

## Fingerboards Mineral Sands Project — Inquiry and Advisory Committee (IAC)

### Expert meeting statement — Radiation

Meeting held *Wednesday 14 April 2021 using the online meeting software Teams*

Experts: *Darren Billingsley (DB), Assoc. Prof. Gavin M. Mudd (GM), Assoc. Prof. Tilman Ruff (TR), Karen Teague (KT)*

Observers: *Brad Cassels, Neil Wain(NW) - both Victorian Department of Health (DH)*

Note taker: *Ben Casillas-Smith*

Date, time and location of meeting(s): *Meeting times were 9am to 12:20pm and 2:45pm to 3:45pm; location was using the online meeting software Microsoft Teams*

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#### References:

RAR – EES Appendix A011, Radiation Assessment Report, SGS, April 2020.

#### Documents reviewed:

Expert Review: Radiological issues for the Proposed Fingerboards Mineral Sands Project, G Mudd, January 2021

Expert Witness Statement: Radiation health impacts of proposed Fingerboards Mineral Sands Mine Projects, Glenaladale, Victoria, T.Ruff, February 2021

#### Key to issues Raised:

	<b>Agreement between all parties following discussion on points of view made at the conclave. It is agreed these issues require no further action or discussion at IAC hearing</b>
	<b>Disagreement between parties warranting further discussion at the IAC Hearing.</b>

The following key issues and areas of agreement and disagreement were identified by the participating experts at the meeting:

#### Assoc. Prof. Gavin Mudd Witness Statement Extracts

Page	Extract (G Mudd comment)	DB Response and conclave outcome
1	<b>A: Executive Summary &amp; Key Issues</b>	
1	A1 Based on the available data from the Fingerboards EES, the region is not significantly elevated in environmental radiation, although further work is clearly required to confirm this over the full proposed project area. This is important in helping to determine potential rehabilitation criteria (if the project proceeds).	No action required addressed below.
1	A2 Considerable further work is required to ascertain the levels of radionuclides naturally present in crops and vegetables as well as in surface water and groundwater.	No action required addressed below.
1	A3 Almost all of data and information which would be required for statutory radiation licences and approvals remains left for 'future work', limiting the ability to assess the standards and procedures for the proposed Fingerboards project.	No action required addressed below.
1	A4 Export of the heavy mineral concentrate raises concerns about relevant uranium and thorium safeguards given the potential to extract these nuclear source materials. This issue, a matter of national environmental significance, is poorly addressed and, in reality, effectively dismissed ignored in the Fingerboards EES.	No action required addressed below.
1	A5 The targets for rehabilitation sound reasonable but lack detailed quantitative or qualitative criteria to facilitate monitoring and assessment.	No action required addressed below.
	A6-A7	Not relevant to Radiation conclave.
4	<b>3. Pre-Mining or Baseline Radiological Conditions</b>	
4	<b>3.1 External Gamma Radiation</b>	

Page	Extract (G Mudd comment)	DB Response and conclave outcome
	<p>15. The average value inside the initial mining area is given as <math>0.13 \pm 0.02 \mu\text{Gy/hr}</math> (based on 107 measurements). The Perry Gully area is stated as <math>0.33 \pm 0.04 \mu\text{Gy/hr}</math> (based on 7 measurements) whilst the Perry Gully Southern Wall area is stated as <math>0.14 \pm 0.02 \mu\text{Gy/hr}</math> (based on 9 measurements). The significance of this is not discussed by SGS (2020), but these slightly elevated levels are presumably due to direct exposure at the surface or shallow sub-crop of mineral sands ore (i.e. a reflection of the monazite containing uranium and thorium).</p>	<p>Correct and all in agreement.</p>
4	<p>16. SGS (2020) state that the radiation meter used has a resolution of <math>0.0001 \mu\text{Sv/hr}</math> for a range up to <math>0.2 \mu\text{Sv/hr}</math> (page 14), but the measurement resolution is not provided at greater than this level. From Appendix H, some 21 measurements are above the equivalent of <math>0.2 \mu\text{Sv/hr}</math>. The resolution (or measurement error) should be explicitly stated for levels <math>&gt;0.2 \mu\text{Sv/hr}</math>.</p>	<p>All in agreement. DB - The instrument has a resolution of <math>0.0001 \mu\text{Sv/h}</math> up to <math>1 \mu\text{Sv/h}</math> which should have been referenced in report for completeness.</p>
4	<p>17. SGS (2020) acknowledged that the large project area and land access issues limited their ability to take more extensive measurements (page 13). Despite this, there appears to be no attempt to map the measurements as site locations are simply given in eastings and northings (Appendix H), not latitude-longitude, making it difficult to accurately map these locations</p>	<p>Acknowledged and all in agreement.  DB- Mapping of gamma survey data in the report would have assisted with interpretation of the data spatially. GM - a map with numbers allows people to see distance from features (house, Perry Gully, etc.).</p>

Page	Extract (G Mudd comment)	DB Response and conclave outcome
4	<p>18. Section 13, the 'Future Work Plan', notes the need for further gamma radiation measurements, including a finer resolution survey – yet I believe this work should have already been completed and presented through the EES process.</p>	<p>Disagree.  DB - The finer grid survey is not part of the EES process. Conventionally it is required prior to soil disturbance and pre-mining including the mining areas, processing, stockpiling, etc. for remediation criteria purposes. A management licence will not be issued without this data being collected.</p> <p>DB The existing survey is intended to provide an indication only of approximate levels for comparison with the natural levels, and to assist undertaking the impact assessment.</p> <p>DB acknowledge that a finer grid survey will assist in identifying other area of outcropping in the project area if they exist.</p>
	<p>19. SGS (2020) also fails to cross-reference or compare against available aerial radiometric mapping, either from Geoscience Australia or the Geological Survey of Victoria ('GSV'). Using GSV's 'GeoVic' online mapping tool<sup>1</sup>, the map below was generated (Figure 1; full map provided as Attachment C). Unfortunately, there is no legend or scale for the radiometric results, leaving the map as a relative scale only with light blue being low and red being high. The map suggests that an area of mineral sands mineralisation appears as a red anomaly west of Glenaladale, although this needs to be assessed in detail with respect to geology and mineralisation – something which the EES fails to do (and is beyond the scope of this report to complete). The radiometric map does not automatically mean excessive gamma radiation levels, as the map is a relative view only, but it is useful in understanding the extent and variation of gamma radiation levels in the Glenaladale region.</p> <p>1</p>	<p>All partially in agreement.</p> <p>DB was aware of the radiometric survey data when compiling the report, and the area of indicated buried mineralisation west of Glenaladale. However map interpretation and attempts to correlate with ground data proved difficult. Efforts were concentrated on the ground survey data only.</p> <p>GM and DB in agreement that the aerial radiometric mapping reinforces the importance of completing a finer grid survey. Closer scrutiny of the aerial data may assist in developing a survey plan.</p> <p>GM and DB agree that the aerial survey averages gamma readings over a very large area whereas a finer grid survey is local point data which is more useful in terms of mine planning, radiation management and site rehabilitation.</p>
5	<p><b>3.2 Radionuclides in Soils</b></p>	

Page	Extract (G Mudd comment)	DB Response and conclave outcome
5	<p>20. The work presented in SGS (2020) includes 10 soils tested for radionuclide content (page 16, Table 2). This is a very small number of tests for such a large project area. Given the variability shown (varying by a factor of almost one hundred), a much larger number of soil samples should have been collected for testing – especially considering rehabilitation criteria and the suitability of different soils and materials for proposed rehabilitation designs.</p>	<p>Disagreement.</p> <p>DB - Table 2 does reference 10 samples predominantly within the mine lease. These samples, similar to the gamma survey provide a snapshot of levels to assist with the impact assessment. Rehabilitation criteria/effectiveness will be based on surface dose rates post mining – not soil activity concentrations. Unsure of benefit of excessive sampling over the mining lease.</p> <p>GM- the benefit is a better characterisation of what’s there before mining. Better understanding of soils from chemical and radiological point of view – that data protects Kalbar as well – there is a better basis to assess what the risk is.</p> <p>DB - Radionuclide concentration of soils will not assist with assessment of the suitability of soils rehabilitation design.</p>
5	21-23.	Acknowledged, no comment required.

Page	Extract (G Mudd comment)	DB Response and conclave outcome
6	<p>24. Section 13, the 'Future Work Plan', notes the need for further assessment of radionuclides in soils, considering "locations relative to the Project area, crop type, cultivation methods, fertilizer use, and gamma survey field measurements" (page 68, SGS, 2020) – yet I believe this work should have already been completed and presented through the EES process.</p>	<p>Agreement after discussion.</p> <p>DB noted that that sampling in the farming district has been undertaken, representing 69 locations which are represented in Table 3 of the RAR (6 composite samples of 10 locations each + 9 individual samples). Monitoring is ongoing by Kalbar.</p> <p>GM – commented on composite samples should be satisfactory in areas of no mineralisation. All agreed individual spot sampling was preferable.</p> <p>Soil monitoring will be an important component of the operational radiation monitoring programme. Crop type, cultivation methods, fertilizer use will be important factors to record during sampling for consideration should soil concentrations change.</p>
6	25.	Acknowledged, no comment required.
6	<b>3.3 Radionuclides in Crops</b>	

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6	<p>26. This sub-section (5.3) is very short and rather terse – plus the values given in Table 4 are calculated only and not directly measured. The transfer factors are not given, nor a basic explanation of the calculations undertaken to derive the values in Table 4. Although it is asserted that the transfer factors are appropriate for the region, there is no direct evidence presented to support this – such as previous scientific studies nor direct sample analyses of crops from the Glenaladale region.</p>	<p>Disagreement.</p> <p>DB - Disagree that it is an ineffective means of impact assessment. There are extremely large errors with lab assessment of foliage due to geometry variations from sample to sample. To identify impacts from operations thus would be difficult, based on dust concentrations expected. A theoretical approach has been taken using factors from IAEA2010, Table 17. ‘Mean’ transfer factors used. ‘temperate’ environment assumed as only other option is ‘tropical’. However importantly, <u>identical</u> factors have been used for the baseline, and the project impact. It is this dose difference (RAR, Table 18) that is of importance – not the factors themselves.</p> <p>GM- I’m familiar with the literature, acknowledge the huge variation, that’s why I’m cautious. Ultimate test is testing the vegetable foliage itself. A lot of literature can be a bit European centric or from North American studies. Not a lot of Australian studies that underpin these transfer factors apart from Ranger at Kakadu.</p>
6	<p>27. Section 13, the ‘Future Work Plan’, notes the need to assess radionuclides in vegetables in Lindenow – yet I believe this work should have already been completed and presented through the EES process.</p>	<p>Partial agreement.</p> <p>DB despite responses in 26, and reservations of the ability to assess impact in the future, acknowledge analysis of radionuclides in crops is important based on concerns in the community. It is a recommendation in my Witness Statement (8.8, page 15).</p> <p>Timing for discussion.</p>
6	28.	Acknowledged, no comment required
6	<b>3.5 Radon and Thoron Aspects</b>	

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	<p>29. The results reported by SGS (2020) in sub-section 5.8, especially Table 8, suggest relatively low levels of radon and thoron in the ambient atmosphere. Specifically, reported radon levels ranged from &lt;15 to 48 Bq/m<sup>3</sup> and thoron levels ranging from &lt;20 to 119 Bq/m<sup>3</sup>. There is virtually no discussion of the variability in the measured radon and thoron results, such as barometric pressure, temperature, rainfall, soil moisture and humidity (e.g. Schery <i>et al</i>, 1989; Mudd, 2008).</p> <p>The values reported by SGS (2020) are within natural global variability (see Table 3 in Mudd, 2008) and reinforce the view that current radon and thoron levels are not of major concern.</p>	<p>Agreed by all.</p>
	<p>30. The comment about the allegedly elevated radon result at 'Hotel in Bairnsdale' is mere speculation and stated without any reference to specific building materials nor any test results of that material. Based on my experience over many years, it should be understood that stones used in buildings can vary widely in radionuclide content but are rarely sufficiently elevated to cause concern from a radiological exposure perspective. Furthermore, the comment is made without any discussion of factors which act to increase or decrease radon levels in buildings such as a hotel (e.g. operated as a closed facility and not open to the outdoor environment). The result simply demonstrates variability of radon levels in the region, nothing more can be discerned without much more widespread testing and assessment</p>	<p>Agreed by all.</p> <p>DB- No conclusions should be drawn from the one indoor result at the Bairnsdale Hotel. It is provided purely as a point of reference for the outdoor results, in a location that locals can associate with.</p> <p>All agreed there could have been further explanation in the RAR as to its relevance.</p>
7	<p>31. Section 13, the 'Future Work Plan', notes the need to conduct detailed radon surveys, especially to understand baseline levels and factors affecting variability – yet I believe this work should have already been completed and presented through the EES process.</p>	<p>Agreement on matter after discussion.</p> <p>DB – clarified the future work plan discusses requirement to undertake monitoring during operations, not baseline.</p> <p>DB reiterated there is now additional baseline data to that shown in the RAR (3+ years in total). Data is discussed in the DB Witness Statement (App. C).</p>

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7	<b>4. Management of Radiological Risks During Proposed Operations</b>	
7	32. SGS (2020) appears to correctly identify the full range of acts, regulations and codes which will required to be met for the proposed Fingerboards project. A major weakness, however, is that many of these plans are still to be finalised and are therefore not available for review as part of the EES and public consultation. For example:	<p>Partial agreement.</p> <p>GM- commented that there is a community expectation that the project can meet regulatory criteria and these details should be included in the EES documentation.</p> <p>DB advised full details will be provided in the RMP for approval prior to licencing and is not part of the EES process. Sufficient detail currently in Section 10 of the RAR</p>
	a) Kalbar will need to apply for a Management Licence under Victoria’s Radiation Safety Regulations – but no specific details are given in sub-section 7.2;	<p>Agreement on matter after discussion.</p> <p>Sufficient detail provided in Section 10. Detail to come in RMP.</p>
	b. Sub-section 7.5 discusses the relevant radiation codes, but there is minimal actual detail on how Kalbar propose to implement these requirements for the proposed Fingerboards project;	<p>Agreement on matter after discussion.</p> <p>Sufficient detail provided in Section 10. Detail to come in RMP.</p>
	c. Sub-section 7.6 and Section 12 discusses the need to consider radiation effects for flora and fauna (i.e. environmental radiation exposure for biodiversity), yet this work is it to be completed in the future with no discussion of how Fingerboards may develop such an assessment (a Radiation Environment Plan) – leaving nothing for discussion or comment as part of the EES	<p>Agreement on matter after discussion.</p> <p>DB – pointed out a Tier 1 assessment was conducted and is provided in Section 9.3 of the SGS RAR, including methodology, assumptions, and outcomes. The full detail will be reported in the REP.</p> <p>DB acknowledged Section 9.3 should have been refenced in Section 7.6 of RAR</p>
	d. Sub-section 7.7 discusses the issue of transport of designated radioactive materials (namely the HMC) but argues that they will most likely be exempt, stating they “will need to have process controls in place to ensure” (page 35). There are no such details provided, however, leaving such critical issues to be determined in future outside the EES process and denies the public transparency and the opportunity to comment;	<p>Agreement on matter after discussion.</p> <p>Transport discussed in 7.7, and section 9.1.6 in detail. Also Appendix G of my Witness Statement.</p>
	e. . Sub-section 10.1 discusses the requirements for radiation protection and management for workers and the public. Whilst	<p>Agreement on matter after discussion.</p> <p>Sufficient detail provided in Section 10. Detail to come in RMP.</p>

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	<p>some specific measures are stated to protect workers, there are no details provided for the radiation monitoring plan, expected to be a requirement of a Management Licence for radiation matters under Victorian approvals. Again, such details should have been presented as part of the whole Fingerboards EES – such plans are widespread in the mineral sands sector and therefore not difficult to develop and include in the EES process</p>	
	<p>f. Section 11 reviews the issue of radioactive waste management. It is agreed that the tailings would not be classified as radioactive waste as per the Australian (and related IAEA) code. The production of the HMC, however, is a designated radioactive material, meaning that a formal Radioactive Waste Management Plan will be required to meet Australian and Victorian regulations – yet this plan is still to be developed and only very generic issues noted in SGS (2020) (page 67).</p>	<p>Agreed by all. A RWMP will be required for the project. This is not part of the EES process.</p>

Page	Extract (G Mudd comment)	DB Response and conclave outcome
8	<p>33. I believe that the discussion in sub-section 7.4 of the designation of the Fingerboards as a 'nuclear action' under the Commonwealth Environment Protection &amp; Biodiversity Conservation (EPBC) Act is incorrect and fails to understand the purpose of this matter of national environmental significance. The processing of the heavy mineral concentrate will lead to the separation of zircon, titanium oxide minerals (rutile, ilmenite) as well as rare earth minerals. Based on Table 9 (SGS, 2020), these products all contain uranium and thorium well above natural crustal abundance (see point 21), with the rare earths product containing uranium concentrations which are similar to existing uranium mines<sup>4</sup>. At present, to the best of my knowledge, there are no thorium mines operating globally with the only supply generated as a by-product from rare earths concentrate processing and refining (mainly in India, Russia and China, possibly others). The EPBC Act is intended to provide for public transparency over nuclear actions such as uranium mining – especially since Australia has maintained a position in the international nuclear fraternity through uranium exports for peaceful purposes. As a member of the International Atomic Energy Agency (IAEA), Australia is bound by its many requirements, especially that all nuclear source materials are sold for peaceful purposes only and follow strict accounting practices and safeguards. Uranium and thorium are both potential nuclear source materials and are therefore required to be meticulously controlled in production and export.</p>	<p>Partial agreement on the following:</p> <p>The issue of potential uranium extraction from Fingerboards heavy mineral concentrate occurring overseas was discussed at length by all experts. It was acknowledged that none were legal experts but the concern was a real issue and needed to be addressed (especially for consistency with other mineral sands and rare earth projects being considered for development around Australia).</p> <p>The example of exporting the concentrate to China was discussed. The agreement<sup>1</sup> states for concentrates other than uranium concentrate “China agrees not to extract nuclear material for nuclear use from ores or concentrates. If there is any change in China's intentions in this regard, nuclear material shall not be extracted until the Parties have consulted and agreed on safeguards measures”. That is, for uranium extraction to proceed would require approval from Australia and mutual agreement on safeguards measures.</p> <p>It was noted that the final destinations for HMC from the proposed project over its life could not be confidently foreseen now, and could potentially involve nations with which Australia does not have pre-existing nuclear safeguards agreements.</p> <p>GM - the issue of potential uranium extraction was a federal responsibility and that the Fingerboards assessment process was not well placed to address a clearly federal responsibility – especially given the lack of clarity from the Federal Government on such matters.</p>

<sup>1</sup> See Annex D: <http://www.austlii.edu.au/cgi-bin/sinodisp/au/other/dfat/treaties/ATS/2007/3.html?stem=0&synonyms=0&query=australia%20china%20nuclear%20transfer%20agreement%202007>

<p>9</p>	<p>34. In addition, Victoria also has the Nuclear Activities (Prohibitions) Act 1983 which remains in force (to my understanding of the law).</p> <p>The relevant clauses are: “5 (1) Subject to section 6, but notwithstanding anything else to the contrary in any Act, and notwithstanding the terms of any mining title, a person shall not explore, mine or quarry for uranium or thorium.” “6 (1) Notwithstanding section 5, a person who is the holder of a mining title and who mines or quarries uranium or thorium in the course of mining or quarrying pursuant to his mining title for some mineral other than uranium or thorium shall not be guilty of an offence under this Act provided that—</p> <p>(a) uranium of an amount greater than .02 per centum by weight or thorium of an amount greater than .05 per centum by weight is not removed from the land covered by the mining title;</p> <p>(b) mined or quarried material containing uranium or thorium is treated in the prescribed manner; and</p> <p>(c) he complies with such conditions (if any) as the Governor in Council may from time to time impose in respect of the mining or quarrying in which he is, or is to be, engaged.”</p> <p>“8 (1) A person shall not construct or operate— (a) a mill for the production of uranium or thorium ore concentrates (except where permitted under section 6);”</p>	<p>Agreement the Act probably does not apply based on the wording.</p> <p>GM: addressed concerns more over the IAEA safeguards implications (discussed in 33)</p> <p>DB: For the Fingerboards project U is 0.0025% and Th is 0.012%.</p> <p>DB: It will be, in accordance with the Victorian Radiation Act and subsequent ML issued.</p> <p>Not applicable.</p> <p>DB: Correct, only HMC is being produced in Victoria, not for the extraction of U or Th.</p> <p>DB: The Victorian Department of Health have advised they will issue a Management Licence for operations (provided all the necessary licence conditions are met).</p>
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		If this occurs, the Nuclear Activities (Prohibitions) Act will not apply.
	35. My expertise is, of course, in Environmental Engineering and not as a lawyer – but, based on my extensive experience in uranium mining issues, points 33 and 34 raise serious legal (and moral) questions about the export of HMC which is expected to be processed in a manner (i.e. acid leaching to extract the rare earths) whereby the uranium and thorium might be readily recovered. This needs much further detailed consideration and very meticulous assessment.	Connected to 33.

Page/comment number	Extract (T Ruff comment)	DB Response and conclave outcome
p1	<b>Summary of Conclusions and Recommendations on Radiation and Health</b>	
1	1. New evidence shows that radiation risks to health are greater than previously thought and are not adequately reflected in regulatory limits. Health risk exists below the maximum permissible doses for the public and for workers.	<p>In disagreement, but in agreement it is a regulatory debate not specific to the Fingerboards Project.</p> <p>Kalbar will be recommended to use Vic limits based on international ICRP protection philosophy. 20 mSv and 1 mSv ‘Limitation’ and Optimisation (Clause 7 of Act). This existing framework ensures doses are minimised.</p> <p>TR- framing point- asked to do this at short notice. Clearly didn’t have benefit of all documentation that came after the start of February. Much of my statement is trying to flesh out a broader context or picture, that there is lots of evidence and practice that provide a compelling basis for higher standards than defined by the regulatory dose limits.</p> <p>TR- agree with your first point, agree this is not a framework to review legal limits, but to ensure that the radiation protection standards and procedures</p>

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		<p>applied to the proposed project keep both occupational and public radiation exposure far below the regulatory maximum limits. Doesn't need specific discussion now.</p> <p>DB- will come back to Q1 later on.</p>
2, 3, 5	<p>2. Radiation health risks are 4 - 5 times greater for children than adults and 40% greater for women and girls than for men and boys at all ages. Young adults are more susceptible than older adults.</p> <p>3. I found no mention in any project documentation I reviewed regarding monitoring or radiation protection measures for sites particularly relevant to children, such as schools, kindergartens, child care centres, playgrounds or sports facilities.</p> <p>5. Radiation protection measures should be informed by age and gender differences in radiation health risks, and should address settings particularly relevant for children.</p>	<p>Partial agreement with statement. Acknowledge that are not included in EIS for radiation.</p> <p>DB - The EIS doses calculated (37 uSv/annum total) do not warrant special targeting of assessment of doses to individual groups. Estimated dose assumptions were explained.</p> <p>Dose was calculated for an infant, but not included in report. Based on lower inhalation dose and higher ingested dose, estimated total dose is 39 uSv/y.)</p> <p>TR- young children should be included. At least some basic identification of where and how children might be exposed to the mine and HMC transport pathways through the various ways (inhalation, road traffic, dust ingestion etc. ) would be prudent to identify. A geographic map could help to identify locations where children spend lots of time apart from homes- eg kindergarten, childcare, schools, playgrounds, sports facilities.</p> <p>KT- we have a figure in the health risk assessment relating to different groups and agreed it wasn't specifically noted in the radiation report.</p>

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4	<p>4. All aspects of project management should aim for radiation exposures for workers and the public which are as low as practicable and well below regulatory limits, and set action levels that would trigger prompt evaluation and response, with involvement of DH. I would recommend that the latter levels (including all exposure pathways) be set at around 1-2 mSv per year for workers and 0.1 - 0.2 mSv/yr for the public.</p>	<p>In Agreement following discussion.</p> <p>DB - Action Levels will be set in the RMP for approval by the DH. Rather than annual doses, investigation and DH reportable levels will be based on discrete sample results (dust, Rn, qtrly TLD) exceeding a specific value. And will ensure annual doses are minimised before they even occur. Need to be careful setting fixed annual dose thresholds too low</p> <p>NW (DH) confirmed this would be difficult to regulate against. The Act does not have offences for exceeding trigger levels and don't have power to create an offence for exceedance of a constraint in a licence condition, but we can require the company to undertake activities like investigations and report back on results. If we feel there is a risk a limit will be exceeded, we can issue a notice or suspend licence to suspend activities.</p> <p>All in agreement that trigger levels will appear in the radiation plan, needs to be real time, multifaceted, include workers and offsite residents, have clear levels that would trigger review, investigation, additional measures, and should be low.</p> <p>DB – made comment expected doses were comparable or less than limits proposed by TR anyway.</p>
P2, 6	<p>6. A major project which will run over more than two decades must consider the implications of global heating and factor them into its mine management.</p>	<p>No agreement could be reached.</p> <p>TR – raised a concern on the impact of more frequent and intense extreme climate-related events including bushfires, drought, high winds and heavy rainfall events over the projected life of the project. Has implications for mobilisation of radioactive substances on and off the project site, including through wind-borne dust, fire smoke and debris, and flooding. These factors</p>

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		<p>should be considered in all facets of the project including radiation exposure modelling assumptions and radiation monitoring and management plans. Extends beyond the area of expertise of the conclave participants.</p>
2, 7	<p>7. To minimise the public health and environmental impacts of both routine and accidental releases of HMC during handling and transport, every effort should be made to minimise multiple handling and especially dust generating loading of HMC onto and off trucks, and onto ships from wharves, and open storage of HMC at the mine or on wharves or anywhere else.</p>	<p>All in agreement.</p>
2, 8	<p>8. As recommended by Dr Joyner and DH, all possible exposure pathways of workers and the public should be assessed and monitored, including through farm work and other types of prevalent local employment or other activities, and sampling of all agricultural products downwind and downstream of the planned mine, including not only vegetables and grain, but fish, and animal products in the form of both meat and dairy products. If any Aboriginal people harvest bush foods in areas potentially affected by the project, associated exposures should also be assessed.</p>	<p>All in agreement issues are of importance. Disagreement of scale of baseline data to collect.</p> <p>DB - Farm work and direct dust ingestion already assessed (section 9.2.3 RAR) to be 1.5 uSv/annum.</p> <p>DB - Livestock assessment to be included in REP. Preliminary assessment indicates human dose from cattle consumption (0.4 uSv), and Dairy consumption (0.3 uSv) per annum. Dose from fish consumption considered insignificant based on already negligible impact on drinking water.</p> <p>DB - Consumption of bushfoods already considered as soil+crops component.</p> <p>TR – Monitoring pre, during and post-project appropriate. Empirical data always much more solid and meaningful than modelling data alone. Importance of effective monitoring of all exposure pathways especially important given public concern and proximity of project to agricultural areas and to the Mitchell River draining into the Gippsland Lakes, extensive</p>

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		<p>environmentally, culturally, economically and recreationally important region.</p> <p>All agreement that some baseline data would be useful for allaying concern of concerns.</p> <p>DB - Based on reported uncertainties in lab analysis techniques, and natural variations in low-level radioactivity expected in livestock radioactivity, project impacts are likely to be unrecognisable.</p>
2, 9	9. All mine personnel should wear appropriate personal radiation dosimeters at all times on site.	All in agreement personal dosimetry important. Integral to the approved RMP required pre licencing.
2, 10	10.All environmental and health relevant monitoring data during every phase of the mine's operation and rehabilitation should promptly be made publicly available.	<p>Not discussed.</p> <p>TR - Based on public health principles and best practice.</p>
2,11	11.All consultative bodies established in relation to the mine should include representatives of community organisations.	<p>Not discussed.</p> <p>TR - Based on public health principles and best practice.</p>
2, 12	An adequate rehabilitation bond should be established to enable timely completion of remediation and rehabilitation to occur without substantial call on the taxpayer to foot the bill if the operating company is unable to complete this task in a timely and adequate way.	Not discussed.

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2, 13	13. Project documentation currently uses the large and cumbersome unit of the Sievert (SV) for ionising radiation equivalent dose, for reasons that are not apparent. It would be clearer if this were changed to usual units which are much more clear, comprehensible and less error-prone in this context - milliSv or when appropriate microSv.	All in agreement.  'mSv' and 'uSv' are used in the RAR. Whereas the main EES document regularly refers to units of 'Sv'
2, 14	14. The proposed project's possible international nuclear safeguards implications should be addressed before any approvals are granted.	Addressed in G. Mudd's comments (refer point 33)
2, 15	15. The implications of the Victorian Nuclear Activities (Prohibitions) Act 1983 for the proposed project should be addressed before any approvals are granted.	Addressed in G. Mudd's comments (refer point 34)
<b>4</b>	<b>Comments in relation to other reports provided</b>	
4.1	<b>Dr KH Joyner</b> I support the recommendation of Dr Joyner and DH that impact on downstream animal products like dairy and animal meat for human consumption should be considered in the risk assessment and form part of the Radiation Environment Plan.	Agreed by all.
4.2	<b>DH</b> I strongly support the recommendation by DH (p4) that "Radiation monitoring will be required for the life of the mining project." I would add that comprehensive monitoring should continue at least through the rehabilitation phase as well.	Agreed by all.

Page/comment number	Extract (T Ruff comment)	DB Response and conclave outcome
4.3	The DH statement (p.21) that “In essence, Kalbar would be required to leave the rehabilitated mine site with no significant increased risk of radiation exposure compared with the radiation exposures that existed prior to mining.” is welcome and appropriate.	Agreed by all.
<b>4</b>	<b>A/Prof Gavin Mudd</b>	
4.4	He notes in particular that given the documented variability of soil radionuclide levels by a factor of almost 100 between 10 samples, a much larger number of soil samples should have been collected for testing (paras 20 and 24); that the need to assess radionuclides in vegetables in Lindenow should already have been completed and presented through the EES process (para 27); and that the detailed radon surveys noted in the EES future workplan should also already have been completed as part of the EES process (para 31).	Addressed in response to Gavin Mudd’s comments (refer points 20,24 and 31)
4.5	Prof Mudd notes that a number of plans for managing radiological risks are still to be finalised, and expresses concern about lack of detail provided for the radiation monitoring plan and radioactive waste management plan (para 32).	Addressed in response to Gavin Mudd’s comments (refer point 32)  Not part of the EES Process.
<b>5</b>	<b>Nuclear safeguards matters</b>	
5.1	The IAEA defines source material as follows, stating that this term “shall not be interpreted as applying to or ore or residue”, but that “ore concentrate is considered to be source material”. <sup>2</sup>	Addressed in G. Mudd’s comments (refer point 33)
<b>7</b>	<b>Consistency of proposed project with Victorian Nuclear Activities (Prohibitions) Act 1983</b>	
7.1	The comparison of uranium and thorium concentrations estimated in Fingerboards heavy mineral concentrate	Addressed in G. Mudd’s comments (refer point 34)

Page/comment number	Extract (T Ruff comment)	DB Response and conclave outcome
	<p>(HMC) outlined in Table 1 of Prof Mudd's report (p7) with projected production of 185 t of uranium and 1050 t of thorium, in a total volume of ore projected at 700,800 t, constitutes average concentrations of 0.026% for uranium and 0.149% for thorium, above the levels which are exempt under the Victorian Nuclear Activities (Prohibitions) Act 1983. This potential lack of compliance with Victorian law also needs to be addressed before any approvals for the project are granted.</p>	<p>It was acknowledged the values quoted are for the HMC concentrate. Whereas the exemption criteria quoted in the Nuclear Activities Act is for ore.</p>
<b>7</b>	<b>Evolving understanding of the effects of ionising radiation on health</b>	
7.2	<p>Any consideration of protecting workers and the public from the health risks of exposure to ionising radiation should consider not only regulatory requirements, but also the evolving current evidence regarding of those risks. Significant evidence has been accumulating in recent years which extends our understanding of radiation health risks and indicates that those risks are greater than previously assumed. The current regulatory standards for radiation protection – essentially 20 mSv maximum average annual permissible additional occupational exposure for workers and 1 mSv additional human origin non-medical exposure for members of the public - were established over 2 decades ago, before much of the current evidence became available. These standards are now arguably inadequate. They are not standards associated with no or with negligible risk.</p>	<p>In disagreement on statement, however all in agreement, this discussion is more of a regulatory debate, and not relevant specifically to the Fingerboards Project.</p> <p>DB - There has always been healthy debate in the rad protection community over low dose exposures. For this reason 'Optimisation' is applied (clause 7 of Vic Act) in addition to the 20 mSv and 1 mSv 'Limitation' to ensure doses are kept to ALARA.</p> <p>DB - Irrespective, for MoP the upper limit is 1000 uSv/y. Estimated project doses are 40 uSv/y which is highly conservative, and still orders of magnitude less than the upper limit.</p>
<b>9</b>	<b>Medical radiation exposure and cancer risk in children</b>	

Page/comment number	Extract (T Ruff comment)	DB Response and conclave outcome
10.1	Together, the CT scan and worker studies definitively demonstrate the absence of a threshold for ionising radiation-related cancer risk, and measurable increases in cancer risk evident with exposures of very few mSv.	Refer comment 7.2 above.
12.1	Taken together these studies confirm biological and health effects of even very small differences in radiation exposure, of the order of 1 mSv or less.	Refer comment 7.2 above.
13	I found no mention in any project documentation I reviewed regarding monitoring or radiation protection measures for sites particularly relevant to children, such as schools, kindergartens, child care centres, playgrounds or sports facilities.	Addressed in comment 1.2 above.
<b>13</b>	<b>Some key aspects of the project relevant to radiation exposures</b>	
14.1	The accelerating impacts of global heating will increase over the next decades. With the exception of Dr Joyner's report, nowhere in the project documentation available to me did I note any discussion of the impacts of climate change. Indirect acknowledgement of their importance lies in a statement in EES 9.7.5.2 that wharf loading of HMC would not occur under wet or windy conditions.	Addressed in comment 2.1 above
14.2	The largest estimated radiation exposures associated with the proposed project are associated with transport of the heavy mineral concentrate produced at the mine. No mention is made in the documentation available to me indicating that workers at the proposed project, including workers transporting the HMC, will have personal radiation exposure dosimetry performed through appropriate personal dosimeters worn at all	All in agreement.  Will be detailed in the RMP. Will be specified in Management licence conditions as deemed required.

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	times on site. This should be standard for all people working with radioactive materials.	
15	To minimise the public health and environmental impacts of both routine and accidental releases of HMC during handling and transport, every effort should be made to minimise multiple handling and especially dust generating loading of HMC onto and off trucks, and onto ships from wharves, and open storage of HMC at the mine or on wharves or anywhere else. Every effort should also be made to minimise the number and distance of truck movements required to transport the HMC, and preferably to eliminate them altogether. The ideal would be for the HMC to be loaded via as closed a system as possible (eg a closed conveyor or pipe) directly into train-borne containers at or immediately adjacent to the mine site, containers which are then sealed and transported by rail to be shipped offshore.	All agreed in principle.  DB – commented that some road transport is likely to be required. My understanding is the transport configurations are still being finalised by Kalbar.
	<b>New comment raised by TR not in Witness Statement</b>	

Page/comment number	Extract (T Ruff comment)	DB Response and conclave outcome
NEW	<p>TR - reading some excellent recent papers by Martin Ralph, Mines Dept in WA, finishing PhD on radiation exposures in WA mining industry, refers to a lot of mineral sands facilities. Revising dose assessments for workers, revised coefficient estimates for worker exposure including uranium and thorium decay series. Part of published work is historical comparison, which show welcome decline but still reasonable doses. Applying the new ICRP dose coefficients (in ICRP-137 (2017) and ICRP-141 (2019)), those dose estimates increase not insignificantly, for up to 2-3 fold. Not yet reflected in ARPANSA documentation and not in main guide that's relevant to this project, but ARPANSA's website recognises that these will need to be taken into account. For the Fingerboards project, these guides are highly relevant.</p>	<p>In general agreement any new internationally recognised guides that are relevant should be reviewed.</p> <p>DB - I am aware of the very new dose conversion factors ICRP-37 and ICRP-41 for calculating internal doses. For Fingerboards, internal dose contributes only 10% of the total worker dose. My understanding is the documents refer to occupational workers and not members of the public.</p> <p>However, if they are deemed suitable, they will be used for dose assessment during the project. Any dose assessment methodology adopted for dose assessment of workers and members of the public will need to be approved in the RMP prior to issuance of a Management Licence.</p>

**Signatures inserted electronically:**

	Darren Billingsley (inserted 16 April 2021)	
	Assoc. Prof. Gavin M. Mudd (inserted 19 April 2021)	

	Assoc. Prof. Tilman Ruff (inserted 16 April 2021)	
	Karen Teague (inserted 16 April 2021)	