Fingerboards mineral sands project – Expert Witness Statement (Hydrogeology)

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Introduction

The following report is my expert review of the groundwater impact assessment within the Fingerboards Mineral Sands Project Environmental Effects Statement (EES). The main issues I have considered in undertaking this review are:

- Potential impacts of the mine on groundwater quality.
- Potential impacts on groundwater supported ecosystems and surface water flows.
- Potential reduction in access to groundwater resources as a result of mine borefield operation.

The review includes the following:

- Analysis of the adequacy of the relevant sections of the EES to address the key groundwater issues outlined above, and the data, methods and modelling used to assess these.
- Adequacy of baseline data collected by the proponent to provide pre-development conditions of the groundwater.
- Adequacy of the proposed environmental monitoring program, and protocols to protect groundwater and associated receptors.

Note that surface water hydrology issues (e.g. impacts of surface discharges associated with mining activity, flooding risk, and mine site water balance) are not examined in this review, as these are outside my primary field of expertise (hydrogeology).

The main documents I have reviewed while writing this report are:

- EES Appendix A006 Groundwater and Surface Water Impact Assessment, and associated technical appendices, including the Groundwater Modelling Report and Geochemical Testing report (Appendices B and D of the impact assessment).
- EES Appendix A007 Water Supply Options Study: Technical Groundwater Assessment
- Water Expert Peer Review and Response

The report contains two major sections. The first is an analysis of the adequacy of the proponent's assessment of the groundwater quality and quantity issues associated with the proposal, baseline data and proposed monitoring program. The second is a response to specific issues outlined in the Letter of Instruction provided to me by Environmental Justice Australia, who requested my review on behalf of Submitter No. 813 (attached as Appendix A).

My relevant expertise/Qualifications

I am an Associate Professor of environmental engineering in the School of Engineering at RMIT University. I received my PhD from Monash University in 2011, on the use of environmental isotopes and geochemistry to assess the sustainability of groundwater usage and controls on groundwater quality in areas of intensive agriculture in northern China. For the last ten years at RMIT I have taught hydrogeology, geochemistry, and groundwater modelling to hundreds of environmental and civil engineering students and supervised multiple Master and PhD projects in applied hydrogeology research.

I have been awarded more than $1 million in research funding as a chief investigator on more than 12 grants, supporting projects examining groundwater sustainability and contamination issues in Australia and internationally. I have published more than 50 peer-reviewed international journal articles, which have been cited more than 1500 times, and served on the editorial board of the Hydrogeology Journal (the journal of the International Association of Hydrogeologists) from 2014 to 2018. I have acted as an independent expert witness examining impacts of mining activities on groundwater on many occasions, including the 2015 Victorian Parliamentary Inquiry into Unconventional Gas, the Northern Territory Scientific Inquiry into Hydraulic Fracturing, proceedings in the Land Court of Queensland (New Acland Stage 3 proposal) and other coal mining and coal seam gas proposals examined by the NSW Independent Planning Commission. My full CV is attached to this report (Appendix B).

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

Summary of findings

1. There are groundwater quality and quantity risks associated with the proposed Fingerboards Mineral Sands project, encompassing the proposed mining activities and associated water supply borefield. These impacts have the potential to impact on groundwater-connected surface water systems and associated ecological communities, as well as other water users in the region. Analysis of these risks has been carried out in the proponent's groundwater and surface water impact assessment and associated reporting, drawing on a significant amount of field data, modelling and analysis. However, there are some important oversights and gaps in the assessment. These include:

2. There is a lack of baseline monitoring of groundwater for certain elements, e.g., uranium and thorium - often associated with mineral sands and shown to be somewhat enriched in the geochemical analysis of materials from the site (Geochemical Testing report). The groundwater monitoring plan makes no mention of analysing these constituents (or associated potential radioactivity) on an ongoing basis, leading to uncertainty about the potential for leaching of these elements into groundwater and associated ecological and health risks. There is also a lack of detailed investigation of the source(s) of cyanide and elevated heavy metals concentrations observed in baseline groundwater monitoring within the Coongulmerang Formation (the target formation where mining is proposed) and uncertainty as to the source of these elements and their potential fate(s) during mine operation.

3. Modelling of increased seepage and mounding of the water table below areas of mining, where tailings are proposed to be stored within un-lined cells, has been conducted, informed by field and laboratory studies. While the approach is generally sound, current groundwater recharge processes are not well understood, and there are significant uncertainties regarding how the major disturbance of the site through mining and emplacement of the tailings would influence recharge/seepage rates, water table levels and flow of groundwater towards surface water bodies and other aquifers in the area. As was pointed out by the water independent peer reviewer, there remain unresolved questions about the level of geological heterogeneity in the target formation and underlying geology, and the potential for perched groundwater bodies, which could have significant implications for the degree of groundwater mounding and associated increases in groundwater seepage experienced as a result of mining. In general, numerical groundwater modelling cannot alone address these issues (it is impractical to simulate high levels of geological

heterogeneity). As such, comprehensive analysis of this risk requires supplementary lines of evidence (e.g. detailed field studies).

4. There is also a lack of detailed analysis of the potential future impacts of increased discharge of groundwater from the Coongulmerang Formation – which is shown in the baseline data to contain elevated concentrations of heavy metals and other contaminants - on ecological communities, such as those associated with the Mitchell River and its alluvium (as well as other potentially impacted beneficial uses of these water sources). The groundwater modelling indicates that significant mounding will occur below the mined cells, and this is likely to enhance the flow and discharge of groundwater from the Coongulmerang Formation towards the Mitchell River floodplain and alluvial aquifer. It has been assumed (without a strong evidence base) that ecological communities in this area would have 'naturally adapted' to elevated heavy metals concentrations within this groundwater. However, the effect of significantly increased discharge rates of the poor-quality groundwater induced by mounding associated with mining, and the associated potential water quality and ecological health impacts have not been thoroughly examined. This requires more extensive site-based studies of the connectivity between the Coongulmerang Formation and other aquifers (e.g. alluvium) and surface water, as well as more comprehensive baseline monitoring and ecological studies in the relevant area to inform site-specific ecological risk assessment. There is also limited characterisation of other groundwater dependent ecosystems – such as the chain of ponds associated with the Perry River – to understand their relationship to groundwater, and the potential for future impacts to these (it is assumed these will be unaffected by the predicted groundwater mounding, due to the distance from the site and inferred depth of the regional water table; however, this has not been characterised in detail). The risk of impacting other beneficial uses in the Mitchell River alluvial groundwater (e.g. Potable, Irrigation, Stock), which is extensively utilised in the Wy Yung WSPA, also warrants careful assessment.

5. The proposed borefield designed to provide part of the mine's water supply would potentially extract a significant volume of groundwater from the Latrobe Group aquifer (depending on whether a surface water and/or groundwater licence is granted). This aquifer is already a heavily allocated water resource, from which mining and irrigation activities extract significant volumes in the Gippsland Basin. Assessment of the cumulative impact of the mine's extraction (at different rates) along with existing impacts elsewhere in the LaTrobe aquifer is limited in the reporting. Regionally, aquifer levels have been falling substantially over time in this aquifer, and it has been determined that current extractions far exceed recharge. As is acknowledged in the groundwater impact assessment, it is therefore doubtful that a new groundwater license for the borefield water supply would be issued by the managing authority, and as such, the mining company would need to seek groundwater via trading. Because the borefield is intended to be a supplementary water supply, it is more likely to be needed during periods of low surface water availability (e.g. in dry years), when demand for groundwater is also typically high, which may be problematic.

6. Analysis of likely drawdown impacts occurring due to groundwater extraction from the borefield has been conducted, based on a pumping test and the numerical groundwater modelling. These methods provide a reasonable indication of the likely extent of groundwater drawdown in the target aquifer and overlying unit - Seaspray Formation, in which existing water users access groundwater, in the short term. However, the pumping

test encountered issues, including noise within the time-drawdown data and a lack of stabilisation of drawdown over time, which result in ongoing uncertainty regarding the response of the aquifer to pumping, the aquifer's extent and hydraulic parameters, the long-term viability of water supply from the borefield and the potential for greater inter-aquifer leakage (and thus impacts on existing bores and other values supported by groundwater). It should be noted that the amount of water extracted during the test is significantly less than what would be potentially pumped during borefield operation, meaning the full effects of the borefield operating at maximum capacity have yet to be tested (other than through numerical modelling).

7. As indicated by the proponent's groundwater modelling, drawdown is likely to be substantial within the target (Latrobe) aquifer and extend more than 10 km from the borefield to the south, where it would exacerbate existing water level declines being experienced in this aquifer due to other activities (e.g. offshore oil and gas). These cumulative effects have not been extensively discussed or analysed in the impact assessment. In addition, the effects of the borefield to the north, where the geology becomes more complicated (and the aquifer appears to thin out) are not carefully analysed and should be considered uncertain at this stage. Impacts on shallower aquifers and associated bores and groundwater dependent ecosystems cannot be ruled out and require more careful analysis and characterisation.

8. As with any numerical groundwater model, there are uncertainties regarding the extent of drawdown impacts and potential for these to impact other water users. While efforts have been made to account for geological uncertainty and heterogeneity in the design and set-up of the numerical model, the following would be required to improve the current predictions and estimate drawdown impacts from the borefield more accurately:

9. Further deep drilling (into the Latrobe Group) and baseline monitoring of groundwater levels in this unit and overlying/adjacent units, to understand geological heterogeneity (e.g., full extent and thickness of the units) and horizontal and vertical hydraulic gradients, noting that water level monitoring is currently limited in the area of the proposed borefield.
10. More extensive site-based testing of pumping/production bores in the aquifer and monitoring of adjacent and overlying formations, to determine with greater confidence the potential for leakage from the aquifer units above and adjacent to the proposed borefield (e.g. longer duration pumping test with additional monitoring bores).
11. Complementary techniques, such as environmental tracer studies, to independently examine the degree of inter-aquifer connectivity throughout the region surrounding the borefield.

12. Baseline groundwater monitoring conducted at the site and in the surrounding areas gives a reasonable indication of groundwater levels, flow directions and water quality in the Coongulmerang Formation. However, the coverage of monitoring wells, and additional field studies conducted to understand connectivity between the Coongulmerang and other shallow aquifers (e.g. Mitchell River alluvium, Balook Formation and La Trobe Valley Group) as well as groundwater dependent ecosystems in the area is limited. Baseline groundwater data between the proposed borefield and mine site – e.g. within the Latrobe group and overlying formations – is also limited at this stage and does not allow for detailed mapping of flow patterns or quality in the deeper formations. As noted above and below (paragraph 2 and 13), there are analytes not included in the baseline monitoring program which should

have been monitored to comprehensively characterise pre-development groundwater quality (e.g. U, Th, Rn-222).

13. The proposed groundwater monitoring program outlined in the impact assessment (chapter 9) has not been thoroughly developed, and provides little detail regarding the proposed locations and numbers of additional monitoring sites required to address some of the important knowledge gaps and risks identified in the impact assessment (e.g. mounding of groundwater and contaminant migration). The full suite of water quality parameters to be monitored in the proposed program - i.e., specific metals and other constituents, is also unclear from the current reporting. Based on existing monitoring, the program appears not to include analysis of uranium, thorium and other related radionuclides (such as radon-222) which should be monitored, including collection of extensive baseline datasets.

Section 1: Analysis of potential groundwater impacts in the groundwater impact assessment.

14. There are two major components of the mining proposal with the potential to impact on groundwater and associated values:

- The mine site, including mine pit excavations, water management dams and mine waste (tailings) storage areas,
- The mine's water supply, including the proposed bore-field designed to extract groundwater for the project from the Latrobe Group aquifer.

15. Kalbar/Coffey have completed a site water balance, groundwater baseline monitoring, field and laboratory studies, a numerical groundwater model, and risk assessments associated with these activities, and have developed proposed management/mitigation measures to address identified groundwater quality and quantity risks associated with the project.

16. Tailings from mining – encompassing coarse and fine fractions, are proposed to be stored on the mine site. In the early phase of mining, coarse tailings will be stored within Perry Gully and fine tailings within a temporary storage facility located on future mine path, until they can be put into mine void. After this initial period, tailings are proposed to be placed within unlined cells within the mine void. Ultimately the mined areas would be backfilled, covered with overburden and re-vegetated.

17. Potential groundwater quality impacts identified in the assessment include possible seepage of water that has interacted with the tailings stored on the site, and/or the pre-existing groundwater within the target formation – the unconfined Coongulmerang Formation - towards other aquifers and surface water bodies (e.g. the Mitchell River and its alluvium):

    "The placement of saturated tailings in the mine void is expected to result in a component of seepage that will recharge groundwater in the Coongulmerang Formation aquifer, and potentially alter groundwater flow directions and levels [i.e., leading to groundwater mounding]."

18. Baseline groundwater quality in the Coongulmerang formation and water that has been in contact with mine waste contain elevated concentrations of certain elements, in some cases above ecosystem protection guidelines, as shown by the baseline groundwater monitoring and geochemical leaching tests (Appendix D). As such there is a potential risk of increased

migration of contaminants towards other aquifers and groundwater dependent ecosystems as a result of mining.

19. Groundwater quantity impacts are primarily associated with the plan to extract groundwater (via borefield) from the Latrobe aquifer. Potential impacts of groundwater extraction from the borefield include drawdown, which may impact water levels in bores operated by other groundwater users within the region. Generally, existing bores in the region are installed in shallower aquifers compared to the aquifer targeted by the borefield (e.g. the Seaspray Formation and Mitchell River alluvium). Therefore, a major question is the extent to which pumping in the deep aquifer may affect shallower aquifers in the region (a question not adequately resolved in the impacts assessment in my view). There is also a question regarding the long-term sustainability and cumulative impacts of pumping in the Latrobe group aquifer, as this aquifer has experienced falling water levels for an extended period, largely due to mining, oil and gas extraction in the basin.

20. Both the risks associated with groundwater mounding and groundwater drawdown are assessed with the aid of a numerical groundwater model, classified as being Class 2 (out of three possible confidence classes) according to Australian Groundwater Modelling guidelines. This implies that the predictive capacity of the model for detailed impact prediction is limited. Typically, if there are significant impacts requiring detailed analysis and prediction, additional lines of evidence are required to supplement modelling results in such cases to account for and reduce model uncertainty.

21. There are 53 potential environmental risks identified in the groundwater/surface water assessment. Following adoption of 30 proposed mitigation/management measures, the proponent argues there will be no major or high residual risks to groundwater or surface water (a finding which is not, in my view, supported with adequate evidence at this stage). The subsequent sections of this report examine the evidence base and rigor with which the groundwater quality and quantity risks have been assessed, and the adequacy of the current baseline and proposed future groundwater monitoring to address groundwater impacts.

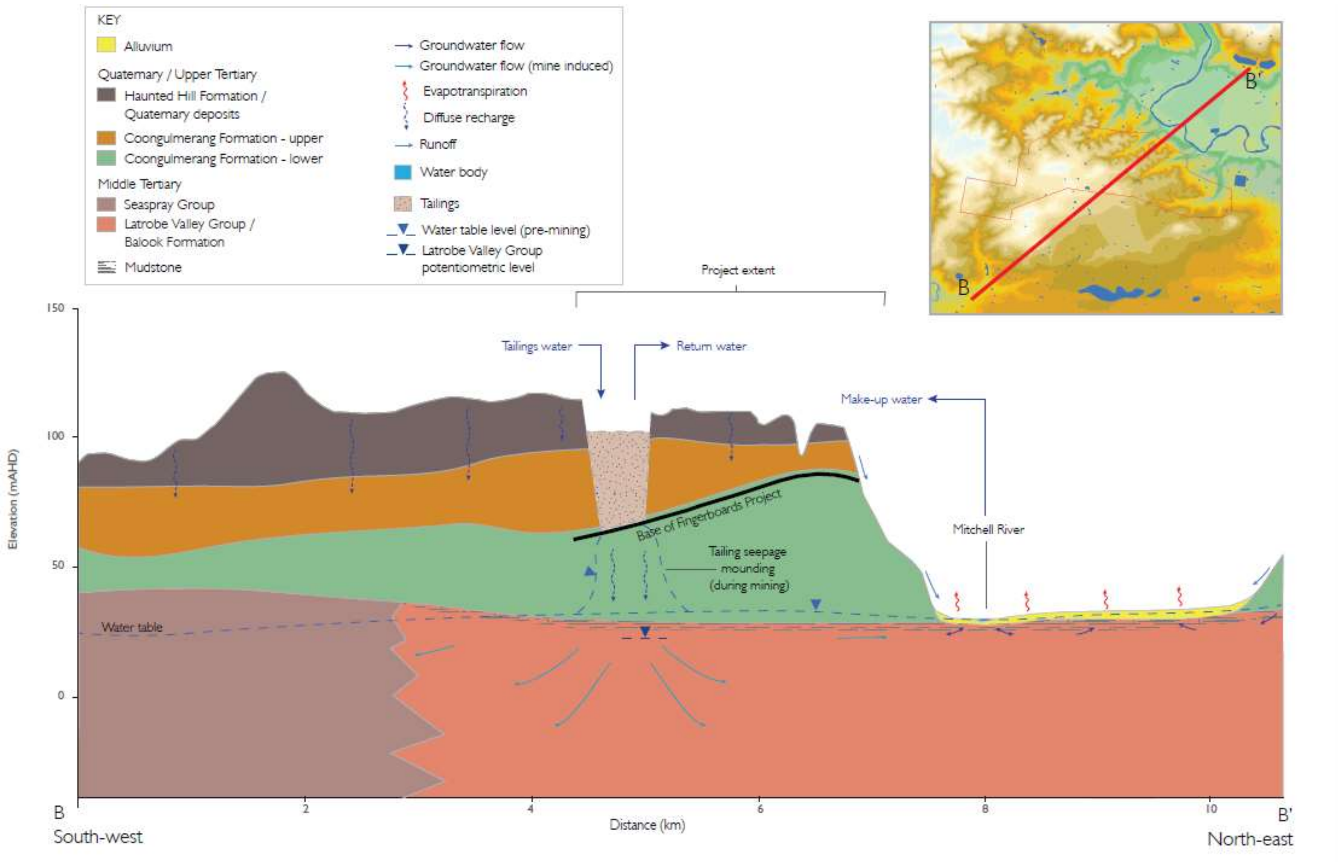
Assessment of groundwater mounding, seepage, and potential contaminant migration associated with mining

22. According to the groundwater level contour maps and baseline gauging data presented in chapter 4 of the groundwater impact assessment (e.g. Fig 4-10 and further details in Appendix I), the mine is planned to be constructed above the current regional water table level in the Coongulmerang Formation, which is generally 30 to 50 m below the surface. This would likely result in limited risk of water table drawdown associated with mining (a common problem associated with open-pit mining operations). However, there is some uncertainty with respect to the configuration of the water table, with at least one bore (MW07) recording a significantly higher groundwater elevation than an adjacent bore (MW08). The possibility of shallower groundwater associated with perched bodies above clay horizons is also discussed, but not extensively studied. The water independent reviewer believes further investigation of possible perching within the formation (and analysis of implications for the risk of groundwater mounding) should be conducted, which I agree is required (see below). To the north of the project area, approaching the Mitchell River, the water table is significantly shallower (within 5 to 10 m of the surface). While mining in this area is not proposed, the potential interaction between groundwater below the mine site

and the shallower water table aquifer near the river, is an imporant topic requiring further attention (see below).

23. As is discussed in the groundwater impact assessment, and predicted in the proponent's groundwater modelling, there is a high likelihood that enhanced seepage beneath mined areas - where mine tailings will be stored permanently in unlined cells - will lead to build-up and mounding of the water table in the Coongulmerang Formation. This may in turn cause increased rates of groundwater flow within this formation towards other shallow aquifers and surface water receptors – e.g. the Mitchell River and its alluvium. Depending on the quality of this groundwater, which will include water that has interacted with tailings in the mine cells, plus the pre-existing groundwater in the Coongulmerang Formation, this may impact water quality in the other shallow aquifers, GDEs and surface water receptors. This warrants detailed risk assessment and modelling according to a source-pathway-receptor model, i.e., in accordance with the National Environment Protection (Assessment of Site Contamination) Measure (1999). Current modelling and risk assessment associated with this process does not (in my view) adequately address this risk.

24. It is predicted in the groundwater modelling that soon after the commencement of mining, groundwater will mound below the tailings-filled cells at the mine site, creating a flow gradient away from these into the surrounding aquifer material. This is shown schematically in the hydrogeological conceptual model (Fig 2.52 of the groundwater modelling report, reproduced below):



Conceptual model- Site based Northeast to southwest cross section

25. Key questions that need to be addressed to properly understand this process and the associated risks are:

    a) What is the rate of seepage/recharge likely to occur during mining activity, how does this compare to natural/baseline recharge, and how rapidly and extensively would groundwater mounding occur?

    b) In what direction(s) and at what rates will groundwater flow away from the mine site following the enhanced recharge and mounding (i.e., could it reach important receptors, and if so, how soon)?

    c) What is the quality of the existing shallow groundwater and the water which will recharge the groundwater following interaction with mine tailings in the cells?

    d) To what extent would such seepage be diluted, and any possible contaminants attenuated during flow towards receptors?

26. The impact assessment has analysed these issues (to some extent) through modelling, fieldwork, and geochemical analysis of the target sand material. While this work is in some respects detailed and provides a basis for analysing the processes and risks involved, there are uncertainties that remain, and the impact assessment does not (in my view) address all of these questions in full (as outlined further below):

27. *Permeability and seepage velocities:* Groundwater modelling was the primary method used to assess rates of seepage and associated mounding of groundwater. This was supplemented by field and lab investigations to understand the permeability of the shallow aquifer material. This included both slug tests and laboratory permeameter tests (on core material) to estimate hydraulic conductivity (K) values in the Coongulmerang Formation. The hydraulic conductivity values were further used to estimate seepage velocity within the Coongulmerang formation (which will control the rate of flow between the mined cells and external receptors). The hydraulic conductivity values derived from these techniques appear to be reliable, and the analysis method sound. Porosity was not measured in the material directly, and this is instead estimated based on a textbook value, which may not be reliable. This introduces a level of uncertainty in seepage velocity calculations. Overall, the issue of increased groundwater flow rates associated with the mounding and possible effects of this has not extensively been discussed and analysed in the assessment. For example, there are no detailed calculations to estimate potential travel times between water beneath the mine site following the development of mounding, and key receptors which may (as a result of mounding) be affected by poorer quality groundwater, such as the Mitchell River floodplain (particle tracking in the modelling is used in a qualitative way to explore this at a superficial level only, with no detailed contaminant transport modelling).

28. *Recharge:* A uniform rate of groundwater recharge (25 mm/year) was adopted across most of the groundwater model area, consistent with previous groundwater modelling for the region (GHD 2010). This is likely a reasonable representation of current recharge volumes; however, confidence in the applicability of this rate over the site should be considered low, as no field-based studies of groundwater recharge have been conducted in the Coongulmerang Formation. The groundwater model sensitivity analysis (Table 6.1 of the Groundwater Modelling Report) shows that the model is highly sensitive to changes in the groundwater recharge rate, which means that the value(s) adopted have a significant impact

on model predictions (including the extent of mounding and rates of groundwater flow away from the site). Given the importance of understanding seepage/ groundwater recharge, the use of field-based recharge estimation techniques, such as chloride mass balance and/or tritium (Healy, 2010[1]) is warranted. This is critical to better constrain the rates of recharge, their spatial variability and any key factors which are important in controlling recharge through the relevant geological material. The modelling by nature can't (on its own) accurately simulate complex recharge processes and geological heterogeneity.

29. To simulate the modified/enhanced recharge occurring due to seepage through mined areas during and following operation of the mine, the following approach was used:

    "The recharge package is used across the mine area to represent tailings seepage at a constant rate of 4,535 kL/day (~53 L/second) throughout the life of mine. This rate represents the losses estimated through the sand tail stream fraction only. A further water loss of 3,682 kL/day (~43 L/second) is estimated for the slime tail stream. Seepage from the slime tail stream is assumed to be negligible with the water either remaining entrained, or eventually released and returned back to the processing plant opportunistically through slime settlement and/or engineering works such as the use of MudMaster's Amphirols (ResidueSolutions, 2018); For the purpose of simulating seepage, the mine area is split into sections over which seepage will occur during each year of operation. The volumetric recharge rate is divided by the area to determine a recharge rate in mm/year for each zone over the corresponding year of operation;" (p. 124 of groundwater modelling report).

    Further:

    "From the tailings dam, seepage to the groundwater system is estimated to be one of the largest components, which has the potential to create groundwater mounding. The permeability value estimated for the slime tailings is around 2.8 x 10-7 m/s. For a situation where 100 mm of water is ponded over 5 m of fine tailings, this would give an estimated drainage rate of 0.48 mm/d, ie a very low free draining rate (Loch, 2019). Some water associated with the slime fraction will remain entrained or be released through other mechanisms including decant ponds, underfloor drainage and/or engineering works such as the use of MudMaster's Amphirols (ResidueSolutions, 2018). Groundwater mounding will require monitoring during mine operations from a pit wall instability and vegetation health perspective. Apart from various tailing management strategies, modern mine sites often install sub-surface drain systems at the base of the tailings pit to assist in the return of water back to the processing circuit. Sub-surface drainage systems are designed to intersect the rising groundwater mound if it reaches the base of the pit, following tailing deposition. Installation of sub-surface drainage systems is the intent for the Fingerboards project."

30. It is difficult to determine, based on current information, whether the recharge/seepage rates adopted according to these methods are likely to be accurate representations of the real situation that will develop at the site during mining, and a significant error/uncertainty margin must be factored into the assessment of the rates of seepage and mounding occurring during mining. This is acknowledged in the statement that mounding will require careful monitoring in the impact assessment, but this should have been supplemented with

[1] Healy, R.W. 2010. Estimating Groundwater Recharge. Cambridge University Press.

further investigations. There are additional field studies which could be conducted to better understand this issue. As was pointed out by the Water Independent Reviewer (AECOM), the permeability of the Coongulmerang Formation is represented in the modelling as being uniform, despite it being known there is significant geological heterogeneity within it. The potential for clay lenses to impede downwards seepage (‘perching’) and enhance localised mounding effects is one potential risk associated with such heterogeneity. Better characterisation of geological material and analysis of the possible impacts on seepage/mounding would help better understand the relevant processes and risks.

31. *Increased groundwater flow towards key receptors.* The modelling of the groundwater mounding indicates that the water table will rise substantially in the Coongulmerang formation associated with the enhanced seepage through tailings cells. This is expected to influence an area extending approximately 4 km from the mine site (with maximum extent of up to 7km). The mounding is as high as ~75m above the pre-mining water table within the mine site after 5 years of mining, and the mounding extends to the edge of the Mitchell River floodplain under both of the adopted geological conceptualisations examined in the modelling (base case and alternative conceptualisation). This would result in enhanced groundwater flow and discharge from this aquifer towards the Mitchell River, it’s alluvium (an important water resource), and associated ecosystems. Due to the poor quality of existing groundwater in the Coongulmerang Formation, this may impact water quality and ecological health (see below). Based on the current groundwater monitoring network and baseline data, the extent of connectivity between the Coongulmerang Formation and Mitchell River alluvial aquifer is not well characterised, representing a knowledge gap in assessing this risk. Further monitoring well transects incorporating both aquifer units and the river should have examined the dynamics of flow and exchange between them.

32. *Water quality associated with seepage/mounding.* Characterisation of tailings material and possible water quality associated with seepage of water through the mined cells was conducted using geochemical leaching studies, in accordance with the Australian Standard Leaching Procedure. It was noted that most heavy metals concentrations are not significantly enriched compared to typical soils; however, concentrations of arsenic, thorium and uranium in the fine tailings are somewhat elevated (an issue of some concern not fully addressed by the baseline monitoring and risk assessments). Leaching testing also indicated some elevated concentrations of metals (e.g. copper) can be expected to occur in the water which interacts with the tailings – this was tested through both leaching with de-ionised water and Mitchell River water.

33. Analysis of baseline groundwater quality within the Coongulmerang Formation (section 4 of the groundwater impact assessment) indicates elevated concentrations of multiple heavy metals above aquatic ecosystem protection guidelines (aluminium, cadmium, chromium, nickel, copper and zinc) as well as other contaminants (e.g. cyanide, nitrate, phosphorous). Generally, the quality of water derived from leaching tests of the tailings material is better than that which is observed in this aquifer currently. Hence, the major water quality risk associated with the mounding of groundwater at the site is likely to be enhanced flow and discharge of the pre-existing Coongulmerang Formation groundwater towards other groundwater and surface water receptors (as opposed to seepage from the tailings cells, assuming the leaching studies are representative of the likely chemistry of recharge from the cells in the long-term). This is an important indirect consequence of mining activity which

has not been examined in detail in the groundwater impact assessment. In the early phases of groundwater mounding, it is likely most of the additional groundwater flowing and discharging to the Mitchell River floodplain and other receptors will be pre-existing groundwater in the Coongulmerang Formation, as there will be a time-lag between seepage from the mine site and arrival of this water at groundwater discharge points. Due to the poor quality of this groundwater, there is a significant potential for adverse water quality impacts associated with this process.

34. While water quantity implications of groundwater mounding have been assessed to some extent in the GDE impact assessment (which examines whether such ecosystems are likely to be able to withstand additional waterlogging), the potential water quality impacts on GDEs are not discussed in detail. As noted above, mining is likely to increase the flow and discharge of groundwater from the Coongulmerang Formation to the Mitchell River floodplain. Particle tracking modelling carried out along with the mounding analysis confirms this flow pathway. This may increase the exposure of ecosystems associated with the river and shallow aquifer to heavy metals and other contaminant concentrations observed to be elevated in the Coongulmerang Formation. In light of this, a detailed risk assessment is required. A comprehensive analysis for this impact would include the following:

   - Field based analysis of the ecological values associated with the Mitchell River and its alluvium, and analysis of the sensitivity of ecological values to increased discharge of groundwater containing the elevated concentrations of metals identified in baseline monitoring of groundwater in the Coongulmerang Formation.
   - Field based analysis of the hydraulic gradients and connectivity between the Coongulmerang Formation and Mitchell River alluvium, including under different hydrological conditions (to better understand the potential for exchange of groundwater between the two units).
   - Further analysis of baseflow to the river (e.g. drawing on the studies conducted by Monash University noted in the report), to analyse the rates and proportions of groundwater discharge to surface water in the river, including during periods of low rainfall/river flow, and incorporated into ecological risk studies.
   - Further local scale analysis and modelling of the possible concentrations of metals and other elements identified in the Coongulmerang Formation groundwater that may discharge to the river at different times, under different groundwater mounding scenarios developed using the numerical groundwater modelling and other lines of evidence.

35. Analysis of the potential impacts of increased discharge of Coongulmerang Formation groundwater into the Mitchell River alluvium on other beneficial uses – e.g. Potable, Irrigation, Stock – should also be included in this assessment, noting that the Mitchell River alluvium is the primary groundwater source utilised within the Wy Yung water supply protection area (and this water is generally low salinity/high quality).

36. A further uncertainty is whether mounding at the mine site may lead to increased discharge of perched water within the Coongulmerang formation from the cliff faces exposed to the west of the Mitchell River (shown in the conceptual hydrogeological model diagram earlier). This risk appears not to have been considered or examined, despite having been noted by

the Water Independent Peer Review (who flagged the potential for 'daylighting' of groundwater as a result of perching above clay layers in the Coongulmerang Formation).

37. The extent of the mounding of groundwater will depend on complex local-scale processes and factors within the Coongulmerang Formation, which the water independent peer reviewer noted is likely to be highly heterogeneous in comparison to its representation within the numerical model. While it is not currently possible to accurately simulate the effect of such heterogeneity under field conditions, the modelling should be viewed as a guide to the potential extent of these impacts only and should be complemented with additional field evidence and monitoring studies. Further drilling investigations to target local clay lenses (as recommended by the peer reviewer) may resolve some of the uncertainty around perching, along with a more comprehensive shallow groundwater monitoring network (as discussed above).

38. The risk of impacts to the chain of ponds system associated with the Perry River associated with mounding is also not extensively analysed, as its relationship to underlying groundwater is not well documented in the baseline data. The groundwater modelling indicates that some degree of groundwater mounding may extend to the Perry River catchment (with a minor water table increase of approximately 0.5 m). It is hypothesised that the system depends on local perched groundwater bodies, which would be unaffected by mounding in the Coongulmerang Formation (based on measurement of the water table depth in the vicinity of the ponds). However, there is limited data to establish this conclusively and characterise the system's interactions with groundwater at different depths. The groundwater modelling predicts that baseflow (discharge of groundwater) to the Perry River is expected to increase, albeit not by large amounts, as a result of mining. Again, the potential water quality implications and ecological impacts of enhanced groundwater discharge to the river should be carefully considered and investigated, given the poor baseline groundwater quality in the Coongulmerang Formation and predictions of increased water table hydraulic gradients away from the site within this formation.

39. While the groundwater modelling predicts relatively small changes in baseflow amounts to rivers compared to current surface water flow volumes, these estimates are characterised by considerable uncertainty. Little field investigation or analysis of local scale groundwater and surface water data from the vicinity of the major streams (e.g. Mitchell and Perry Rivers) has been undertaken to understand ground-surface water exchanges and their dynamics at different river levels and flow rates. Baseflow may comprise a significant fraction of streamflow during periods of low rainfall (as documented by research carried out by Monash University), and as such, overall percentage estimates of baseflow - as presented in the impact assessment - may miss key periods when groundwater comprises a significant fraction of streamflow. At such times, ecological communities may be particularly vulnerable to exposure to adverse quality groundwater, e.g. as a result of the process(es) described above associated with mining.

40. A further long-term risk not examined in detail in the EES is the potential for migration of water from the Coongulmerang Formation towards and into the Latrobe Group aquifer due to the enhanced hydraulic gradients caused by borefield pumping (see next section). The particle tracking conducted during groundwater modelling indicates some migration of water from the areas of groundwater mounding in the Coongulmerang Formation into the

Latrobe group, which would be expected to lead to some mixing and increasing concentrations of metals in Latrobe group groundwater. This is likely to be a relatively long-term effect and the input of water from the shallow aquifer is likely to be small and highly diluted; however, this should still be considered a potential groundwater quality risk and analysed accordingly.

Water independent peer review and response

41. The water independent peer review (conducted by AECOM) raised some important issues regarding the conceptual hydrogeology presented in the groundwater impact assessment, which are relevant to the issue of groundwater mounding below the site. These include concern that the heterogeneity of the Coongulmerang Formation (and potential for perched water to develop above clay horizons) has not been adequately considered, and secondly, that evidence regarding the permeability of the Balook Formation (in drilling data) had not been properly accounted for in assessing the permeability of this unit (which underlies the Coongulmerang Formation). The main implications of these issues are that groundwater mounding could potentially be more extensive below the mine site than predicted in the modelling, as the underlying aquifer(s) may be less able to dissipate mounding in the long term, compared to what is modelled (i.e., homogeneous Coongulmerang Formation, and relatively permeable Balook Formation).

42. Flow-on effects that could arise (as indicated by the reviewer) include increased seepage ('daylighting') of groundwater along slopes, such as the escarpment west of Mitchell River (see above), and potential issues with more rapid rises in the water table than is expected based on the numerical modelling, which may interact with mine infrastructure and cause stability issues.

43. The proponent's response to these issues does not (based on my reading) fully address the reviewer's concerns – e.g., through additional completed or proposed field investigations to better understand the properties of the Balook formation and nature and extent of clay horizons and associated perching in the Coongulmerang Formation. While some efforts were made to examine alternative groundwater conceptualisations which may impact mounding behaviour – e.g. running the model with an extended Seaspray Formation based on additional drilling data - and this is informative work, the alternative conceptualisation does not address the specific points raised by the reviewer about heterogeneity in the Coongulmerang and Balook Formations.

Assessment of groundwater drawdown associated with borefield water supply

44. One of the other major potential issues with the proposed development is the extent to which extraction of groundwater from the Latrobe aquifer may cause or exacerbate drawdown of groundwater levels in this system and affect other water users accessing the same aquifer or adjacent/overlying aquifers. There are many registered bores in the area surrounding the borefield and mine site, particularly in the Seaspray Formation overlying the Latrobe aquifer.

45. Regionally, within the Gippsland Basin, falling groundwater levels and associated impacts (e.g. loss of access among some water users) in the Latrobe Group Aquifer have been well documented:

"It is a matter of record that groundwater pressures within the Gippsland Basin of Victoria, in particular, those associated with the Latrobe Aquifer, have fallen dramatically over the past decades. Associated with this pressure decline are impacts on water supplies as well as concerns regarding potential land subsidence" (Hatton et al., 2004[2])

46. The decline in groundwater levels in this aquifer is a result of the combined effect of significant extractions for coal mining, offshore oil and gas extraction and locally, irrigation extraction. At the outset, the groundwater impact assessment and modelling should have acknowledged this wider context and addressed the possibility of cumulative impacts of the bore-field along with other existing activities in the basin, which are causing continued declines in groundwater levels (this issue is acknowledged in section 2 of the groundwater modelling report but not extensively discussed in the impact assessment). While the proposed borefield is generally further north of where the largest existing groundwater extractions from this aquifer occur, the drawdown predicted in the modelling will be significant, and this will extend more than 10 km to the south of the borefield. This drawdown would therefore interact with (and add to) existing declines in groundwater levels occurring within the region.

47. There are relatively few monitoring bore records from deep bores in the Latrobe aquifer near the proposed borefield; however, the closest government bore monitoring the target aquifer, near Bairnsdale, is identified in the impact assessment 47063. Records from this bore show a long-term declining trend, with some recent stabilisation (see figure below). Additional bores in the government network that do not appear to have been used in the groundwater modelling are 77945 (Perry Bridge) and 90614 (Loch Sport), which show impacts of depressurisation of the Latrobe aquifer as well. Southern Rural Water's analysis of the aquifer water balance notes that overall, in the Latrobe Group aquifer, current extraction is greater than estimated recharge, leading to a deficit (estimated to be 60 GL/yr as of 2012)[3].

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[2] Hatton, T., Otto, C., Underschultz, J. 2004. Falling water levels in the Latrobe Aquifer, Gippsland Basin: Determination of cause and recommendations for future work. CSIRO, 13th September 2004.

[3] Southern Rural Water, 2012. Gippsland Groundwater Atlas.

Figure source: Visualising Victoria's Groundwater (vvg.org.au) accessed 18th January 2021.

48. In this context, it is doubtful, or at least questionable, that a significant volume of additional groundwater extraction from this aquifer would be considered sustainable and be approved by the managing authority (Southern Rural Water). Extractions from the Latrobe aquifer are currently capped, meaning no new licenses are being issued (as acknowledged in the impact assessment). As such, the proponent would be required to secure water through trading with other existing licensed users. This would potentially be difficult during times of large water demand in the region (when it is most likely the borefield would be required).

49. As shown on Figure 3.6 of the groundwater modelling report, there are a substantial number of registered bores within the region surrounding the project. This predominantly includes bores in the Seaspray Group to the south of the project area (not far from the proposed borefield) and bores in the Latrobe Valley Group/Balook Formation to the north of the project, as well as a considerable number of bores in the Mitchell River alluvial aquifer (Wy Yung WSPA). As such, the potential for drawdown to propagate from the proposed borefield into these adjacent aquifers and impact levels in these bores is a key issue. Estimation of drawdown associated with the borefield is conducted in two ways:

a) through a pumping test conducted within the target aquifer (reported in the Water Supply Options Technical Groundwater Assessment), and

b) using the numerical modelling of the groundwater system (which in part incorporates information derived during the pumping test analysis), including uncertainty analysis.

50. Modelled drawdown in registered bores is presented in Figure 7.39 of the groundwater modelling report (Appendix B of the Groundwater and Surface Water impact assessment), and is generally between 0.2 and 2.0m, which is considered unlikely to have a major impact

on the ability of existing users to access water from their bores, although in some cases this could be a significant impact. The modelling indicates that much of the drawdown related to borefield pumping is confined within the Latrobe aquifer, with limited propagation into the Seaspray Formation and other adjacent aquifers (due to low inter-aquifer connectivity). This issue warrants further detailed consideration as there is some conceptual uncertainty regarding the geology to the north of the borefield, approaching the edge of the Gippsland Basin (see below). The level of connectivity has not been fully established and as such greater drawdown impacts on shallower aquifers than have currently been modelled can't be ruled out.

51. The modelling appears to give a reasonable indication of drawdown impacts in the target aquifer in the short-term. however, there are some residual uncertainties with respect to drawdown impacts in the longer term, particularly relating to the question of the aquifer's extent, heterogeneity and connectivity with adjacent aquifer units (particularly to the north of the borefield). Inherently, groundwater modelling simplifies real-world processes and is not able to represent in detail the effect of geological heterogeneity on aquifer behaviour. As such it must be supplemented with complementary lines of field-based evidence (e.g. geology, geophysics, geochemistry). Issues with the analysis of drawdown include the following:

52. The Latrobe Group aquifer extent and thickness are not entirely known throughout the region, and there are relatively few bores that cover the full stratigraphic sequence including this deep aquifer unit. This, along with sparse availability of water level data for the unit to use in groundwater model calibration creates a level of uncertainty with respect to drawdown predictions (using both analytical and numerical modelling), and the aquifer's hydraulic parameterisation in the groundwater modelling. Based on the proponent's drilling data (which has made efforts to understand the stratigraphy of the site), the Latrobe aquifer thins and disappears to the north of the proposed borefield. It is not clear how accurately this has been determined and/or represented within the groundwater numerical model. This issue could have important implications for predicting the drawdown during pumping, due to boundary effects (see below).

53. The pumping test, described in section 2.12 of the groundwater modelling report and Appendix A007 – Water Supply Options Technical Groundwater Assessment, gives an indication of the extent of drawdown and Latrobe group aquifer parameters, which will ultimately control how the aquifer responds to extraction from the borefield. However, there are some important limitations and deficiencies with this pumping test:

- The length of time for the test was 96 hours (4 days). This is less than the minimum time typically required for major groundwater license applications (e.g. by Southern Rural Water). Recovery data was not monitored following the cessation of pumping, which was a missed opportunity to gain further information about the aquifer's response to pumping.
- Groundwater level/drawdown in the target aquifer was only recorded within one monitoring bore in the Latrobe Group aquifer during the test – i.e., not the pumping bore itself, as well as a monitoring bore in the overlying Seaspray Formation. Obtaining data from two or more bores in each aquifer would have given greater confidence in the interpretation of the drawdown response and the estimation of aquifer hydraulic

parameters. This also would have allowed for analysis of the geometry of the drawdown cone, providing important information about the aquifer extent, capacity, and boundary effects.

- The data quality - e.g. level of noise in the drawdown data and fit of the observed drawdown trend to a type curve for time-drawdown (as shown on Figures 2.40 and 2.41 of the Groundwater Modelling Report) is less than ideal, indicating potential issues with the well efficiency and/or construction (this was pointed out by the Water Independent Peer Review). The pumping rate was not fully constant through time (as it should be), which may have contributed to noise in the data.
- The drawdown recorded during the test did not appear to stabilise over time, as would normally be expected for a confined aquifer. Rather, a significant increase in the drawdown occurs late in the test – i.e. an increasing trend in the drawdown vs time log-normal plot after Day 1, rather than a straight line, as would expected for a large, horizontally confined aquifer. This implies that one or more factors cause the drawdown to increase abnormally throughout the pumping, such as a boundary effect (drawdown reaching the limit of the aquifer). This may be related to the thinning and pinching out of the Latrobe Group aquifer to the north of the site where the test was conducted (as shown on Fig 2.46 and Fig 2.47 of the groundwater modelling report), which has important ramifications.
- Ultimately, this could mean that the borefield may be unable to source water from the aquifer north of the borefield, and as such, drawdown to the south or into different aquifers to the north (above/adjacent to the La Trobe aquifer) could be more extensive. It may also indicate somewhat limited aquifer capacity, which may be of concern, given that the pumping rate used in the test is considerably lower than the volumes proposed for extraction in the operational borefield. Limited aquifer capacity may (in the long term) result in enhanced rates of leakage from the overlying Seaspray and/or Balook Formations and/or an inability for the borefield to supply water at the rates desired.

54. The groundwater modelling references the CSIRO 2010 study of the Gippsland basin, which notes that the (Latrobe) "aquifer outcrops or sub-crops at shallow depths where it receives recharge from direct infiltration of rainfall" (see p.47 of the groundwater modelling report). No identification of areas where Latrobe aquifer outcrops or sub-crops near basin margins has been presented, nor has the effect of borefield pumping on water levels in such areas been monitored or anlaysed in detail. Understanding whether there are areas where the Latrobe aquifer is near the surface and/or unconfined, and what would be the impacts if drawdown from the borefield reached such areas, is an important unresolved question. It is assumed that drawdown propagates only into the overlying confining unit(s) (e.g. Seaspray Formation) and does not affect any shallow/unconfined aquifer water levels. There are however case studies (e.g. Barwon Downs borefield in southwest Victoria) where pumping a confined aquifer results in drawdown of water levels in the recharge/outcrop areas of the unit, resulting in significant ecological impacts (e.g. drying of wetlands).

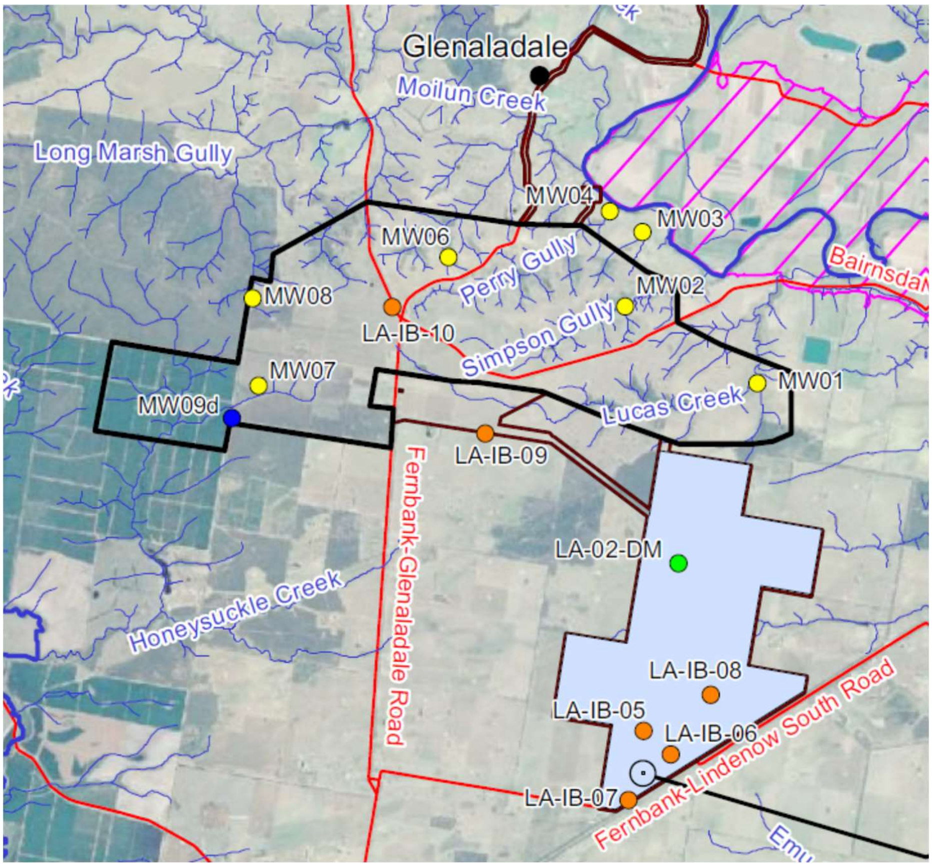
55. In the groundwater modelling, uniform aquifer properties are assigned to each geological unit in the region. This is expected to simplify the hydrogeological behaviour of the system as it is likely there is significant geological heterogeneity within each unit (as discussed earlier). For example, the multiple units known to occur within the Seaspray Group (above the borefield's target aquifer) are grouped into one layer, with a uniform hydraulic conductivity. While it may not be possible or appropriate to assign alternative aquifer

parameter zones within each different layer, steps should be taken to address the uncertainty associated with averaging of aquifer properties and simplification of the heterogeneity. This would include further alternative modelling scenarios involving different levels of geological heterogeneity, and/or additional field studies to mitigate model uncertainty. Given the issues with the pumping test described above, additional pumping test analysis is warranted, using a wider array of nested monitoring bores and a longer duration. Environmental tracer studies, e.g. examination of residence time and other isotope tracers would also be valuable in indicating the degree of inter-aquifer connectivity, independently of the pumping test analysis and modelling.

56. The above issues mean that the effect of pumping from the borefield on groundwater levels throughout the region, and the long-term viability of the borefield as a major water source remain uncertain.

Groundwater monitoring and baseline data

57. Seven monitoring bores have been drilled within the target formation for mining (Coongulmerang Formation) along with one deeper bore in the Balook Formation, to characerise baseline groundwater levels and quality within and surrounding the proposed mine site (shown in the figure reproduced below). A further three monitoring bores were installed in the vicinity of the proposed borefield, two within the Latrobe Group (target aquifer) and one in the overlying Seaspray Formation. Based on the descriptions provided in chapter 4.2 of the groundwater impact assessment, these wells were drilled, constructed, and developed appropriately, noting that post-development water quality was not measured initially in all bores. The following issues with the monitoring network were identified:



58. The number of shallow monitoring wells surrounding the mine site and water level data from these provides a basic indication of water table depth and groundwater conditions within and surrounding the site. The data allow for a baseline assessment and monitoring of groundwater flow directions and variability through time. However, as discussed above, the current monitoring network does not allow for detailed characterisation of the flow gradients and connectivity between the Coongulmerang Formation and the Mitchell River alluvial aquifer and river, which are likely to be significantly influenced by mining – e.g. through groundwater mounding (as predicted in the modelling). As such, further baseline monitoring is required to address associated risks to these receptors – e.g. enhanced flow of poor quality groundwater into the alluvium and potentially, river.

59. Groundwater monitoring in the vicinity of Perry Gully, where tailings from the mine are proposed to be initially stored is also limited, meaning baseline conditions and detailed assessment of the impact of the tailings storage on shallow groundwater can't be assessed. Similarly, there is little baseline data near the Perry River and Providence Ponds (classified as an important Type 2 GDE and considered to have high ecological value). It is stated that the water table is considerably below the surface in the region of Providence Ponds and that the chain of ponds probably rather depends on perched shallow groundwater above localised clay horizons. While this may be the case, the high ecological value of the area warrants detailed field investigations (as opposed to speculation) - e.g., careful analysis of drill cores and installation of shallow piezometers, field surveys of the ponds to establish their level of dependence on groundwater. It is noted that the closest monitoring bore to the Perry River (MW07) recorded an abnormally high groundwater level, along with relatively poor groundwater quality compared to the other monitoring bores. Further characterisation of groundwater levels, flow patterns and quality in this area between areas of proposed mining and the Perry River, are thus required. Flow/discharge from perched layers could potentially result in mounding effects and seepage of groundwater to the surface that are different to what is currently predicted in the modelling (which cannot simulate such effects). This issue was flagged by the independent water expert reviewer (section 3.1.2 of Water Independent Expert Review).

60. There is limited information from the current monitoring network regarding vertical hydraulic gradients (e.g. water levels between multiple aquifers occurring at different depths below the site) and thus the relationship(s) between shallow and deeper aquifer units. This is important for understanding inter-aquifer connectivity, which will control both the extent of mounding at the site (and the extent to which this is dissipated by underlying aquifers) and drawdown into shallow aquifers above the proposed borefield. The monitoring well set-up at the proposed borefield, and between this site and the mine area is also relatively limited (3 active monitoring bores, with other sites recently drilled and proposed for ongoing monitoring).

61. Groundwater quality monitoring reported in the impact assessment has largely focussed on standard groundwater chemical parameters but did not appear to sample a full suite of heavy metals, including uranium and thorium, which are commonly associated with mineral sands deposits. This is important given the geochemical assessment indicated some enrichment of these elements in the sampled material. Monitoring for other radionuclides in

the uranium and thorium decay series - e.g. Radon-222, which can pose a health risk, is also required, in light of the enrichment of these elements in the mineral deposits.

62. The baseline groundwater chemistry data indicates naturally elevated levels of metals in the groundwater within the target formation (Coongulmerang Formation), including Al, Cd, Cu, Cr, Mn, Ni and Zn, as well as cyanide. The levels of these elements exceed ecosystem protection guideline values, as noted in section 4 of the impact assessment report. Cyanide is not a typical naturally occurring component of groundwater (it is not a heavy metal as implied on page 133, but rather an inorganic molecule often associated with gold mining). The source of cyanide in the groundwater (along with other elevated contaminant concentrations) warrants careful analysis and investigation, as it may indicate a pre-existing legacy contamination issue within the groundwater, which could be mobilised/exacerbated by the proposed mine.

63. The presence of nitrate, E. Coli and phosphorus in groundwater also indicates the groundwater in the Coongulmeran Formation is likely impacted to some extent by agricultural impacts. The specific processes responsible are not investigated in detail. This could in future make it difficult to distinguish impacts related to mining activity and other possible legacy impacts.

64. It is argued that the local ecosystems which may be exposed to this relatively poor-quality groundwater under current or future conditions would be 'naturally adapted' to the elevated levels of these constituents. This is speculative (and in my view unreliable) and this should be thoroughly examined through thorough ecological risk assessments, conducted with the aid of detailed field sampling (see earlier discussion on this point). The current level of exposure of water dependent ecosystems to these elements and/or expected future change in exposure to them due to mounding and enhanced flow of water from the Coongulmerang Formation during mining, is not clearly documented in the impact assessment or baseline studies (a major oversight). It is likely that the predicted mounding associated with mining would increase the flow of groundwater containing these elements towards surface water systems (in line with the conceptual hydrogeological model, with flow towards the Mitchell River floodplain). This may increase ecosystem exposure to these elements and thus expose them to higher levels than have historically occurred. Risks to other beneficial uses of the groundwater in the Mitchell River alluvium (an important water source in the Wy Yung WSPA) similarly need careful consideration.

Proposed groundwater monitoring program

65. The proposed groundwater monitoring program outlined in chapter 9 of the impact assessment appears to be essentially a continuation of the baseline monitoring program discussed above, with little detail regarding specific additional monitoring measures that will be initiated to mitigate the risks to groundwater quality and quantity identified through the risk assessment. It is noted that a separate monitoring plan is intended to be developed in the future should the project proceed, with further details provided at that time. This provides little confidence in the rigor and appropriateness of ongoing groundwater monitoring associated with the mine. While the need to monitor in greater detail to characterise mounding impacts, contaminant migration and borefield drawdown is noted in the impact assessment, there is currently little indication of how this is proposed to be conducted.

66. The selection of targeted additional monitoring sites, including within the aquifers below and adjacent to the Coongulmerang Formation, to address potential quality and quantity risks, should now be possible based on analysis of the numerical modelling results. The monitoring plan currently does not indicate locations or number of additional sites intended to be commissioned for ongoing monitoring. It appears from table 9-1 that no additional monitoring bores in the Coongulmerang Formation are intended to be constructed to examine mounding and contaminant migration, only an unspecified number of additional bores in the underlying Balook formation. Based on the deficiencies in the baseline data identified above, this is likely to be inadequate to identify and mitigate mounding and associated water quality risks. Additional bores beyond the current seven sites in the formation should be added to the network. Given the potential for enhanced flow of groundwater towards and into the Mitchell River alluvium (discussed above), it is also vital to monitor groundwater levels and quality in the area where these two formations (alluvium and Coongulmerang Formation) adjoin each other and interact near the river. Baseline data should be collected to allow for more comprehensive analysis of ground-surface water interaction, groundwater dependence of ecosystems, and how these may be impacted by the predicted groundwater mounding (from both quantity and quality perspectives).

67. Detail about the proposed groundwater quality indicators to be monitored is also very vague. It is proposed that TDS, major ion chemistry and a 'metals suite' will be analysed in the ongoing groundwater monitoring program. However, the specific metals to be analysed within this suite are not listed in the report, resulting in ongoing questions about whether it would be sufficiently comprehensive to address all water quality risks. As discussed above, given the enrichment of arsenic, uranium and thorium observed within the sand (detailed in the geochemical assessment) it is essential these elements be monitored both for baseline data and during site operations, along with other potential indicators of radioactivity (e.g. radionuclides such as radon-222).

<u>Section 2 – Specific issues identified by Environmental Justice Australia</u>

68. On behalf of its client (submitter 813), EJA requested my advice on the following specific issues associated with the proposal:

    a. The compliance of the hydrological components of the EES with relevant key policies and guidelines in Victoria

    Based on my understanding, I believe the hydrogeological components of the EES largely comply with the relevant Victorian policies and guidelines including the Water Act, Environment Protection Act and State Environment Protection Policy. However, it should be noted that my knowledge and familiarity with these policies is not extensive. My expertise is primarily of a technical nature, and I do not analyse or apply these policies and guidelines regularly in my professional work.

69. b. The adequacy of the baseline data collected by the project proponent to confidently describe pre-development conditions of groundwater, and any further baseline data that should be collected.

    As discussed in the previous section of this report, I believe there are some major gaps in the baseline data collected for the project to date. These include a lack of monitoring for uranium, thorium, and radionuclides in groundwater, and areas near important potential receptors where the groundwater levels and quality are not well characterised. There is also a need to further examine groundwater levels and quality in nested monitoring sites surrounding the proposed mine site and borefield and conduct more extensive field investigations of groundwater and the ecological values it supports in the vicinity of key potential receptors, such as the Mitchell River floodplain and Perry River.

70. *c. The appropriateness of the methods, including modelling, to identify and evaluate the effects of the project and relevant alternatives on groundwater.*

Generally, the groundwater modelling and field and laboratory data collection conducted to analyse the potential quality and quantity impacts on groundwater have been carried out according to sound methodologies. However, there are key limitations and data/knowledge gaps, as discussed above. These issues result in ongoing uncertainty with respect to:

- The potential risk posed by mounding and migration of poor-quality groundwater in the Coongulmerang Formation towards the Mitchell River floodplain and other possible receptors
- The connectivity between different aquifer units that may be impacted by groundwater mounding and enhanced flow/seepage and/or drawdown (related to borefield operation)
- Heterogeneity in the geology, and the extent to which this may affect groundwater mounding, seepage/discharge to the surface, and the propagation of drawdown impacts.
- The detailed relationships between key groundwater dependent ecosystems and their associated aquifers, e.g., the extent of the chain of ponds system associated with the Perry River's dependence on perched layers, as opposed to the regional water table and the importance of groundwater for sustaining ecological health at different time periods and water levels.

In combination, these (and other issues detailed above) result in residual risks to both groundwater quality and quantity which could be significant.

71. *d. Whether the actual or likely risks are identified and or appropriately assessed in terms of their level of risk, including the changes to groundwater quality and changes to groundwater availability.*

See previous response – there are potential groundwater quality and quantity risks that have not been adequately assessed or characterised and warrant greater attention and further data collection and analysis (described in more detail in the previous section).

72. *e. The adequacy of the proposed environmental monitoring and protocols to adequately protect groundwater and any further monitoring or protocols which should be required.*

As outlined in the previous section of this report, the proposed groundwater monitoring program has not been outlined in sufficient detail to give confidence that it will allow for adequate assessment and management of all groundwater quality and quantity risks. Further monitoring requirements to address these risks are outlined in the previous section of this report.

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

As discussed in the previous section of this report, there are risks – particularly associated with the enhanced movement of poor-quality groundwater present in the Coongulmerang Formation towards other shallow groundwater and surface water bodies (and associated ecological communities), which remain uncertain and may be of high significance.

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

As noted in the introduction to this review, my expertise is primarily in the science of hydrogeology. My expertise in the field of surface water hydrology is limited, and as such, I have not reviewed the surface-water impact assessment in detail (other than examining possible groundwater-surface water interaction and associated issues). My knowledge and familiarity with key water and environmental policies in Victoria (Environment Protection Act, Water Act, State Environment Protection Policy) is also not extensive.

4 January 2021

Associate Professor Matthew Currell
Chemical and Environmental Engineering
School of Engineering
RMIT University

By email only: [redacted]

Dear Associate Professor Currell

Fingerboards Mineral Sands Mine Project, Glenaladale, Victoria

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

We write to you as an expert on hydrogeology. The purpose of this letter is to seek your expert opinion on the environmental effects of the project.

We request that your expert opinion be provided as an expert witness statement to be submitted to the Inquiry and Advisory Committee (**IAC**). We request that your expert report be provided by **27 January 2021**, with a draft provided by **21 January 2021**. Further details are set out below.

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

Background

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

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

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

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

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

5. An Inquiry and Advisory Committee (**IAC**) has been appointed to review the EES and public submissions (**Tab 1.2 / Terms of Reference**). The IAC will hold public hearings for 7 to 8 weeks, after which it will produce a report for the Minister for Planning. Following receipt of the IAC's report, the Minister for Planning will then make an assessment as to whether the likely environmental effects of the project are acceptable (**Minister's Assessment**).

6. All EES documents are available online at: [redacted]

Instructions

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

   a. The compliance of the hydrological components of the EES (listed below) with the relevant key policies and guidelines in Victoria:

      Technical Studies

      i. Groundwater and Surface Water Impact Assessment (Appendix 6), including Appendices B, G-L as relevant (**Tab 2.3.1**)

ii. Water Supply Options Study: Technical Groundwater Assessment (Appendix 7) (**Tab 2.3.2**)

iii. Water Supply Options: East Gippsland / Mitchell River Concept Design and Investigation (Appendix 8) (**Tab 2.3.3**)

Chapters and Attachments

iv. Environmental and socioeconomic context (Chapter 8, Sections 8.3 and 8.4, pp 66-99) (**Tab 2.1.3**)

v. Environmental and socioeconomic impact assessment (Chapter 9, Section 9.2 and 9.3, pp 66-126) (**Tab 2.1.4**)

vi. Environmental Management Framework (Chapter 12, pp31-34) (**Tab 2.1.5**)

vii. Water Independent Peer Review Report and Proponent Response (Attachment I) (**Tab 2.2.2**)

viii. Risk Report (Attachment F) (**Tab 2.2.1**)

b. The adequacy of the baseline data collected by the project proponent to confidently describe pre-development conditions of groundwater, and any further baseline data that should be collected.

c. The appropriateness of the methods, including modelling, to identify and evaluate the effects of the project and relevant alternatives on groundwater.

d. Whether the actual or likely risks are identified and or appropriately assessed in terms of their level of risk, including the changes to groundwater quality and changes to groundwater availability.

e. The adequacy of the proposed environmental monitoring and protocols to adequately protect groundwater and any further monitoring or protocols which should be required.

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

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

8. Further to the matters set out at paragraph [7], we request that specific consideration be given to impacts of the project on the 'Chain of Ponds' within Providence Ponds and the Perry River Catchment. For background, we include the Strategic Directions Statement for the Providence Ponds and Perry River Catchment in the electronic brief (**Tab 3.2**).

9. We also request that a number of further materials be considered by you when undertaking your review of the hydrogeological components of the Environment Effects Statement (EES):

   a. Rainfall figures for the local area (**Tab 3.3**); and

   b. The EES Targeted Technical Review undertaken for East Gippsland Shire Council by SLR Consulting, as relevant to hydrogeology (i.e. Section 2 (pp 22, 28-32) and Section 3.5) (**Tab 3.4**).

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

Expert Witness Code of Conduct

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

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

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

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

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

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

    e. the following declaration:

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

Important dates

13. We request your final expert witness report be provided by 27 January 2021, with a draft report provided by **21 January 2021.**

14. The IAC will conduct public hearings over a period of 7-8 weeks, commencing on **15 February 2021.** [redacted] is scheduled to make their case in the first week of March 2021. Accordingly, please advise of the days on which you will **not** be available to give evidence before the Inquiry and Advisory Committee in the first week of March 2021.

Confidentiality

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

Fees

16. [redacted]

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

Yours faithfully

[redacted]

Virginia Trescowthick
Lawyer

Matthew James Currell, Ph.D.
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Mobile: [redacted]
E-mail: [redacted]

Qualifications:
PhD (Geoscience), Monash University, 2011.
BSc (Hons, Earth Sciences) / BA (Chinese Language), University of Melbourne, 2006.
Graduate Certificate, Tertiary Teaching and Learning, RMIT University, 2012.

Areas of expertise:
- Hydrogeology & environmental geoscience: groundwater geochemistry, environmental isotopes and other tracers, contaminant fate & transport, climate-land use-hydrology linkages;
- Environmental engineering: groundwater contamination risk assessment, management and remediation;
- Groundwater management & policy, environmental impact assessment

Employment History

2019 – Current
Associate Professor, School of Engineering (Chemical & Environmental), RMIT
Program Manager: BH080 Bachelor of Engineering (Environmental Engineering)(Hons)

2016 - 2018
Senior Lecturer, Environmental Engineering, School of Engineering, RMIT
Program Manager: BH080 Bachelor of Engineering (Environmental Engineering)(Hons)

2011 - 2015:
Lecturer, Environmental Engineering, School of Civil, Environmental & Chemical Engineering, RMIT

2010:
Environmental consultant, groundwater division, Sinclair Knight Merz Australia

2007-2010: PhD candidate, Monash University School of Geosciences.
Project: *'Geochemical and isotopic study of sustainability of groundwater extraction in northern China: Yuncheng Basin'* (Degree conferred 31/10/2011).

2004-2005:
Research Assistant, School of Chemistry (Analytical & environmental), University of Melbourne

Learning and Teaching

My approach to teaching is centered on **inspiring** students about the impact they can make as professionals, **linking** theoretical concepts to real-world issues, and **encouraging** curiosity and continuous knowledge development through critical analysis and building independent research skills.

Key duties in learning and teaching
Since 2011, I have taught and coordinated numerous undergraduate courses in the environmental and civil engineering programs at RMIT, consistently coordinating 3 to 4 courses per year since 2015 (Table 1).

The predominant units I have taught and coordinated are: CIVE1184 *Hydrogeology* (coordinator from 2013 to 2019); CIVE1122 *Advanced Hydrogeology* (coordinator from 2013-2019) and OENG1113 *China's Environmental Challenges* (Coordinated form 2015 to 2019). In addition, I have coordinated and delivered *Geological Site Investigation* (2017) and *Land Contamination & Geohazards* (2012 -2017) and assisted in the delivery of *Geology* (2013-14).

Since 2012-13 I have steadily increased my level of oversight, responsibility and leadership in teaching and learning, including taking on coordination roles, developing new coursework, and ultimately being appointed Program Manager (coordinator) for the Bachelor of Engineering (Environmental Engineering)(Hons).

Year	Courses delivered	Courses coordinated	GTS (%) Year average	OSI (%) Year average
2011	3	0	69.4	70.2
2012	4	0	83.4	79.1
2013	4	2	93.1	92.2
2014	4	2	85.7	92.3
2015	4	4	94.3	96.2
2016	4	3	93.7	91.7
2017	3	3	93.8	90.3
2018	3	3	97.7	100
2019	3	3	96.8	100
2020	3	2	94.2	90.3
Average	**3.7**	**2.0**	**90.1**	**89.7**

Table 1 – Number of courses and course experience survey scores since 2011.
GTS = Good teaching scale; OSI = Overall satisfaction index (Course Experience Survey results).

Student feedback
My teaching is highly regarded by students, as evident in consistently outstanding qualitative and quantitative feedback (Figure 1). Highlights include:

- Eighteen courses I have taught and/or coordinated over the past 7 years have received Good Teaching Scale (GTS) scores in the range 90 to 100%; considered 'Outstanding' by RMIT. This includes 15 out of the 17 courses I coordinated between 2015 and 2020, receiving GTS scores above 90%.

- The course CIVE1122 *Advanced Hydrogeology,* which I co-ordinate and deliver has been recognized as one of the College of Science, Engineering and Health's 'Top Courses' every year from 2014 to 2020 inclusive, achieving GTS scores ranging between 94.0 and 100%.

- In 2015 I developed a new course - OENG1113 *China's Environmental Challenges*, involving a two-week overseas intensive module in the North China Plain. This course has received GTS scores of 100% twice (2016 and 2018).

- In 2017, I took over coordination of a poor-performing course - EASC1076 *Geological Site Investigation* and conducted a thorough re-design of content, delivery mode and assessment, leading to an improvement in GTS of more than 50 points (from 42.2 to 99.1%) in one year.

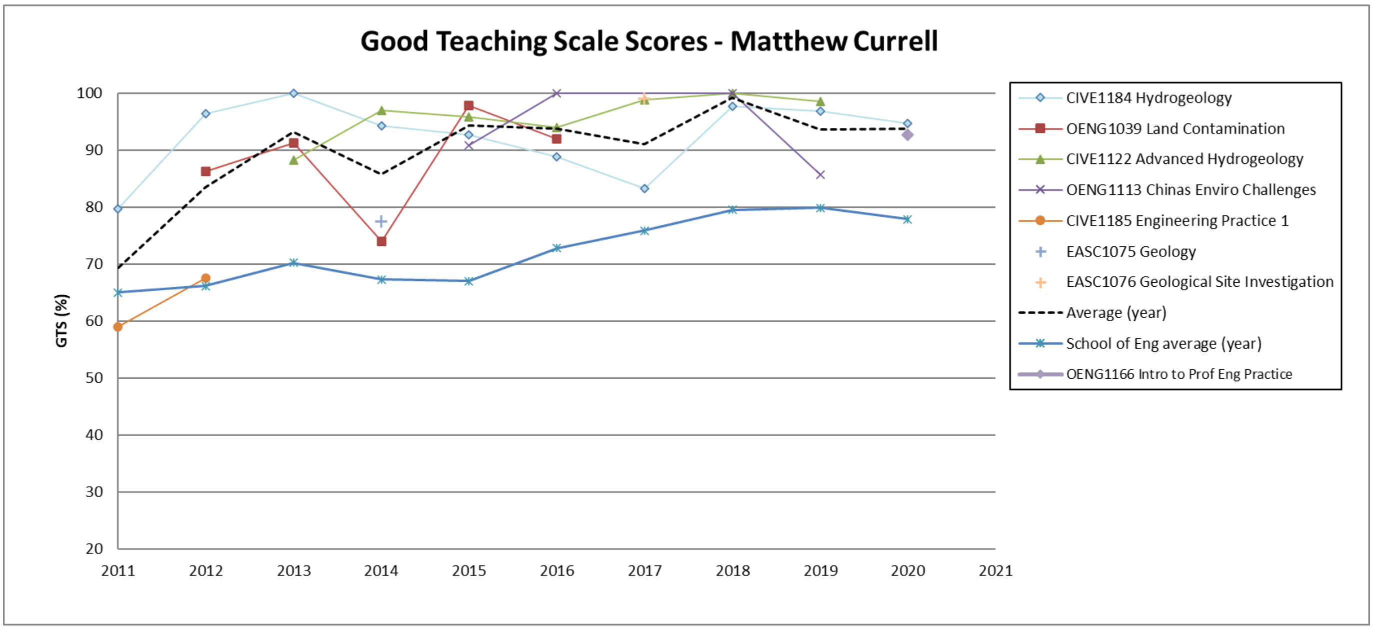

Figure 1 – Good Teaching Scale scores (%) for courses coordinated and/or taught at RMIT, 2011-19

Learning and Teaching awards, honors and grants

2020: **Vice Chancellor's Awards for Strategic Contributions to Learning and Teaching**: *Initiatives that Exemplify RMIT's Commitment to Reconciliation in the Curriculum*: Commendation (with Dr Nick Brown).

2019: **Vice-Chancellor's Award for Strategic Contributions to Learning and Teaching**: *Collaborations that enable innovative and inclusive learning environments:* Stasinopoulos, P., Ryan, R., McLaughlin, P., **Currell, M.**, Shimeta, J., Allinson, G., Henderson, D., Brown, N., Horan, E., Maqsood, T., Hassell, K. Self-sufficiency and Sustainability in Remote South Pacific Islands (Fiji)

2018: Awarded $49,500 from Australian Government's *New Colombo Plan* to support OENG1113 *China's Environmental Challenges* Program

2016: Awarded $33,000 from the Australian Government's *New Colombo Plan* to support OENG1113 *China's Environmental Challenges* Program

2015: Awarded $21,500 from the AsiaBound scheme (Australian Department of Education) to support *China's Environmental Challenges* Program.

2013: **Teaching Excellence Award**, Higher Education, Early Career Academic (Commendation)

Coursework research project supervision
I am actively involved in the design and supervision of coursework projects in engineering for final year Capstone and Masters coursework students. I actively seek to engage private and government sector partners in the design and supervision of these projects, to give students work-integrated learning experiences. Partners I have worked with include: South East Water, Melbourne Water, EPA Victoria, Golder, GHD, Jacobs, Wannon Water, Optimos Solutions, Victoria Golf Club and many others. These projects have helped contribute to solving real-world problems, and many have led to employment opportunities for students. Twice, students I have supervised were nominated for the *Sir Ronald East Prize*, awarded by the Water Engineering Branch of Engineers Australia. One student (Lisa Duncan) was awarded the prize in 2013 on the basis of outstanding work on the topic of coal seam gas produced water management.

Year	Final year 'Capstone' projects supervised	Masters by coursework students supervised
2011	1	-
2012	8	-
2013	10*	-
2014	9	-
2015	8	-
2016	10	1
2017	8	2
2018	11	1
2019	8	1
2020	13	-
Total	**86**	**5**

*Student Lisa Duncan awarded the Sir Ronald East prize for best water engineering project at a Victorian university

Learning and Teaching Leadership:

- In 2014-15 I developed a new undergraduate course for the environmental engineering program, involving a 2-week study tour intensive in China, focusing on the country's unprecedented environmental challenges and transformations: OENG1113 *China's Environmental Challenges*. This received funding support from AsiaBound and New Colombo Plan schemes in 2015, 2016 and 2018. The program has a strong web presence and is a drawcard for prospective students: https://www.youtube.com/watch?v=pao59PK1ftc.

- In 2016 I was appointed Program Manager for the BH080 Bachelor of Engineering (Environmental Engineering)(Hons) program, a role which involves significant administrative, leadership and external engagement duties on behalf of the discipline. I chair the program and staff-student committee meetings, participate in Industry Advisory Committee meetings, oversee timetabling and other administrative duties, sit on the School's Learning and Teaching committee and lead the environmental engineering presence at Open Day (among other day to day management duties).

- Upon commencing as Program Manager, I instigated and conducted a review of the BH080 program structure and content, incorporating feedback from industry and government stakeholders, and current and past students of the program. This led to a proposal for minor course content and program structure changes, which were approved in 2017 and adopted in 2018.

- Following appointment as Program Manager, improvements in graduate outcomes in the national Student Experience Survey results were achieved in 2017, 2018 and 2019 with more than 90% of graduates securing full time employment after graduating, and scores of 100% and 92% for ‘teaching quality’ and ‘overall educational experience’.

Research & Scholarship

Awarded research grants

Beginning in 2012, I have had considerable success in attracting external research funding from competitive and industry-funded grant schemes (Tables 2 and 3). This has provided opportunities for higher degree by research and other students to conduct cutting-edge and industry-relevant research under my supervision, resulting in high-impact research outputs. In recent years, I have been the driver and lead chief investigator on the majority of secured research grants.

Competitive Grant Schemes (Category 1 income):

2020-2023: Australian Research Council (ARC) Linkage Program: *‘Hydrogeological drivers and fate of spring flow in a semi-arid setting’*. $349,177 (4th of eight CIs).

2016: Australian Institute of Nuclear Science and Engineering (AINSE) Research Award: *‘Groundwater age dating to constrain rates of contaminant movement in an urban re-development precinct’* $23,570 (Project leader, sole CI)

2012: Australian Institute of Nuclear Science and Engineering (AINSE) Research Award: *“Geochemical Investigation of mixing, flow dynamics and salinisation processes in a coastal aquifer vulnerable to seawater intrusion: Westernport Basin, Victoria”* $19,800 (Project leader, sole CI)

CRC and Industry funding schemes (Category 2 and 4 income):

2020: Australian Contaminated Land Consultants Association (ACLCA): ‘*Impacts of legacy landfills on groundwater quality: Fishermans Bend’*. $7500 (Lead/sole CI).

2018 – 2019: South East Water corp: *‘Assessment of sources and mechanisms of groundwater contamination at Southeast water treatment plants’* $30,000 (Project leader, sole CI)

2017-2019: CRC CARE and South East Water: *‘Novel tracers to delineate groundwater contamination from wastewater treatment plants’*. $110,000 (Project leader, one of 3 CIs)

2017-2019: CRC CARE and South East Water: *‘Novel bioremediation tools for nitrogen contaminated groundwater’*. $110,000 (third of 3 CIs)

2017: Australian Contaminated Land Consultants Association (ACLCA): *‘Determining concentrations of PFAS in Victorian groundwater systems’* $11,500 (second of two CIs)

2015-2017: CRC CARE: *‘Developing decision support tools for groundwater remediation in urban re-development precincts: Fisherman’s Bend, Melbourne’* $230,000 (Project leader, one of 4 CIs)

2014-2015: Department of Environment and Primary Industries Victoria (DEPI): *‘Isotopic investigation of methane in Victorian sedimentary basins: characterizing baselines and determining key processes in areas of potential future unconventional gas activity’* $80,000 (Project leader, sole CI)

2013-2015: Melbourne Water Corporation: *‘Impacts of urbanization on groundwater recharge and quality’* $102,500 (Project leader, sole CI)

2013: National Ground Water Research and Education Fund (U.S.): *'Aquifer Storage and Recovery of Recycled Water: Identifying Emerging Contaminants in Source Water and Examining Their Fate and Transport'* $7,895 (Project leader, one of two CIs).

2013: Australian Contaminated Land Consultants Association: *'Determining background concentrations of inorganic contaminants in southeast Melbourne's aquifers'* $9,872 (Project leader, sole CI)

2012: Environment Protection Authority Victoria: *'Literature Review: Background concentrations of inorganic contaminants in soil and groundwater – a Victorian perspective'* $10,000 (2nd of four CIs)

Year	Project / Grant title	Funding agency	Role	$Income awarded	$Income Share
2012	Geochemical investigation of groundwater flow and mixing in a vulnerable coastal aquifer	AINSE	Lead/sole CI	23,700	23,700
	Literature review: background contamination in Victorian soils & groundwater	EPA Victoria	4th of 6 CIs	44,940	7,639.8
2013	Investigating impacts of land-use change on groundwater recharge in SE Melbourne	Melbourne Water	Lead/sole CI	102,500	102,500
	Aquifer storage and recovery using recycled water: contaminant fate & transport	NGWREF	Lead CI (2 CIs)	7,300	3,650
	Background levels of inorganic contaminants: Brighton Group, SE Melbourne	ACLCA	Lead/sole CI	9,782	9,782
2014	Methane and isotopic sampling of groundwater in the Otway and Gippsland Basins	DELWP Victoria	Lead/sole CI	80,000	80,000
2015	Integrated decision-support tools for groundwater remediation	CRC CARE	Lead CI (4 CIs)	230,000	115,000
	Report for Parliamentary Committee on Unconventional Gas in Victoria	State of Victoria	Lead/sole CI	26,000	26,000
2016	Groundwater age dating to constrain rates of contaminant movement	AINSE	Lead/sole CI	23,570	23,570
2017	Determining concentrations of PFAS in Victorian groundwater systems	ACLCA	2nd of 2 Cis	11,500	5,750
	Novel tracers to delineate groundwater contamination from WWTPs	CRC CARE	Lead CI (2 CIs)	110,000	55,000
2018	Novel bioremediation tools for nitrate contaminated groundwater	CRC CARE	3rd of 3 CIs	110,000	36,666
2019	Assessment of sources and mechanisms of groundwater contamination at South East Water's Blind Bight and Boneo plants	South East Water	Lead/sole CI	30,000	30,000
2020	Hydrogeological drivers and fate of spring flow in a semi arid setting	Australian Research Council	4th of 8 Cis	$349, 177	16,000
	Impacts of legacy landfills on groundwater quality, Fishermans Bend.	ACLCA	Lead/sole CI	$7500	$7500
Totals				**$1,165,969**	**$519,258**

Table 2 – Summary of successful research grants and awarded income 2012-2018.

Postgraduate / Higher Degree by Research Supervision

In the last 4 years, four students under my supervision have completed Higher Degrees by Research (two masters and two PhDs). I have also contributed to research scholarship and development of early career researchers through examination of PhD theses (7 in the last 5 years).

Completed/Graduated higher degree by research (HDR) students:

1. Emily Hepburn (PhD, primary supervisor) 2015 - 2019: "Development of a Decision Support Tool for Precinct-Scale Assessment and Management of Contaminated Groundwater" – Study funded by CRC CARE. **Thesis passed and archived 31st October, 2019.**

2. Benjamin Hall (PhD – Primary supervisor) 2013-2018: "Influence of urbanization on groundwater groundwater resources in southeast Melbourne" – Study funded by Melbourne Water **Thesis passed and archived 11/9/2018**

3. Paul Ter (MSc – Associate supervisor) 2014-2016: "Ichnology and palaeoecology of the Neogene Beaumaris Sandstone: a reconstruction of palaeoenvironments using trace fossils as interpretive tools", (Associate supervisor). **Thesis passed & archived 22/09/2016**

4. Stephen Lee (MEng – Primary Supervisor) 2014-2015: "Investigating the origin and dynamics of salinity in a confined aquifer system in southeast Australia" (Primary supervisor) **Thesis passed & archived 28/9/2015**

5. Dona Grace Amara (PhD – Associate Supervisor) 2011-2015: "Chronic kidney disease of unknown origin in Sri Lanka and its relation to drinking water supplies", (Associate supervisor) **Thesis passed & archived 9/07/2015**

Current supervisions:

Thanh Trac Tran (PhD, primary supervisor): 2016 - current: "Aquifer recharge using storm water in Bin Duong, Vietnam: determining water quantity and quality constraints" *Thesis submitted September 2020.*

William McCance (PhD, primary supervisor): 2017 - current: "Novel tracers to delineate groundwater contamination from wastewater treatment plants" – Study funded by CRC CARE and the Water Industry. *Thesis submitted December 2020.*

Justin Morrisey (PhD, Associate supervisor): 2018 - current: "Novel bioremediation tools for nitrate-contaminated groundwater" – Study funded by CRC CARE and Water Industry consortium

Leandra Rhodes-Dicker (PhD, Associate supervisor): 2020 – current: "Exploring barriers to sanitation in challenging contexts in the Asia-Pacific' – Study supported through collaboration with Engineers Without Borders, Australia.

Examined higher degree/doctoral theses:
Tim Robson (La Trobe University), PhD
Joshua Dean (La Trobe University), PhD
Genevieve Larsen (Queensland University of Technology), PhD
Marnie Louise Atkins (Southern Cross Univerisity), PhD

Jorge Matinez (Queensland University of Technology), PhD
Stacey Priestley (Flinders University), PhD
Scott Cook (UNSW), PhD

Editorial board and peer review work

- In 2020-21 I was commissioned to edit an upcoming book on *Threats to Springs in a Changing World* by Wiley and the American Geophysical Union, as part of their Monograph Series.

- From 2014 until early 2018 I served on the Editorial Board of the *Hydrogeology Journal* (Impact Factor: 2.109), the journal of the International Association of Hydrogeologists, as an associate editor.

- In 2016-17 I was invited to guest-edit a Special Issue for the journal *Environmental Science and Pollution Research* (Impact Factor: 2.741), which was published in early 2017.

- I have peer-reviewed dozens of research papers for prestigious international publications including *Proceedings of the National Academy of Sciences* (PNAS), *Scientific Reports*, *Environmental Science and Technology*, *Environmental Pollution, Journal of Hydrology* and many other international journals. My review record over the past 5 years (completing more than 90 reviews) places me in the top 5% of peer-reviewers on Publons.com, a database of journal peer-review work: https://publons.com/author/660212/matthew-currell#stats

- Co-chaired session on Groundwater Quality Management at the 2019 Australian Groundwater Conference in Brisbane.

Research Publications

Since beginning my academic career, I have consistently published research in high impact, internationally recognized journals. This began in 2007 following my Honours year and continued throughout my PhD (2007-2011) and subsequent time in academia (2011-present). In recent years I have greatly increased both the number and quality of journal paper outputs - e.g., increasing from an average of 2.4 papers per year (0.8 in Q1 journals) between 2011 and 2015, to 6.3 papers per year (4.0 in Q1 journals) from 2016 to 2018 (Table 3).

Year	**Published papers**	**'Q1' papers (Web of Science)**
Pre-2011 (2007-10)	5	4
2011	3	1
2012	3	2
2013	1	0
2014	3	1
2015	2	0
2016	6	3
2017	8	6
2018	7	5
2019	6	4
2020	8	6
Total	**53**	**31**

Table 3 – Publications in international peer-reviewed journals

Refereed journal articles:

1. Han, D.M., Cao, G.L., **Currell, M.J.**, Priestley, S.C., Love, A.J. 2020. (2020) Groundwater salinization and flushing during glacial-interglacial cycles: Insights from aquitard porewater tracer profiles in the North China Plain. *Water Resources Research* **56**: e2020WR027879.
2. McCance, W., Jones, O.A.H., Cendón, D.I., Edwards, M., Surapaneni, A., Chadalavada, S., Wang, S., **Currell, M.J.** (2020) Combining environmental isotopes with contaminants of emerging concern to characterise wastewater derived impacts on groundwater quality. *Water Research* 116036.
3. **Currell, M.J.,** Irvine, D.J., Werner, A.D., McGrath, C. (2020) Science sidelined in approval of Australia's largest coal mine. *Nature Sustainability* **3**: 644-649.
4. McCance, W., Jones, O.A.H., Surapaneni, A., **Currell, M.** (2020) Characterising sources of groundwater contamination: A guide to the use of novel groundwater tracers at wastewater treatment plants. *AWA Water e-journal* 5(2): 1-16.
5. Thomann, J.A., Werner, A.D., Irvine, D.J., **Currell, M.J.** (2020) Adaptive management in groundwater management: A review of theory and application. *Journal of Hydrology,* 124871.
6. Hepburn, E., Cendón, D.I., Bekele, D., **Currell, M.** (2020) Environmental isotopes as indicators of groundwater recharge, residence times and salinity in a coastal urban redevelopment precinct in Australia. *Hydrogeology Journal* **28**: 503-520.
7. Hall, B., **Currell, M.,** Webb, J. (2020) Using multiple lines of evidence to map groundwater recharge in a rapidly urbanising catchment: Implications for future land and water management. *Journal of Hydrology* **580**: 124265.
8. Cartwright, I., **Currell, M.J.,** Cendón, D.I., Meredith, K.T. (2020) A review of the use of radiocarbon to estimate groundwater residence times in semi-arid and arid areas. *Journal of Hydrology* **580**: 124247.
9. Hepburn, E., Cendón, D.I., Bekele, D., **Currell, M.** (2019). Environmental isotopes as indicators of groundwater recharge, residence times and salinity in a coastal urban redevelopment precinct in Australia. *Hydrogeology Journal* (in press, doi: 10.1007/s10040-019-02077-x).
10. Hepburn, E., Northway, A., Bekele, D., **Currell, M.** (2019) A framework and simple decision support tool for groundwater contamination assessment in an urban redevelopment precinct. *Hydrogeology Journal* **27**: 1911-1928.
11. Wang, S., Wei, S., Liang, H., Zheng, W., Li, X., Hu, C., **Currell, M.J.**, Zhou, F., Min, L. (2019) Nitrogen stock and leaching rates in a thick vadose zone below areas of long-term nitrogen fertilizer application in the North China Plain: A future groundwater quality threat. *Journal of Hydrology* **576**: 28-40.
12. Hepburn, E., Northway, A., Bekele, D., **Currell, M.** (2019) Incorporating perfluoroalkyl acids (PFAA) into a geochemical index for improved delineation of legacy landfill impacts on groundwater. *Science of the Total Environment* **666**: 1198-1208.
13. Hepburn, E., Madden, C., Szabo, D., Coggan, T.L., Clarke, B., **Currell, M.** (2019) Contamination of groundwater with per- and polyfluoroalkyl substances (PFAS) from legacy landfills in an urban re-development precinct. *Environmental Pollution* **248**: 101-113.
14. Adebowale, T., Surapaneni, A., Faulkner, D., McCance, W., Wang, S., **Currell, M.** (2019) Delineation of contaminant sources and denitrification using isotopes of nitrate near a wastewater treatment plant in peri-urban settings. *Science of the Total Environment* **651**(2): 2701-2711.
15. Furlong, C., Jegatheesan, J., **Currell, M.,** Iyer-Raniga, U., Khan, T., Ball, A.S. (2019) Is the global public willing to drink recycled water? A review for researchers and practitioners. *Utilities Policy* **56**: 53-61.

16. McCance, W., Jones, O.A.H., Edwards, M., Surapaneni, A., Chadalavada, S., **Currell, M.** (2018). Contaminants of emerging concern as novel groundwater tracers for delineating wastewater impacts in urban and peri-urban areas. *Water Research* **146**: 118-133.

17. Szabo, D., Coggan, T.L., Robson, T.C., **Currell, M.**, Clarke, B.O. (2018). Investigating recycled water use as a diffuse source of per- and polyfuoroalkyl substances (PFAS) to groundwater in Melbourne, Australia. *Science of the Total Environment* **644**: 1409-1417.

18. Han, D.M., **Currell, M.J.** (2018). Delineating multiple salinization processes in a coastal plain aquifer, northern China: hydrochemical and isotopic evidence. *Hydrology and Earth Systems Science* **22**: 3473-3491.

19. Hepburn, E., Bekele, D., Northway, A., Liu, G-J., **Currell, M.J.** (2018). A method for separation of heavy metal sources in urban groundwater using multiple lines of evidence. *Environmental Pollution* **241**: 787-799.

20. Wang, S., Yuan, R., Tang, C., Song, X., **Currell, M.J.,** Yang, Z., Sheng, Z. (2018) Combination of CFCs and stable isotopes to characterize the mechanism of surface water-groundwater interaction in a headwater basin of the North China Plain. *Hydrological Processes* **32**: 1571-1587.

21. Yu, Q., Wang, Y., Xie, X., **Currell, M.J.** (2018) Reactive transport model for predicting arsenic transport in groundwater system in Datong Basin. *Journal of Geochemical Exploration* **190**: 245-252.

22. Tan, Y. Smith, J. Li, C. **Currell, M.** and Wu, Y. (2018) Predicting external water pressure and cracking of a tunnel lining by measuring water inflow rate. *Tunnelling and Underground Space Technology* **71**: 115-125.

23. Cartwright, I., Cendón, D.I., **Currell, M.**, Meredith, K. (2017). A review of radioactive isotopes and other residence time tracers in understanding groundwater recharge: Possibilities, challenges, and limitations. *Journal of Hydrology* **555**: 797-811.

24. Han, D.M., **Currell, M.J.**, Cao, G., Hall, B. (2017) Alterations to groundwater recharge due to anthropogenic landscape change. *Journal of Hydrology* **554**: 545-557.

25. Cartwright, I., Hofmann, H., **Currell, M.J.**, Fifield, L.K. (2017). Decoupling of solutes and water in regional groundwater systems: The Murray Basin, Australia. *Chemical Geology* **466**: 466-478.

26. Wang, S., Zheng, W., **Currell, M.**, Yang, Y., Zhao, H., Lv, M. (2017). Relationship between land-use and sources and fate of nitrate in groundwater in a typical recharge area of the North China Plain. *Science of the Total Environment* **609**: 607-620.

27. **Currell, M.J.**, Werner, A.D., McGrath, C., Webb, J.A., Berkman, M. (2017). Problems with the application of hydrogeological science to regulation of Australian mining projects: Carmichael mine and Doongmabulla Springs. *Journal of Hydrology* **548**: 674-682.

28. Han, D., **Currell, M.J.** (2017). Persistent organic pollutants in China's surface water systems. *Science of the Total Environment* **580**: 602-625.

29. **Currell, M.J.,** Han, D. (2017). The Global Drain: Why China's water pollution problems should matter to the rest of the world. *Environment: Science and Policy for Sustainable Development* **59**(1): 16-29.

30. **Currell, M.J.,** Banfield, D., Cartwright, I., Cendón, D.I. (2017). Geochemical indicators of the origins and evolution of methane in groundwater: Gippsland Basin, Australia. *Environmental Science and Pollution Research* **24**(15): 13168-13183.

31. Han, D., **Currell, M.J.,** Cao, G. (2016). Deep challenges for China's war on water pollution. *Environmental Pollution* **218**: 1222-1233.

32. Cao, G., Han, D., **Currell, M.J.**, Zheng, C. (2016) Revised conceptualization of the North China Basin groundwater flow system: Groundwater age, heat and flow simulations. *Journal of Asian Earth Sciences* **127**: 119-136.

33. **Currell, M.J.** (2016) Drawdown "triggers": a misguided strategy for protecting groundwater-fed streams and springs. *Groundwater* **54**(5): 619-622* **This article was one of the top 20 most downloaded articles in the journal in 2017 with >1000 downloads in 12 months.**

34. Han, D., Song, X., **Currell, M.** (2016) Identification of anthropogenic and natural inputs of sulfate into a karstic coastal groundwater system in northeast China: evidence from major ions, $\delta^{13}C_{DIC}$ and $\delta^{34}S_{SO4}$. *Hydrology and Earth System Sciences* **20**(5): 1983-1999.

35. Lee, S., **Currell, M.,** Cendon, D.I. (2016) Marine water from mid-Holocene sea level highstand trapped in a coastal aquifer: Evidence from groundwater isotopes, and environmental significance. *Science of the Total Environment* **544**: 995-1007.

36. **Currell, M.J.**, Gleeson, T.P. Dahlhaus, P.D. (2016) A new assessment framework for transience in hydrogeological systems. *Groundwater* (issue paper) **54**(1): 4-14.

37. **Currell, M.J.** Dahlhaus, P.D., Ii H. (2015) Stable isotopes as indicators of water and salinity sources in a southeast Australian coastal wetland: identifying relict marine water, and implications for future change. *Hydrogeology Journal* **23**: 235-248.

38. Yu, Q., Wang, Y., Xie, X., **Currell, M.J.,** Pi, K., Yu, M. (2015) Effects of short-term flooding on arsenic transport in groundwater system: A case study of the Datong Basin. *Journal of Geochemical Exploration* 158, 1-9.

39. Han D.M., Song, X.F., **Currell, M.J.,** Yang, J.L., Xiao G.Q. (2014) Chemical and isotopic constraints on the evolution of groundwater salinization in the coastal plain aquifer of Laizhou Bay, China. *Journal of Hydrology* **508**: 12-27.

40. **Currell, M.J.** (2014) Mega-scale groundwater quality challenges and the need for an inter-disciplinary approach. *Hydrogeology Journal* **22:** 745-748.

41. Han D.M., Tong, X.X., **Currell, M.J.,** Cao, G.L., Jin, M.G., Tong, C.S. (2014) Evaluation of the impact of an uncontrolled landfill on surrounding groundwater quality, Zhoukou, China. *Journal of Geochemical Exploration* **136**: 24-39

42. **Currell, M.J.,** Cendon, D, Cheng X. (2013). Analysis of environmental isotopes in groundwater to understand the response of a vulnerable coastal aquifer to pumping: Western Port Basin, south-eastern Australia. *Hydrogeology Journal* **21**: 1413-1428

43. **Currell, M.J.,** Han, D.M., Chen, Z.Y., Cartwright, I. (2012). Sustainability of groundwater usage in northern China: Dependence on palaeowaters and impacts on water quality, quantity and ecosystem health. *Hydrological Processes* **26**: 4050-4066

44. **Currell, M.J.,** Han, D.M., Cartwright I., Cao, G.L., Song, X.F. (2012). Distribution and evolution of groundwater isotopic ages, and sustainable utilization of groundwater in the Yuncheng Basin, China. *Hydrogeology and Engineering Geology* **39**(6): 1-5. *水文地质工程地质*（In Chinese with English abstract)

45. Han, D.M., Song, X.F., **Currell, M.J.,** Tsujimura, M. (2012). Using chlorofluorocarbons (CFCs) and tritium to improve conceptual model of groundwater flow in the South Coast Aquifers of Laizhou Bay, China. *Hydrological Processes* **26**: 3614-3629

46. Han, D.M., Song, X.F., **Currell, M.J.,** Cao, G.L., Zhang, Y.H., Kang, Y.H. (2011) A survey of groundwater levels and hydrogeochemistry in irrigated fields in the Karamay Agricultural Development Area, northwest China: implications for soil and groundwater salinity resulting from surface water transfer for irrigation. *Journal of Hydrology* **405**: 217-234.

47. **Currell, M.J.,** Cartwright, I., Raveggi, M., Han, D.M. (2011) Controls on elevated fluoride and arsenic concentrations in groundwater from the Yuncheng Basin, China. *Applied Geochemistry* **26**: 540-552. (Citations: 92*) ***This paper was recognized by the International Association of Geochemistry as one of the influential papers (most cited over 5 years) published in the journal Applied Geochemistry for 2011.**
48. **Currell, M.J.,** Cartwright, I. (2011) Major-ion chemistry, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ as indicators of hydrochemical evolution and sources of salinity in groundwater in the Yuncheng Basin, China. *Hydrogeology Journal* **19**: 835-850.
49. **Currell, M.J.,** Cartwright, I., Bradley, D.C., Han, D.M., 2010. Recharge history and controls on groundwater quality in the Yuncheng Basin, north China. *Journal of Hydrology* **385**: 216-229.
50. Han, D.M., Liang, X., Jin, M.G., **Currell, M.J.,** Song, X.F., Liu, C.M., 2010. Evaluation of groundwater hydrochemical characteristics and mixing behaviour in the Daying and Qicun geothermal systems, Xinzhou Basin. *Journal of Volcanology and Geothermal Reseach*, **189**: 92-104.
51. Han, D.M., Liang, X., **Currell, M.J.**, Song, X.F., Chen, Z.Y., Jin, M.G., Liu, C.M., Han, Y., 2010. Environmental isotopic and hydrochemical characteristics of groundwater systems in Daying and Qicun geothermal fields, Xinzhou Basin, Shanxi, China. *Hydrological Processes* **24**: 3157-3176
52. Han, D., Liang, X., Jin, M., **Currell, M.J.,** Han, Y., Song, X. 2009. Hydrogeochemical indicators of groundwater flow systems in the yangwu river alluvial fan, Xinzhou Basin, China. *Environmental Management*, **44**: 243-255.
53. Lomonte, C., **Currell, M.J.**, Morrison, R.S.J., McKelvie, I.D., Kolev, S.D., 2007. Sensitive and ultra-fast determination of arsenic (III) by gas-diffusion flow injection analysis with chemiluminescence detection. *Analytica Chimica Acta* **583**: 72-77.

Book chapters

1. McLaughlin, P., Stasinopoulos, P., Shimeta, J., Ryan, R., **Currell, M.**, Allinson, G., Brown, N., Maqsood, T. 2020. *From small things: Building cross-disciplinary, transformative learning experiences through a global mobility experience for higher education students. In:* McLaughlin, P., Chester, A., Kennedy, B., Young, S. (eds) Tertiary Education in a Time of Change, pp 65-81.

Invited Editorials

1. Li, P., Howard, K.W.F., **Currell, M.** 2017. Cultivating hope for a better future: research contributions from young scholars in earth and environmental sciences. *Environmental Science and Pollution Research* **24**(15): 13149-13153.
2. Voss, C., **Currell, M.** 2015. Editors' message: The 2014 Editors' Choice articles and the 2014 'Coolest Paper' award. *Hydrogeology Journal* **23**(2): 215-216.
3. Voss, C., **Currell, M.**, Gleeson, T. 2014. Editors' message: The 2013 Editors' Choice articles, a new editor, and the 2013 'Coolest Paper' award. *Hydrogeology Journal* **22**(2): 293-294.

Other research outputs (non-peer reviewed, e.g. commissioned reports)

Bourne, G., **Currell, M.,** Fiedler, T., Lawrence, R., Park, S., Pelle, N., Taylor, M., Viney, G., Ziller, A. 2020. Submission to the Independent Planning Commission on the Proposed Narrabri Gas Project SSD 6357.

Submitted by a specific knowledge expert group convened by the Sydney Environment Institute. 40pp: http://sydney.edu.au/environment-institute/wp-content/uploads/2020/07/2020-07-23-SEI-IPC-Submission.pdf

Werner, A.D., Love, A.J., Irvine, D., Banks, E.W., Cartwright, I., Webb, J., **Currell, M.** 2019. Position Paper by Concerned Scientists: Deficiencies in the scientific assessment of the Carmichael Mine impacts to the Doongmabulla Springs. Published as an Academic Commons piece under Creative Commons license: https://dspace.flinders.edu.au/xmlui/handle/2328/39203

Currell, M., Drew, D., Davison, A., Guggisberg, S., Pendlebury, T., Mullins, M. 2018. High nitrate concentrations in Western Australian Goldfields community drinking water supplies: Causes, governing factors and possible solutions. *Report from RMIT-Optimos-Risk Edge collaborative project*

Currell, M.J., Banfield, D.M., 2015. An assessment of methane and environmental isotopes in groundwater and the near surface atmosphere: Gippsland and Otway Basins, Victoria. *Report prepared for the Victorian Department of Environment, Land, Water & Planning, to inform the Victorian Water Science Studies.* 75pp.

Rahman, M.A., **Currell, M.J.**, Reichman, S. 2015. An assessment of heavy metals in canned peaches imported from China to Australia and comparison with local products: Health risk implications. *Report prepared for SPC Ardmona, Food Standards Australia & New Zealand and The Commonwealth Department of Health.* 22pp.

Invited commentaries / Op-ed pieces:

Global Water Forum (http://www.globalwaterforum.org):
Currell, M.J., 2017. China's 'war on water pollution' must tackle causes of deep groundwater pollution. Published 03/04/2017: http://www.globalwaterforum.org/2017/04/03/chinas-war-on-water-pollution-must-tackle-causes-of-deep-groundwater-pollution/

China Policy Institute (Online journal of the China Policy Institute: https://cpianalysis.org/)
Currell, M.J., 2018. Hungry cities, thirsty farms: China's growing hunger is becoming the world's thirst. Published 30/05/2018: https://cpianalysis.org/2018/05/29/hungry-cities-thirsty-farms-chinas-growing-hunger-is-becoming-the-worlds-thirst/

Currell, M.J., 2017. The global drain: why China's water pollution crisis should matter to the rest of the world. Published 14/03/2017: https://cpianalysis.org/2017/03/14/the-global-drain-why-chinas-water-pollution-crisis-should-matter-to-the-rest-of-the-world/

***China Dialogue** (https://www.chinadialogue.net/)*
Currell, M.J., 2012. The shrinking depths below. *China Dialogue*, March 19, 2012. http://www.chinadialogue.net/article/show/single/en/4814-The-shrinking-depths-below

Currell, M.J., 2010. Losing lifeblood in north China. *China Dialogue,* 17th September, 2010. https://www.chinadialogue.net/article/show/single/en/3823-Losing-lifeblood-in-north-China

***The Conversation** (https://theconversation.com/au)*:

Currell, M.J. 2020. Australia listened to the science on coronavirus. Imagine if we did the same for coal mining. Published 12/05/2020.

Werner, A.D., **Currell, M.J.** 2019. Adani is cleared to start digging its coal mine – six key questions answers (invited commentary). Published 14/06/2019.

Currell, M.J., Werner A.D., 2019. Unpacking the flaws in Adani's water management plan (Invited commentary). Published 01/05/2019.

Whitmore et al., 2015. Greg Hunt approves Adani's Carmichael coal mine, again: experts respond (*Interview*) Published 16/10/2015.

Currell, M.J. 2015. Groundwater: the natural wonder that needs protecting from CSG *(Invited commentary)*. Published 20/05/2015.

Whitmore, J., **Currell, M.J.**, Rolfe, J., Jones, R. 2014. Approval of Australia's largest coal mine ignores climate and water (*Interview*). Published 29/07/2014.

Currell, M.J. 2014. Alpha Coal ruling breaks new ground for protecting water *(Invited commentary)*. Published 10/04/2014.

Currell, M.J. 2014. Coal seam gas water leaks could be a problem for decades *(Invited commentary).* Published 24/03/2014.

Currell, M.J. 2013. Shanghai's 'airpocalypse': can China fix its deadly pollution? *(Op-ed)*. Published 10/12/2013.

Currell, M.J., 2013. Coal and gas projects can't be rushed: here's why *(Invited commentary)*. Published 09/10/2013.

Currell, M.J., 2013. Coal's damage is cumulative: let's assess it that way *(Op-ed)*. Published 13/08/2013.

Currell, M.J., 2013. Has the western world exported cancer to China? *(Op-ed)*. Published 23/04/2013.

Water Underground *(http://blogs.agu.org/waterunderground/)*

Currell, M.J. 2016. Protecting springs from groundwater extraction: is a 'drawdown trigger' a sensible strategy? *Water Underground*, June 15th 2016: https://waterunderground.org/2016/06/15/protecting-springs-from-groundwater-extraction-is-a-drawdown-trigger-a-sensible-strategy/

Conference papers & presentations:

Currell, M., Hall, B., Webb, J.A. 2019. Using multiple lines of evidence to characterize groundwater recharge in a rapidly urbanizing catchment: implications for future land and water management. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

McCance, W.G., Jones, O.A.H., Edwards, M., Surapaneni, A., Chadalavada, S., Cendon, D., Currell, M. Use of stable and radiogenic isotopes in characterizing wastewater derived impacts in urban and peri-urban areas. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Morrissy, J., Currell, M., Ball, A., Megharaj, M., Surapaneni, A., McCance, W., Reichman, S. Novel bioremediation strategies for nitrogen contaminated groundwater. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Cabrera, A., Currell, M., Cendon, D., Catwright, I., Ma, X., Blarasin, M., Cabrera, A.E., Matteoda, E., Giacobone, D., Lutri, V. 2019. Using environmental isotopes to constrain pollutant migration pathways in an intensive agricultural area – Pampas, Argentina. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Thomann, J.A., Werner, A.D., Irvine, D.J., Currell, M.J. 2019. Guidelines for the application of adaptive management to groundwater contexts. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Werner, A.D., Currell, M.J., Webb, J.A. Evolution of groundwater concerns over the Carmichael Mine: 2014-2019. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Hall, B., Currell, M., Webb, J. 2019. Influence of new constructed wetlands on groundwater recharge in a rapidly urbanizing catchment. Austalasian Groundwater Conference, Brisbane, 24th – 27th November, 2019.

Currell, M., Drew, D., Davison, A., Guggisberg, S., Pendlebury, T., Mullins, M. 2018. High nitrate concentrations in Western Australian Goldfields community drinking water supplies: Causes, governing factors and possible solutions. Safe Water Summit, University of Queensland, November 2018.

Currell, M.J., Cartwright, I., Cendon, D.I. 2017. Stable isotopes ($\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$) as indicators of dissolved methane sources and cycling in a multi-layered aquifer system: Gippsland Basin, Victoria. Australasian Groundwater Conference, Sydney, 10th – 14th July, 2017. **Awarded Best Oral Presentation (Career Scientist Category)***

Hepburn, E., Currell, M., Cendon, D.I., Northway, A. 2017. Origins of groundwater salinity at Fishermans Bend, Australia: Evidence from groundwater ages, stable isotopes and tidal influences. International Association of Hydrogeologists 44th International Congress, Dubrovnic, Croatia, 25th- 29th September 2017.

Hall, B., Currell, M. 2016. Changing recharge dynamics due to urbanization in southeast Melbourne. International Association of Hydrogeologists 43rd International Congress, Montpellier, France, 25th- 29th September 2016.

Hepburn, E., Currell, M., Northway, A., Liu, G-J., Bekele, D. 2016. Heavy metal cycling in former industrial land: implications for safe and effective urban renewal. 18th International Conference on Heavy Metals in the Environment, Ghent, Belgium, 12th – 15th September 2016.

Gaffney, M., Currell, M., 2015. Assessing background concentrations of inorganic contaminants in the Brighton Group aquifer, southeast Melbourne (Paper TA14). CleanUp Conference 2015, Melbourne, Australia 13th-16th September.

Currell, M., 2015. A framework and graphical tools to assess transience in groundwater systems in response to land use and climate. Australian Groundwater Conference 2015, Canberra, Australia 3rd-5th November.

Banfield, D., Currell, M. 2015. Using isotopes to better understand dissolved gas hydrogeochemistry and the risk of unconventional gas development in the Gippsland and Otway basins. 13th Australasian Environmental Isotope Conference, Sydney, Australia 8th-10th July.

Duncan, L., Currell, M., Hardie, R., 2014. Designing a method for assessing the use of produced water from coal seam gas projects to supplement environmental flows. Proceedings of the 7th Australian Stream Management Conference. Townsville, Queensland, pp 360-368.

Lee, S., Currell, M., Cendon, D. 2014. Investigating the origin of salinity and aquifer interaction in a seasonally pumped confined aquifer system in southeast Australia. Australian Earth Sciences Convention, Newcastle, Australia, 7th-10th July *(Winner, Audience choice award for best student paper)*

Dahlhaus, P., Currell, M., Ii, H., McKenna, K. 2014. Groundwater dependence of lakes in southwest Victoria, Australia. International Association of Hydrogeologists 41st International Congress, Marrakech, Morocco, 15th-19th September.

Hall, B., Currell, M. 2014. Impacts on groundwater recharge from urbanisation in southeast Melbourne. International Association of Hydrogeologists 41st International Congress, Marrakech, Morocco, 15th- 19th September.

Currell, M., Han, D., Cao, G. 2013. Assessing changes to a regional groundwater flow system and water quality impacts in the Yuncheng Basin, China. Proceedings fo the International Symposium on Regional Groundwater Flow. Xi'an, China, 21-23rd June.

Currell, M., Han, D., Cao, G. 2013. Links between palaeo-climate and groundwater recharge in northern China from isotopic indicators. International Association of Hydrogeologists 40th International Congress, Perth, Australia, 15th – 20th September.

Currell, M., Lee, S., Hall, B. 2013. Using environmental isotopes to understand the response of a coastal aquifer to pumping. International Association of Hydrogeologists 40th International Congress, Perth, Australia, 15th – 20th September.

Currell, M., Cendon, D. 2012. Using Environmental Isotopes to understand the response of a vulnerable coastal aquifer to pumping. International Association of Hydrogeologists 39th International Congress, Niagara Falls, Canada,

Currell, M., Dahlhaus, P., Ii H. 2012. Understanding groundwatwer-surface water interaction in an internationally protected wetland: the Lake Connewarre Complex. 15th International River Symposium, Melbourne, Australia.

Currell, M. 2011. Groundwater recharge in the Yuncheng Basin (China) & relationships with palaeoclimate. 11th Australasian Environmental Isotope Conference, Cairns, Australia.

Currell, M. 2011. Managing northern China's groundwater resources in changing rural-urban landscapes. 2011 Melbourne Conference on China, University of Melbourne, Australia.

Invited Lectures

2019 – Keynote at National Centre for Groundwater Research and Training, Environmental Tracers in groundwater short-course, 26th February, Melbourne: *Groundwater and Unconventional Gas: How isotopes can help solve burning questions.*

2017 – Contemporary China Seminar Series (University of Melbourne): *China's groundwater pollution crisis and why it matters to the rest of the world.* 14th September 2017.

2017 - Geological Society of Australia Victoria Branch: *Deep challenges: using geochemistry to understand water quality and quantity problems in China's stressed aquifer systems*. 25th May 2017.

Citations

Google Scholar citations: Total citations: **1717**, h-index = **22**
https://scholar.google.com.au/citations?user=Kk324IkAAAAJ&hl=en

Scopus: Total citations: **1348**, h-index = **21** https://www.scopus.com/authid/detail.uri?authorId=15755329600

Research Awards & honours

2020: Winner: Innovation that has advanced the practice of contaminated site assessment. Australasian Land and Groundwater Association Annual Awards: McCance W., Currell, M., Jones, O., Surapaneni, A., Cendon, D., Edwards, M., Chadalavada, S.: Novel Groundwater Tracers for Delineating Groundwater Contamination from Wastewater Treatment Plants.

2017: Best Oral Award (Career Scientist Category), Australian Groundwater Conference 2017. Selected by an independent panel from more than 200 conference presentations.

2016: Paper: 'Drawdown Triggers: a mis-guided strategy for protection of groundwater dependent streams and springs' one of the top 20 downloaded papers for the year in the journal *Groundwater*

2016: Paper: 'Controls on elevated fluoride and arsenic concentrations in groundwater from the Yuncheng Basin, China' selected by the International Association of Geochemistry as one of its *"influential papers"* published in *Applied Geochemistry* 2011-16.

Leadership, impact and engagement

I continually make efforts to translate my research and teaching expertise into real-world outcomes that benefit society and contribute to public debate and policy formulation.

Expert witness, Policy advice, community and professional society work

2020

- Engaged as an expert witness in hydrogeology by North West Alliance and EDO to analyse potential risks to groundwater from the Narrabri Coal Seam Gas Project. Authored an expert report and presented oral and written submissions to the Independent Planning Commission of NSW during their assessment of the project. Several media outlets covered the proceedings and quoted my evidence and statements (Australian Financial Review, Sydney Morning Herald, ABC News)**.**
- Invited to contribute to a report by Sydney Environment Institute outlining expert views on the Narrabri Gas Project, which was submitted to the Independent Planning Commission: http://sydney.edu.au/environment-institute/publications/narrabri-gas-project/
- Engaged by CELCOR/EDO to provide an expert report analyzing the geochemistry, groundwater and surface water impacts of the proposed Frieda River copper-gold mine in PNG
- Provided an expert report (pro bono) at the request of EDO analyzing the NT Governments draft framework for preparing baseline studies in areas of future unconventional gas (fracking) development.
- Engaged by Australian Rainforest Conservation Society in Planning and Environment Court case over proposal to develop new groundwater supply near the Springbrook World Heritage Rainforest area.

2019: Co-authored a Position Paper (Werner et al., 2019) regarding the likely impacts of the Carmichael Coal Mine on groundwater dependent ecosystems, presented to the Queensland Government in the leadup to the approval decision on the mine's Groundwater Management Plan. Along with two other groundwater experts, I met with the Director-General of the Queensland Department of Environment and Science to discuss the implications of the paper, in the lead-up to their decision on approval of the groundwater management plans.

2019:

- Engaged by EDO NT to review draft code of practice for onshore petroleum activities
- Engaged by EDO Qld to analyse the hydrogeological science contained in the Associated Water License application for the New Acland Stage 3 mine proposed expansion.
- Engaged by EDO NSW to attend Independent Planning Commission of NSW hearing regarding the United Wambo coal mine and present to the panel regarding possible groundwater impacts of the project.

2017-18: Engaged by EDO NSW to provide an expert report on the proposed Narrabri Gas Project, regarding environmental risks to groundwater and surface water. Commissioned to write two independent expert reports analyzing the project environmental impact statement, and invited by the Department of Planning and Environment NSW to attend expert panel meetings to discuss technical issues and provide input to the panel's report. Invited by the ABC, SBS and The Guardian to provide interviews and commentary for television and print media on this issue.

2017: Engaged by EDO NT to provide an expert report to the Northern Territory's Inquiry into Hydraulic Fracturing (Fracking Inquiry) and invited to present at the Inquiry's Hearings in Alice Springs. Provided extensive expert technical advice to the Inquiry between July and September 2017 (at the panel's request), during finalization of Inquiry's report.

2016-17: Expert witness in Land Court of Queensland case, OCAA vs New Acland Coal. One of five groundwater experts appointed to advise the court on groundwater issues associated with mine expansion plans. Produced two expert reports on the topics of groundwater conceptualization and quality, which were used and quoted extensively in the Court's final decision: http://archive.sclqld.org.au/qjudgment/2017/QLC17-024.pdf

2016-17: Engaged by EDO NSW to provide two expert reports and participate in the NSW Planning and Assessment Commission hearings into the United Wambo Open-Cut Expansion proposal Environmental Impact Statement.

2016: Invited to provide input into the revised Koo Wee Rup Groundwater Management Plan by the managing authority, Southern Rural Water. This is in recognition of the significance of findings from multiple research projects undertaken in the Western Port Basin, including a completed MEng, current PhD and three final year projects.

2015: Expert witness called to provide evidence to the Parliamentary Inquiry into onshore unconventional gas in Victoria. My submission and evidence to the inquiry were extensively quoted and cited in the Inquiry's final report: https://www.parliament.vic.gov.au/images/stories/committees/SCEP/GAS/Report/EPC_58-03_Text_WEB.pdf

2013 - Current: Committee member, International Association of Hydrogeologists (IAH), Victorian Branch

2012 – Current: Lower Barwon River Wetlands Community Advisory Committee member (invited by Corangamite Catchment Management Authority).

2013-2014: Steering committee, Southern Rural Water Port Phillip & Western Port Groundwater Atlas project

2012 - 2014: Steering Committee Member, IAH Early Career Hydrogeologists Network (ECHN)

Engagement roles in Indigenous and humanitarian engineering

2017 - Current: RMIT School of Engineering Indigenous Reconciliation Facilitator. In this role I work to implement the University's Reconciliation Action Plan. Since 2016 I have acted as RMIT's lead academic involved in planning and running the Victorian Indigenous Engineering Winter School (VIEWS), which brings Indigenous school students from around Australia to Melbourne to inspire them about a career in engineering. In 2017-18, I was a key staff member involved in organising the inaugural *David Unaipon Birthday Celebration*, created to enhance staff knowledge about indigenous contributions to engineering. For these and other Indigenous engagement activities, I have worked extensively and constructively with staff and students from RMIT's *Ngarara Willim* Centre.

2018-20: Developed project with the University of Western Australia's Rural Clinical School and Optimos Solutions to work with remote Indigenous communities to deliver safer drinking water supplies, via student Capstone project in environmental/humanitarian engineering.

2017-20: Key member of RMIT team developing relationship with the Barefoot Collective, Yasawa Islands, Fiji, to provide opportunities for community development through undergraduate student projects in humanitarian engineering

Television, Radio and Print media appearances

I work to actively discuss and translate my research findings and expertise for the wider mass-media through interviews, commentaries and articles in the mainstream media. These media appearances have all been invited interviews or commentaries instigated by media organisations:

- Australian Financial Review: 28th July 2020. Quoted in regard to possible groundwater impacts of Narrabri gas project: https://www.afr.com/companies/energy/narrabri-gas-opponents-heartened-by-dig-into-water-risks-20200727-p55fqf
- Australian Financial Review: 23rd July 2020. Interview regarding impacts of Narrabri gas project on groundwater: https://www.afr.com/companies/energy/ipc-warned-of-serious-water-risk-from-narrabri-gas-20200723-p55eqd

- ABC Coffs Coast FM. Quoted extensively regarding groundwater issues associated with the Narrabri Gas Project after presentation to Independent Planning Commission.
- Sydney Morning Herald: 23rd July 2020. Comments at IPC quoted in article on Narrabri Gas project: https://www.smh.com.au/environment/conservation/rejected-critics-unload-on-proposed-santos-gas-project-20200723-p55ewh.html
- 2GB, 2SM (Sydney) & ABC Far North Queensland radio: 10/6/2019. Interviews regarding Adani's Carmichael coal mine Groundwater Management Plan.
- SBS News: 10/6/2019. Interviewed for story on regarding Adani's Carmichael coal mine Groundwater Management Plan, following meeting with head of Queensland Department of Environment and Sciences: https://www.sbs.com.au/news/scientists-say-desert-springs-face-extinction-under-adani-mine-plan
- AM (ABC Radio): 18/04/2019. Interviewed for story regarding water plans for Adani's Carmichael coal mine.
- ABC 7pm News (National): 17/12/2018. Interviewed in story about Adani's Carmichael coal mine and the scientific basis for claims about impacts on Doongmabulla Springs.
- ABC Radio Nightlife program: 13/12/2018 What is fracking and why is it so controversial? (extended interview and talkback questions)
- ABC Radio National Breakfast Program: 6/12/2018 Interviewed as groundwater expert regarding impacts of Adani mine on groundwater. https://www.abc.net.au/radionational/programs/breakfast/dr-matthew-currell/10588314
- SBS *Insight* Program (National television): 29/05/2018 Appeared as a groundwater expert in program 'Power Divide' about proposed coal seam gas development in NSW: https://www.sbs.com.au/news/insight/tvepisode/power-divide
- ABC Radio Capricornia (Breakfast show): 12/04/2018 Interviewed about impacts of large mining projects on groundwater in the Great Artesian Basin.
- ABC 7pm News (Qld): 21/03/2018 Appeared in TV interview and quoted in online news story about groundwater impacts of Adani Carmichael coal mine: https://iview.abc.net.au/programs/abc-news-qld/NU1805Q069S00
- Channel 10's *The Project* (National televiation): 25/9/2017 Interviewed about hydraulic fracturing in Queensland's channel country: https://tenplay.com.au/channel-ten/the-project/extra/season-9/the-beef-with-fracking
- *Guardian Australia* Interview: 27/5/2017 Interviewed and quoted in article: https://www.theguardian.com/australia-news/2017/may/27/toxic-waste-danger-to-drinking-water-if-santos-csg-project-goes-ahead-report
- ABC 7pm News (NSW): 06/04/2017 Appeared in interview in story about managing environmental risks from coal seam gas: http://www.abc.net.au/news/2017-04-06/nsw-csg-project-sparks-fierce-debate-over-energy-future/8418102
- 3CR Radio 'Into Science' program: 07/02/2017: Interviewed about China's Water Pollution and why it should matter to the rest of the world: http://www.3cr.org.au/lostinscience/episode-201702090830/chinas-water-pollution-chocolate-pollinators-and-kicking-new-year
- 3AW *Drive* program with Tom Elliot: 30/04/2016 Interview given in response to Victorian Government ban on hydraulic fracturing for unconventional gas.
- SBS TV *Insight* Program (National television): 25/8/2015 Appeared as an academic expert on groundwater and mining: https://www.youtube.com/watch?v=II9qUsbLltU

- China Radio International: 14/2/2014 Interview: China's south-north water transfer project: will it help ease stress on groundwater in northern China?
- Sky News *Newsnight with Stan Grant* (National television): 11/12/2013 Interview about China's 'airpocalypse' and 'war on pollution'.
- Sky News *Newsnight with Stan Grant* (National television): 24/04/2013 Interview about Pollution in China and why it matters internationally.

Referees

Professor Ian Cartwright (principal PhD supervisor 2007-2010)
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Monash University
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Professor Adrian Werner (research collaborator)
Professor of Hydrogeology & ARC Future Fellow
College of Science and Engineering
Flinders University
Tel: +61 8 82012710, E-mail: Adrian.werner@flinders.edu.au

Dr Dioni Cendòn (research collaborator)
Senior Research Scientist
Australian Nuclear Science and Technology Organisation (ANSTO)
Tel: +61 2 9717 3937, E-mail: Dioni.cendon@ansto.gov.au