Tailings aspects of Fingerboards Environment Effects Statement, Glenaladale, Victoria: Expert witness statement

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Table of contents

Review of tailings aspects of Fingerboards Environment Effects Statement, Glenaladale, Victoria: Expert witness statement

1. This document presents the findings of my review of tailings aspects of the Fingerboards Environmental Effects Statement. It was limited by time and resource constraints. I consider that four aspects of the Fingerboards Environmental Effects Statement warrant further consideration. These are: i) the potential chemical hazards to human and environmental health presented by tailings to be generated at the proposed Fingerboards mine were not adequately assessed; ii) the hazard presented by flocculants that are to be used for the treatment of tailings at the proposed Fingerboards mine was not assessed; iii) the potential connectivity of the proposed tailings storage facility and mining void with shallow groundwater at the Site does not appear to have been adequately assessed; and iv) the National Environmental Protection (Assessment of Site Contamination) Measures 1999 and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) guidelines were inappropriately used to assess the potential risks presented to human health and the environment by contaminants released from the tailings to be generated at the proposed Fingerboards mine.

A. Acknowledgement of expert witness code of conduct

2. I have read Planning Panels Victoria (PPV) Guide to Expert Evidence and agree to be bound by it;

3. I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel

B. Qualifications

4. I am an environmental chemist — that is, my area of expertise is focused on understanding the fate and behaviour of chemicals in the environment, be these naturally occurring salts formed through the decomposition of rock; nutrients applied to land as means of stimulating agricultural yield; or pollutants

generated through human activity. I am particularly focused on the interactions of chemicals with soil and water, including both rivers and groundwater.

5. My expertise has been developed over more than a decade of consulting and research, within both universities and the private sector. I majored in Ecology during my undergraduate science degree at the University of Otago, where the fundamentals of soil science, climatology, hydrology, zoology, botany, chemistry, and statistics were laid down. During my third year of study at the University of Uppsala, in Sweden, I further specialised in the study of limnology — that is, inland water systems — and wrote my first thesis on the contamination of a lake within the confines of a Scania truck factory. I moved to Australia to complete my honours degree at the University of Canberra, where I investigated ecosystem impacts of pollution within a coal-power plant cooling reservoir and wrote my second thesis. My training progressed to understanding how chemicals behave in soil and groundwater systems within my PhD, undertaken at the Australian National University. My third thesis was completed for this PhD and outlines the origin of salinity in the Hunter Valley, New South Wales. All my theses involved extensive field work and an understanding of chemical movement in an applied context — that is, using data collected at the location of interest rather than from, for example, a laboratory or computer models.

6. After graduating with my PhD, I worked as a contaminated lands consultant, collecting field data on soil and groundwater pollution driven by improper waste disposal, leaking underground storage tanks at petroleum depots and service stations, and agriculture. I have written a number of reports and supported Site Auditors in assessing the integrity of other consultants' findings. I held this role for almost two years before starting Murrang Earth Sciences in 2013.

7. I have worked to assess the contamination status of drillers mud — a term that describes various types of muds (with or without additives) generated through the use of high-powered water to drill holes non-destructively — on numerous occasions as part of my work at Murrang Earth Sciences over the last seven years. I have also worked on almost all aspects of chemical contamination, from the assessment of a chemical's effectiveness as a pesticide (i.e. efficacy) to the assessment of the hazards and risks associated with a chemical's use in a field context, the assessment of contamination at sites after chemicals have been used, the remediation of sites found to be contaminated by chemicals, and the assessment of the potential to reuse wastes that contain potentially hazardous chemicals.

8. I continue to conduct research at Murrang Earth Sciences, collaborating with CSIRO researchers on projects ranging from transport of nutrients to crops to seawater intrusion into coastal aquifers and soils; and

researchers at the Australian National University on subjects including the transport of pollutants by dust and the impact of pesticides on soil microbes.

C. Conflicts of interest

9. Dr Laura-Lee Innes, an employee of Murrang Earth Sciences and therefore my colleague, is being engaged by EPA Victoria to provide an expert witness statement with regards to the radiation aspects of the Fingerboards Environment Effects Statement (the Fingerboards EES). I have in no way discussed any part of my finding presented herein with Laura-lee, and she has not discussed any part of her findings.

10. This Expert witness statement was peer-reviewed by Dr Kyle Horner, Principal Hydrogeologist of LOMAH Water Solutions. The peer review was undertaken to ensure the rigour of the statements presented herein. All opinions presented, however, are my own.

D. Instructions

11. Provision of expert opinion regarding the tailings aspects of the Fingerboards Mineral Sands Project Environmental Effects Statement (EES) August 2020 was sought from Murrang Earth Sciences by Environmental Justice Australia on behalf of Members of Submitter No. 813. I have undertaken this review work on behalf of Murrang Earth Sciences, given my skills and expertise are most suited to this role.

12. Instructions on how to proceed were received by Murrang Earth Sciences from Environmental Justice Australia. I was instructed as follows (Attachment 2):

We request that you undertake a review of the tailings management components of the EES and prepare an expert witness statement providing your opinion on:
The compliance of the tailings management components of the EES (listed below) with the relevant evaluation objective in the Scoping Requirements (Tab 1.1):
Technical Studies
i. Landform, Geology and Soil Investigation (Technical Study, Appendix 1) (as relevant to tailings) (Tab 2.3.1)
ii. Geochemistry and Mineralogy (Technical Study, Appendix 2) (Tab 2.3.2)
iii. Geotechnical Assessment (Technical Study, Appendix 3) (Tab 2.3.3)
iv. Groundwater and Surface water Impact Assessment (Technical Study, Appendix 6) (Tab 2.3.4)
v. Tailings Management Strategy (Technical Study, Appendices 23) (Tab 2.3.5)
Chapters and Attachments
i. Draft Work Plan (Attachment B) (Sections 5.6 and 8.5) (Tab 2.2.1)
ii. Risk Report (Attachment F) (Tab 2.2.2)
iii. Mitigation Register (Attachment H) (Tab 2.2.3)
iv. Water Independent Peer Review Report and Proponent Response (Attachment I) (Tab 2.2.4)

b. *The adequacy of the baseline data collected by the project proponent to confidently describe pre-development conditions (as relevant to tailings management).*

c. *The appropriateness of the methods used to identify and evaluate the effects of the project (as relevant to tailings management).*

d. *Whether the actual or likely risks are identified and or appropriately assessed in terms of their level of risk.*

e. *The adequacy of the proposed design and mitigation measures relating to the management of tailings.*

f. *Any other matters you identify which you consider relevant within the limits of your expertise.*

g. *Any appropriate qualifications or conditions that should be attached to findings or conclusions, such as uncertainties or gravity of threats or impacts.*

2. As an expert you are able to consider any such material you consider relevant to your enquiry. Please identify in your report any further materials you consult outside of the briefed materials.

13. This Expert Witness Statement is, for the most part, based on information contained in the Fingerboards EES' technical reports that related to tailings. Specifically, Attachments F, H, and I; and Appendices A001, A002, A003, A006, and A0023 were considered. I also drew information from Attachment B, noting that a review of contents relating to radiation, engineering, and geotechnical aspects of tailings are outside my expertise and no comment in relation to these aspects is presented herein. Only limited comment in relation to regulatory science is presented. I sought further information from relevant sources such as government organisations (e.g. Bureau of Meteorology) or textbooks where I considered such information necessary to support my views. References are cited in the text and presented as footnotes on the relevant pages for ease of use. Information was also attained from an online discussion held with Submitter No. 813 on the 21 of October 2020. This information pertained to geographical features of the Site, such as dams and landform. Written confirmation of the points raised in relation to dams and landform was sought from Submitter No. 813 and is presented in Attachment 1. No site visits were conducted by me as part of my scope of works to undertaken this Expert witness statement.

14. I wrote a separate report to that presented herein for Environmental Justice Australia and on behalf of Submitter No. 813, entitled "*Review of tailings aspects of Fingerboards Environment Effects Statement, Glenaladale, Victoria: Draft expert opinion report (draft)*" and dated 16 October 2020 (the draft expert opinion report). The draft expert opinion report was undertaken to assess whether aspects of the Fingerboards EES relating to tailings warranted further scrutiny. The expert witness statement presented herein is separate to the draft expert opinion report and was undertaken as I considered that aspects of the Fingerboards EES indeed warranted further scrutiny.

E. Findings

E.1 Chemical hazards presented by tailings

15. I consider that the potential chemical hazards[1] to human health and the environment presented by tailings to be generated at the proposed Fingerboards mine were not adequately assessed in the Fingerboards documents I reviewed (outlined in Point 13) for the purposes of this Expert witness statement. The method by which hazards at sites contaminated by industrial activities, including mining activities, should be assessed are outlined in Australia's national contamination guidelines — that is, the National Environment Protection (Assessment of Site Contamination) Measures 1999 (ASC NEPM).

16. The ASC NEPM does not apply to the prevention of site contamination but is relevant for the evaluation of potential contamination at the proposed Fingerboards mine. The ASC NEPM states the following with regards to prevention of site contamination (Schedule B2, Section 1.2):

The National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) does not provide guidance on prevention of site contamination. Owners and occupiers of sites on which potentially contaminating activities are occurring are subject to the environmental protection legislation applying in each jurisdiction. Legislation provides for appropriate controls on potentially contaminating sources, including licensing of industrial activities, to minimise emissions and its application is the principal strategy for prevention of soil and groundwater contamination.

17. I have received advice from Murrang Earth Sciences' Regulatory Scientist Dr Jess Drake that the ASC NEPM will, however, apply for assessing contamination at the proposed Fingerboards mine at the time the mining licence is relinquished. This is regulated through Victoria's Environmental Protection Act (1970) — soon to be the Environment Protection Act 2018 — and the State Environment Protection Policy [Prevention and Management of Contaminated Land (2002)]. I consider this to be appropriate basis for use of the ASC NEPM to assess potential chemical hazards at the proposed Fingerboards mine.

18. Based on my review of documents outlined in Point 13, I consider that the chemical hazards presented by the fine tailings proposed to be generated at the Fingerboards Site were not accurately identified in the Fingerboards EES, nor were they considered in a way that falls within the parameters set out in the

[1] Although commonly mixed, the difference between the terms hazard and risk is important in the assessment of contamination and in the context of this section. Hazards are phenomena that have the potential to cause harm, while the probability a given hazard will cause harm is termed risk.

ASC NEPM. The framework for undertaking a preliminary assessment of site contamination is presented in Schedule B2 (Section 2.1) of the ASC NEPM as follows*:*

The preliminary investigation should be sufficient to:
• identify potential sources of contamination and determine potential contaminants of concern
• identify areas of potential contamination
• identify potential human and ecological receptors
• identify potentially affected media (soil, sediment, groundwater, surface water, indoor and ambient air).

Key steps in assessing the impact of contamination are therefore identifying what the sources of contamination are. In the case of the proposed Fingerboards mine this means the chemicals that might occur at the Site as a result of the proposed mining process, where within a site these will occur, and what organisms and parts of the ecosystem, including humans, dwellings, and playgrounds, might be affected (i.e. the receptors). The text in the remainder of Section E.1. will follow this framework and will identify what chemical hazards might occur at the Site and the areas in which they might occur. The potential receptors of such contamination are elucidated in Sections E.2 and E.3.

19. The EES states that tailings produced as a result of mineral extraction at the Fingerboards site are to be in two forms. These are the non-economic mineral sands and fine tailings made up of silts and clays (Appendix 006, Section 1.4.5):

Two forms of tailings will be produced from the processing of the ore in the WCP [wet concentrator plant]*: fines tailings from the thickener in the WCP; and the coarser sand fraction from the gravity separators. Both types of tailings are non-economic materials.*

20. Sands are particles of a size between 20 µm (micro-metres) and 2 mm in diameter according to the Australian Soil and Land Survey Field Handbook[2]. These sands can be either individual minerals[3], collections of minerals, or collections of elements and other chemicals[4]. In the case of the proposed Fingerboards mine, economically valuable sands are to be separated from the non-economic sands. EES Appendix A003 (Section 1) states that the economic sands are comprised of zirconium-containing minerals (zircon), titanium-containing minerals (rutile, ilmenite), and rare earth element-containing minerals (monazite, xenotime):

[2] The National Committee on Soil and Terrain. 2009. Australian Soil and Land Survey Handbook. Third edition. Collingwood: CSIRO Publishing.
[3] A collection of elements in an ordered structure.
[4] Elements sometimes occur within rocks and sands in an unordered structure.

The mineral resource estimate for the Fingerboards resource contains 1.19 billion tonnes (Bt) of ore at 0.5% zircon, 1.4% titanium minerals and 0.05% rare-earth minerals. Kalbar plans to produce eight million tonnes (Mt) of magnetic and non-magnetic heavy mineral concentrate (HMC) from 170 Mt of ore for up to 20 years. The mine life includes approximately two years for construction and commissioning and 15 years of production at full capacity (12 Mt/year) followed by closure activities (decommissioning, rehabilitation and post-closure). Final closure may require an additional five years of management.

21. The EES states that the non-economic sands are largely composed of silica, consistent with sands commonly seen on beaches and in soils. The non-economic sands are differentiated from more common silica sands by the presence of the mineral chromite (Appendix A002, Section 5):

The mineralogical analysis [of 59 ore and processing samples from the Fingerboards Project] *determined the following:*

•ZrO2 is found almost exclusively in the mineral zircon;

•TiO2 is found in a variety of titanium-bearing minerals – the most common being ilmenite and rutile;

•The titanium minerals often are intergrown with silica;

•Cr2O3 is found almost exclusively in the mineral chromite;

•The rare-earth elements are found in the minerals monazite and xenotime; and

•SiO2 is predominantly found in the minerals quartz, zircon and intergrown with titanium mineral (Section 5).

22. The non-economic silica and chromite sands represent the majority of the sands which occur in the Fingerboards ore body (Appendix A002, Section 2):

The mineral resource estimate for the Fingerboards resource contains 1.19 Bt of ore at 0.5% zircon, 1.4% titanium minerals and 0.05% rare earths. Kalbar plans to produce eight million tonnes (Mt) of heavy mineral concentrate (HMC) from 170 Mt of ore. The 20-year mine life includes approximately two years for construction and commissioning, 15 years of production at full capacity and decommissioning and rehabilitation activities…

This means that of the 170 Mt of ore to be extracted from the Fingerboards site, 162 Mt of sand tailings are to be produced.

23. Silts and clays are minerals or collections of minerals that behave differently than sands because of their tiny size, ranging from 2 to 20 μm in the case of silts, to less than 2 μm in the case of clays. Silts and clays are referred to as 'fines' due to their fine size. Fines adsorb and desorb other chemicals in far greater quantities relative to sands, retain far more water, and behave very differently (i.e. stockpile and dry

differently to sands). The clays and silt tailings that are to be generated by the proposed Fingerboards project are composed of commonly occurring minerals largely made up of silica (quartz and mica) or aluminium and silica (kaolinite and mica). Rutile silts and clays also occur, with rutile being a titanium oxide mineral that is less common (Appendix A002, Section 5):

The quantitative XRD determined that the minerals present in this fraction [fine tailings] *were:*

Quartz: 47%

Kaolinite: 25%

Mica: 28%

Rutile: 1%

24. Some of the silica in the fines is in a dangerous, respirable form that is known to cause cancer (Appendix A002, Section 5):

The fine tailings samples contained 2.3% quartz as the RCS [respirable crystalline silica] fraction

The EES states that the concentrations of RCS generated from the Fingerboards site are to be within acceptable limits (Appendix A002, Section 5):

The modelling by Katestone (2019) shows that the predicted levels of RCS during mining operations will be well below the maximum level of 3 µg/m^3 required by the Protocol for Environmental Management (Mining and Extractive Industries).

25. Other potentially toxic chemicals also occur within the ore and tailings to be generated at the Fingerboards Site (Appendix A002, Section 6):

The titanium, chromium and vanadium levels in the ore and tailings is higher than in the surrounding regional area topsoil samples…

26. Potentially toxic chemicals such as uranium and thorium also occur in the ore itself (Appendix A002, Appendix D):

With the sample of HMC [heavy metal concentrate]*, the only element in the analytical suite that was significantly enriched (GAI≥3)[Geochemical Abundance Index] compared to the median soil abundance value was thorium (120 mg/kg). There was also minor enrichment (GAI=1) with uranium (9 mg/kg). As HMC is a product of processing that will be shipped to buyers these enrichments are not of environmental consequence for the project. It is also worth noting that the concentrations of thorium and uranium in the tailings and overburden samples were markedly less than in the sample of HMC, and also less than the respective thorium and uranium concentrations in the bulk 10t composite feed used to produce the tailings, which were 81 and 15 mg/kg, respectively.*

27. While thorium and uranium chemicals are to be exported as part of the economic components of the ore, there is potential for these chemicals to be mobilised into tailings water and therefore entrained into the

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fine tailings themselves as part of tailings processing. This was considered by Kalbar and its delegates with the leachability of samples from the Fingerboards assessed (Appendix A002, Appendix D):

> *The ASLP* [Australian Standard Leaching Procedure] *allows for use of different extractant fluids depending on the type of samples. Typically, dilute acetic acid is used when simulating landfill conditions, but deionised water is often more appropriate for mining situations, as the use of deionised water means the extractions occur at the existing pHs of the test samples. Accordingly, the ASLP tests carried out by Envirolab on Fingerboard samples involved deionised water, which provides a more appropriate simulation of rainfall leaching conditions.*

28. I consider the use of rainwater to assess the leachability of potentially toxic chemicals from the ore and tailings to be produced at the Fingerboards site potentially spurious. This is because the ore is to be processed not with rainwater, which has a low salt content[5] and is generally slightly acidic with pH of around 5.5[6], but with groundwater from the Latrobe aquifer. Based on Table 2.14 of Appendix A006, Appendix B, groundwater in the Latrobe aquifer has a pH of 7.6 and a salt content of 506 mg/L. Supplementary water is to be attained from the Mitchell River when required (Appendix A006, Appendix B, Section 1.1.4):

> *Approximately 3 GL of water will be required on an annual basis for processing, dust suppression and rehabilitation. Water for the project will be sourced from surface water (winterfill from the Mitchell River) and groundwater from the Latrobe Group Aquifer (from a proposed borefield within the infrastructure options area).*

29. The chemistry of the groundwater and river water used to process the ore, and not rainwater, will therefore dictate what chemicals are leached from the ore. Such details are critical in understanding the potential for toxic chemicals to be leached from ore, with the acidity of the water and the amount of oxygen (i.e. reduction-oxidation potential) in the processing medium and/or tailings dams key factors influencing whether these metals will dissolve or not. For example[7]:

> *The pH and Eh in groundwater play an important role in controlling uranium mobility. Uranium is easily mobilized under oxidizing conditions, whereas it is immobilized under reducing conditions at a neutral pH [1]. Figure 7 shows some relationships between uranium and radon with respect to pH and Eh. The pH of groundwater ranges from slightly acidic to alkaline. Although the relationship is not clear, uranium concentrations are somewhat related to pH (Figure 7a). At a high pH, formation of uranium–carbonate complexes may accelerate uranium desorption from aquifer materials [26–28], giving rise to an increase in uranium in groundwater*

[5] The salt content of six rainwater samples collected on my behalf from the upper Hunter Valley between 2006 and 2007 had total dissolved solid (a measure of salts) concentrations of between 0.2 and 22 mg/L

[6] Wetzel RG. (2001). Limnology: Lake and River Ecosystems. Third edition. San Diego: Elsevier.

[7] Cho BK and Choo CO. (2019) Geochemical behaviour of uranium and radon in groundwater of Jurassic Granite Area, Icheon, Middle Korea. *Water*, 11, 1278.

30. The use of rainwater within the ASLP experiments conducted on samples collected from the Fingerboards site is also inconsistent with the ASC NEPM. Section 11 of Schedule B3, for example, states the following:

The choice of leaching reagent should be based on the environmental conditions to which the soil or wastes are likely to be exposed — ideally using actual surface and groundwater from the relevant site.
The two most relevant leaching tests for Australian conditions are:

- *Australian standard leaching procedure (ASLP) as per Australian standards 4439.1 (AS4439.1-1999), 4439.2 (AS 4439.2-1997) and 4439.3 (AS 4439.3-1997)*
- *toxicity characteristic leaching procedure (TCLP) as per US EPA method 1311, (US EPA SW846, Method 1311).*

The ASLP allows a wide range of leaching reagents to be used and is generally the most appropriate leach test to cover a range of conditions encountered in contaminated site management in Australia, whether soil is to remain on site or be moved.

31. Based on my understanding of the Fingerboards EES, the contaminants in recovered water to be captured for reuse at the proposed Fingerboards site will increase in concentration as a result of water conservation measures (Attachment F, Section 3; Attachment H, SW23):

Water will be recovered and reused where practicable (such as runoff from ore stockpiles and supernatant water from the temporary TSF and tailings areas within the mine voids) (SW23).

Attachment A006, Section 1.4.7:

The project will reuse water where practicable (such as flood runoff and supernatant water from the TSF and tailings area within the mine void) and will optimise operations to maximise water use efficiency

Attachment B, Section 8.4:

Water runoff management systems for the Fingerboards project have been designed to achieve the following objectives:
…• Capture and reuse water that has been used in ore processing or movement of ore.

…• Water falling directly onto fines tailings cells and coarse sand tailings will be recovered and report to the process water circuit. The process water dam has been designed with sufficient freeboard to accommodate rainfall from a 1% annual exceedance probability (AEP), 72-hour event.

32. I consider that the impact of this reuse on the concentration of contaminants of concern at the Site was not adequately assessed within the Fingerboards EES. Reuse of the recovered water has the potential to expose the environment to chemicals in this water — noting that in my opinion accurate concentrations of chemicals in this leachate have not yet been constrained (Point 15). This reuse will, in addition, create conditions that increase the concentration of these chemicals at the Site via evaporation, in much the same way as dryland salinity is generated at a number of locations within Australia.

33. Evapoconcentration can increase the concentration of a chemical in locations such as the Fingerboards Site, where potential evaporation exceeds precipitation. That is, where relatively low rainfall and relatively high evaporation occurs. The Bureau of Meteorology's records state that rainfall at the weather station "*Mitchell River at Glenaladale (number: 85270*)", approximately 10 km east of the Site, was 425.2 mm in 2019[8]. The Bureau of Meteorology states that annual pan evaporation in the region is 1000 to 1200 mm. This means that recovered water reused at the Site will evaporate to leave non-volatile chemicals such as uranium, thorium, and vanadium behind within the soils. These chemicals can further increase in concentration within the soils via evaporation and transpiration until they are released as pulses of contamination during rainfall events that push them into groundwater. Such pulses may then present a hazard to aquatic ecosystems either within the aquifers in which this groundwater occurs or when this groundwater discharges to aquatic ecosystems at the ground surface.

E.2 Tailings management

34. I consider the use of flocculants for tailings management may present a hazard to the environment associated with the proposed Fingerboards mine. The need to assess the hazard of flocculants was identified in the Fingerboards EES, however, no assessment was undertaken by the proponent beyond committing to the use of these chemicals in accordance with safety data sheets.

35. Dry excavation of the ore at the Fingerboards site will allow for ore to be handled and managed using standard operating equipment such as excavators and trucks (Appendix A006, executive summary):

The mining method is open cut dry mining using conventional earthmoving equipment. The mine will operate 24 hours a day, 365 days a year.

36. The tailings generated will be transported from mining unit plants to a temporary storage area (Appendix 003, Section 2.6):

The ore will be sent to two mining unit plants (MUPs), mixed with water to form a slurry, and pumped to a wet concentrator plant (WCP). At the WCP, the slurry will undergo initial processing to produce HMC [heavy metal concentrate] and non-economic mineral sands tailings. The HMC will then be separated using wet high intensity magnets to produce magnetic and non magnetic concentrates. The concentrates will be exported for further processing in mineral separation plants in Asia into commercial products such as zircon and rutile.

Attachment B, Section 8.5.4:

[8] http://www.bom.gov.au/climate/current/annual/vic/summary.shtml

The tailings are delivered to the off-path TSF from the WCP through HDPE pipes. Tailings deposition takes place in the facility via multiple spigots located on the perimeter embankments of the facility, with spigots located at up to 50 m centres. Spigot points are to be rotated in such a way to maintain a supernatant pool around the decant water collection pumps to facilitate water return to the WCP. The decant pools for the cells are to be located away from the outer embankments. Tailings deposition will be sub aerial.

37. Different methods of dewatering are proposed for the coarse and fine tailings. I have no experience of dewatering of tailings using physical means such as dewatering cyclones and mud farming at the scale within the proposed Fingerboards mine and cannot comment on these approaches as an expert (Attachment B, Section 8.5):

Coarse sand tailings will be dewatered to approximately 65% solids by means of dewatering cyclones and then will be pumped back to the tailings disposal areas in the mine void (and adjacent areas until there is sufficient space within the mine void). An underdrainage system will be provided beneath the in-pit coarse tailings storage. Water collected in the underdrainage system will be returned to the process water circuit.

38. I do have some experience in assessing the potential hazards presented by the flocculants to be used as chemical means of dewatering the fine tailings, however, and my experience is that the potential hazard to the environment is poorly presented in the safety data sheets issued to consumers by the suppliers of these chemicals. This is because the safety data sheets do not describe the chemical with enough detail for one to know how it behaves in the environment, with only trade names provided (Attachment B, Section 8.5):

Fine tailings will be partially dewatered in a thickener by dosing with flocculant (~100 g/t). The thickened fine tailings will be removed from the thickener as underflow. Fines tailings will initially be managed in an on mine path TSF, consisting of four cells, which will be located close to the WCP. 'Mud Farming' or accelerated mechanical consolidation (AMC) will be used to assist with the management of the tailings, maximizing water return to the WCP and to ensure adequate consolidation of the fine tailings to allow future mining through this area, i.e. mechanical relocation of the fine tailings material.

Attachment B, Section 6.8:

The probable flocculants to be used at Fingerboards (eg. Nalco Optimer® 83384 and BASF Magnafloc 5250®) are not acutely toxic to fauna or people and are not expected to bioaccumulate in the environment (Auckland Regional Council, 2004), as is stated in the Safety Data Sheets provided by these companies for these materials.

39. A Google search resulted in polymer sales websites that presented Nalco Opimer 83384[9] and BASF Magnafloc[10] 5250 as polyacrylamides, as are most of the flocculants used to separate liquids from solids in

[9] https://www.zauba.com/import-water-soluble-polymer/hs-code-39069090-hs-code.html
[10] https://www.indiamart.com/proddetail/magnafloc-5250-22450421788.html

industry part of the polyacrylamide chemical family[11]. Publicly available research on the potential environmental hazards presented by polyacrylamides is lacking in my experience[10,12]. I have been called upon to review the potential hazards and risks presented by this group of chemicals on at least two occasions.

40. The research I have conducted found that polyacrylamides can be broken down into smaller, toxic chemicals called acrylamides in low-air environments (i.e. anaerobic) — such as in muds within dams and other forms of sediments — with these chemicals highly mobile and toxic in aquatic environments[11]. In my opinion, further investigation into the potential hazard presented to the aquatic environment from the flocculants to be used at the proposed Fingerboards mine is therefore warranted. I note that further hazard assessment of flocculants was to occur as part of the ERR work plan (Attachment B, Appendix A, Table A1):

Describe physical and chemical composition of mineral waste materials, identifying potential hazardous substances, including the presence of sulphides (if acid sulphate soil has been excavated and/or chemicals will be used in processing). This description is to include any added chemical treatments / flocculating agents… Where addressed in work plan: Figure 4-11; Section 5; Section 8; See also Appendix; B (Risk Management Plan

I saw no evidence that further hazard assessment of the potential hazard presented to the environment by the flocculants that are to be used at the propose Fingerboards mine described in the sections cited in the text of Attachment B of the Fingerboards EES.

41. Some dewatering of the tailings storage facility is expected to occur as a result of seepage through the base of the storage facility (Attachment F, Section 3):

The temporary TSF will be constructed using engineered cells with lined walls. Water will be managed using a decant system, sumps and drains to capture and reuse seepage (SW22).

and (Appendix A006, Table 8-2):

The potential for seepage from tailing deposition to the TSF will exist during operation and until the deposited tailings are relocated to the mine void. During this time seepage rates will be minimised by construction of engineered cells with a low permeability base and installed with a decant system, sumps and drains to capture infiltration.

[11] Bolto B and Gregory J. 2007. Organic polyelectrolytes in water treatment. *Water Research* 41 (11): 2301–24.
[12] Xiong B, Loss RD, Shields D, Pawlik T, Hochreiter R, Zydney AL, and Kumar M. 2018. Polyacrylamide degradation and its implications in environmental systems. *NPJ Clean Water 1* (1).

Disposal of fine tailings and sand tailings in the unlined mine void and Perry Gully: Hydraulic loading from the deposited tailings is expected to result in increased recharge to groundwater during operation. Numerical modelling has predicted infiltration to the Coongulmerang Formation beneath the backfilled mine void and Perry Gully resulting in the development of a groundwater mound beneath the project area. The groundwater mound has been modelled throughout the mine life and impacts to nearby surface water features and GDEs assessed. Impacts associated with altered baseflow contribution to surface water features are presented in Table 8-4.

Based on this, infiltration of water through the base of the tailings storage facility and mine void is expected to occur and there is therefore potential for break-down products of polyacrylamide to be transported into leachate and groundwater.

E.3 Hydrogeological impacts

42. I consider that the connectivity between groundwater created by seepage from the tailings storage facility and the mining void, and the soils in the landscape within and surrounding the proposed Fingerboards Site are not sufficiently characterised to allow the hazards presented by this connectivity to be constrained, particularly given the quality of the potential leachate has not been appropriately characterised (e.g. Points 28 and 40).

43. Leachate will form at the proposed Fingerboards mine as water flows through tailings and chemicals leach out. This leachate may be discharged from the tailings storage facility or mine void and mix with groundwater, impacting groundwater quality. Modelling of the leachate generated at these two locations indicates possible leachate infiltration to groundwater beneath the Fingerboards Site as outlined in Appendix A006 (Table 8-2):

The potential for seepage from tailing deposition to the TSF will exist during operation and until the deposited tailings are relocated to the mine void. During this time seepage rates will be minimised by construction of engineered cells with a low permeability base and installed with a decant system, sumps and drains to capture infiltration.

Disposal of fine tailings and sand tailings in the unlined mine void and Perry Gully: Hydraulic loading from the deposited tailings is expected to result in increased recharge to groundwater during operation. Numerical modelling has predicted infiltration to the Coongulmerang Formation beneath the backfilled mine void and Perry Gully resulting in the development of a groundwater mound beneath the project area. The groundwater mound has been modelled throughout the mine life and impacts to nearby surface water features and GDEs assessed. Impacts associated with altered baseflow contribution to surface water features are presented in Table 8-4.

And, according to Attachment F, Section 3:

The temporary TSF will be constructed using engineered cells with lined walls. Water will be managed using a decant system, sumps and drains to capture and reuse seepage (SW22).

The Fingerboard EES states that discharge of leachate from coarse and fine tailings is predicted to create a groundwater mound beneath the site (Appendix A006, Section 7.3.3):

Kalbar propose in-pit tailings storage which will include depositing saturated fine and sand tailings in the mine void. Supernatant water will be recovered and returned to the process water circuit. A component of the deposited water is unlikely to be recovered, and infiltration is expected to occur through the deposited tailings, ultimately discharging to the underlying Coongulmerang Formation aquifer.

44. A groundwater mound is formed when water infiltrates into a groundwater body from one point or within one area, creating a localised area of groundwater that is closer to the ground surface than the groundwater in its surrounds. Such mounding may impact mining operations at the Fingerboards Site, and groundwater flow patterns in the mine region. The EES states, in response to review comments presented in tabular format, that (Attachment I, Appendix A):

…Mining is above water table, but tailings placement in mine path likely to cause water table mounding.

and, Appendix A006, Section 6.2:

Depending on the infiltration capacity of the unsaturated soil profile above the watertable, and the transmissivities of the site aquifers, groundwater mounds could develop beneath the mine pits due to seepage from tailings deposition. These mounds have the potential to increase groundwater flow radially from the site and towards the floodplain region.

Appendix A006, Section 7.7.1:

The groundwater modelling has demonstrated that local groundwater mounds may develop beneath the Fingerboards mine site due to seepage from tailings (Figure 6-13). The base case modelled scenario predicts that localised mounding could develop directly beneath the tailing cells, meaning that the peak of the watertable surface could be hosted within the tailing cells, with a 0.5 m mounding contour expected to extend around 4 km from the mine site.

45. The EES does not present a discussion of leachate infiltration into the surrounding landscape from the floor of the tailings storage facility or mine void. Infiltration through the tailings storage facility lining is anticipated, as outlined in Points 42 to 44 above. To understand what infiltration through the floor of the lined tailings storage facility and mine void might look like, an understanding of the site topography (that is the lay of the land — where the hills are relative to the rivers etc) is needed. A diagram presenting the location of the tailings storage facility was presented in Section 8.5.2 of Attachment B of the EES as follows, with an additional diagram drafted by me presented after the EES diagram, to show the location of the tailings storage facility and mining void relative to the topography of the proposed mining location:

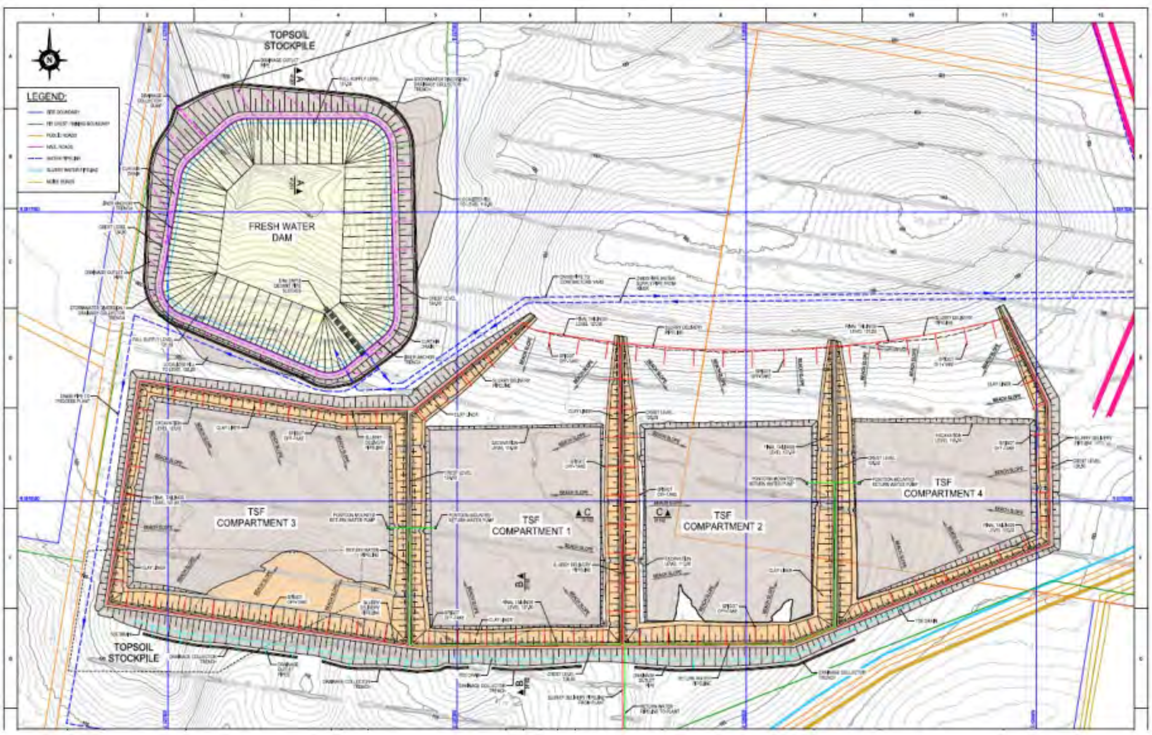

Figure 8-2: TSF configuration (plan view)

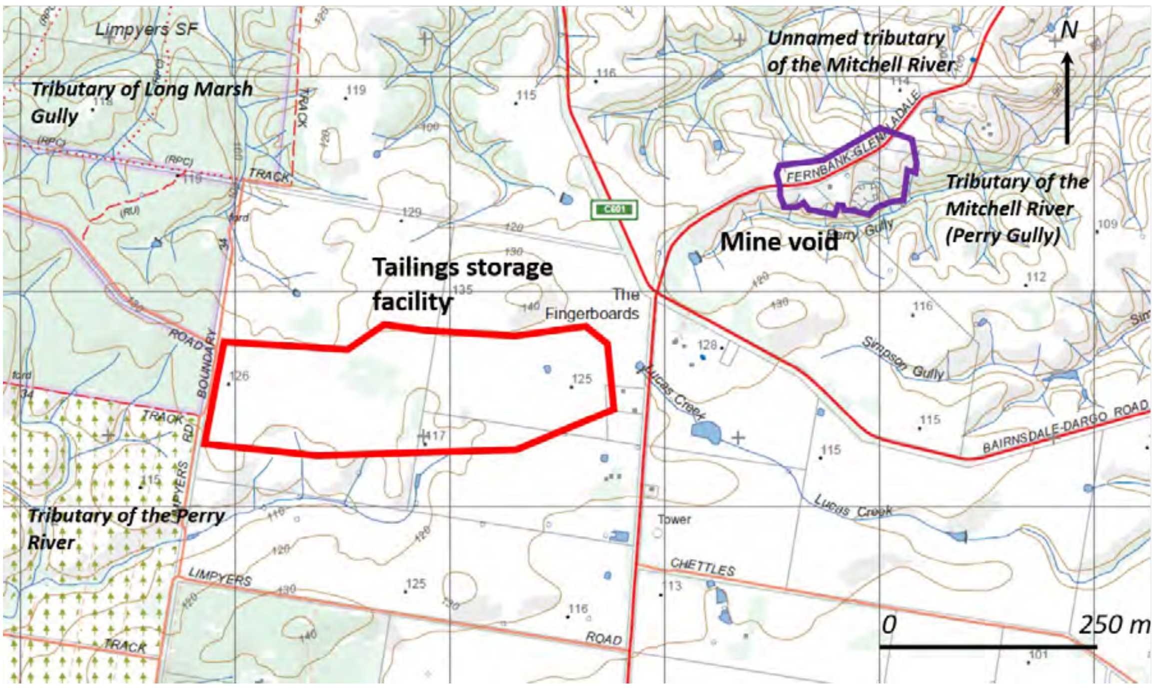

Figure A. Figure drafted by me, depicting the location of the tailings storage facility and mine void relative to the topography at the proposed Fingerboards mine site.

46. The diagrams show that the tailings storage facility is to be located on a shallow ridge line between four catchments — these are the Long Marsh Gully catchment; the Lucas Creek catchment; and the Perry Gully catchment; and the Perry River catchment (Attachment B, Section 8.5.1):

The location of the TSF has been selected to avoid existing drainage lines and to minimise up-stream catchment areas. The TSF is positioned on relatively flat terrain near the catchment divide between the Perry River drainage system and the subcatchments that flow to the Mitchell River system. The general fall of the TSF is towards the south.

47. The mine void is to be located across a ridge line between two separate tributaries of the Mitchell River. Both the tailings storage facility and mine void are to be located within geological materials comprising sands and gravels (Table 3, Appendix A001):

Table 3. Summary of geological units.

Geological Unit	Material Type	Thickness (m)	Geological age
Alluvium	Silty sand, fine to medium grained, with non-plastic silty fines.	0.2 – 0.7	Pleistocene to Holocene 2.6 to 0 Ma (million years)
Dunal deposits	Silty sand, fine to medium grained.	0 - 10	Pleistocene 2.6 to 0.1 Ma
Haunted Hills Formation	Upper unit of Clay with variable sand content and medium plasticity	2 – 16	Pliocene to Pleistocene 5.3 to 0.1 Ma
	Basal gravel deposit, 2 to 12m thick	2 – 12	Pliocene to Pleistocene 5.3 to 0.1 Ma
Coongulmerang Formation	Upper sands, subdivided for grade purposes into three ore strata, plus overburden (or interburden). Upper Sands – Low grade, overburden or interburden where USA is present Upper Sands A, Upper Sub Marker – Mid grade, Ore Marker Unit – High Grade, Ore	0 - 30	Pliocene 5.3 to 2.6 Ma
	Lower sands, subdivided for grade purposes into two ore strata and an underlying unit. Sub Marker – Mid Grade, Ore Lower Sands – Waste, upper contact defines floor of pit where possible.	60 to 80	Pliocene 5.3 to 2.6 Ma
Basement	Sedimentary and Igneous rocks		Palaeozoic 541 to 252 Ma

48. The tailings storage facility is to be up to 15 m deep (Appendix A006, Section 8.4.7):

> *An off-path TSF will be constructed 500 m north of the WCP consisting of four compartments covering a tailings area of about 69 ha. The embankment heights will range between 3 m and about 15 m. The off-path TSF will provide storage capacity for approximately 60 months (5 years) of tailings production. The TSF will be raised in two stages to provide a total storage volume of 9.17 Mm^3. The TSF will therefore meet national and international definitions of a 'large dam'.*

The mine void is to be up to 50 m deep (Appendix A006, Appendix B, Section 2.14):

• open cut pits will be used to dry-mine the ore, with depth ranging from around 50 mbgl to just a few metres;

The walls of the tailings storage facility are to be earthen (Attachment B, Section 8.5.1):

The external walls of the tailings storage cells will comprise homogeneous earth embankments with 1:2.5 (v:h) slopes both upstream and downstream, as dictated by stability analyses and design economics . The embankments will be constructed using low permeability material sourced from local borrow pits and HHF overburden. Due to the potentially dispersive nature of the on-site soils, the upstream slopes of the perimeter embankments will be stabilised with 3% lime, a technique that has been successively used in water storage structures in the project locality. However, further testing is required during the detailed design stage to confirm this. Unsuitable material including alluvium and topsoil will be removed from the embankment footprint areas prior to construction.

49. Typically, a conceptual site model is used to enable a conceptual understanding of what a process, such as leachate moving from a storage facility, might look like in reality, as described in the National Environmental Protection (Assessment of Site Contamination) Measures 1999 [the ASC NEPM (Schedule B4, Section 1.4.2)]:

A conceptual site model (CSM) is a representation of site-related information regarding contaminant sources, receptors and the exposure pathways between those sources and receptors. The development of a CSM is an essential part of all site assessments and provides the framework for identifying how the site became contaminated and how potential receptors may be exposed to contamination either in the present or in the future.

50. A conceptual model of the site is presented in written format within Appendix A006, Appendix B, Section 2.14, with the follow points considered salient by me to the information presented herein:

• open cut pits will be used to dry-mine the ore, with depth ranging from around 50 mbgl to just a few metres;

• the pre-mining water table is hosted within the basal section of the Coongulmerang Formation, with premining groundwater levels ranging from around 39 m AHD at the centre of the project site to around 27 m AHD within the Mitchell River floodplain;

• groundwater depths range between 5 m and 59 m at the monitoring bore locations however deeper groundwater depths > 80 m can occur in higher topographic regions of the project site;

• groundwater levels indicate groundwater does not discharge to the west towards the Perry River. The Perry River in the vicinity on the Fingerboards Project is considered a losing system and has no groundwater baseflow component; groundwater levels in the area are around 30 m below the Perry River bed elevation;

51. A schematic conceptual diagram of tailings monitoring and seepage is also presented in Attachment B, Section 8.5.6:

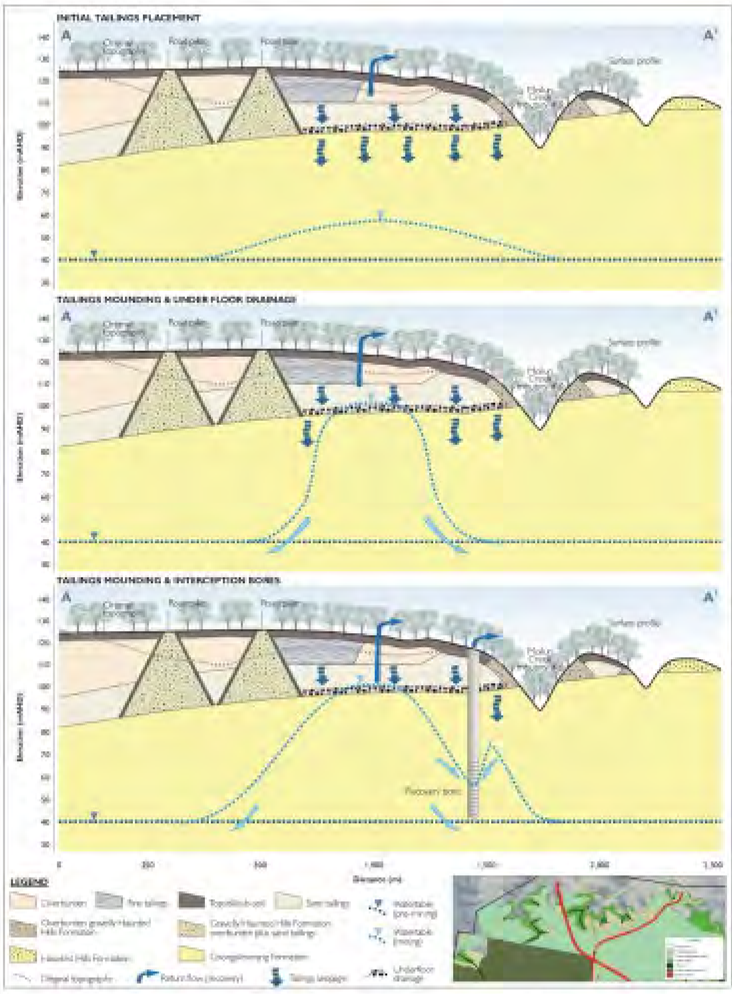

Figure 8-3: Sand Tailings Seepage Monitoring and Management (After EMM, 2020b)

52. To aid my understanding of the potential impacts of tailings stored in the tailings storage facility relative to the surrounding geology, I made the following diagram:

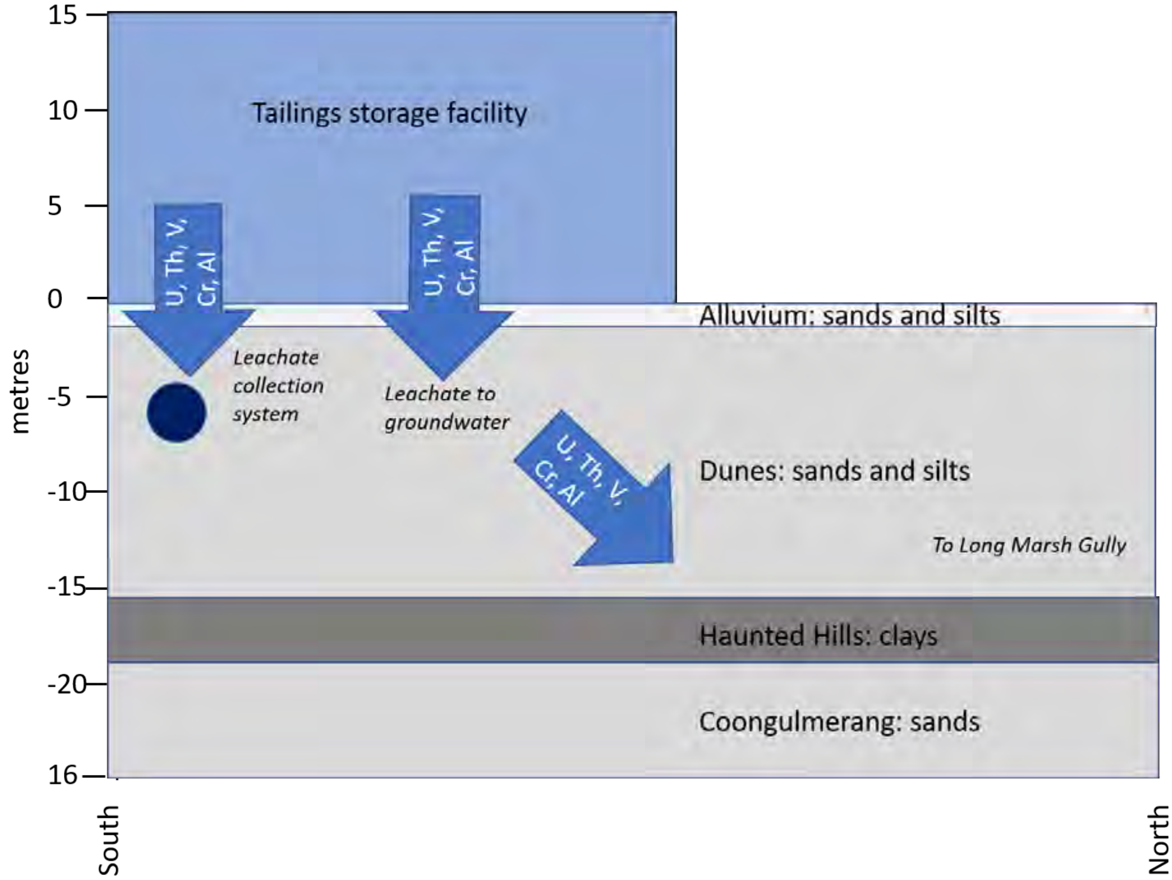

Figure B. Conceptual diagram depicting how contaminants may move from the tailings storage facility into the surrounding landscape.

53. The diagram presented in Point 52 is based on the tailings storage facility being located on a shallow ridge line between four catchments — these are the Long Marsh Gully catchment; the Lucas Creek catchment; and the Perry Gully catchment; and the Perry River catchment, and the site topography of those locations (Point 45). As such, it is one of four similar diagrams that could be made for the tailings storage facility. Three others could be made that would be the same, except for showing that leachate could move through the floor of the tailings storage facility into the Lucas Creek, Perry River, and Perry Gully catchments. This shows that leachate that moves through the floor of the tailings storage facility could discharge into the sands and silts that occur within the Pleistocene dunal deposits at a depth of between 2 and 10 metres

below ground level (m bgl). This is in addition to the flow into the Coongulmerang Sands that are considered conceptually within the Fingerboards EES.

54. I made a similar conceptual diagram depicting leachate movement from the mine void. This shows similar outcomes to the conceptual site model made for the temporary storage facility, except that leachate from the mine void can also move into Perry Gully and is to be collected in a water management dam constructed in Perry Gully (Attachment B, Section 4.7):

While placing tailings sand into Perry Gully, risk of erosion and subsidence will be minimised by:…
•Prior construction of the water management dam in the gully below the sand stack to intercept water that may have contacted the tailings or other materials disturbed by mining

The location of the mine void across a ridgeline means that leachate could also infiltrate the dune sediments at this location and move into an unnamed tributary of the Mitchell River.

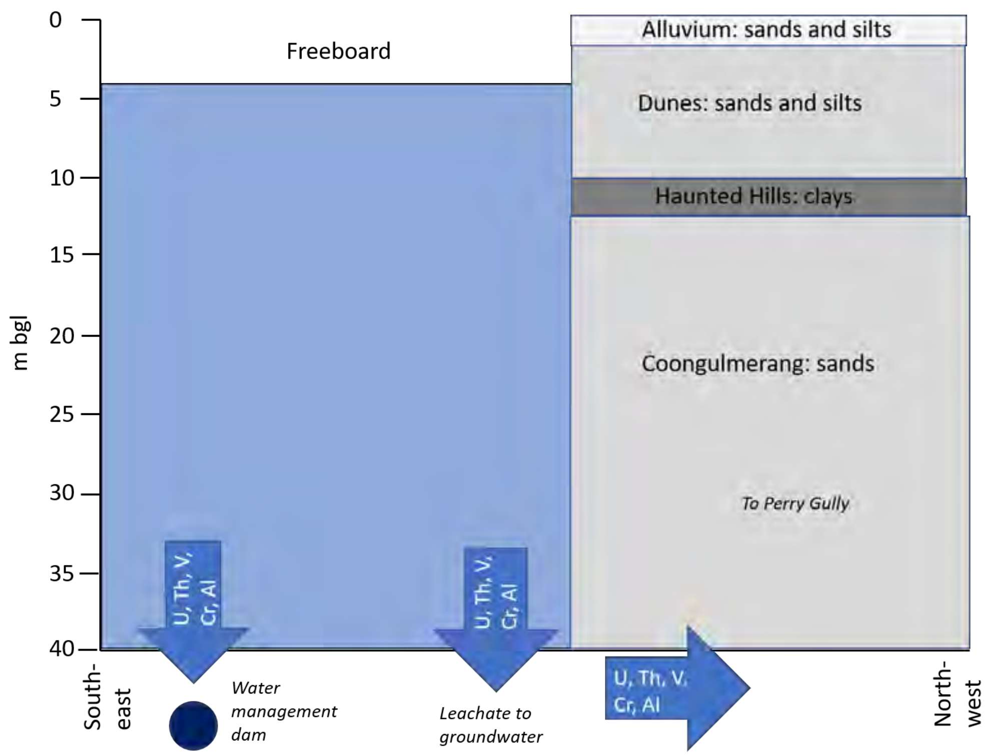

Figure C. Conceptual diagram depicting how contaminants may move from the mine void into the surrounding landscape.

55. Based on evidence presented in Appendix A006, Appendix B, the EES concludes that the potential impact of leachate on surface water (such as rivers, creeks, and dams) is likely to only occur as the result of discharge via the Coongulmerang Formation (Appendix A006, Table 8-2):

Disposal of fine tailings and sand tailings in the unlined mine void and Perry Gully: Hydraulic loading from the deposited tailings is expected to result in increased recharge to groundwater during operation. Numerical modelling has predicted infiltration to the Coongulmerang Formation beneath the backfilled mine void and Perry Gully resulting in the development of a groundwater mound beneath the project area. The groundwater mound has been modelled throughout the mine life and impacts to nearby surface water features and GDEs assessed. Impacts associated with altered baseflow contribution to surface water features are presented in Table 8-4.

56. Leachate movement through the floor of the mine void and tailings storage facility is to be captured via recovery wells (Point 51). The potential for leachate to impact shallow groundwater that occurs above the Haunted Hills Formation was not clearly considered within the Fingerboards EES, with anecdotal evidence indicating that the depth to groundwater at the Fingerboards site is more variable than is currently modelled to occur (Appendix A006, Appendix B):

Section 2.7.4
Groundwater levels do not indicate flow to the west towards the topographic low associated with the Perry River. Within the study area of the Fingerboards Project the Perry River is considered a losing system and has no groundwater baseflow component; groundwater levels in the area are around 30 m below the Perry River bed elevation…

Section 2.14
Groundwater levels indicate groundwater does not discharge to the west towards the Perry River. The Perry River in the vicinity on the Fingerboards Project is considered a losing system and has no groundwater baseflow component; groundwater levels in the area are around 30 m below the Perry River bed elevation;

Section 3.4.1

Although data are scarce for the Perry River, it is known to be largely an ephemeral system. However, sections of the river most likely intersect baseflow from the surrounding upper aquifer system all year round in areas where the depth to groundwater is shallow, such as the region around the Providence ponds reserve. The groundwater in this region may be associated with perched or shallow sub-surface water, rather than groundwater from the phreatic system (see Section iv below).

In terms of an exposure pathway, the north section of the Perry River is located within 1500 m of the mine site; however, depth to groundwater can be well over 50 m in this region. Thus, any impact from groundwater mounding or groundwater extraction associated with the mine site is unlikely to affect the Perry River system.

Providence Ponds is a chain of ponds system, located adjacent to the Perry River. The catchment is significant as it is one of only a few in Victoria with a chain of ponds formation across large sections of the waterway. In the Providence Ponds and Perry Catchment, the chain of ponds formation supports a diversity of plants and animals including the endangered Sandy Flood Scrub Ecological Vegetation Class. The catchment also *hosts other high value communities including the Gippsland Red Gum Grassy Woodland and Seasonal Herbaceous Wetlands*

Section 7.8

The most significant outcomes of the water balance modelling include:
• predicted impacts show a change no larger than 2.3%, compared to the 'No Mine' water balance scenario, and relates to an increase in groundwater baseflow reporting to the Perry River;

Section 10
Impacts on water balances at key receptors were also investigated, with the largest water balance change expected to be no larger than 1.3%, corresponding to a small increase in inflow and outflow reporting to the Mitchell River alluvials and associated river. Insignificant effects are predicted for the Gippsland Lakes system, Providence Ponds, the Perry River, the Woodglen ASR site and the Boisdale groundwater resource

57. This anecdotal evidence was provided by the landowner of 2705 Bairnsdale-Dargo Road, Glenaladale on 21 October 2020. The evidence indicates that groundwater within the Fingerboards Site occurs at the ground surface in a number of locations, in the form of permanent dams built around springs (Attachment 1). These appear to be conceptually similar to the chain-of-ponds ecosystems that occur in the Perry River catchment within which part of the proposed Fingerboards site is located.

58. The landowner of 2705 Bairnsdale-Dargo Road, Glenaladale stated that permanent dams occur on his property despite a rainfall of around 350 mm some years. The permanence of these dams in a low-rainfall environment is significant, as it indicates the dams are not capturing rainwater but instead yielding water from elsewhere — either artificial recharge or groundwater.

59. Google Earth provides historical aerial photography back to the year 2010. This imagery was used to corroborate the landowner of 2705 Bairnsdale-Dargo Road, Glenaladale's statement that dams at the proposed Fingerboards mine site contain permanent water. The imagery shows dams shining in sunlight within the proposed Fingerboards mine site as well as its surrounds on 29 November 2019, a year in which rainfall at the site was below to very much below average according to the Bureau of Meteorology[13].

60. As stated in Point 33, the Bureau of Meteorology's records state that rainfall at the Mitchell River at Glenaladale, approximately 10 km east of the Site, was 425.2 mm in 2019. The Bureau of Meteorology states that annual pan evaporation in the region is 1000 to 1200 mm per annum[14]. This means that around three times more water evaporated from the dams within the proposed Fingerboards site than was directly

[13] http://www.bom.gov.au/climate/current/annual/vic/summary.shtml

collected on their surface (i.e. 425 mm falls on the dams and 1000 mm evaporates from the dams). Given the high potential evaporation in the area, these dams would require regular replenishment to maintain water levels throughout the summer. Dams were not refilled by land owners (Attachment 1).

61. Based on the description of the sand and clay materials beneath the ground surface (Point 47) and on the presence of permanent dams within the bounds of the proposed Fingerboards mine site, it is possible that perched aquifers occur.

62. Perched groundwater systems can occur on pockets of low-permeability clays and silts that prevent the groundwater infiltrating deeper into the ground. They are associated with landforms consistent such as the Haunted Hills Formation described in Point 47, where pockets of gravels occur within pockets of clays that allow groundwater to become perched in some places and not in others.

63. As such, perched groundwater systems are limited in extent and may not be connected to other "local" groundwater systems that extend across a landscape, such as that described as occurring at the Fingerboards in Section 2.7.4 of Appendix A006, Appendix B:

The local groundwater elevation contours across the site are shown in Figure 2.13…). The water table is hosted within the Coongulmerang Formation at the project site with groundwater levels ranging from above 45 m AHD in the north-western section of the project site to around 27 m AHD within the adjacent Mitchell River alluvium floodplain to the east.

64. The limited extent of perched groundwater systems means they can be difficult to find using a standard drilling program (i.e. the scope of drilling to investigate the properties of soil and rock, and to install groundwater wells), especially when such programs are undertaken in drier years where the extent of a perched system may be more limited than in wetter years. Perched aquifers may be an important source of water to the ecosystem present at the proposed Fingerboards mine site, and I consider further investigation into their presence is warranted.

65. The information in Points 58 to 64 are evidence supporting landowner of 2705 Bairnsdale-Dargo Road, Glenaladale's belief that dams at within the Fingerboards site are recharged by groundwater. I saw no discussion of these dams in the Fingerboards EES and the landowner of 2705 Bairnsdale-Dargo Road, Glenaladale stated that no sampling of these dams has taken place as part of assessment works for the proposed Fingerboards mine. This information suggests additional investigation for the potential for groundwater flow within the dunal system at the Fingerboards site is warranted.

E.4 Guidelines

66. I consider that the use of the ASC NEPM and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) guidelines (the water quality guidelines) within the Fingerboards EES documents I reviewed were inappropriately used to assess the potential risks presented to human health and the environment by contaminants released from the tailings generated by the proposed Fingerboards mine. The ASC NEPM presents guidelines for the assessment of contamination in groundwater and soils. The basis for the use of the ASC NEPM in assessing chemical hazards at the proposed Fingerboards mine is presented in Point 17, Section E.1.

67. The water quality guidelines are used to provide guidance on management of water quality, including sediments and rivers[15]:

The objective of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality is to provide authoritative guidance on the management of water quality in Australia and New Zealand. Our guidance includes setting water quality and sediment quality objectives designed to sustain current, or likely future, community values for natural and semi-natural water resources.

I have received advice from Murrang Earth Sciences' Regulatory Scientist Dr Jess Drake that the water quality guidelines are regulated in Victoria through the State Environment Protection Policy (Waters) 2018 and apply to water immediately adjacent to the proposed Fingerboards mine at all times (i.e. prior to, during, and post-mining). Victoria's Environmental Protection Act [1970 (soon to be the Environment Protection Act 2018)] and State Environment Protection Policy [Prevention and Management of Contamination Land (2002)] will apply to water quality within the proposed Fingerboards mine site after the mine licence is relinquished. On this basis, I consider the use of the water quality guidelines to be appropriate for assessing negative impacts to water quality as a result of the proposed Fingerboards mine.

68. I noted the use of the ASC NEPM and the water quality guidelines in two instances within the Fingerboards EES documents I reviewed. These were in Appendix A002, and Appendix A006.

69. It is not clear that reference to the freshwater ecosystem criteria referred to in Table 7-7 is appropriate, with Section 7.3.4 of Appendix A006 of the Fingerboards EES, stating the following:

Results reported by EGI (2019) and Kalbar are compiled in Table 7-7 and have been compared to Australian Drinking Water Guideline (ADWG, 2018) criteria values and ANZECC (2000) Freshwater aquatic ecosystem

[15] https://www.waterquality.gov.au/anz-guidelines/about.

protection criteria. Screening against these two criteria are intended to provide a preliminary assessment of the health and environmental risk that may be posed by tailings in the case where undiluted tailings water impacted a sensitive receptor.

70. Instead, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018)[16] state the following with regards to the use of guideline values for the assessment of water quality:

Ideally, you should use guideline values that are relevant to your to local conditions or situation. We call these 'site-specific guideline values'.

Check with relevant local authorities in your jurisdiction who might have developed site-specific guideline values.

We provide guidance in the Water Quality Guidelines on methods for deriving site-specific guideline values for protecting surface water aquatic ecosystems, which focus on the use of biological field-effects data, laboratory-effects data, reference-site data and the use of multiple lines of evidence…

If site-specific guideline values are not available, or have been agreed as being unnecessary, we provide or give directions to default guideline values (DGVs) for a range of stressors relevant to different community values, such as aquatic ecosystems, human health and primary industries.

DGVs represent a useful starting point for assessing water quality, and are recommended for generic applications in the absence of more relevant guideline values. DGVs may not be representative of your local conditions or situation but they can, to some extent, be tailored to make them more relevant to local conditions….

Guideline values should not be the only tool by which water quality is assessed.

You should use guideline values in conjunction with other lines of evidence in a weight-of-evidence process to assess and manage water quality. This process will help you to assess water/sediment quality by looking at multiple indicators across lines of evidence for pressures, stressors and ecosystem receptors.

Guideline values for physical and chemical (PC) stressors and toxicants fall within the stressor lines of evidence.

71. The ASC NEPM includes guidelines for the assessment of hazards to human health and the environment presented by contaminants of concern in soils and groundwater. These guidelines are prescribed by regulations in Australian states and territories for the assessment of such contamination. The measures have a number of volumes that outline — clearly and in detail — the process by which such contamination should be assessed if such assessment is to be rigorous. These guidelines were not referenced in Appendix A006, particularly in Table 7-7 where comparison to drinking water guidelines and freshwater ecosystem criteria is instead made.

72. A number of issues are apparent in Table 7-7 of Appendix A006 that can be related to inadequate use of ASC NEPM. For example, a key part of assessing the potential risk presented to human health or the environment is identifying the receptors that might be exposed to this contamination. As discussed herein, groundwater dependent ecosystems are a key receptor of potential contamination occurring at the proposed Fingerboards mine. Livestock are also a potential receptor if leachate moves from the tailings storage facility and mine void into dams in the surrounding area via the dunal sand system. As river water is treated prior to use in Australia, and there was no clear evidence for groundwater in the Fingerboards area being used for drinking within Appendix A006, there does not appear to be an intention to drink water potentially impacted by leachate generated by the proposed Fingerboards mine. It is therefore unclear to me why drinking water guidelines have been used to assess the potential risks presented by the leachate. It is also unclear why guidelines for the assessment of potential hazards presented to livestock and groundwater dependent ecosystems that might be exposed to contaminated groundwater and outlined in the ASC NEPM have not been used.

73. The ASC NEPM were referenced in Appendix A002. The ASC NEPM Health Investigation Levels (HILs) that were presented in Table 11 (of Appendix A002) for residential properties with garden/accessible soil (home grown produce <10% fruit and vegetable intake, no poultry) also include children's day care centres, preschools and primary schools, and are referred to as HIL A guidelines. As the proposed Fingerboards Site occurs in a rural area with agricultural development, the HIL A guidelines are too conservative (i.e. the guidelines are lower than is needed for the protection of human health) and not are appropriate to assess chemical hazards potentially presented by the proposed Fingerboards mine site. Use of the HIL A guidelines are appropriate as a conservative screening tool; however, the implications of using the HIL A guidelines in this way should be noted in the text of the Fingerboards EES.

74. Ecological investigation levels, termed EILs, are relevant for the assessment of risks presented to the environment from contaminants in the tailings, with these defined within the ASC NEPM as follows (Schedule B1, Section 2.1.1):

Ecological investigation levels (EILs) have been developed for selected metals and organic substances and are applicable for assessing risk to terrestrial ecosystems. EILs depend on specific soil physicochemical properties and land use scenarios and generally apply to the top 2 m of soil.

No EILs were presented for the assessment of risks presented by tailings to the environment.

75. Guidelines — whether these be drinking water, HILs or EILs — were not presented for a number of analytes (chemicals that are the subject of analysis) presented in Table 7-7 of Appendix A006 and Table 11 of

Appendix A002. These analytes include, but are not limited to, thorium, uranium, titanium, and vanadium. These four chemicals are all considered to potentially occur in elevated concentrations within tailings or tailings leachate, and are all considered to be either hazardous to aquatic environments; are listed as priority hazardous substances; or are considered potentially carcinogenic by the European Union and/or the Agency for Toxic Substances and Disease Registry in the USA. The ASC NEPM states the following with regards to chemicals of concern for which guidelines are not provided (Schedule B2, Section 3.2.2):

Procedure if no generic investigation or screening levels are available
Site-specific investigation levels will need to be developed when:

- *investigation or screening values are not available for the contaminants of concern and/or insufficient data is available for the derivation of generic guideline values*
- *site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivation of the generic investigation or screening levels.*

And Schedule B4, Section 5.1.1:

Toxicity assessment in contaminated land risk assessment is primarily a literature-based research exercise. For contaminants which have an HIL, the findings of the literature review undertaken are presented in Schedule B7. In many risk assessments, reference to the appropriate review in Schedule B7 will provide adequate information to inform the toxicity assessment. In cases where no HIL is presented, or where the risk assessor is aware that more recent information is available, the toxicity review should be compiled and reviewed by an appropriately qualified toxicologist from reliable peer-reviewed sources.

In principle, risk assessments would ideally be based on research that has been carried out, peer reviewed and recommended by Australian health authorities as appropriate for Australian circumstances. In practice, there is limited Australian-specific information available, and Australian health standards for air quality and drinking water (for example, NEPC 2004, NHMRC 2011) are also largely based on international data sources, in particular, WHO publications…

Data sources listed in Table 4 are considered to provide information that is compliant with Australian requirements for setting public health standards. They should generally be considered in the order listed in Table 4; however, it should be noted that the reliability of the data used in a risk assessment should not be based solely on the position of its source in the table. The most important consideration is that the data is supported by sound science and contemporary risk assessment methodologies, and that a weight-of-evidence approach has been used to assess their worth. This means that risk assessors should not simply rely on 'looking up numbers' but should gain an appreciation of the currency of the source and the underlying science from which the numbers have been derived. Such an evaluation should be undertaken by an appropriately qualified toxicologist.

76. The use of analyte-specific guidelines to assess the potential risks presented to receptors is discussed in Points 66 to 75 above. Receptors of contamination generated by the proposed Fingerboards site may be exposed to a mixture of contaminants, however, rather than one contaminant at a time. Therefore, the actual hazard presented to receptors of contamination generated at the proposed Fingerboards site is

more adequately assessed by looking at the leachate as a whole, rather than at each contaminant individually (Schedule B4, Section 6.5 of the ASC NEPM):

Contaminated land studies frequently involve assessing the health risks associated with soil where a number of different chemical contaminants are present. In contrast, toxicological studies usually assess the effects of a single chemical. The risk assessor faces a difficulty in determining whether the effects of the mixture might be additive, greater than additive (synergistic) or less (antagonistic) (Priestly 2009). It is possible that such effects are not important at the low doses common in environmental exposure, leading to the concept of an 'interaction threshold' below which the effects of mixtures are insignificant (Hamm et al. 2005). Additive effects are being found to be more common than synergism.

Despite the limitations in the data, risk assessors have been incorporating additivity into their assessments for some time. This is done by adding all risks from all chemicals together to get total risk for a site and also by adding risks from all pathways. There are likely to be situations where the chemicals cause quite different effects by quite different mechanisms and so it is possible that summing risks in this way can overestimate risks in such situations. However, most sites have a mix of chemicals that are similar because they have arisen due to the particular activities on a site.

No such assessment of the risks presented to human health and the environment from contamination as a whole, rather than from specific analytes within tailings or tailings leachate, was seen by me in the documents I reviewed within the Fingerboards EES.

77. Finally, I saw no evidence that Aboriginal people had been engaged in relation to any aspects of the tailings impacts to the environment within the Fingerboards EES documents I reviewed. Such consideration is outlined in the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (2018), as follows[17]:

Many indigenous people believe that the land, sky, water and its people are inseparable; they are all connected.

To achieve the best outcomes for the preservation and enhancement of cultural and spiritual values, water quality planning must be integrated with water allocation (quantity) planning and management processes because they are intrinsically linked.

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[17] https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/cultural-values

We have developed principles and processes to guide water quality planning in a way that considers cultural and spiritual values and protects the intellectual property of the indigenous knowledge holder.
Appropriate up-front and ongoing engagement of relevant indigenous people is a key element of the process, particularly with regard to ensuring the proper identification, free prior informed consent, prioritisation and consideration of cultural and spiritual values throughout the water quality planning process (see Box 1).

A range of indigenous engagement protocols and references exist in Australia and New Zealand, and should be used as circumstances require.

Given the importance of permanent water bodies in arid landscapes to Aboriginal people, such engagement is considered a circumstance requiring Aboriginal engagement.

F. Limitations

78. Consideration of regulatory aspects of the Fingerboards EES are outside my area of skills and expertise. These were therefore not considered as part of my review.

79. I only reviewed information presented within the Fingerboards EES' technical reports that related to tailings, due to time and resource constraints. Specifically, Attachments B, F, H, I; and Appendices A001, A002, A003, A006, and A0023 were reviewed. This is not considered to have substantial impacts upon the outcomes of this review, as chapters within the EES were informed by the technical data and information presented within these attachments and appendices.

80. I was unable to review geotechnical or radiation aspects of the rehabilitation, waste or soil issues. This includes the engineering of the tailings storage facilities. The mixing of soils with tailings as part of disposal in terms of environmental chemistry and its appropriateness as a means of waste disposal is considered by Murrang Earth Sciences in a separate report and not reviewed herein.

81. I note that the Fingerboards EES did not include all referenced documents as appendices. This review was therefore limited by what was provided as part of the EES.

82. I did not review the appropriateness of the methods used to assess the data collected by Kalbar or its delegates, due to time and resource limitations. These time and resource limitations mean that this review is therefore high-level. It is possible that methods were inappropriate, and the outcomes of tests or models therefore spurious. It is also possible that additional problems or indeed solutions to problems raised within this statement, occur within the EES.

G. Attachment 1: Correspondence from Submitter No. 813

Gmail

Julia Jasonsmith <julia.jasonsmith@murrang.com.au>

Fingerboards EES - spring fed dams

2 messages

Virginia Trescowthick [redacted] Fri, Dec 4, 2020 at 9:34 AM
To: Julia Jasonsmith [redacted]
Cc: Jessica Drake [redacted]

Hi Jules

In response to your question with respect to the spring fed dams and, specifically, whether the farm dams were recharged by groundwater during the drought of 2016 to 2020 (rather than recharged artificially through pumping from the local river system and or trucked in from elsewhere), the farmers at 2705 Bairnsdale-Dargo Road, Glenaladale, provide the following information:

- *We confirm the dams we refer to as spring fed were not artificially recharged during the recent drought (2016 - 2020).*
- *In the case of the dam on our property, it was the only available water, and was actively pumped **from** for around two years as the sole supply of water for our livestock. All our other dams had completely dried up.*
- *During the two year period we were pumping from the dam, over time its level dropped to a certain point, and then remained constant. That is, it was refilling from the groundwater at around the same rate it was losing water through our pumping and evaporation.*
- *Our dam does not have a large catchment and has not completely filled this year despite above average rainfall. The constancy of its water supply is not due to water infiltration through the soil profile from its catchment.*
- *Our dam has never dried up.*

Please let us know if you require further information about the above.

We will provide the final letter of instruction early next week (we are awaiting instruction from the client before sending).

Kind regards

Virginia Trescowthick | Lawyer

T: (03) 8341 3100

W: www.envirojustice.org.au
Facebook: envirojustice Twitter: EJ_Aus

Environmental Justice Australia

Please note the EJA office is closed and we are working from home due to COVID-19

Julia Jasonsmith [redacted] Fri, Dec 4, 2020 at 2:25 PM
To: Virginia Trescowthick [redacted]
Cc: Jessica Drake [redacted]

Thanks Virginia this is perfect - as with my other experience with farming folk, their knowledge of their land and detail of their observations is excellent!
Jules

Dr Julia Jasonsmith

Director and Environmental Chemist
Murrang Earth Sciences

Honorary Lecturer
Fenner School of Environment and Society
Australian National University

T: [redacted]
M: [redacted]
E: [redacted]
W: http://www.murrang.com.au
Tw: @MurrangEarthSci

Ngunnawal Country, GPO Box 2310, CANBERRA 2601

Murrang is the Wiradjuri word for mud. Murrang Earth Sciences is grateful to the Wiradjuri people for their language. Our offices are proudly located on Ngunnawal country in Canberra and Dja Dja Wurrung Country in North Central Victoria. We acknowledge the Traditional Owners of the land on which we work, and their knowledge, culture, and spiritual connection to Country.

[Quoted text hidden]

H. Attachment 2: Letter of instruction from Environmental Justice Australia

17 December 2020

Dr Julia Jasonsmith
c/. Dr Jess Drake
Murrang Earth Sciences

By email only: ***jessica.drake@murrang.com.au; julia.jasonsmith@murrang.com.au***

Dear Dr Jasonsmith

Fingerboards Mineral Sands Mine Project, Glenaladale, Victoria – tailings management

We act on behalf of [redacted] a not-for-profit community group formed in response to the proposed Fingerboards mineral sands mine project (the **project**).

We write to you as an expert on environmental chemistry, including tailings management. The purpose of this letter is to seek your expert opinion on the environmental effects of the project.

We request your expert opinion be provided as an expert witness statement to be submitted to the Fingerboards Mineral Sands Project Inquiry and Advisory Committee. We request that your expert report be provided by **27 January 2021**.

References to Tab numbers in bold in this letter are to the documents in an electronic brief which we provide to you via DropBox [redacted]

Background

1. Kalbar Operations Pty Ltd (**Kalbar**) propose to develop an open pit mineral sands mine covering an approximate area of 1,675 hectares within the eastern part of the Glenaladale mineral sands deposit in East Gippsland, Victoria. The site is located near the Mitchell River and approximately 2km south of Glenaladale, 4km south-west of Mitchell River National Park and 20km north-west of Bairnsdale.

2. The proposal includes the development of an open pit mineral sands mine, two mining unit plants, wet concentrator plant, water supply infrastructure, tailings storage dam and additional site facilities (i.e. site office, warehouse, workshop, loading facilities and fuel storage). The proposed mining methods involve open pit

mining to extract approximately 170 million tonnes (Mt) of ore over a projected mine life of 20 years to produce 8 Mt of mineral concentrate. Heavy mineral concentrate, separated into magnetic and non-magnetic concentrates, are proposed to be transported via road, rail or a combination of both for export overseas.

3. The project would require up to 9000 kilovolt-ampere (kVA) hours of power likely to be supplied from the electricity grid and water requirements of approximately 3 gigalitres per annum (**Tab 2.1.2 / Project Description**).

4. On 18 December 2016, the Minister for Planning issued a decision determining that an Environment Effects Statement (**EES**) was required for the project due to the potential for a range of significant environmental effects. The purpose of the EES is to provide a sufficiently detailed description of the proposed project, assess its potential effects on the environment and assess alternative project layouts, designs and approaches to avoid and mitigate effects (**Tab 1.1 / Scoping Requirements**)

5. An Inquiry and Advisory Committee (**IAC**) has been appointed to review the EES and public submissions (**Tab 1.2 / Terms of Reference**). The IAC will hold public hearings for 4 to 6 weeks, after which it will produce a report for the Minister for Planning. Following receipt of the IAC's report, the Minister for Planning will then make an assessment as to whether the likely environmental effects of the project are acceptable (**Minister's Assessment**).

6. All EES documents are available online at: https://ees.fingerboardsproject.com.au/download.

Instructions

7. We request that you undertake a review of the tailings management components of the EES and prepare an expert witness statement providing your opinion on:

    a. The compliance of the tailings management components of the EES (listed below) with the relevant evaluation objective in the Scoping Requirements (**Tab 1.1**):

    Technical Studies

    i. Landform, Geology and Soil Investigation (Technical Study, Appendix 1) (as relevant to tailings) (**Tab 2.3.1**)

    ii. Geochemistry and Mineralogy (Technical Study, Appendix 2) (**Tab 2.3.2**)

iii. Geotechnical Assessment (Technical Study, Appendix 3) (**Tab 2.3.3**)

iv. Groundwater and Surface water Impact Assessment (Technical Study, Appendix 6) (**Tab 2.3.4**)

v. Tailings Management Strategy (Technical Study, Appendices 23) (**Tab 2.3.5**)

Chapters and Attachments

i. Draft Work Plan (Attachment B) (Sections 5.6 and 8.5) (**Tab 2.2.1**)

ii. Risk Report (Attachment F) (**Tab 2.2.2**)

iii. Mitigation Register (Attachment H) (**Tab 2.2.3**)

iv. Water Independent Peer Review Report and Proponent Response (Attachment I) (**Tab 2.2.4**)

b. The adequacy of the baseline data collected by the project proponent to confidently describe pre-development conditions (as relevant to tailings management).

c. The appropriateness of the methods used to identify and evaluate the effects of the project (as relevant to tailings management).

d. Whether the actual or likely risks are identified and or appropriately assessed in terms of their level of risk.

e. The adequacy of the proposed design and mitigation measures relating to the management of tailings.

f. Any other matters you identify which you consider relevant within the limits of your expertise.

g. Any appropriate qualifications or conditions that should be attached to findings or conclusions, such as uncertainties or gravity of threats or impacts.

8. As an expert you are able to consider any such material you consider relevant to your enquiry. Please identify in your report any further materials you consult outside of the briefed materials.

Expert Witness Code of Conduct

9. We have enclosed a copy of the *Guide to Expert Evidence provided by Planning Panels Victoria*, which is the relevant guidance for hearings before the IAC (**Tab 3.1**).

10. In preparing your final expert witness statement, please ensure that you include:

    a. your name, address, qualifications, experience and area of expertise

    b. details of any other significant contributors to the report (if there are any) and their expertise

    c. all instructions that define the scope of the statement (original and supplementary and whether in writing or verbal)

    d. details and qualifications of any person who carried out any tests or experiments upon which the expert has relied in preparing the statement

    e. the following declaration:

    'I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.'

Important dates

11. We request your expert witness report be provided by **27 January 2021.**

12. The IAC will conduct public hearings over a period of 4-6 weeks, commencing on **15 February 2021**.

Confidentiality

13. This request for an expert opinion and the subsequent expert witness statement, as well as any correspondence relating to this request, is for the purposes of the Fingerboards mineral sands mine project EES process, including the public hearings before the IAC. It is therefore confidential and is protected by legal professional privilege.

Fees

14. [redacted]

Please contact Virginia Trescowthick if you have any questions or require further information.

Yours faithfully

[redacted]

Virginia Trescowthick

Lawyer