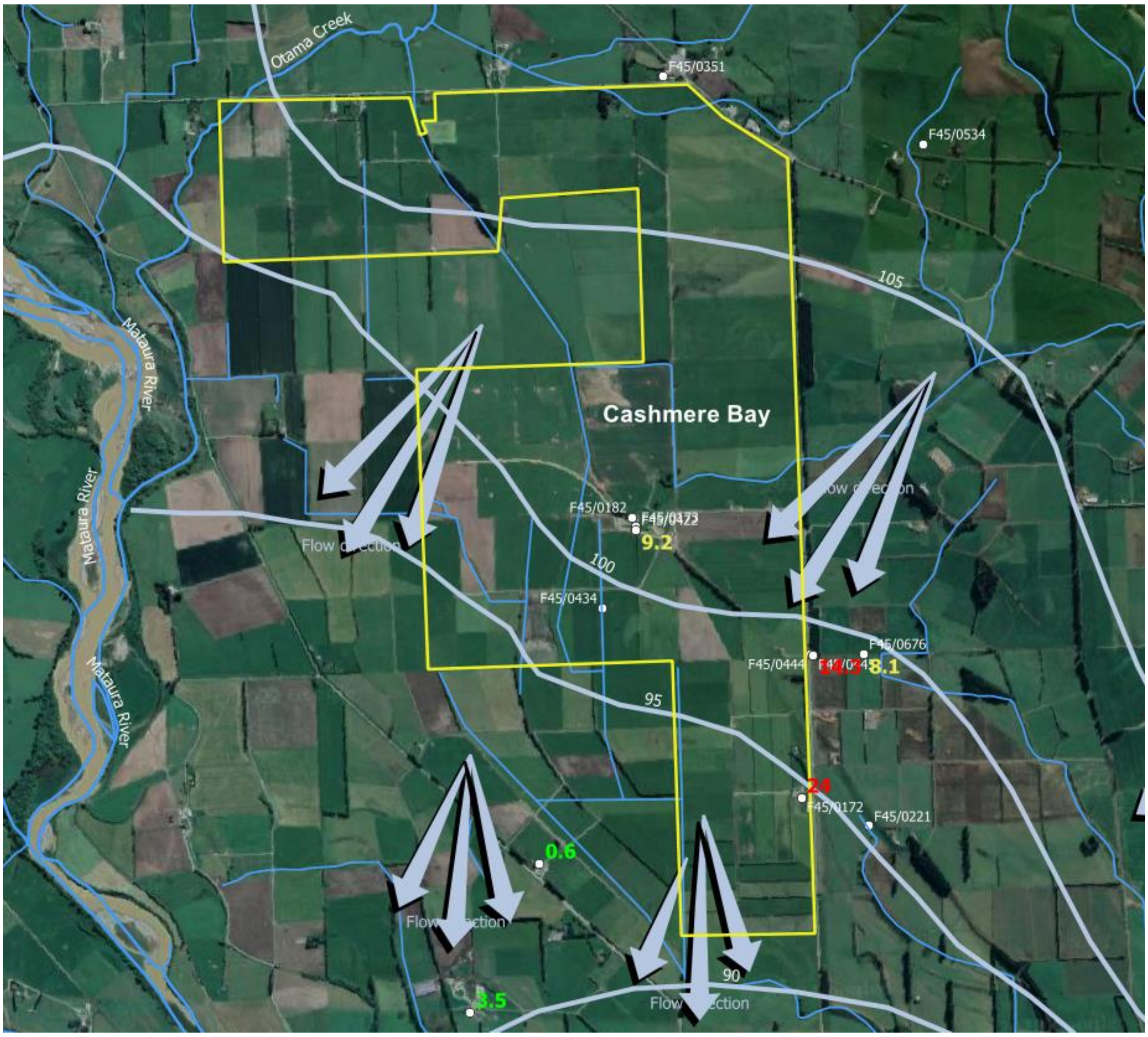

Figure 13: Location of Otama School bore F45/0351 north of Cashmere Bay Dairy

48. Bore F45/0351 is just north of Cashmere Bay Dairy directly north and upgradient of the farm. This bore is marked on Environment Southland's Beacon public database as drilled but not used.

Otama Primary School is not registered on the Taumata Arowai register of self-suppliers: https://www.taumataarowai.govt.nz/for-communities/public-register/.

49. The Beacon database does not specify a bore depth but given depths of other bores in this location it is likely to be less than 20 m deep and if it has a viable water supply it would be unconfined and vulnerable to contamination, including elevated nitrate nitrogen concentrations as outlined earlier in this report.

50. The proposed changes as outlined in the evidence of Ms Hunter and Ms Ballinger provide strong evidence for the conclusion that the proposed changes are highly likely to result in a significant reduction in the loss of contaminants to water. In addition, the distance from bore F45/0351 to the closest location of dairyshed effluent discharge is approximately 1.3 km down gradient from the bore (refer to Ms McRae's evidence and proposed conditions.

51. The combination of the location of bore F45/0351, upgradient from the farm, the distance from any effluent disposal location and the proposed mitigations means that I consider that the proposed changes will not have a significant adverse effect on the existing risks to groundwater quality that could conceivably be abstracted from bore F45/0351 in the future.

Conclusions and recommendations

52. The Knapdale area is characterised by unconfined, shallow, thin, low permeability/slow moving groundwater recharged locally with no significant river recharge. This hydrogeological background combined with intensive land use of the overlying land has resulted in generally elevated nitrate nitrogen concentrations. This is a similar situation to the Balfour Hotspot[12].

53. Groundwater from two bores (F45/0172 and F45/0343) in this area have had very high concentrations of nitrate nitrogen; over twice the NZ drinking water standard MAV of 11.3 g N/m^3. Some other shallow bores in the area have elevated nitrate nitrogen concentrations between 8 and 11 g N/m^3.

54. A range of good management practices, farm system changes, and wellhead protection measures would almost certainly reduce the loading of contaminants to groundwater in this area. However, significant measurable improvements in groundwater quality would require these measures to be taken across whole catchments. These measures would generally include:

[12] Hughes B (2008) Balfour Nitrate hotspot, Report prepared for Environment Southland.

- Installing recommended wellhead protection as illustrated in Figure 8.
- Farm system changes as proposed for Cashmere Bay Dairy e.g., careful management of intensive winter grazing, reduced nitrogen fertiliser applications and avoidance of application during high drainage periods (late autumn to early spring).
- Minimise effluent application and intensive winter grazing on free-draining soils e.g., Oreti and Mataura soils.
- Restricting effluent application to low application depths and only when there is an adequate soil moisture deficit.
- Upgrading septic tank effluent disposal systems to replace any existing soak holes/boulder pits with modern treatment systems such as drip irrigation and sand trenches.

MIKE FREEMAN

SENIOR SCIENTIST/PLANNER- LANDPRO LIMITED

6 May 2022