Before an Expert Panel **Bendigo-Ophir Gold Project**	**FTAA-2507-1089**

Under the	Fast Track Approvals Act 2024
In the matter of	an application for approvals to establish, operate, and remediate an open pit and underground gold mine at Bendigo and Ardgour Stations
By	**Matakanui Gold Limited** Applicant

STATEMENT OF EVIDENCE OF PROFESSOR JENNIFER WEBSTER-BROWN
GEOCHEMISTRY AND WATER QUALITY

10 April 2026

Environmental Defence Society Inc
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Introduction

1. My full name is Jennifer Gaye Webster-Brown.

2. I have been asked by the Environmental Defence Society Inc. (EDS) to provide independent expert evidence on how mine geochemistry and operation may affect receiving water quality for Matakanui Gold Ltd's proposed Bendigo-Ophir Gold Project (Project) in the Shepherds Creek and Bendigo Creek catchments in the Dunstan Mountains of Central Otago.

3. I am a water quality scientist and environmental geochemist with 45 years research, teaching and consulting experience in this field. I have worked for DSIR, ESR (a CRI) and University of Auckland as a research scientist and lecturer. My most recent appointments were as Professor of Water Resource Management at the University of Canterbury and Lincoln University (2009-2019), and as Director of the Our Land and Water National Science Challenge (2020-2024). I am based in Christchurch, where I now work mainly as a consultant in a technical consultancy partnership called GEOKEM.

4. I hold a BSc (Hons 1) in geology and chemistry from the University of Otago and a PhD in geochemistry from the University of Western Australia. I have published more than 70 peer-reviewed scientific journal papers and book chapters in international and national literature. I have also written and produced more than 40 internally peer-reviewed contracted technical reports.

5. My fields of expertise relevant to the Project include:

    a. Trace metal release and distribution during the exploitation and natural weathering of geothermal and mineral ore deposits.
    b. The chemical form and toxicity of trace metals in freshwater systems.
    c. The adsorption (surface binding) of trace metals to Fe oxide.
    d. Geochemical modelling of trace metal solubility and adsorption processes.
    e. The derivation and use of water quality criteria and guidelines to protect freshwater ecosystems.

6. Since 1992 I have routinely provided technical advice and evidence for Environment Waikato on water quality and geochemistry aspects of consent applications for the gold mines of the Coromandel Peninsula, including the Golden Cross mine at Waitekauri and the Martha, Favona, Quattro, Trio, Correnso and, most recently, the Waihi North, mines at Waihi. I have also provided technical advice and evidence for Environment Waikato and Watercare Services

Ltd on factors controlling the concentrations of geothermal arsenic in the Waikato River, and implications for drinking water treatment and quality.

7. I served for two years (2017-2019) on the NZ Government's Science and Technical Advisory Group for the development of the National Policy Statement (NPS) for Freshwater Management (2020). Our advice concerned the setting of attribute limits for freshwater quality as part of the National Objectives Framework. I also served on Environment Southland's Technical Advisory Group (2016-2018) to help it implement the requirements of earlier NPS freshwater management policies within its "Land and Water 2020" initiative.

Code of Conduct

8. I have read the Environment Court code of conduct for expert witnesses, and I have prepared this evidence in accordance with that code. I confirm that my evidence is within my area of expertise, except where I state I am relying on the evidence of another person. I have acknowledged the material and expertise relied on in the preparation of this evidence and in forming my opinions. To my knowledge I have not omitted to consider any material facts known to me that alter or detract from the opinions I express in this evidence.

Materials reviewed for evidence and site visits

9. In preparing this evidence I have read and reviewed the following documents from the applicant:

    - A.08 - A.14 inclusive - original Substantive Application reports.
    - B.03 - Groundwater existing environment and effects assessment
    - B.04 - Surface water and catchment existing environment effects assessment
    - B.06 - Mine Impacted Water Overview and the 15 technical reports included as appendices to the overview.
    - B.07 - Recommended Water Quality Limits for the Bendigo Ophir Gold Project
    - B.32 - Preliminary Site Investigation
    - B.40 - Mine Closure Plan
    - G.01 - Water Management Plan
    - G.16 - Tailings Management Plan
    - G.20 - Soil Management Plan
    - K.01 - Post Closure impacts on the Ardgour Aquifer
    - K.05 - BOGP MWSF Seepage Risk Assessment

10. I have also read E3 Scientific's technical report prepared for Otago Regional Council[1].

11. I am familiar with the Project site and its setting. I have visited historical mining features around the area 10 years ago and I attended a site visit hosted by Santana Minerals Ltd in March 2026.

12. In preparing this evidence, I am aware that the Panel has issued a number of requests for further information from the applicant dated 1 April 2026, some of which are relevant to my area of expertise. My evidence has been prepared in advance of the applicant's responses being provided to the Panel and parties, including EDS.

13. As a result, I wish to reserve my ability to update my evidence in light of the additional information provided, where material and relevant to my expertise. In addition, I understand that proposed consent conditions may evolve during the fast-track process, and I request an opportunity to comment on material changes to these, again where relevant to my area of technical expertise.

The Bendigo-Ophir Gold Project

14. In its application, Matakanui Gold Ltd proposes a gold mining operation that will include four open cast mines, the largest of which will be continued at depth as an underground mine, a tailings storage facility (TSF) in the head of Shepherds Creek, three engineered land forms (ELFs) to store overburden waste rock, temporary waste rock and top soil stacks, an ore processing plant in lower Shepherds Creek, and administration / operational buildings on Ardgour Terrace further down the catchment[2].

15. The Project is proposed to be an active mining operation for 14 years before entering an "Active Closure" phase for the next 20 years and thereafter a perpetual "Post Closure" phase in which minimal maintenance of the site is anticipated.

16. In the Post Closure phase there are anticipated to be two pit lakes (the other two open cast mines are proposed to be back-filled), the rehabilitated TSF and three ELF features, and a passive treatment system that will continue to treat seepage and run-off from the site.

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[1] E3 Scientific (2026) Technical Review of Surface Water Modelling, Groundwater and Geochemistry for the Fast-Track Bendigo Ophir Mine. Report for Otago Regional Council.
[2] A.10 Section 3: Project Description.

17. In technical reports supporting the application, standard geochemical techniques and modelling processes have been used to inform predictions of seepage, runoff and ore-processing fluid chemistry, at various stages of the mine's life. These predictions are based on the host rock and ore geochemistry, anticipated mining operation processes and the chemistry of analogous fluids at Macraes gold mine.

18. Most of these fluids are predicted to have elevated concentrations of toxic trace metals, particularly arsenic[3], nitrogen-bearing compounds such as cyanide and nitrate, and sulfate (collectively referred to as "principal constituents of concern" or PCOC in the application). Unless captured and treated effectively to remove these constituents, both during mining and after mining has ceased, such fluids have the potential to create a legacy of material environmental contamination in surface waters and groundwater aquifers of the area.

19. While reputable hydrological and geochemical models have been used for predicting PCOC concentrations in various fluids emanating from the mine site, modelled predictions are only ever as good as the input data and the assumptions that have been made about prevailing conditions. Comprehensive geochemical testing and analysis support some of the modelling inputs, but others are based on assumptions largely unsupported by evidence and represent an optimistic assessment of the mine's likely impact on local water quality. Rather than contest every unsupported assumption or model input, in my evidence I have focussed on the consequences of underestimating the water quality impacts of operating the proposed mine in this environment.

Scope of evidence

20. This evidence covers my main concerns for how mine geochemistry, and the type of mining operation proposed, will impact on water quality. These are:

    a. The presence of two pit lakes remaining in this catchment in perpetuity. There are many national and international examples of pit lakes where water quality is poor and has deteriorated further with time, forming a reservoir of contaminated water and posing a risk to ecology and human health.

    b. The lack of effective capture and treatment of all contaminated fluids on site. Seepage through the base of the TSF, ELFs and waste rock stacks is likely as no liners are currently proposed. The potential for contamination of shallow groundwater and spring-fed streams is high.

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[3] Note that arsenic is not technically a trace metal. It is a trace "metalloid". However, for the sake of simplicity I have included it within the category of "trace metals" in my evidence.

c. Underprediction of the concentrations of arsenic in mining impacted waters on site and in receiving waters.

d. The efficacy of passive treatment as a future (in perpetuity) treatment option for mine impacted water.

e. Prediction of PCOC concentrations in mine impact waters do NOT include the undissolved component of each contaminant (e.g., the portion bound to suspended sediment or other solids in the fluid). For trace metals in particular, this can be a significant (sometimes dominant) means of transport in mine impacted waters and thereafter in receiving freshwaters.

f. The compliance monitoring proposed, even if compliance with the water quality limits suggested is demonstrated, is unlikely to prevent the contamination of downstream water and sediment environments by mine-generated trace metals.

21. Unless otherwise noted, my comments on how Matakanui Gold Ltd has addressed these concerns are based on the comprehensive geochemical information provided in application report *B.06 Mine Impacted Water Overview Report (MWM, 2025*). I have specified which of the 15 technical reports attached to this report as Appendices A-O, includes the detailed information.

Pit lakes in perpetuity

22. Lakes typically form in open cast mines after dewatering ceases, as the groundwater rises back up to its natural (pre-mining) level. They usually take many years to fill and the initial water quality is determined mainly by the chemistry of the groundwater and runoff from the pit walls. The latter is generally of poorer quality, due to the reaction of rainwater with mineralisation in the exposed pit walls.

23. For the Project, hydrological modelling predicts that the SRX Pit lake will take 5 years to fill and become hydrologically stable, and the larger RAS pit lake will take 25 years[4]. The mineralogy of the pit walls for both lakes includes sulfide minerals of arsenic, lead, zinc, copper and cobalt[5], which oxidise in the presence of air and water releasing these contaminants into surface runoff and the filling pit lake.

24. I am very concerned that the water quality of the pit lakes, and the implications this has for rehabilitation and future use of the site, has not been not been

[4] B.06 - Appendix N: Water Load Balance Model Report.
[5] B.06 - Appendix F: Geoenvironmental Hazards Factual Report.

adequately assessed. Modelled predictions for RAS and SRX pit lake quality are based on mixing pit wall runoff (assumed to be similar to that of Fraser's pit at Macraes mine, as reported by Golders in 2011[6]) with groundwater anticipated to fill the pit, diluted by rainfall. The modelling is acknowledged to have significant limitations, applying only to average water quality conditions, not accounting for biogeochemical processes (other than for nitrate) and ignoring the effects of seasonal stratification and remixing of the lake water on water quality.

25. A more credible prediction of pit lake water quality is needed, as well as a thorough assessment of the implications for the future value of these water bodies. Having a large contaminated reservoir of water perched in the head of this catchment in perpetuity would certainly impact the local environment, businesses and community in multiple ways. This is not an unlikely scenario. There is a proliferation of toxic pit lakes around the world[7] including some very high profile examples such as Berkley pit lake in Montana, USA and Rum Jungle pit lake in Australia. The type of information that is needed for a full assessment of future pit lake quality, but is currently absent from this application, is described the following paragraphs.

26. The modelling predicts arsenic, aluminium and copper concentrations would be elevated well above surface water quality guidelines for aquatic ecosystem health used in New Zealand[8] and above those proposed for this Project[9]. Given that the pit lakes remain connected to the groundwater that filled them, it is significant that predicted arsenic, antimony, iron and molybdenum concentrations in the pit lakes also exceed the proposed groundwater quality guidelines. An assessment of the environmental (and societal) implications of this poor water quality is needed. It is likely to preclude the development of a functional aquatic ecosystem in these two pit lakes, for example, and restrict other water uses such as stock or wildlife drinking water, or irrigation supply.

27. The modelling uses only average contaminant concentrations in the modelling inputs (referred to source terms). It is usual practice to model a range of input concentrations, including maximums for a 'worst case' scenario. This type of sensitivity analysis would provide greater confidence that a realistic assessment of the likely *range* of future pit lake water quality conditions has been presented.

28. The predicted arsenic concentrations are particularly worrying, with an average concentration approximately 10 times higher than the drinking water standard for

[6] B.06 - Appendix I: Source Term Definition Report.
[7] Blanchette & Lund (2016) Pit lakes are a global legacy of mining. In *Current Opinion in Env Sustainability* 23, 28-234.
[8] ANZG, 2018. Australian and New Zealand guidelines for fresh and marine water quality. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default
[9] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.

human health. Should human recreation be considered in the future, the average arsenic concentration would be twice the recreational water guideline[10]. Such high arsenic levels would also pose a risk to terrestrial wildlife and grazing animals as they also exceed ANZG stock drinking water guidelines. Lake weeds may accumulate the arsenic to toxic levels, as has been observed in the Waikato River. Future use of this water for horticulture or pasture irrigation would also be compromised, based on ANZG guidelines for these water uses.

29. Nitrogen compounds from blasting residues are also predicted to be initially very high in the pit lakes (over 30 mg/L)[11]. Although nitrate concentration is predicted to decrease over a 5-10 year period through biogeochemical processes[12], direct toxicity to aquatic life and the formation of toxic algal blooms in these lakes poses a significant risk to aquatic and terrestrial wildlife. This risk needs to be acknowledged and assessed in the application.

30. The modelled concentrations of all trace metals are predicted to increase over the first 100 years, and remain constant thereafter[13]. This is an unrealistic prediction - an artefact of the assumption that trace metals would not participate in chemical reactions in the lake water. In reality, trace metals can adsorb and desorb from weathered mineral surfaces, precipitate as mineral phases as they become more concentrated and redissolve when conditions change, and bioaccumulate in plants and aquatic organisms. This will occur to varying degrees for each trace metal, depending on their chemical nature. Assuming trace metals will not react is only a conservative (worst case) modelling approach if water quality conditions are homogeneous and unchanging. This is not the case for most pit lakes due to stratification of the lake's water column and the contribution from ongoing pit wall runoff.

31. Thermal stratification is a common phenomenon in pit lakes as they are typically very deep relative to their surface area. As the RAS pit lake is anticipated to be approximately 200m deep, thermal stratification is almost certain. Given the significant air temperature variation in this region, a degree of seasonal lake "turnover" in the colder months, bringing deep water to the surface of the lake, is also to be expected. The omission of stratification from the modelling process is acknowledged as a limitation, but failure to consider the consequences of lake stratification in the modelling means that changes in contaminant concentrations with time are incorrectly predicted and likely underestimated.

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[10] ANZECC & ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
[11] B.06 - Appendix N: Water Load Balance Model Report.
[12] B.06 - Appendix I: Source Term Definition Report.
[13] B.06 - Appendix N: Water Load Balance Model Report.

32. When lakes stratify, water at depth becomes deoxygenated and its toxicity increases due to the formation of hydrogen sulfide from the sulfate present, and the release of trace metals bound to iron and manganese oxides, such as arsenic, lead, copper and zinc, as the host oxides dissolve. Nutrients such as nitrogen and phosphorous are also released due to degradation of algal and plant material.

33. A turnover event in the RAS pit lake could therefore release a significant quantity of hydrogen sulfide, a toxic unpleasant smelling gas, into the air as there is predicted to be abundant sulfate available for reduction to sulfide. It would also increase the toxicity of the near-surface waters through increased concentrations of dissolved sulfide and trace metals, and potentially promote further algal blooms through the availability of more nitrate and other plant nutrients.

34. The RAS pit lake is predicted to have similar dimensions to the pit lake anticipated to form in the Martha Pit at Waihi. There has been extensive pit lake modelling undertaken for Martha to establish future pit lake behaviour (including stratification and turn over frequency) and water quality. This has included a PhD thesis under my supervision[14] and 4 co-authored scientific papers from this thesis, as well as mine-commissioned reports from US consultants. This modelling has informed mine rehabilitation plans, particularly as they relate to minimising exposed sulfide mineralisation in the pit walls, optimising water quality and future use of the pit lake.

35. As demonstrated in Waihi, the short and long term water quality of these lakes requires considerable detailed assessment. I am very concerned that this has not been undertaken for the Project's pit lakes. In my opinion it is essential that the full implications of poor pit lake water quality after lake filling ***and*** the likely further degradation due to ongoing pit wall runoff, lake stratification and turnover, are adequately assessed for both pit lakes before any decision on the Project is made.

Fluids escaping capture and treatment

36. Three ELFs are proposed to permanently store overburden waste rock and to encapsulate mineralised waste rock: The Shepherds ELF to buttress the TSF in Shepherds Creek, the SRX ELF beside the SRX pit in the Rise and Shine Creek catchment and the Western ELF beside the CIT pit in the Clearwater Creek catchment.

[14] Castendyk (2005). An Interdisciplinary Approach to the Prediction of Pit Lake Water Quality, Martha Mine Pit Lake, NZ. PhD thesis, University of Auckland.

37. ELF construction is designed to minimise oxygen access to encapsulated waste and to minimise vertical water percolation through the landform[15]. A percolation as low as 20% of annual precipitation is deemed to be achievable, once the ELF is covered[16]. This is based on net percolation measured at Macraes mine, and has been used in all water quality and water balance modelling. However, this may well be an underestimate of percolation, as predictions of 30-50% of annual rainfall are also made. This potential underestimation of percolation, and its implications for predictions of mine impacted water composition, is also noted in a review of the Project undertaken for Otago Regional Council[17]

38. For the Shepherds ELF and TSF, percolation is anticipated to be captured by underdrainage lying in a layer of moderately weathered (non-acid forming) coarse rock at the base of the ELF and TSF[18,19]. The TSF, and part of the ELF, lie within the Shepherds Creek gully where there is a direct hydrological connection with shallow groundwater. Although three zones of low permeability compacted rock appear to be proposed as a basal layer for TSF construction in the overview report[20], these zones do not appear to be mentioned in supporting technical documents. The proposed sparse underdrainage[21] would capture no more than a fraction of percolation, unless there is an impermeable layer laid beneath it. There needs to be an explicit requirement for an impermeable liner or, at the very least, a very low permeability compacted clay layer, beneath the Shepherds ELF and TSF.

39. An underdrainage seepage collection system is also proposed for the Western ELF, but not for the collection of CIT ELF or SRX ELF seepage. For all of the ELFs, seepage is anticipated to collect at a sump at the toe of the ELF, to be recirculated as process water or directed for treatment as appropriate. There is no plan to place an impermeable liner beneath any of these ELF structures so, again, only a portion of the seepage will be collected.

40. Nor are liners proposed for temporary waste rock or arsenic-rich topsoil stockpiles on the site. Again, this will allow seepage to percolate through the underlying rock and potentially into the shallow groundwater system.

41. Geochemical predictions of seepage quality from ELFs and from the waste rock used to backfill the CIT pit, indicate elevated concentrations of arsenic and iron in

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[15] B.06 - Appendix J: Engineered Landform Design Philosophy.
[16] B.06 - Appendix K: Net Percolation Assessment.
[17] E3 Scientific (2026) Technical Review of Surface Water Modelling, Groundwater and Geochemistry for the Fast-Track Bendigo Ophir Mine. Report for Otago Regional Council.
[18] B.06 - Appendix J: Engineered Landform Design Philosophy.
[19] K.05 - BOGP MWSF Seepage Risk Assessment.
[20] A.10 - Section 3: Project Description.
[21] G.01 - Water Management Plan (Figure 9).

particular, but also manganese, molybdenum, selenium, antimony, strontium, uranium and zinc[22]. All are above the proposed water quality compliance limits for receiving surface water and/or groundwater systems[23]. Nitrate concentrations are also predicted to be elevated above the proposed water quality limits.

42. Peak PCOC concentrations in the seepage are anticipated to occur around 5-10 years after emplacement of the ELF or backfill, but will remain above the proposed water quality limits for over 100 years for some contaminants, including antimony, molybdenum, strontium, uranium and selenium.

43. *In situ* precipitation of iron oxide, capable of adsorbing arsenic and some of the trace metals, is proposed as a likely mechanism to reduce contaminant concentrations to levels less than those predicted. However, this is in contrast to the reported observations from Macraes, where arsenic and iron concentration have remained high and constant with time[24]. Precipitation of iron oxide requires high levels of oxygen to be present, and this is specifically excluded from the core and base of the ELF, through which seepage passes.

44. TSF seepage composition has been predicted based on seepage from analogous tailings storage at Macraes mine[25]. This indicates that seepage would have high arsenic, iron, nitrate, sulfate and potentially cyanide concentrations, exceeding proposed surface water quality guidelines[26]. Predicted concentrations were less certain, but still higher than proposed water quality guidelines, for other PCOCs identified for the Project site but not apparently reported for Macraes. These include nickel, chromium cobalt, manganese, molybdenum, antimony, selenium, zinc and lead.

45. The composition of seepage from waste rocks stacks was also estimated from those at Macraes mine, which showed highly variable compositions but similar generation of high sulfate and high trace metal seepage.

46. Given the poor quality of seepage predicted to emanate from multiple sites across the Project footprint, the potential for long term contamination of shallow groundwater and downstream surface water receiving environments is high.

47. The likelihood of shallow (aka. alluvial or veneer) groundwater flowing beneath monitoring site SC01, and therefore not being captured in compliance monitoring, is noted in the water management plan[27]. Modelling of the likely

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[22] B.06 - Appendix L: ELF Water Quality Forecast Report.
[23] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.
[24] B.06 - Appendix L: ELF Water Quality Forecast Report.
[25] B.06 - Appendix I: Source Term Definition Report.
[26] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.
[27] G.01 - Water Management Plan.

impacts of contaminants in Shepherd Creek on the Ardgour and potentially Lindis alluvial aquifers[28] notes that there may be multiple plumes of the creek water in the Ardgour aquifer and that there may be significant mixing, but little dilution, of contaminant concentrations. It is also noted that there is not enough information available to model this process with confidence. Contamination of this aquifer therefore appears to be a significant risk.

48. The quality of the groundwater in the Bendigo region is generally good and the aquifers highly utilised for drinking water and irrigation[29]. The movement of seepage with high concentrations of arsenic and other contaminants from the mine site into the local groundwater system would be a major long term problem affecting landowners and businesses who rely on this water source for drinking water, stock water and horticulture and viticulture irrigation.

49. Effective collection and treatment of this seepage is therefore essential. In my opinion the only way to ensure this is to place impermeable liners, or at the very least, low permeability liners, beneath all temporary and permanent waste rock and tailings storage facilities. Given the uncertainties around percolation rates through the waste piles, as well as the poor water quality predicted for the seepage (and the uncertainties in these predictions also), a ‘try it and see’ approach is not an appropriate option here. Liners cannot be retrospectively fitted to large structures such as the TSF and ELFs, when significant loss of seepage is identified. This is not a case for adaptive management.

50. I note that the recently approved proposal for the Waihi North mine extension on the Coromandel Peninsula will include a fully lined new TSF, with a geosynthetic liner at depth and a compacted clay liner near the surface. Waste rock and rock stockpiles will also be placed on heavy gauge geotextile liners or low permeability bases[30]. The Project should be held to the same standards as required for the recently approved Waihi North mine.

Underprediction of arsenic concentrations

51. Arsenic is one of the most common naturally occurring toxins. It is naturally elevated in geothermal systems, some groundwaters and in mineralised rocks, including the gold mineralization in the Otago schists. Well known for its acute toxicity to humans from the many cases of deliberate and accidental poisonings, chronic toxicity is also an issue, characterised by skin lesions and pigmentation changes and neurological effects[31]. It has been identified as a human carcinogen,

[28] K.01 - Post Closure Impacts on the Ardgour Aquifer.
[29] ORC (2023) State and Trends of Rivers, Lakes, and Groundwater in Otago 2017 – 2022.
[30] https://www.waihinorth.info/tailings-storage-3.html.
[31] https://www.who.int/news-room/fact-sheets/detail/arsenic.

prompting the WHO to reduce their recommended drinking water limit from 0.05 mg/L to 0.01 mg/L in 1993.

52. Arsenic in groundwater is a major problem for drinking water supply in many parts of the world. While this does occur in New Zealand, the contamination of rivers, streams and lakes by geothermal arsenic and the extensive use of copper-chrome-arsenate as a soft wood timber preservative have been higher priority issues. Water quality guidelines for arsenic are set to prevent its toxicity to aquatic life as well as its accumulation in plants, crops and soil when present in irrigation water[32]. It can also be challenging to remove from drinking water supplies, requiring comprehensive treatment in order to meet drinking water standards[33] and ANZG stockwater guidelines.

53. Arsenic is arguably the contaminant of greatest concern at the Project site. Arsenic levels in the soil are already greatly elevated by historic mining, exceeding human health and ecological protection guidelines[34]. Arsenic concentrations are high in the ore to be mined and processed on site, as well as in the waste rock and tailings[35]. The movement of arsenic off the site, on dust or in water, during and after mining, is a major concern for the local wine industry.[36]

54. However, in many of the technical reports appended to the geochemical predictions of mine water chemistry report[37], the movement of arsenic off site is not considered a major concern because of its ability to bind strongly to iron oxide surfaces. This is put forward as a reason why the arsenic concentrations predicted in mine impacted waters would actually be lower than had been indicated in experimental leach testing or during modelling.

55. In column leach testing of tailings, for example, arsenic proved to be highly leachable, achieving concentrations of 5-6 mg/L in the leachate, and appeared unlikely to decrease with time[38]. However, in the water load balance model, the source term for TSF seepage includes an arsenic concentration of only 2.05mg/L[39,40]. Similar arsenic reductions are assumed for mine waters impacted by ELF runoff, haul roads and hardstand areas, where arsenic adsorption on iron

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32 ANZG, 2018. Australian and New Zealand guidelines for fresh and marine water quality. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default
33 NZ Drinking Water Standards https://www.legislation.govt.nz/secondary-legislation/pco-drafted/2022/168/en/latest/#LMS698021
34 G.20 - Soil Management Plan.
35 B.06 - Appendix F: Geoenvironmental Hazards Factual Report.
36 WWLA (2026) Proposed Bendigo-Ophir Mine Environmental Effects Review: Arsenic. Draft report for the Central Otago Winegrowers Association.
37 B.06 - Mine Impacted Water Overview Report (MWM, 2025).
38 B.06 - Appendix H: Factual Report - Column Leach Test.
39 B.06 - Appendix N: Water Load Balance Model Report.
40 B.06 - Appendix I: Source Term Definition Report.

oxide is assumed to reduce arsenic to below detectable levels. By contrast, static leach testing had indicated the soil runoff may have up to 0.33 mg/L arsenic, and ore and waste rock runoff up to 1.0 mg/L[41].

56. The Project site is already an arsenic-rich landscape with the existing state posing a risk to human and ecological health[42]. This can only be exacerbated by the massive ground disturbance that mining will require. It is critical that the risk of arsenic transfer into the wider environment via surface water and groundwater pathways is properly and realistically assessed.

57. Proceeding on the assumption that this risk will be lower because arsenic adorbs to iron oxide is not realistic. Arsenic adsorption requires abundant fresh iron oxide surfaces to be available and is favoured by highly oxidising and more acidic pH conditions[43]. These conditions are not predicted to exist in the seepage systems of the TSF and ELF features.

58. Even the assumption that dissolved arsenic will be removed during ore processing as a co-precipitate with an oxidised form of iron, that will be a “long term stable form that is stored in the TSF”[44] is unlikely to be correct. The tailings pile is a not an oxidising environment - it is referred to as “sub oxic” at best and is likely to be fully deoxygenated at its base. Neither oxidised iron nor the arsenic bound to it are expected to be stable in this environment. Instead, the dissolution of the iron oxide will release arsenic into the TSF seepage.

59. Also, geochemical models, such as the PHREEQC model used in the derivation of some of the source terms for the water balance model[45], typically greatly overestimate arsenic adsorption and co-precipitation with iron in natural systems where oxide surface are not freshly formed and there is competition for adsorption sites from other ions[46].

60. Proposed management of the existing arsenic-rich soils entails stockpiling them until they can be replaced as topsoil in areas previously known to be high in arsenic due to historic mining operations[47]. Such stockpiles are not only vulnerable to arsenic leaching via seepage and runoff or erosion into nearby drainage systems during storm events, but also to fine soil / dust dispersal by wind. Proposed soil stockpile management to prevent arsenic (and cadmium) dispersal extends only to dampening the pile and establishing a vegetative cover

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[41] B.06 - Appendix G: SPLP and SEM EDS Analysis.
[42] A.09A - Section 2. Existing Environment.
[43] Dzombak & Morel (1990) Surface Complexation Modelling hydrous Ferric oxide. John Wiley & Sons.
[44] A.10 Section 3: Project Description.
[45] B.06 - Appendix I: Source Terms Definition Report.
[46] Webster-Brown & Lane (2005) Modelling seasonal arsenic behaviour in the Waikato River, NZ. Advances in Arsenic Research, American Chemical Society Symposium Series 915.
[47] G.20 - Soil Management Plan.

(to prevent dust emission), and directing stockpile drainage to dedicated sediment ponds. The latter would only be effective if the stockpile is lined and incorporates an underdrainage collection system, and the sediment pond has sufficient storage capacity to handle large rainfall events.

61. After closure, the plan to replace the arsenic- and cadmium-rich topsoils onto the areas from which they had been removed negates a potential environmental benefit of mining this site. The option of improving surface soil quality by encapsulating these soils in (lined) ELFs or including them in pit lake backfill does not appear to have been considered.

62. In summary, in my opinion there is a major risk of significant arsenic emission from the proposed mining operation into the wider environment, via surface water, shallow groundwater and even wind. I consider this has been significantly downplayed in the application documents, often obscured by a wealth of other geochemical data of lesser consequence. All viable methods to minimise or even avoid such arsenic emissions need to be incorporated into mine design and management plans. Compliance water quality monitoring needs to include total arsenic concentrations being transported off site, as well as dissolved arsenic (this is further discussed in my evidence under "Modelling / monitoring only for dissolved metals").

Reliance on Passive Treatment Post-Closure

63. It is proposed to build and operate a water treatment plant (WTP) to treat all collected mine impacted water generated from the site after the mining operation ceases. This is anticipated to continue operating through the "Active Closure" phase of the mine. The WTP would be designed to remove trace metals by hydroxide / oxide precipitation, remove sulfate via mineral precipitation, destroy residual cyanide in the TSF seepage (which is expected to dominate mine impacted water volumes for first 5 years) and remove nitrate via a biological process[48].

64. I have no doubt that a water treatment plant could be designed to achieve effective removal of PCOC's in the collected mine impacted water from this site, although I note that nitrate removal is always difficult and usually expensive.

65. The WTP plant is anticipated to operate for 20 years, possibly up to 50 years after mine closure, depending on how waste flows and quality change with time, and how ELF cover systems perform. Thereafter, a complete transition to passive (constructed wetland) treatment of the predicted 25 L/s waste stream from the

[48] B.06 - Appendix M: Water Treatment study.

site would be made[49]. I consider that reliance on passive treatment in the longer term "Post Closure" phase poses a significant environmental risk.

66. The application anticipates that a passive treatment system, which includes both oxidation and reduction stages, can achieve efficient removal of all PCOC, based on their predicted average concentrations in the collected waste streams[50]. While there are many examples of passive treatment systems for mine drainage around the world (e.g., Wales), these are typically for treating legacy mine discharges, have varying degrees of success and require regular maintenance. When dealing with mine waste and toxic contaminants, passive treatment can be problematic.

67. For example, at the former Golden Cross mine site at Waitekauri on the Coromandel Peninsula, the use of a passive treatment system to treat ongoing seepage and runoff for the site has yet to be successful. The mine closed in 1998 after only 7 years of operation, and the restoration and rehabilitation work undertaken at the mine site was widely considered world-leading at that time. I have personal experience of this site having worked for Environment Waikato on closure consents and reviewing post-closure monitoring data, as well as leading university field trips to the site to monitor restoration progress until 2008, and supervising a Masters thesis project[51] on the passive treatment system they put in place.

68. In brief, several different designs for passive treatment were tried at Golden Cross but none were able to consistently achieve sufficient contaminant removal to allow site discharge to the Waitekauri River. The water treatment plant that operated throughout the mine's life remains active to this day, being maintained and operated nearly 30 years after the mine closed. There appears to be no solution in sight for Coeur Gold NZ, who operated the mine. Unexpected developments have included an emission of hydrogen sulfide gas, from a bioreactor in the passive treatment train, making its way down the Waitekauri Valley, killing fish and worrying residents.

69. Finally, a common misperception about passive treatment systems is that they can be put in place and left to operate on their own. For systems treating mine waste in particular this is not the case, as toxic metals build up in the sediments and plants over time[52]. These need to be removed and the system replanted at regular intervals for as long as contaminated water continues to emanate from the mine site. I note that the fate of contaminated sludge and sediment from

[49] B.06 - Appendix I: Source Term Definition Report.
[50] B.06 - Appendix M: Water Treatment study.
[51] Whelan (2007). Plants for constructed mine wetlands in NZ: A Case Study at Golden Cross. University of Auckland MSc thesis.
[52] Chague-Goff (2005) Metal accumulation and speciation in the sediments of constructed treatment wetlands. In *Metal Contaminants in New Zealand.* Resolutionnz Press.

both the active WTP and passive treatment system proposed for the Project is yet to be decided[53].

70. In my opinion, alternative options to passive treatment in the Post Closure phase need to be identified and their feasibility assessed. It also needs to be made clear who would take responsibility for maintaining the treatment system and finding alternative methods for mine impacted water treatment if the passive system does not perform effectively.

Modelling / monitoring only for dissolved metals

71. In surface freshwater systems, trace metals are transported in both dissolved and solid forms[54]. In solid form, trace metals are bound (adsorbed) onto suspended sediments and plants or biota and, in oxygenated freshwaters, this can be the predominant form for readily adsorbed metals such as lead, copper and arsenic. Downstream of metal-enriched areas, such as mine sites, the load of trace metals transported as solids can be high[55], leading to sediment contamination when the suspended solids settle out in pools, lakes or estuaries. While in solid form, trace metals are not usually directly toxic to aquatic life. However, contaminated sediment can act as a reservoir for further contamination, releasing dissolved metals when pH or oxygen conditions change (e.g., in the bottom of lakes or in wetlands). They can also adversely impact biota living in porewaters within the sediment.

72. It is standard water quality sampling practice to filter water samples for the determination of dissolved (or 'soluble') metals and to use unfiltered samples for the determination of 'total' metals[56]. The distinction is arbitrarily set as a 0.45 micron filter, so suspended solids are defined as being greater than 0.45 micron in size.

73. The application's baseline water quality survey of the catchment creeks and groundwater[57] determined both dissolved and total metals in all samples. However, only dissolved constituents appear to be used in the predictions of mine impacted water quality[58].

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[53] G.01 - Water Management Plan.
[54] Webster-Brown (2005) A review of trace metal transport and attenuation in surface waters. In *Metal Contaminants in New Zealand.* Resolutionnz Press.
[55] Webster-Brown & Craw (2005) Examples of trace metal mobility around historic and modern mines. In *Metal Contaminants in New Zealand.* Resolutionnz Press.
[56] NEMS (2019) National Environmental Monitoring Standards: Sampling, Measuring, Processing and Archiving of Discrete Water Quality Data.
[57] B.06 - Appendix D: Baseline Water Quality Report.
[58] B.06 - Mine Impacted Water Overview Report and appendices.

74. The baseline water quality report [59] includes appended laboratory reports for the water quality analytical data, which show that the transport of trace elements on suspended solids is likely to be important at this site. For example, in the Rise and Shine catchment waters the proportion of arsenic transported on the suspended solids typically ranges from 40-60% of the total amount of arsenic in the water. This provides a reasonable indication of how any further arsenic added to these waters, as a consequence of mining, would also be carried.

75. Trace metal transport on suspended solids is particularly important during high rainfall events when suspended solid concentration are high. Baseline water quality data for site RS1, for example, showed a total arsenic concentration of 5 mg/L during one such event, over 99% of which was bound to the abundant (1200mg/L) suspended sediments. The applicant is proposing to allow sediment retention ponds that collect and hold mine impacted water, to spill over into clean water diversion channels in Shepherds Creek during high rainfall events[60]. This is when settlement ponds get overwhelmed and are least effective. It is also when trace metal binding to suspended sediment would be at a maximum, and a large discharge of trace metal would occur.

76. However, predictions of trace metal and arsenic concentrations in mine impacted waters during and after operation seem to refer only to dissolved concentrations. Analytical data for static and column leach tests are only given for dissolved concentrations[61,62]. Source terms[63] appear to have accounted only for dissolved metals, although not explicitly stated, as this is what the conservative trace metal modelling approach used for the water load balance model[64] required. It also enabled comparisons to be made with the proposed compliance monitoring water quality limits which are only for dissolved trace metal concentrations[65] (discussed in the next section).

77. In summary, the predictions made for the composition of mine impacted waters for the Project do not include trace metals being transported on suspended sediment. This represents a significant omission for those trace metals that bind strongly to suspended sediment. Contaminants moving off site in this form will go undetected in compliance water quality monitoring which focusses on dissolved constituents only.

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[59] B.06 - Appendix D: Baseline Water Quality Report.
[60] A.10 - Section 3: Project Description.
[61] B.06 - Appendix H: Factual Report: Column Leach Tests.
[62] B.06 - Appendix G: SPLP and SEM EDS analysis.
[63] B.06 - Appendix I: Source Term Definition Report.
[64] B.06 - Appendix N: Water Load Balance Model Report.
[65] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.

Water quality limits and compliance monitoring deficiencies

78. Water quality compliance limits are proposed to be applied at two surface water monitoring sites (SC01 in the Shepherds Creek catchment and RS03 in the Rise and Shine / Clearwater catchment) and at a single groundwater well (MW101)[66,67]. I note that during the operational phase, monitoring of the base bore for drinking water supply to the mine site would also be undertaken.

79. For surface water, the proposed water quality limits are based on the ANZG water quality trigger values for a 90% level of protection, typically applied to an ecosystem which is more than "moderately disturbed"[68]. For those PCOC for which ANZG has not provided guidance, other guidelines (e.g., Canadian) or evidence is cited in support of the value proposed.

80. The proposed level of protection is lower than the 95% level recommended by ANZG, to be applied to a "slightly-moderately disturbed ecosystem", which is the level more commonly applied in New Zealand. Using a 90% level of protection would only allow the state of surface water ecosystems to degrade further, as a consequence of mining activity; there is little potential for improvement. This point is also raised in Kathryn McArthur's review of the Project for the NZ Fish and Game Council[69].

81. There are a number of contaminants that are likely to be elevated in mine impacted water, that currently lack water quality limits proposed for surface water. These include iron and sulfide, for which I would argue compliance water quality limits do need to be proposed. Iron compliance limits are usually set downstream of mining activity to prevent the formation of iron oxide solids, which can coat stream sediments and impact on macroinvertebrates and fish. In the absence of an ANZG recommendation, direction could be taken from other mining consent conditions. Hydrogen sulfide can be generated during anaerobic processes (as are proposed for the passive treatment system), and dissolved sulfide is highly toxic to aquatic organisms including fish. ANZG does recommend a trigger value for dissolved hydrogen sulphide.

82. There are trace metals that can bioaccumulate in the food chain, even when barely detectable in surface water. Mercury and selenium are two such metals. While these metals may have been below the detection limits used in water analysis and experimental leaching studies, they are reported to be present in the site's mineralised rock[70]. There are ANZG recommended trigger values for these

[66] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.
[67] G.01 - Water Management Plan.
[68] ANZG (2018) Australian and New Zealand guidelines for fresh and marine water quality. ANZECC.
[69] McArthur (2026) Review of Bendigo-Ophir Gold Project FTAA on behalf of NZ Fish & Game Council.
[70] B.06 - Appendix F: Geoenvironmental Hazards Factual report.

metals, which should be included in the proposed compliance surface water quality limits. I note that periodic measurement of their levels in sediments and fish is an approach which has been taken for the Waihi mines.

83. The proposed compliance limits refer to dissolved concentrations for all trace metals other than antimony. If total concentrations are not monitored during compliance testing, trace metals bound to suspended sediment will escape detection. There will be no information gathered on the total load of trace metal being discharged from the mine site.

84. The generally recommended approach in water quality assessment is for total recoverable trace metal concentrations to be compared to water quality limits (or trigger values) in the first instance[71]. If the limit is exceeded, then the dissolved portion is checked against the limit. If this is exceeded, then further analysis and speciation modelling can be undertaken to establish the toxic fraction of the trace metal present. Important information about the toxicity and potential fate of a critical contaminant is gained at each step of this process.

85. The Project's impacts on sediment quality in downstream waterways and potentially in Lake Dunstan, does not appear to have been considered. As noted previously in this evidence, sediment contamination is likely if metals bound to suspended sediment are not controlled in a discharge. There are no sediment quality guidelines referred to in the Project application and, as noted above, the only surface water quality limits proposed for trace metals are for dissolved constituents.

86. For groundwater, proposed water quality limits[72,73] are based on New Zealand's drinking water standards and on draft livestock drinking water guidelines published by ANZG[74], as befits two of the principal uses of this aquifer. However, I note that irrigation water quality limits do not appear to have been considered, despite the extensive use of groundwater for irrigation in this area; a point also noted in the Project review undertaken for Otago Regional Council[75]. ANZG provide draft default guideline values for irrigation water and these include limits for boron (noted to be elevated in column leach tests of tailings[76]), mercury and selenium. None of these contaminants are currently included as proposed compliance groundwater quality limits. There are also ANZG default guidelines for

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[71] ANZECC & ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
[72] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.
[73] G.01 - Water Management Plan.
[74] ANZG (2018) Australian and New Zealand guidelines for fresh and marine water quality. ANZECC.
[75] E3 Scientific (2026) Technical Review of Surface Water Modelling, Groundwater and Geochemistry for the Fast-Track Bendigo Ophir Mine. Report for Otago Regional Council.
[76] B.06 - Appendix H: Factual Report - Column Leach Test.

copper, iron, manganese, cobalt and uranium in irrigation water that are lower than those proposed for the Project's groundwater quality compliance limits[77].

87. I am concerned that only one compliance well is proposed. Given the level of uncertainty regarding how any contamination plumes from Shepherds Creek would interact with the Ardgour aquifer[78], and their direction of travel, I would have expected more comprehensive groundwater compliance monitoring, with a greater ability to detect contamination plumes, particularly in shallow groundwater.

88. The report recommending water quality compliance limits for the Project does not include guidance on how monitoring data should be compared to compliance limits for most of the trace metals. For example, monitoring frequency and the values that should be used (e.g., mean, maximum, 95th percentile or alternative) are not recommended. This will need to be proposed and, if approved, specified in the consent conditions.

89. In summary, while it is good to see rational compliance water quality limits being developed, there is further development required. Currently their use would not prevent contaminants, particularly arsenic, moving off the Project site while bound to suspended solids - a process which will peak during storm events. Their use would not prevent the contamination of downstream stream and possibly lake sediments. They are also somewhat incomplete in their coverage of key contaminants, in light of the potential impacts on ecosystems and water uses down catchment from the mine site. Further details of how the compliance water quality limits would be applied, monitoring programme design and contingency plans in the event that they are exceeded, are needed.

Conclusion - Too many uncertainties

90. While some of the technical information provided for this application is robust, particularly for the geochemical testing and parts of the water modelling, there are too many sources of uncertainty in the predictions of site water quality and its effects on downstream environments. For example, there are major uncertainties in percolation rates (generating mine impacted seepage), the effectiveness of seepage collection systems, the ability of compliance modelling to detect mine impacted water moving off site, the mobility of arsenic, the long term evolution of pit lake quality and the effectiveness of a passive treatment system to provide long term treatment of water emanating from the site.

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[77] B.07 - Recommended Water Quality Compliance Limits for the Bendigo-Ophir Project.
[78] K.01 - Post Closure Impacts on the Ardgour Aquifer.

91. There are also major deficiencies in design specifications and management plans that need to be addressed. Optimistic assumptions about how water would behave at the site abound. The assumption that all seepage through waste rock, topsoil and tailing storage areas will be collected without the use of impermeable or low permeability liners is one such assumption. For compliance monitoring it is assumed that trace metals would leave the site only in dissolved form. This is patently untrue and neglects to account for trace metals bound to suspended sediment moving off the site, particularly during heavy rain events, and the impact this would have on downstream water and sediment quality.

92. Assurances are made that performance monitoring would be used to reduce the uncertainties in the water quality and quantity predictions, once the mine is operating. An adaptive management approach would then be taken. Apart from the fact that the exact nature of the performance monitoring is unclear (different recommendations for this are provided throughout the documents), adaptive management cannot address all problems. Liners cannot be retrospectively fitted to existing TSF and ELF structures, for example. Contamination of groundwater cannot be reversed.

93. Cumulatively, the uncertainties and assumptions being made in the application greatly erode my confidence that the proposed mine could operate in this catchment without leaving a legacy of contaminated surface and groundwater for the community to live with.

List of outstanding questions

94. As a result of my review of the application documents, I have the following outstanding questions. These questions are in addition to the list of questions posed by the Panel in its 1 April 2026 request for further information. I consider these matters to be of critical importance to understanding the Project’s material adverse impacts on freshwater receiving environments. Without full clarity on the matters addressed in the questions, I do not consider that the Project’s impacts can be fully assessed and understood.

    a. Has any assessment of the effect of pit lake stratification and seasonal lake turnover on lake water quality been undertaken? If so, how is this likely to affect the predictions of trace metal, sulfate and nitrate concentration change with time after lake filling?

    b. Can some clarity be provided on whether source term definition and modelling is based on dissolved or total trace metal data? This includes the data cited and used from the Macraes mine.

c. What is the reason why liners are not proposed to prevent seepage from the ELFs, TSF and waste rock and topsoil piles, into the ground and into the shallow groundwater?

d. Can water load balance modelling be undertaken for a likely range of contaminant concentrations, to augment the modelling based only on mean concentrations?

e. What is the contingency plan, if the passive treatment system fails to collect and treat the mine impacted water adequately? Also, who would take responsibility for long term maintenance of the passive treatment system and assessment of its performance?

f. Can further details of how compliance monitoring would be undertaken, and how analytical data would be used to assess compliance, be provided?

g. Has the possibility of a legacy of poor water quality in this catchment been raised in consultation with the community? If so, are they aware of the implications for the use and enjoyment of this catchment, and for local farms and businesses reliant on clean groundwater and customer perceptions of products coming from a 'clean green' environment.