Submission Cover Sheet

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Fingerboards Mineral Sands Project Inquiry and Advisory Committee - EES

Request to be heard?: Yes

Full Name: Dr Dora C. Pearce

Organisation:

Affected property:

Attachment 1: Pearce_Submissio

Attachment 2:

Attachment 3:

Comments: See attached submission

Submission in response to the

Fingerboards Mineral Sands Project EES:

Dear Inquiry and Advisory Committee members,

I make this submission in response to the Environment Effects Statement (EES) prepared for the proposed Fingerboards mineral sands mine to express my opposition to the project for the reasons discussed in detail below.

SUMMARY:

Recent epidemiological and ecological research identifies numerous concerns about environmental health impacts associated with rare earth elements, their coexistence with radionuclides, and current mineral sands mining practices. *The Human Health Risk Assessment* prepared by Coffey Services Australia Pty Ltd (August 2020) highlights numerous adverse environmental health impacts that could occur if the Fingerboards mineral sands mine is granted approval but does not implement best practice management strategies during the construction, operation and rehabilitation phases, and as a consequence of which the health and wellbeing of neighbouring communities could be undermined.

My concerns are twofold:

- As an Environmental Epidemiologist: the potential for adverse environmental health impacts on neighbouring communities due to chronic exposure to inhaled and/or ingested mine contaminants via offsite dust emissions, surface water runoff and seepage into waterways and groundwater could increase the burden of disease for current and future generations due to the persistence of some contaminants in environment media and human organs and tissues;

- As a founding member of the Whitehorse Canoe Club: the possible environmental degradation of the Mitchell River and connecting waterways that could occur as a result of water depletion, sedimentation and contamination could adversely impact future generations of recreational canoeists.

Approval of the Fingerboards mineral sands mining proposal would necessitate strategic and ongoing monitoring of environmental pollutants, regulatory enforcement of compliance with best practice mining protocols, and human health risk assessment including identification of biomarkers and disease outcomes corresponding to predetermined risks and hazards: the complexity of which is exacerbated by the latency period between environmental exposures, symptom onset and disease diagnosis.

1. BACKGROUND on potential impacts of mineral sands mining:

As applications for rare earth elements (REEs) expand and diversify, research into human exposure pathways and health impacts on populations living in close proximity to REE mining and processing operations is also increasing (Pagano et al., 2019). Evidence of elevated REE body burden in exposed communities has emerged (Tong et al., 2004), indicating that off-site emissions are potentially hazardous to neighbouring communities and that effective regulatory controls are essential to protect environmental health. REE contamination of soils may lead to contamination of agricultural products, with bioaccumulation in plants ultimately leading to REEs entering the food chain, and necessitate management strategies to prevent contamination of surface waters and groundwater in proximity to REE mining operations (Adeel et al., 2019). Further, the Australian landscape is already marred by abandoned mines posing environmental health risks (Werner et al., 2020).

In Australia, monazite is the principal rare earth mineral exploited, typically with radioactivity due to a thorium component, since REEs and uranium/thorium mineralization often coexist: this co-deposition with radionuclides adds complexity to the processing of REE ores, which require high water and energy use and produce waste streams including tailings and wastewater (Haque et al., 2014). Extraction and separation of individual REEs involves sequential processes including physical separation, chemical leaching, solvent extraction and ion exchange, possibly involving the use of acid and/or alkali, and treatment and disposal of radioactive waste, hence REE mining developments should not be in close proximity to sensitive ecosystems (Golev et al., 2014). Enrichment of thorium in waste from REE processing has the potential to contribute to offsite contamination (Findeiβ & Schaffer, 2017), while removal of radioactivity from mineral sands products has become increasingly regulated (Hart et al., 1993).

Effective onsite management of waste water is crucial to prevent disastrous consequences such as occurred at the Mountain Pass operation which resulted in leakage of thorium into a nearby lake (Ault et al., 2015), and contamination of surface and groundwater near a REE mine in China (Hao et al, 2016), particularly given the close proximity of Fingerboards to the Mitchell River, the Lindenow vegetable growing area and the Gippsland Lakes, a Ramsar designated site. Of particular concern is the potential for plant uptake and phytotoxicity if nearby agricultural soils are contaminated, making toxicity monitoring crucial: aboveground and belowground biomass reduction is plant species and REE dependent, uptake and accumulation are proportionate to dose, with native species more adversely impacted than crops (Carpenter et al., 2015). Contamination of soils and accumulation by pasture plants can also contribute to uptake from both of these sources by grazing animals (Abad-Valle et al., 2018).

Mining operations in close proximity to Indigenous communities, in addition to cumulative contamination of nearby soil and water sources as mining progresses and a reduced water supply, intrude on cultural practices and beliefs and further undermine trust and wellbeing (Basu et al., 2010). Community conflict, reduced cohesion and resentment may arise due to mining impacts on local economies, in particular agriculture, transient workers, increased traffic and noise, local economic inflation, perceived lack of information and communication, and concern over potential environmental impacts (Bec et al., 2016). Attitudes to mining also depend on the perceived ability of governments and legislation to protect the environment: that is, trust in governance capacity to enforce compliance with environmental regulations (Moffat et al., 2014). Suppression of expert scientific knowledge may obscure and hinder the environmental assessment process (Driscoll et al., 2020), suspicion of which further hinders community acceptance of proposals.

The Fingerboards mineral sands mining proposal has the potential to provide much needed resources but also the potential to cause irreversible damage to the local environment and communities if best practice management strategies are not implemented in association with regulatory enforcement of compliance.

2. POTENTIAL SOURCES of ENVIRONMENTAL CONTAMINATION due to FINGERBOARDS:

According to the *Fingerboards Mineral Sands Project: Environment Effects Statement: Summary Report* (Kalbar, 2020a) there are multiple potential sources of dust due to ongoing processes of removal, stockpiling and management of overburden, and extraction, processing and transportation of ore. Surface water and groundwater could be impacted through water depletion, seepage, runoff and sedimentation. Dust and water sources could potentially be contaminated with rare earth elements and radionuclides.

The following highlights several specific routes for contamination of the local environment:

> In Section *5.1. Contamination overview* of the Human Health Risk Assessment (HHRA), Coffey (2020) differentiate between the contribution of "…*high levels of metals, metalloids and radioactive substances*…" present in ore bodies to elevated background levels of these potential toxicants in "…*soils, ambient air and water…"* and contamination due to anthropogenic activities. In Section *5.2.1. Hydrogeological setting: Surface water*, it stated that "*The majority of surface water runoff from the project area drains via gullies … which discharge directly to the Mitchell River*." Further, *5.2.1. Hydrogeological setting: Groundwater* states that "*The drainage lines within the project area exist as incised surface drainage channels and gullies and are likely to act as localised groundwater recharge points during storm and flood events*." and "*The groundwater discharge provides a base flow to the Mitchell River during low rainfall periods*.". Section *5.2.1. Hydrogeological setting: Domestic and agricultural water sources* states that "*The water … obtained from both the Mitchell River and drawn from the Mitchell River aquifer."* is used for drinking water by numerous townships as well as "…*agricultural uses, including crop irrigation and stock watering*…". Section *5.2.2. Land use and social setting: Settlements, towns and social settings* states that there are "… *nine settlements and towns within a 10-km-wide radius of the project area.".*

And the following describes aspects of the mining operation of potential concern to the neighbouring communities:

> "*The Glenaladale mineral sands deposit … contains heavy minerals such as zircon, rutile, ilmenite and rare-earth minerals (monazite and xenotime)."* according to Section *5.3. Project description*. Section *5.3.1. Mining and mineral processing* describes the mining method as "… *open cut dry mining using conventional earthmoving equipment including scrapers, excavators and trucks and tractor scoops for topsoil removal… Topsoil and overburden … will be stockpiled separately … The concentrates will be stockpiled at a loading facility adjacent to the WCP before being transported to port via road and rail.".* Coffey (2020) state that "… *fines tailings (less than 38 µm* …)" will be deposited as a slurry in Section *5.3.3. Tailings*.

The Fingerboards mineral sands mining proposal is highly complex and multifaceted and will require strict management strategies to control the numerous processes described above. Whereas unforeseen and unplanned events such as accidental spills and overflows, leakage and leaching may potentially result in catastrophic environmental and ecological impacts, such as the tailings dam collapse with devastating consequences in Brazil (Molly Lempriere, 27 March 2019, Mining Technology <https://www.mining-technology.com/features/time-to-talk-about-tailings-dams/ > Accessed 19 October 2020) , it is stated in Section *6.2. Contaminant transport pathways*:

> "*The focus of the HHRA is on planned or expected contaminant releases associated with the movement of soils, dust emissions, water and tailings storage and exhaust emissions; therefore,* ***unplanned events such as the uncontrolled release of mine contact water via spillways from water management dams during a major rain or flood event are not addressed in this report."***

Edahbi et al. (2019) report that the potential threat of environmental impacts due to REE exploitation presents numerous challenges for processing and waste management. REEs share physico-chemical properties, may be mobilised and dispersed through mine waste waters into aquatic environments, sediments and soils, contributing to plant uptake and dust, and resulting in human exposure pathways via ingestion and inhalation (Gwenzi et al., 2018). The potential for dam failure or overtopping, and the toxicity of waste water and tailings if not properly controlled and managed, raise concerns for contamination of surrounding soils, surface water and groundwater during operation, waste disposal and rehabilitation of the site on closure (Filho, 2016).

Managing and monitoring numerous sources of anticipated, and unanticipated, potential contamination will be essential to protect the surrounding communities and horticultural and agricultural industries, given the potential for mobilisation of contaminants, and chemical reactions due to oxidation, sorption and solubility of various chemical species, during the mining process. According to the Environmental management framework, Kalbar (2020b) will conduct a monitoring program of environmental aspects including air quality, surface water and groundwater that should provide evidence of compliance with environmental regulations that will be available for the public to access. Of concern is that a recently published audit of mine rehabilitation in Victoria (VAGO, 2020) reported "*systemic regulatory failures*" by the Earth Resources Regulation (ERR) unit, including "*lack of enforcement activities*". What assurance has the community that environmental monitoring during the operation of Fingerboards will be subject to regulatory enforcement and demonstrable compliance?

3. POTENTIAL HUMAN HEALTH IMPACTS due to FINGERBOARDS:

The complex scenario of multiple contaminants and exposure pathways arising from the Fingerboards proposal warrants close scrutiny to protect neighbouring communities in the short and long term. Investigation of biomarkers in blood, urine, hair, or tissue samples, that could indicate exposures to mine waste toxicants via various and/or multiple exposure routes, including inhalation, ingestion and/or dermal absorption, should be undertaken as part of environmental health risk assessments (Plumlee & Morman, 2011).

It is stated in the Section *8.1.3. Soil: Topsoil and overburden in the project area* (Coffey, 2020) that:

> "*Offsite receptors will not be directly exposed to the project area soils* ***except where the subsurface soils are exposed resulting in potential contaminant or substance migration to the regional area via the generation of dust, runoff waters or groundwater infiltration."***

It is further stated in the HHRA by Coffey (2020) in *Table 10.1 Uncertainty Assessment*:

> "*…The health risk assessment evaluation of potential exposures considered modelling associated with dust migration, runoff waters, infiltration to groundwater and discharge to Mitchell and Perry rivers. The modelling of such releases to environmental media resulting from project activities* ***are based on the implementation of key management measures during the construction and operations phases, to prevent or minimise the release of contaminants to air, groundwater, surface waters*** *and during the transport of HCM via road or rail."*

Clearly, it would be crucial for best practice management measures to be implemented, with demonstrable effectiveness, to prevent offsite environmental contamination, such as those described in Section *6. Exposure pathway identification.* Numerous soil components that could generate fugitive dust emissions and leach into surface water and groundwater through mine processing, extreme precipitation events that could cause runoff and overflows, sedimentation, leaching and tailings seepage, unless controlled by suitable management strategies, are identified by Coffey (2020). Chemicals of potential concern (COPC) identified by Coffey (2020) include the metals (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, zinc), radionuclides (uranium and thorium), other selected elements (titanium, iron, aluminium, manganese, tin, vanadium and tungsten), respirable crystalline silica and particulates (PM_{10}, $PM_{2.5}$), NO_2 and SO_2.

As discussed below in the section on DUST, there is potential for airborne pollutants to be transported beyond a 5 km radius of the Fingerboards project area for which this HHRA was conducted. This is of particular concern since numerous communities have been identified within a 10 km radius, including primary school campuses and a kindergarten: young children being susceptible receptors to environmental contaminants (Coffey, 2020). However, in Section *6.5. Selection of potential exposure pathways* it is stated that some exposure pathways were excluded on the basis of being "… *incomplete (i.e., the COPC would not reach a receptor) due to distance from the source and likely extent of substance migration in off-site areas* …".

In addition, it is stated in Section *7. Understanding contaminant toxicity* that "***Radiation, particulate material and metals can cause toxic and other health effects in humans** …"* (Coffey, 2020). Airborne particulates may contain radionuclides, metals, metalloids (eg. arsenic), and respirable crystalline silica, each with potential adverse health consequences if inhaled or ingested (Coffey, 2020). Importantly, in *Table 8.1 Ambient air quality Tier 1 screening criteria* it is noted that there is **no Tier 1 screening criterion for Thorium in dust** identified, and neither is there a *Tier 1 screening criteria Residential land use* identified for Thorium in *Table 8.9 Tier 1 screening criteria – soil [mg/kg]* (Coffey, 2020).

Radiological concerns increase when monazite is concentrated from the mineral sands due to the thorium content: high energy gamma rays in the thorium decay chain enter the body externally; and inhaled airborne alpha particles contribute to internal lung dose, and depending on particle size, may cause alpha radiation exposure throughout the lung tissue and if transported, irradiation of other organs (Hartley & Toussaint, 1986). Thorium oxides have a long half-time of clearance from the lung after dust inhalation (Hewson, 1997), and alpha emissions cause cellular damage when inhaled (Ali, 2014). While processing, storage and transport of monazite are potentially hazardous due to radiation levels (Hartley & Toussaint, 1986), external gamma radiation exposures may be higher in monazite storage areas than in processing plants (Hewson & Hartley, 1990).

The physicochemistry of particulates arising as fugitive dust and dispersed offsite will determine their potential to be "… *an irritant, a toxicant, or a carcinogen* …" (Filho, 2016). Offsite dust emissions from a Sri Lankan minerals sands mine that includes monazite and thorium were implicated in a finding that employees and residents living within 5 km were found to have elevated numbers of micronuclei, a predictive biomarker of cancer risk and implicating chronic low-dose exposures (Warnakulasuriya et al., 2017). Inhaled airborne particulates containing cerium (Ce) compounds have been linked to pulmonary inflammation, lung fibrosis and pneumoconiosis (Ma et al. 2017), and dust exposure during extraction of thorium from monazite was associated with lung and bladder cancer mortality (De Vathaire et al., 1998).

Exposure *in utero* to air pollution, including fine particulate matter ($PM_{2.5}$), has been attributed to lung function deficits in early childhood (Jedrychowsk et al., 2010; Willis et al., 2020), and REEs have been detected in human milk colostrum soon after childbirth (Poniedziałek et al., 2017), indicating exposure during pregnancy and potentially posing a risk for newborns. Cerium has been detected in toenail clippings from patients experiencing their first acute myocardial infarction (AMI) and likely reflects exposure during the preceding year (Go´mez-Aracena et al., 2006). While detection of toxic elements in toenail clippings suggests excretion subsequent to systemic absorption resulting from episodic exposures (Pearce et al., 2010), REEs have been detected in various human organs and tissues (Koeberl & Bayer, 1992).

Of concern, it is stated in *8.2. Tier 1 summary and data uncertainties* (Coffey, 2020) that:

> "… ***the uncertainties regarding the adequacy and quality of the data set and potential data gaps should be accounted for when considering the conclusions of the Tier 1 baseline evaluation… of this HHRA***."

Nevertheless, it is stated in Section *9.4.2. Impacts to a critical group of the public* that:

> *"The annual estimated dose to the members within the Critical Group is estimated to be considerably lower than the acceptable annual dose limit for the public (after background) of 1 mSV (1000 µSv).".*

Community acceptance of the conclusions of low risk exposures to environmental pollutants that are based on Tier 1 assessments is unlikely, given the uncertainty attributed to the data used to model these predictions.

Whereas the scope of an Environmental Health Risk Assessment (EHRA) is to evaluate the potential human health impacts of environmental hazards: identifying the extent of the potentially exposed population and their baseline health status, uncertainties, factors that influence the nature and magnitude of the risk, population variability and susceptibility, synergistic and cumulative impacts, exposure duration and lag time until disease and/or symptom onset (enHealth, 2012); the Tier 1 approach to HHRA, a comparison between modelled exposure predictions and health-based criteria, is potentially limited by uncertainty and oversimplification, and may fail to detect possible adverse health impacts on exposed communities.

The exposure pathways, itemised in the HHRA by Coffey (2020), to potentially toxic contaminants in water and dust are of major concern to neighbouring communities, and unless assured that best practice management strategies will be implemented throughout the Fingerboards mining operation, if approved, and compliance with regulatory requirements is publicly demonstrated, community concern regarding potential adverse impacts on their health and livelihoods due to Fingerboards will persist.

4. COMMUNITY PROFILE:

The susceptibility of the communities living in close proximity to the proposed Fingerboards mineral sands mine cannot be estimated based on demographic and health-related data at an appropriately fine spatial resolution, necessitating consideration of data aggregated to include the entire population of the Shire of East Gippsland as representative of the potentially exposed population.

The neighbouring communities are potentially susceptible to exacerbations of pre-existing respiratory conditions such as asthma if exposed to increased levels of airborne particulates and toxic contaminants (Grzywa-Celińska et al., 2020). For the period 2010 to 2014, among males there was a relatively high incidence of lung cancer (Standardised Ratio (SR) 122 (95% Confidence Interval (CI) 101-143)), and in 2017-2018, the modelled estimate of asthma prevalence of 14.4 (95% CI 12.4-16.5) was consistent with the elevated SR of 105 for asthma-related hospital admissions (PHIDU, 2020).

Additional vulnerabilities arise due to the elevated male lymphoma (SR 135 (95% CI 100-170)) rate, female colorectal cancer (SR 129 (95% CI 106-152)) rate, high smoking rates and alcohol consumption among males and females, and socio-economic disadvantage reflecting low income and educational attainment, high unemployment and high levels of income support within the community (AIHW, n.d.;

PHIDU 2020). Aboriginal Australians comprise 3.5% of the total population in East Gippsland Shire, representing a relatively high proportion of Indigenous people who typically experience substantial health disparities (PHIDU, 2020; Shepherd et al., 2012).

Further, children are particularly susceptible to the effects of air pollution because of increased doses of particulates due to outdoor play, mouth breathing relatively close to ground level, higher respiratory rates relative to body size, and ineffective particle filtering in the nasal passage which facilitates transfer of particles into the lungs (Goldizen et al., 2016). Their developmental stages influence their ability to eliminate environmental contaminants, making them more susceptible to small doses (Ferguson et al., 2017).

Human health impacts of various environmental exposure scenarios may be modified by the local community's prevalence of pre-existing comorbid conditions, social and cultural characteristics, with children being sensitive receptors of environmental exposures and subsequent generations put at risk due to epigenetic mechanisms, thus confounding hazard identification and the health risk assessment of multiple and cumulative exposures (Entwistle et al. 2019).

5. DUST:

Sources of dust:

Dust is likely to be a key air pollutant associated with the Fingerboards mineral sands mining project for the duration of construction, operational and rehabilitation stages of the mine: two years for construction, and 15 years for operation and 5 years for rehabilitation (Coffey, 2020). Dust emissions from the proposed operation will therefore represent a potential source of ongoing exposure of the surrounding community for around two decades.

Kalbar Operations Pty Ltd (Kalbar, 2020a) *EES Summary Report: Air Quality* (Page 16) states that:

> *"**The project will result in emissions of dust and exhaust pollutants due to earthworks, wind erosion from bare ground and stockpiles, vehicle movements along unsealed roads and the use of on-site diesel generators**"*

Further, it is stated in Section *7.2. Particulates in airborne dust* that "*Dust typically emitted as a result of mining operations is assessed in terms of total suspended particulates (TSP), particulate matter with an aerodynamic diameter less than 10 micrometres (PM_{10}) and particulate matter with an aerodynamic diameter less than 2.5 micrometres ($PM_{2.5}$) … Inhalation exposures to respirable crystalline silica particles has the potential to cause serious health conditions including silicosis"* (Coffey, 2020).

While Coffey (2020) states that dust from mining consists primarily of larger, non-respirable particles generated through the handling of rock and soil, through wind erosion of stockpiles and exposed ground, and from vehicular wheel generated dust during transport of material across the site, recent studies have shown that respirable particles may also be generated during the mining process (reviewed in Csavina et al., 2012; Martin et al., 2017). This is of concern, not only because $PM_{2.5}$ penetrates more deeply into the lungs, but because smaller particles in mine wastes, residues, and mining-affected soils are often characterised by greater contaminant concentrations (Kim et al., 2011; Martin et al., 2017). Further, windblown transport of $PM_{2.5}$ in the vicinity of erodible mine tailings has been linked to adverse health outcomes irrespective of its chemical composition (Stovern et al., 2014).

Monazite is a rare earth phosphate which typically contains 5 - 7% thorium and 0.1- 0.3% uranium, and contributes substantially to radioactive airborne dust despite comprising only 0.5% of total mineral sand production (Hewson, 1997). Although the primary separation of heavy mineral concentrate from the gangue typically uses a wet process based on specific gravity, a radiation hazard through inhalation may be incurred due to dust generated during the secondary separation of heavy mineral concentrate into individual minerals if a dry process is used (Hewson & Hartley, 1990). Fine particle size grains (2-10 µm) of monazite have been detected in mineral sands processing plants (Hartley & Toussaint, 1986), and particulates containing thorium and uranium have been detected with mass median aerodynamic diameters of 1.15 µm, thus in the respirable fraction of airborne dust (Dias Da Cunha et al., 1989). REE enrichment in atmospheric particulates sampled around the Baotou REE mine tailings, and a gradient in the direction of the prevailing wind, were identified (Wang & Liang, 2014).

In Section *8.1.2. Air* it is concluded that baseline levels of respirable crystalline silica, PM_{10} and $PM_{2.5}$, particulate matter metal, Uranium and Thorium, and ambient gamma radiation were within acceptable limits (Coffey 2020). In *Table 8.1 Ambient air quality Tier 1 screening criteria* of this HHRA (Coffey, 2020), the Tier 1 screening criteria applied for 24h averaging periods are 60 µg/m^3 and 36 µg/m^3 for PM_{10} and $PM_{2.5}$, respectively, based on the Protocol for Environmental Management (Mining and Extractive Industries) PEM MEI (EPA, 2007). These criteria are both substantially higher than the currently legislated criteria, hence less protective of public health: the currently in force National Environment Protection (Ambient Air Quality) Measure (2016) states that for PM_{10}, the maximum concentration standard for a one day averaging period is 50 µg/m^3 with no allowable exceedances, and for $PM_{2.5}$ the standard is 25 µg/m^3, also with no allowable exceedances (NEPM AAQ, 2016). According to data reported in *Table 8.3 Baseline summary 24-hour ambient particulate matter* the baseline maximum 24 hour averaging period measurements for PM_{10} and $PM_{2.5}$ were 57.3 µg/m^3 and 13.7 µg/m^3, respectively, during baseline data collection from 1 October 2017 to 30 September 2018 (Coffey, 2020). While this exceedance was a single event (Katestone, 2020), it is of concern and unclear why pre-mining PM_{10} levels were in exceedance of the NEPM AAQ.

These observations highlight the importance of emission source characterisation of both the coarse and fine fraction of airborne emissions from mine wastes when assessing the risk to human health. It is therefore imperative that all sources of potential emissions be comprehensively characterised to enable an informed approach to reconciling the contribution of mining to regional air quality impacts.

Dust modelling predictions:

The precision of dust modelling predictions is dependent on assumptions pertaining to regional topography and local weather patterns, as they affect plume generation and dispersion and also deposition locations (Stovern et al., 2014). Coffey (2020) report that Katestone (2020) used air modelling to predict TSP, PM_{10} and $PM_{2.5}$ emissions from major dust generating activities at the point of exposure for key receptors and dispersion modelling to predict ground-level concentrations of other selected pollutants, assuming a range of mitigation and control measures. Respirable crystalline silica emissions were estimated proportionate to $PM_{2.5}$ emissions and emissions of metals and radionuclides were estimated proportionate to PM_{10} emissions from overburden, topsoil and ore.

It is concerning that some of the modelling predictions, upon which the HHRA in relation to air quality conducted by Coffey (2020) is based, have been called into question by an independent reviewer. Denison (2019) has criticised the baseline monitoring data sets used by Katestone (2020), their failure to identify measures intended to reduce emissions in order to achieve best practice or to the maximum extent achievable based on mineral sands mines; and selection of indicators assessed as pollutants of concern. Further criticism was raised of Katestone's justification for the period used as the basis to model predicted emissions, which should be based on a worst-case scenario to facilitate measures of compliance and to provide maximum protection for nearby "receptors"; and their failure to base their assessment on the appropriate mineral sands mining NPI estimation manual (Denison, 2019).

Denison (2019) stated that to avoid exceedances and achieve compliance with air quality criteria it may be necessary to specify additional strategies to be implemented if real-time monitoring of PM_{10} indicated that an immediate response based on a reactive management strategy was required when elevated particle levels were detected in the short term. Additional detailed discussion was also recommended in regard to preventing contamination of resident's rain water tanks with heavy metal emissions, and conducting dust deposition monitoring to avoid adverse impacts on neighbour's amenity (Denison, 2019).

Predicted 24-hour average concentrations of PM_{10} levels during the operational phase were likely to exceed "*… the Tier 1 screening criteria on, at most, three days of the year*." when **standard** mitigation measures were applied (Section *9.1.2. Particulate matter and dust deposition*; Coffey, 2020). However, it is reported that "***Additional mitigation measures, for example, ceasing overburden transport in both pits, and product transport between 6:00 p.m. and 7:00 a.m. on selected days, would be sufficient to prevent these exceedances*.".** Nevertheless, neither "*… ground-level concentrations of all heavy metals …*" nor radiation exposures due to "*… inhaled airborne dust particles containing radioactive* material …" were predicted to pose concerns (Coffey, 2020).

The implementation of "*additional mitigation measures*" to prevent exceedances of PM_{10} criteria will require responsive monitoring and management strategies to trigger immediate and effective dust suppression activity when necessary, and ongoing monitoring to demonstrate the effectiveness to the public and regulators. A willingness to suspend mining operations when necessary to prevent offsite emissions adversely impacting nearby sensitive receptors may therefore be required.

Dispersion of dust:

Mining operations can release dust (and any contaminants attached to the dust) into the environment, which is then dispersed via the action of the wind through the atmosphere. Active mining operations produce and/or mobilise dust to varying degrees in all stages of the mining process: during the removal of overburden; during all aspects of the handling of ore, including its extraction, transportation and further processing; as part of waste disposal operations; and as a result of wind erosion of exposed areas (Aneja et al. 2012).

The Cataby mineral sands mine in Western Australia reported to the National Pollutant Inventory for 2018-2019 that they produced air emissions of 1,100,000 kg of PM_{10} and 16,000 kg of $PM_{2.5}$ (NPI, 2020). While difficult to compare with legislated air quality criteria, such quantities of inhalable and respirable dust generated annually and in close proximity to residential communities and horticultural crops could cause severe adverse health consequences and crop damage.

The distance that dust travels depends on the size of particulates, and wind speed and direction, leading to exposures via inhalation and ingestion of potential toxic elements (PTEs) (Martin et al., 2016). Daily maximum wind data from the Bairnsdale weather station indicates that winds predominantly have a westerly component, with gusts up to 104 km/hr, with 62% of winds from the South West being ≥50 km/hr recorded for October 2019 to September 2020 (BOM, 2020). Figure 1 shows that wind gusts well in excess of 50 km/hr occur frequently. Figure 2 indicates that these high speed winds occur consistently throughout this 12 month period while days of high rainfall occur infrequently.

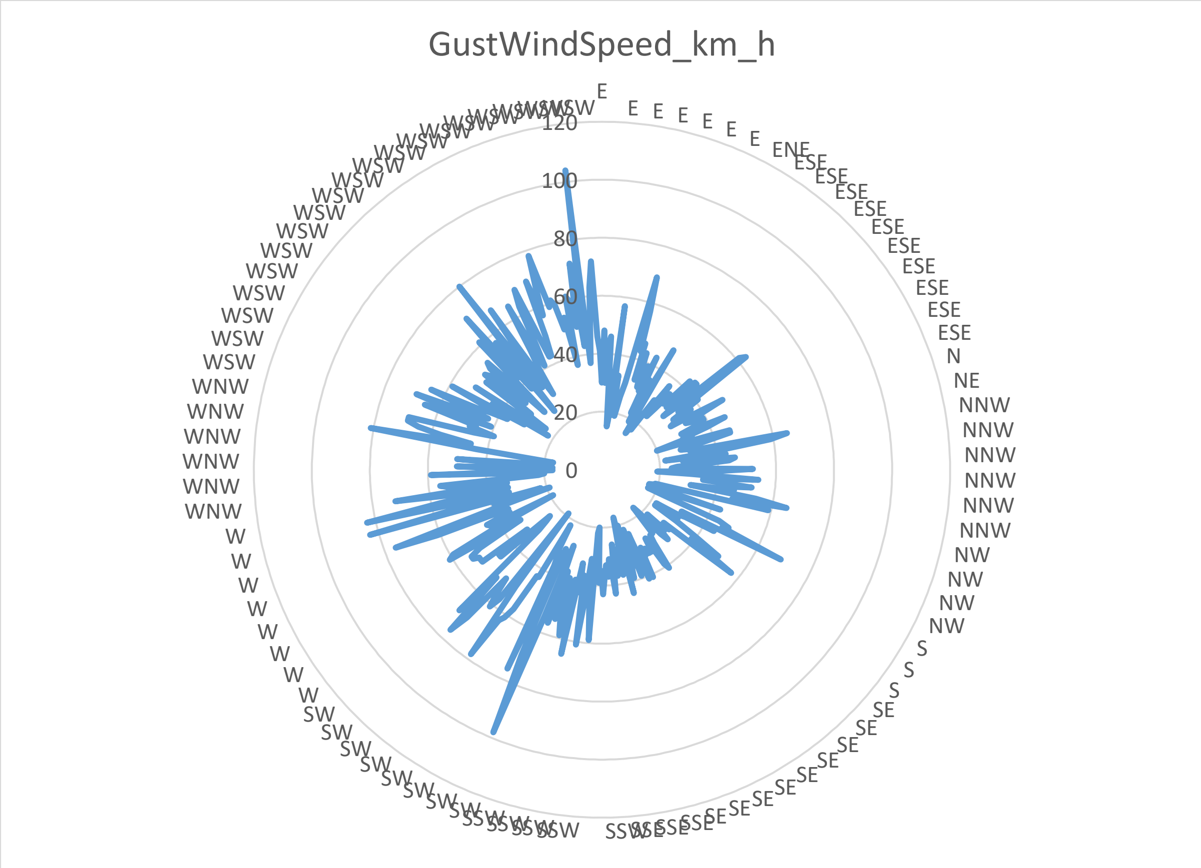

Figure 1. Daily maximum wind speed and direction October 2019-September 2020 at Bairnsdale. Source: Australian Government. Bureau of Meteorology (BOM) 2020. Daily Weather Observations for Victoria (A - B) <http://www.bom.gov.au/climate/dwo/IDCJDW0301.shtml > Accessed 9 October 2020.

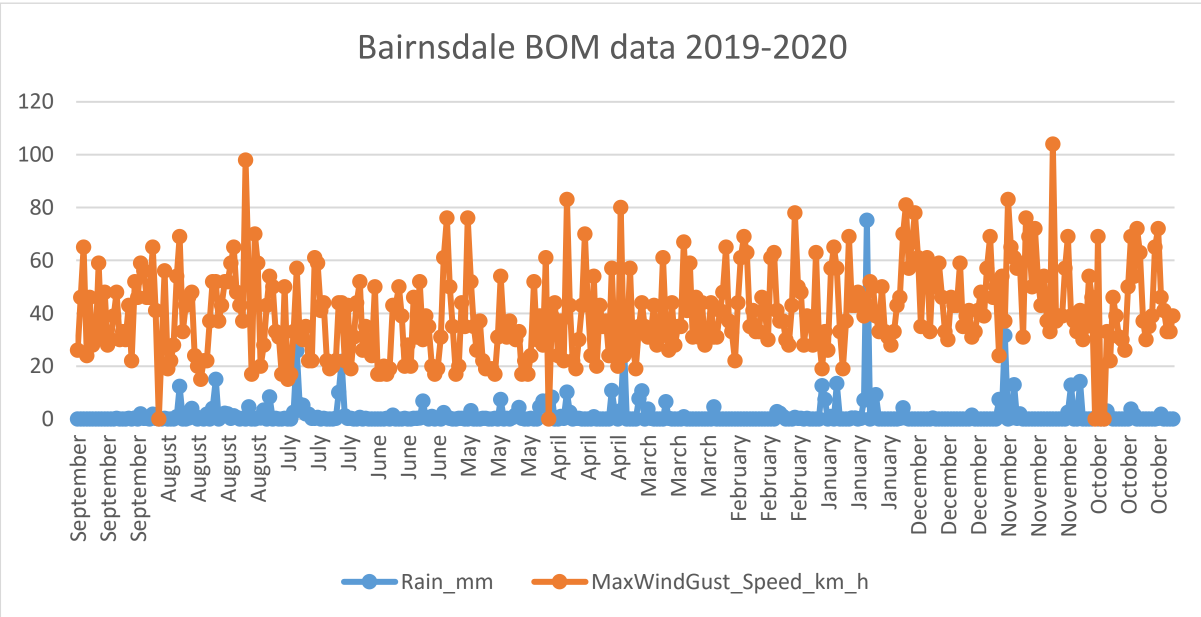

Figure 2. Distribution of daily maximum wind gusts and rainfall for October 2019- September 2020 at Bairnsdale. Source: Australian Government. Bureau of Meteorology (BOM) 2020. Daily Weather Observations for Victoria (A - B) <http://www.bom.gov.au/climate/dwo/IDCJDW0301.shtml > Accessed 9 October 2020.

Since wind gusts tend to be highest from a westerly direction, dust from the Fingerboards project will tend to be dispersed towards sensitive receptors to the east, which includes the Lindenow horticultural district approximately 5 km to the east. Winds above 40 km/hr may potentially transport PM_{10} particulates and any PTEs over 5 km, and $PM_{2.5}$ particulates may be transported 5 km by winds as light as 10 km/hr (Chemtek Inc., 2019), putting this important food source at risk of contamination with REEs and thorium and exposing communities to an increased risk via inhalation and ingestion. Vehicular transportation originating within the mine to offsite areas contributes to the distribution of mine contaminants to roadside fine dust, potentially impacting local communities (Tian et al., 2019).

Radiation in fine particulates

While a radiation monitoring program to assess "*environmental airborne activity concentrations*" during all stages of operations was recommended, in Section *5.7 Airborne dust concentrations* (SGS, 2020) it is reported that analysis of PM_{10} samples "… *registered* …" U and Th concentrations below the minimum detection level (MDL), and further, "… *U and Th radionuclides, associated with sediments or heavy mineral ore, were present in concentrations less than the MDL.".*

These findings suggest that alternative more sensitive analytical and/or sampling techniques should be utilised to enable detection and measurement of U and Th in PM_{10} to facilitate environmental monitoring and health impact assessment.

Inhalation of fine particulates:

Communities living in the vicinity of mining operations may be exposed to airborne particulate matter (and their associated contaminants) through absorption after dermal contact, ingestion or inhalation (Shi et al., 2013). Inhalation of coarse particles (PM_{10}) may lead to lung inflammation and injury (Becker et al., 2005). Fine particles, however, are considered more hazardous as they can penetrate into the gas exchange region of the lung and enter the bloodstream (Miller et al,. 1979). Children are particularly susceptible to inhalation exposure due to their behavioural and physiological factors (Goldizen et al. 2017).

Ingestion of contaminated horticultural products:

The Section *8.1.2. Air: Dust deposition – Lindenow area* describes the harvesting method of various horticultural products and their distribution to local and interstate markets (Coffey, 2020). It is of concern that this produce could be contaminated with surface dust originating from the Fingerboards mineral sands mine, or contaminated with elements accumulated from soil contaminated by dust deposition. Loss of revenue to the growers could result if marketing of produce was terminated. As discussed above, wind gusts exceeding 50km/hr occur frequently in the Fingerboards project area (BOM, 2020) suggesting that effective dust control measures, and appropriate monitoring to demonstrate this effectiveness, will be crucial throughout the construction, operation and rehabilitation periods of the project, if approved. The local horticultural and agricultural industries are also potentially at risk of contamination from contamination of surface waters and groundwater if management strategies fail to prevent offsite releases of contaminants.

Dust fallout from the Fingerboards operation has the potential to impact not only the horticultural products themselves but also cause adverse health consequences for consumers of these products. Stachiw et al. (2019) report that it is possible to distinguish between trace elements detected in plants due to dust deposition versus uptake via plant roots because contaminants deposited via dust are removable by washing. Fine dust particles may enter leaves directly through the stomata or, depending on the solubility of contaminants, dissolution may liberate contaminants on leaf surfaces. Whereas essential micronutrients that are taken up by the roots tend to be enriched within the plant tissues, toxic contaminants that are mobile in the soil environment may also be bioavailable for plant uptake (Stachiw et al., 2019).

Concerns have been raised that REEs may accumulate in soils with continued application of phosphate fertilisers produced from monazites which could eventually result in adverse toxicological impacts on plants (Thomas et al. 2014). Dust deposition may also contaminate soil directly, and excessive accumulation over time may adversely impact soil macrofauna whose role is to help regulate the soil environment through promoting decomposition of organic matter and activity of soil microbes (Li et al., 2010). REEs share chemical and physical properties, and of concern is that Yttrium (Y) has been shown to reduce photosynthesis, transpiration and growth in young maize plants (Maksimović et al., 2014). Ultimately, contaminants from dust may become bioaccessible for human consumers of contaminated produce. Concerns regarding long term low level consumption of REE contaminated cereals in childhood in China have been raised because they accumulate in blood, brain and bone, and have been linked to neurodevelopment in childhood (Zhuang et al., 2017).

In addition to contaminants such as arsenic and chromium, radionuclides may also be present in dust. Radionuclides can be absorbed from soil via roots into plants, including edible portions, although a study near a mineral sand deposit in Sri Lanka with elevated natural radiation background found that the dietary intake of local produce was radiologically safe for adults, despite surface contamination with fine dust necessitating washing of fruit and vegetables and peeling of root vegetables prior to ingestion (Jayasinghe et al., 2020).

Kalbar Operations Pty Ltd (2020) *EES Summary Report: Agriculture and* horticulture (Pages 18-19) states that:

> "*Rehabilitation of mined areas* ***will aim to restore land to pre-mining uses,*** *or an alternative as agreed with the landholder*."
>
> "*Air dispersion modelling during operations predicted dust deposition rates and concentrations of PM2.5 … would be below relevant air quality criteria at all sensitive receptors. Exceedances of PM10 … were predicted during operations at up to 23 receptors for a maximum of four days of the year*."
>
> "*Modelling also predicted that radiation concentrations in the soils in horticulture areas at the end of the project life would* ***be only marginally higher*** *than existing concentrations and* ***posed little risk*** *to vegetable production*."

It is further reported in Section *9.1.4. Dust deposition – crops* that neither the rate of dust deposition nor the radiation doses due to incidental ingestion of soil contamination on horticultural products, consumption of vegetables contaminated by radionuclides in dust nor accumulated from contaminated soil, will exceed criteria.

Despite Kalbar's (2020a) modelling predictions that $PM_{2.5}$ dust deposition rates would not exceed air quality criteria, and that PM_{10} exceedances would be few in the vicinity of this prime horticultural district, wind gust data from the prevailing westerly direction (BOM, 2020) suggest that fine and course particulates, and component PTEs, could easily be transported as far as the Lindenow horticultural district, which is approximately 5 km to the east of Fingerboards. Should this occur, dust contamination of crops could contribute to ongoing radiation doses through ingestion, and ingested dose must be considered in addition to dust inhalation over the lifetime of the mine and beyond. Since REEs and thorium will persist in soil well beyond mine closure, their potential uptake and accumulation in plants may prevent the restoration of horticultural and agricultural land to pre-mining use.

6. WATER SOURCES:

Rain water tanks:

Importantly, in Section *8.1.6. Rainwater tanks and dams,* no baseline exceedances based on average concentrations for Tier 1 health screening criteria for drinking water, or the 0.5 Bq/L threshold criteria, were detected in harvested rainwater samples. Modelling predictions detected negligible sedimentation in tanks and dissolved metal concentrations due to dust deposition generated by Fingerboards (Section *9.3.2. Rainwater tanks and dams*; Coffey, 2020).

However, ongoing monitoring of water quality in rain water tanks identified as at risk by dust monitoring, which may extend beyond the 5 km radius of Fingerboards, if approved, would provide assurance to residents and/or provide early detection of contamination.

Water depletion and potential for contamination:

In the Section *5.3.4. Water supply, storage and management* it is stated that "*Approximately 3 GL of water will be required for processing, dust suppression and rehabilitation on an annual basis. Water for the project will be sourced from surface water (winterfill from the Mitchell River) and groundwater from the Latrobe Group Aquifer…*".

Clearly, water usage, supply and quality will be major concerns throughout the life of the proposed mineral sands mine, if approved, and possibly well beyond closure of the mine.

7. SURFACE WATER:

The location of Fingerboards is in close proximity to major water ways, including the Mitchell River which discharges into the Gippsland Lakes Ramsar site, and the Perry River (Kalbar, 2020a, page 15).

Kalbar's (2020a) *EES Summary Report: Surface water* (Page 15) states that:

> "***Where possible***, *clean water upstream of the active mine void will be diverted to avoid generating additional stormwater that has come into contact with mined or disturbed areas. Runoff from outside the mine void, or water intercepted by dams will be offset by the release of water from a freshwater storage dam to the appropriate catchment. Runoff from disturbed and mining activity areas will be captured and directed to water management dams,* ***reducing*** *runoff volumes within gullies and the risk of erosion and sedimentation of downstream watercourses*"

The above statement raises concerns regarding the risk of contamination and sedimentation of the Mitchell River and connected watercourses during the operation of Fingerboards as it implies the inevitability of some degree of environmental contamination. Even with tight environmental controls, treatment of waste water and sludge from REE mining have been identified as potentially being major contributors to ecological impacts (Schreiber et al., 2016). Therefore, in order to protect surface waters offsite, any discharged waste water must be adequately treated and meet water quality criteria (Black Moher et al., 2013).

Impact on water quality of Mitchell River system:

In Section *8.1.4. Sediment* (Coffey, 2020) it is stated that:

> "***Sampling from upstream of the site on the Mitchell River was not possible*** *due to … the high energy flow of the Mitchell River, sediments are flushed through the system*.".

This statement raises the question that if the flow rate in the Mitchell River is reduced by water depletion of the system through mining requirements in addition to agricultural requirements, will sedimentation occur?

While in Section *8.1.5. Surface water: Baseline screening assessment – surface* water (Coffey, 2020) it is stated that chromium, lead, manganese and arsenic occasionally exceeded criteria for potable water, no exceedances of Tier 1 screening criteria were detected for recreational uses; and in Section *Baseline screening assessment – radiation* it is reported that no exceedances of the 0.5 Bq/L threshold criteria were detected. No baseline exceedances were reported for surface water runoff in Section *8.1.7. Surface runoff water: Baseline screening assessment – surface water runoff* for drinking water or recreational uses.

However, it is stated in Section *9.3.1. Surface water* (Coffey, 2020):

> "***Heavy rainfall on exposed soils, including ore stockpiles, has the potential to leach metals and radionuclides from the soils and rocks, mobilising these contaminants in runoff towards surface water features. Chemical contaminants, as well as increased sediment load, could impact the quality of surface water if not managed effectively.***"

Proposed strategies to prevent contaminated storm water runoff include construction of drains, sedimentation ponds and dams, although it is further stated that:

> "***During extreme precipitation events, water levels in on-site storages*** *(such as the freshwater storage dam, process water ponds, TSF, mine voids and sediment retention ponds)* ***could rise above the maximum design operating level. In such events, there is potential for uncontrolled discharges and subsequent impacts to surface water features. The levels of metals or radionuclides in surface water systems could increase as a result of such discharges, should they occur***." (Coffey, 2020).

However, no exceedances of metals for drinking water or recreational use in the Mitchell River were predicted (Section *9.3.1. Surface water: Metals in mine contact water*; Coffey, 2020).

It is stated in Section *9.3.1. Surface water: Radionuclides*:

"No significant long-term impact was identified on radioactivity levels in the Mitchell River arising from operations, and the disposal of tailings and other waste. This conclusion was primarily based on the low migration potential of radionuclide constituents in heavy mineral sands, which are considered to be highly inert and bound strongly in the mineral structure."

However, it is further stated:

"***Monitoring of the Mitchell River waters will be undertaken as part of the overall environmental monitoring program to confirm there are no significant impacts from project activities on water sources in the region. Whilst there may be natural, seasonal and regional variations in radium concentrations, the conditions specific to the area must be considered when assessing possible long-term impacts of mining or mineral processing on the water sources discharging the Mitchell River.***"

While the assertion that an environmental monitoring program of the Mitchell River will be undertaken provides some assurance that the water quality will be sustained, unforeseen events have had catastrophic consequences due to failures in effective onsite management of waste water at REE mines elsewhere (Ault et al., 2015; Hao et al, 2016). Moreover, REEs have been shown to accumulate in fresh water fish, the ingestion of which could contribute to body burden (Mayfield & Fairbrother, 2015).

8. GROUNDWATER:

Australia's arid climate creates a dependence on groundwater for town drinking water supplies and agricultural and horticultural use in many areas, including the Fingerboards locality. Worryingly, groundwater depletion, water quality and capacity for recharge are now under question globally (Famiglietti, 2014). The likely impacts due to Climate Change compound the need to conserve water quantity and quality.

Kalbar's (2020a) *EES Summary Report: Groundwater* (Page 15) states that:

"… abstraction of water from the Latrobe Group Aquifer for project water supply …" **could reduce *"… groundwater levels in the immediate vicinity by… 12.5 metres during construction and 14 m during operations*** *…".*

It is further stated that the Latrobe Group Aquifer:

"…***provides supplemental water supply to towns such as Bairnsdale, Lindenow, Lakes Entrance, Paynesville and Metung***."

And:

"Tailings seepage is predicted to remain relatively localised to the project area and does not represent a hazard to the uses (including potable water supply) of the shallow Coongulmerang Formation aquifer that underlies the mining void. The naturally occurring concentrations of metals in the groundwater are higher than those predicted to be contained in seepage water."

Viswanathan (1990) found that groundwater that was extracted for urban human consumption and other purposes via bores could be adversely impacted by mineral sands mining in the vicinity because of induced physicochemical or biochemical processes instigated by the disturbance of the aquifer's equilibrium. Also, while Huang et al. (2016) found no evidence of U or Th contamination of groundwater due to leakage of the Bayan Obo REE tailing pond, they found evidence of inorganic contaminants, which posed risks for nearby agriculture, rivers and ecosystems. This is of concern because any reduction in the quality and quantity of this aquifer could potentially damage the water supply of these local communities, agriculture and horticulture.

Sources of contamination:

The following statements raise concerns about the sustainability of aquifers in the region if the Fingerboards proposal is approved and best practice management and monitoring strategies are not implemented:

Section *8.1.8. Groundwater* reports that sampling detected some exceedances of specified elements; that the monitoring bores targeting "… *the local aquifer*…"; and during sampling "... ***the bores generally had low yields and were unlikely to provide enough extracted water for domestic or other beneficial uses***."; that groundwater within the Coongulmerang Formation of the project area is characterised by elevated dissolved metals and is slightly acidic; but no "… *exceedances of the 0.5 Bq/L threshold criteria* …" were detected.

While Coffey (2020) state in Section *9.3.3. Groundwater*:

> "***Disposal of saturated fine tailings to the TSF, or placement of tailings material in the mine void, creates the potential for water with elevated concentrations of dissolved metals, radionuclides and other contaminants to infiltrate to the underlying aquifer. The additional contaminant load (above background) to the underlying groundwater may be altered from baseline conditions. Such changes could result in the water being unsuitable for the extractive uses such as drinking, domestic and recreation purposes. The discharge of contaminated groundwater to regional waterways may also impact on the use of surface waters for potable or recreational purposes.".***

However, the above statement was preceded by a qualifying statement that the impact of Fingerboards on groundwater would be negligible if management strategies were fully implemented:

> "*A groundwater impact assessment was undertaken by Coffey (2020b) to evaluate the potential impacts of contaminants migrating to groundwater as a result of project activities.* ***The assessment assumed full implementation of the design and management requirements and found that groundwater impacts due to contamination resulting from spills or leaks would be negligible.***"

The statement in Section *9.3.3. Groundwater: Contaminant monitoring* provides some assurance regarding groundwater quality:

> "*To comply with statutory requirements, a groundwater monitoring program will be implemented to monitor water quality data for the aquifer within the potentially impacted areas associated with the Mitchell River floodplain.* ***The plan will include trigger levels for environmental protection and for implementation of mitigation measures***."

Clearly, the protection of groundwater quality and quantity, and avoidance of contamination with REEs, radionuclide and metals, is crucial for human consumption and agricultural and horticultural needs, necessitating best practice management strategies for waste water and tailings, prevention of dam failure or overtopping, and controlling surface runoff (Adeel et al., 2019; Filho, 2016; Hao et al, 2016; Huang et al., 2016; Viswanathan, 1990). It is imperative to protect groundwater quality in the vicinity of Fingerboards since aquifers are interconnected and ultimately there is some discharge into the Mitchell River (Section *9.3.3. Groundwater: Particle track modelling* (Coffey, 2020). Public access to monitoring data and the demonstration of regulatory compliance will minimise community concern regarding the maintenance of groundwater quality and depletion if approval is granted for the Fingerboards project.

9. **MONITORING**:

It is essential that optimal monitoring strategies and techniques be instigated to ensure that any offsite breaches of environmental health regulations are promptly detected to facilitate urgent responsiveness of best practice remedial action.

Particulates:

- PM_{10} and $PM_{2.5}$ dispersion and chemical analysis

Continuous Emission Monitoring System (CEMS) data enables reporting of real-time hourly emissions automatically (Environment Australia, 2001) and would be ideal to record offsite emissions, since the National Pollutant Inventory report for 2018/2019 by ILUKA RESOURCES LIMITED, Cataby Mineral Sands Mine, WA < http://www.npi.gov.au/npidata/action/load/emission-by-individual-facility-result/criteria/state/WA/year/2019/jurisdiction-facility/WA1559 > included particulate matter under 10 µm (PM_{10}) of 1,100,000 kg, particulate matter under 2.5 µm ($PM_{2.5}$) of 16,000 kg, and numerous other potentially toxic emissions to air including antimony, arsenic, carbon monoxide, chromium (III) compounds and sulphur dioxide. REES and radionuclides must also be monitored in particulates.

- Radioactivity

Appropriate control measures to prevent radiation exposures associated with thorium, both external gamma radiation and inhalation of long-lived alpha emitters in dust, are required (Hewson & Hartley, 1990), as are monitoring strategies to detect both gamma radiation and alpha particle emissions. Regulatory compliance and stringent enforcement are essential when in close proximity to residential communities while ongoing health monitoring may assuage community concerns if evidence of a lack of adverse health impacts is detected over the long term (Ali, 2014).

Surface water and groundwater:

The complexity of REE processing operations requires that wastewater treatment systems are well managed and have secondary containment should a failure or breach occur. (Ali, 2014). While the intention may be to prevent surface runoff from processing and mining areas, spills or weather conditions may cause contamination events that require direct measurement of flow rates and chemical composition, including suspended particulate matter, of runoff (Environment Australia, 2001).

The risk of contaminating groundwater due to seepage must also be monitored by estimation of seepage rates and chemical composition of the seepage (Environment Australia, 2001). Comprehensive monitoring offsite must also be instigated throughout the operation of the Fingerboards project to detect any unforeseen contamination events via dust emissions and also sediment transport into surface water ways and into groundwater. Monitoring of radionuclide contamination of groundwater and surface water must also be implemented.

Horticultural products:
Monitoring uptake of REEs, thorium and other contaminants by plants and agricultural products, in conjunction with modelling of long term accumulation of contaminants in soils through dust deposition, would be prudent to validate modelled predictions and persistence of soil contaminants.

A model to estimate short and long term risk due to ingestion of vegetables contaminated with pesticide residues, based on the estimation of a hazard quotient obtained by dividing the estimated daily intake by the acceptable daily intake, has been developed (Gad Alla et al., 2015). Given the likelihood of contamination of the Lindenow horticultural district due to its proximity to Fingerboards and the direction of prevailing winds, it would be prudent to undertake ongoing analyses to determine the uptake of REEs and thorium in edible portions of vegetable produce and estimate the long term risk associated with ingestion patterns these elements, similar to investigations conducted for pesticide residues.

10. REGULATORY ENFORCEMENT of COMPLIANCE and REHABILITATION:

Regulatory enforcement of monitoring and compliance is crucial throughout the operation and rehabilitation phases of Fingerboards, if approved.

In Section *9.5. Potential exposures following mine closure* it is stated:

> *"The Radioactive Waste Management Plan developed for the site will cover the closure of the mine site, rehabilitation of the area, any long-term controls over future land use,* ***maintenance of records pertaining to past operations at the site, a program for long-term radiation monitoring and surveillance (which may also include ground and/or surface water monitoring if warranted),*** *site inspection to assess the post-closure integrity of the rehabilitated areas and contingency plans for remediation of any defects that might become apparent in the rehabilitated site.*
>
> *…*
>
> *Monitoring activities are likely to continue for several years post-closure, depending on the agreed closure criteria. Surface waters and the seepage of mine contact water from the TSF, process water storage and mine voids* ***will be monitored post-closure so that proactive management of identified impacts, if any, can be implemented****. Given potential impacts to surface water and groundwater will be identified during operations, closure and post-closure, and addressed accordingly, the potential future exposures to the selected receptor populations post-closure is considered to be negligible."*

Community concern over potential environmental impacts (Bec et al., 2016), the perceived ability of governments and legislation to protect the environment through enforced compliance with environmental regulations (Moffat et al., 2014; VAGO, 2020), and the myriad of abandoned mines posing environmental health risks across Australia (Werner et al., 2020), may engender scepticism about the probability that the post-mine landscape will return to pre-mine usage and visual amenity. Importantly, there is considerable community concern regarding the extent to which the mine site will be rehabilitated and restored to its former agricultural and horticultural usage and natural amenity, and the adequacy of the rehabilitation bond that will be held in trust for this purpose.

11. ENVIRONMENTAL HEALTH RISK ASSESSMENT:

The Fingerboards EES: HHRA (Coffey, 2020) only considers Tier 1 Assessments of a limited range of sensitive receptors and is based on predictive modelling that has yet to be validated by real-time, ongoing monitoring.

Section *11.1. Receptor populations and potential exposure* identifies several exposure pathways and at risk population groups for whom an HHRA was conducted, including residents living within "… *a 5 km radius of the project area*."

For reasons discussed above, the "*at risk*" population should be extended substantially to ensure that all those potentially exposed to contaminated dust, surface water or groundwater are included in HHRA.

Further, it is stated in Section *11.3. Human health – modelled predicted project conditions* (Coffey, 2020) that **predictions are based on the implementation of "… *key management measures*** …" and that environmental conditions during mining construction, operation and rehabilitation were similar to baseline, although it may be necessary to instigate additional management measures to protect regional residents from PM10 exceedances due to dust migration offsite due to extreme weather events (*Table 11.2 Tier 1 screening assessment – modelled/predicted project impacts*).

Environmental Health Risk Assessment aims to evaluate the potential cumulative human health impacts of concurrent environmental hazards, taking into account the duration of exposures, and the extent and susceptibility of the potentially exposed population (enHealth, 2012). As the evidence-base of adverse environmental and human health impacts of REEs expands, the capacity for more precise risk assessments due to multiple and cumulative exposures also evolves. Advanced techniques, such as synchrotron-based X-ray microprobe techniques, enable detection of REEs in situ hence facilitate investigation of biomarkers of disease outcomes caused by environmental exposures (Entwistle et al. 2019). Risk of internal radiation dose must also be assessed because inhaled monazite dust containing thorium is retained in the lung (Hewson, 1997). Should the Fingerboards project proceed, it is essential that the environmental health of the surrounding community is protected.

I thank the Panel members for this opportunity to make a submission regarding the Fingerboards mineral sands mine proposal with the expectation that should it be approved, appropriate monitoring strategies will be instigated to assist regulatory agencies to fulfil their role in enforcement of compliance and hence protect the surrounding environment and health and wellbeing of neighbouring communities.

Dr Dora Pearce PhD

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