BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY
AT WELLINGTON

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
AND	
IN THE MATTER	of a decision-making committee appointed to reconsider a marine consent application by Trans Tasman Resources Limited to undertake iron ore extraction and processing operations offshore in the South Taranaki Bight

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EXPERT REBUTTAL EVIDENCE OF DR MICHAEL DEARNALEY ON BEHALF OF TRANS TASMAN RESOURCES LIMITED

23 JANUARY 2024

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Contents

INTRODUCTION

Qualifications and experience

1. My name is Michael Dearnaley. I am the Director of Science at HR Wallingford (HRW) in the United Kingdom (UK). I hold the degrees of Bachelor of Science (Geophysical Sciences) and Doctor of Philosophy (Oceanography) from the University of Southampton in the UK.

2. Over the course of my time at HRW (some 33 years) I have led pioneering research associated with field and laboratory measurement and numerical modelling of the properties of cohesive material (mud) and the release of fine material from different types of dredging and disposal activity.

3. I have provided advice to developers and regulators on dredging including the mining of gravels and sands from the sea, the disposal of dredged material to sea and the beneficial use of dredged material including reclamation.

4. I previously gave evidence for Trans-Tasman Resources Limited (TTR) before a Decision Making Committee in 2017 (2017 Committee).

5. My evidence before the 2017 Committee comprised:

   (a) Expert Evidence of Michael Dearnaley on behalf of TTR dated 15 December 2016;

   (b) Expert Rebuttal Evidence of Michael Dearnaley on behalf of TTR dated 9 February 2017;

   (c) Joint Statement of Experts in the Field of Sediment Plume Modelling dated 13 February 2017, including 2 appendices;

   (d) Responses to Karen Pratt Submission of 18 February 2017 by Michael Dearnaley;

(e) Summary of expert evidence of Michael Dearnaley on behalf of TTR dated 20 February 2017;

(f) Oral evidence on 20 February 2017 (Transcript pages 251-313);

(g) Joint Statement of Experts in the Field of Sediment Plume Modelling—Setting Worst Case Parameters dated 23 February 2017;

(h) Supplementary Statement of Michael Dearnaley on behalf of TTR dated 28 March 2017;

(i) Response to questions posed by the DMC in Minute 41, by letter dated 28 April 2017;

6. Attached as **Appendix 1** to my 15 December 2016 statement is a list of relevant projects that I have been involved in.

7. I also helped to prepare various reports which formed part of TTR's application, listed here:

(a) Support to Trans-Tasman Resources, Laboratory Testing of Sediments (HRW, October 2014);

(b) Support to Trans-Tasman Resources, Source terms and sediment properties for plume dispersion modelling (HRW, October 2015);

(c) Support to Trans-Tasman Resources, Worst case scenario sediment plume modelling (HRW, March 2017)

Code of conduct

8. I confirm that I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note dated 1 January 2023. I agree to comply with this Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another

person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

9. I have been asked to respond to aspects of the evidence filed by submitters that are within my field of expertise, namely the near-field dispersion characteristics of sediment that will be discharged from TTR's project. In particular, I respond to the evidence of Mr Greer, Professor Luick, Dr Barbara, Mr Jorissen and the submission of Ms Pratt.

10. I am instructed that the Supreme Court in *Trans-Tasman Resources Ltd v Taranaki-Whanganui Conservation Board and Others* [2021] NZSC 127 held the 2017 Committee made legal errors in its assessment of the sediment discharge effects of TTR's project. Specifically, I am instructed that the Supreme Court held that the approach of the 2017 Committee failed to favour caution and environmental protection, and failed to protect the environment from material harm.

11. I have also been asked to address whether any aspects of the evidence I gave in 2017 require updating.

12. Taking all of the above matters into account, I have been asked to address whether the matters covered in my evidence on near-field sediment dispersion

    (a) are the best available information; and

    (b) provide a suitable basis for related assessments of far-field dispersion and the environmental or other effects of sediment dispersion.

13. To prepare this evidence, I have reconsidered the evidence I gave in 2017, the statements of evidence of Drs Macdonald and MacDiarmid dated 19 May 2023, and the statements of

evidence of Mr Greer, Professor Luick, Dr Barbara, Mr Jorissen and the submission of Ms Pratt.

UPDATING EVIDENCE

14. I am not aware of new information relating to the character and properties of the material to be mined and returned to the seabed.

15. The near-field numerical modelling undertaken by my team at HR Wallingford has not been updated.

16. Dr Macdonald reports in her evidence that there has been no update to the far-field sediment plume modelling undertaken by NIWA.

17. In the time since the modelling was undertaken computer processing power has been updated and it would now be practical to undertake longer and or higher resolution simulations than those previously reported. I do not consider that such simulations would materially change the assessment in the far-field.

18. I understand that there is information relating to new reefs in the proximity of the Patea Shoals. If the locations of these reefs are such that they may be within the near-field zone of the mining operations, by which I mean within about 3km, then the potential for impact on these locations would be better informed from the results of the near-field modelling than the far-field sediment plume modelling undertaken by NIWA.

19. In the following sections I consider in turn matters raised by Mr Greer, Professor Luick, Dr Barbara and Mr Jorissen in their respective evidence. I also address some points raised by Ms Pratt in her submission. Some matters I consider for one expert also apply to others. Where I have not commented upon a

particular point it should not be assumed that I am in agreement with that point.

EVIDENCE OF DOUGAL GREER

20. I note that at paragraph 15 of his evidence Mr Greer's view is that insufficient caution has been included in the 'worst-case scenario' for the reasons he outlines in his sub-sections (a), (b), (c) and (d). I disagree for the reasons set out below.

21. Regarding paragraph 15(a), sensitivity testing was undertaken in the near-field modelling reported by HR Wallingford. This addressed different wave heights and periods and this was used to inform the assumptions for the scenarios simulated in the NIWA far-field modelling.

22. I observe that at the times of the highest and longest period wave conditions, when the rates of release of fines from the mining pit will be increased, the background suspended sediment concentrations in the environment which will be influenced by the sediment plume would be elevated, especially near the coast.

23. In paragraph 15(b), Mr Greer is concerned that there may be significant periods of time when material with higher than 2.25% of ultra fine material would be mined. In the worst-case model scenario one-third of the material to be mined was assumed to be with a content of 2.25% ultra fines and the remainder with 1.60% ultra fines. The modelling assumed that material with 2.25% ultra fines could be mined continuously for a 20 day period (14.8 days of mining and 5.2 days of downtime).

24. The Joint Witness Statement of the sediment plume experts recommended a condition to enforce an upper limit of 2.25% ultra fines content, averaged over a one week period. In paragraph 302 of the 2017 Committee report it is recorded that TTR proffered a condition that there would be no more

than 1.8% fines content, averaged over a week. In paragraph 303 of the 2017 Committee report the 2017 Committee noted that:

> *'Conditions 4, 5, 6, 51, 52 and 87f and the SSC limits in Schedule 2, will act together to keep the size and nature of the sediment plume at or below the modelled levels of impact. In our opinion, these conditions represent a robust approach because they address both output and receiving environment parameters'.*

25. Condition 4 states that the following limits shall apply:

> *(a) The rate of extraction of sediment from the seabed material, averaged over any monthly period, shall not exceed 8,000 tonnes per hour ("t/hr"); and*
>
> *(b) The rate of discharge of de-ored sediment onto the seabed, averaged over any monthly period, shall not exceed 7,190 t/hr; and*
>
> *(c) The rate of discharge of de-ored sediment having a size of <38 microns ("µm") shall not exceed:*
>
> > *i. 130 cubic metres per hour ("m^3/hr"), averaged over any 48 hour period; and*
> >
> > *ii. 83 m^3/hr, averaged over any seven (7) day period; and*
> >
> > *iii. 66 m^3/hr, averaged over any three (3) month period.*
>
> *(d) Averaged over any one (1) week period, the extraction of sediment seabed material having a size of <8µm, shall not exceed 1.8% of the total seabed material sediment extracted.*
>
> *For the purpose of (c) of this condition, the average value shall be derived from the use of continuous flow measurement and the analysis of one daily composite sample comprised of not less than 12 individual samples collected during each 24 hour period at a point immediately prior to discharge to the marine environment.*
>
> *For the purpose of (d) of this condition, the average value shall be derived from the analysis of a minimum of 20 representative samples of the excavated seabed material.*
>
> *The Consent Holder shall record Particle Size Distribution, and the rate and volume/mass of the discharge of de-ored sediment continuously. The Consent Holder shall advise the EPA of any exceedances of the discharge limits specified in clauses (b), (c) and (d) within 24 hours of any exceedance.*
>
> *The information collected in accordance with this condition shall be reported on as part of the Quarterly Operational Report required by Condition 103.*

26. The worst-case scenario significantly exceeded all three of the rates in condition 4(c) and also condition 4(d) with the average rate of release in the simulation being 1.82% ultra

fines (2.25% for one third of the time and 1.6% for two-thirds of the time), more than double that allowed under condition (c)iii. In the modelling the average source term for the most slowly settling (0.01mm/s) fraction was increased by an average of 74%.

27. Results for background conditions from the NIWA far-field sediment transport model of the South Taranaki Bight (**STB**) have been compared with measured suspended sediment concentrations. The comparisons have shown that the model is able to simulate the inputs of fine material from the rivers in the region and the storm resuspension of fine material from the seabed. The model credibly reproduces the time-varying gradients in suspended sediment from the coastal zone to the offshore areas.

28. Building upon the baseline modelling, the NIWA model has been used to predict the dispersion of the sediment plume from the mining operation. The far-field modelling of the plume, by which I mean distances of more than about 3km from the mining operation, has clearly demonstrated that impacts on suspended sediment concentration and deposition are generally insignificant compared to the variability in baseline conditions. In contrast to Mr Greer (at his paragraph 15(c)), I do not consider that a more refined calibration of the baseline suspended sediment concentrations in the nearshore would alter this conclusion.

29. Mr Greer raises a concern in his paragraph 15(d) that only three samples were used in the laboratory analysis to calculate the erosion threshold and settling rates used in the near field and far field modelling.

30. The samples that were used for the laboratory testing were bulk samples. To collect these required closely spaced drilling to collect between 700kg and 3 tonnes in each case, to

provide a suitable volume of material for use in the pilot processing plant. Three sub-samples were provided to HR Wallingford for testing of the behaviour of the fines. The three sub-samples provided to HR Wallingford were not run of mine but comprised fines derived through different methods. One was of fines which had remained in suspension after the bulk sample had been allowed to settle. The other two samples were derived after processing in the pilot plant. The samples incorporated both the fines naturally in the run of mine material and those generated by the processing.

31. Our interest in the laboratory analysis of these samples was to determine if the fines flocculated, settling faster than in their particulate state, and if they did, what proportion of the mass of fines settled at what rate.

32. We found that the fines from the three different samples all flocculated to similar extents with some flocs settling at rates in excess of 10mm/s. We then used one of the three samples (So-called Sediment 3 - Tails from processing of Sample Bulk 501) to examine the settling rate distribution in more detail and to establish the critical stress for resuspension of the fines released from the mining operation. Experiments were repeated using fines from the same bulk sample at different initial concentrations or following different periods of consolidation.

33. We did not extend this detailed analysis to look at the behaviour of the fines from the two other bulk samples we had. The initial settling tests showed the fines fractions present had similar properties. In my view to undertake further testing would not have significantly improved our understanding of the behaviour of the fines fraction arising from the mining process.

34. The near-field modelling was run as a series of sensitivity tests to provide input conditions to the far-field modelling in terms of the settling velocities of fines which would disperse from the mining pits. The mass of fines released from the mining was distributed across four settling classes, respectively 0.01mm/s, 0.1mm/s, 1mm/s and 10mm/s. All material settling at 10mm/s was found to deposit close to the mining operation so the far-field modelling used the three more slowly settling classes equivalent to settling rates of about 1m, 10m and 100m per day respectively.

35. In terms of the assumptions in the worst-case modelling it was agreed to use the NIWA interpretation of the settling velocity distribution of mass rather than the HRW distribution, or an average of the two. Based upon the information we had, this was a more conservative assumption resulting in a greater proportion of fines being released in the lower settling velocity classes.

36. The erosion threshold that was used in the NIWA modelling (0.2 Pa) was unchanged compared to the earlier modelling. It was already demonstrated to be conservative based upon the results of the laboratory analysis which demonstrated resuspension thresholds in the region of 0.2 to 0.3 Pa.

37. I accept that it would be possible to come up with alternative assumptions for a more severe worst case modelling scenario but I do not see the value in so-doing to inform the far-field impact assessment. Such an assessment would be unrealistic given the discharge conditions (see paragraphs 24 and 25 above).

EVIDENCE OF PROFESSOR JOHN LUICK

38. In his evidence Professor Luick raises points regarding flocculation. I disagree with Professor Luick at his paragraph 11 that it is common or standard practice to consider the

process of flocculation within plume models or to base settling velocities upon laboratory experiments.

39. In my experience of reviewing the work of other consultants undertaking sediment plume modelling it is often the case that flocculation is not taken into account. Often the settling velocities of suspended sediment within a plume are simulated as being associated with the physical size of individual particles, as was the case with the original NIWA modelling. This can lead to overly conservative predictions of suspended sediment concentrations and associated impacts at distance from a plume source. Conversely, it can also lead to under prediction of impacts closer to the release point of the sediment plume with proportionately higher near bed suspended sediment concentrations and deposition.

40. In my experience it is also not common for laboratory measurements of settling velocity to be used to inform numerical modelling. Such measurements are complex to undertake requiring specialist equipment and expertise as well as appropriate samples of material to test.

41. Professor Luick raises a concern in his paragraph 12(b) about the time dependency of the flocculation. The Longer Settling Tests undertaken at HRW (HRW 2014) showed the consequence of differential settling rates over time, reducing the concentration of suspended matter. However, they demonstrated specifically that over time, if additional mass were encountered, re-flocculation could occur.

42. As a consequence of this result the NIWA modelling can be considered conservative in that the settling velocity of classes of material remains constant over time. Once released from the mining, material that is characterised as having the lowest settling velocity, cannot settle faster in the NIWA model. The expectation being that the most slowly settling class of

material would in reality be subject to some amounts of further flocculation if it encounters zones of increased turbulence or other suspended material during the processes of advection, settlement and resuspension.

43. By including for the effects of flocculation and basing the settling velocities on observations from the laboratory the reliability of the plume modelling undertaken by NIWA is improved. I maintain that the approach adopted for representing the settling properties of the fines in the 2017 NIWA sediment plume modelling is an example of best practice.

44. In the last paragraph of his 12(e) Professor Luick makes a comment about verifying the NIWA modelling with order of magnitude estimates. Dr Macdonald provides more comment on this point in her January 2024 evidence. Professor Luick refers to settling at around the 50 metre depth contour suggesting that sediment starting from the surface and settling at 10 m/day would settle within 50 days. For the record I would like to point out that this is clearly a miscalculation or typographical error. At such a settling rate (equivalent to approximately 0.1 mm/s) the sediment would settle through the water column in 5 days. If it were settling ten times more slowly (at 0.01 mm/s) it would settle within 50 days not 500 days. Sediment starting from halfway down the water column would settle twice as quickly. These timescales are comparable to, or shorter than, the residence time of fine material (1-2 months) in the Sediment Model Domain when released from the mining area before passing westward through the Cook Strait. In the assessment no sediment has been attributed a settling velocity of 0.001 mm/s, equivalent to the 500 day settling scenario that Professor Luick mentions.

EVIDENCE OF DR GREGORY BARBARA

45. At his paragraph 43 Dr Barbara states that the TTR mining process will result in returned sediments being finer than the ambient sediments. I am not clear where Dr Barbara has found the evidence for this statement or to what size fractions he is referring to when he says the returned sediments will be finer. Regarding the finest fraction of the in-situ sediment the expectation is that a proportion of these fines will be advected away in the sediment plume. As a result the amount of the finest material present in the sediment that remains in the bed of the mining area will be less than it was prior to the mining operation. Over time, as a result of reworking by larger waves and stronger currents, the uppermost layer of the returned sediment will become armoured by coarser material.

46. In his paragraphs 51 to 53 Dr Barbara raises his concerns that ultra fines content of the sediment released in the plume will be higher than that assessed. TTR's proposed discharge standards and my discussion of them (paragraphs 24, 25 and following) address this point.

47. Dr Barbara also raises concerns about the presence of pockets of muds and clays across the proposed mining area in his paragraph 51. I observe that the mining operation by the crawler will be removing sediment from the bottom of a mining face over a width of about 24m. The mining face will on average be 5m in height but could be up to 11m. The crawler will slowly move forward into the mining face swinging its cutter back and forth across the face to mine the material on the face. The crawler will slowly cut into the mining face along the north eastern edge of the mining pit. With a mining depth of 5m and a cut width of 24m the crawler will move at about 35m/hour along the edge of the mining pit to achieve a production rate of about 8,000T/hour. This means that over

the course of a full operational day the crawler would move approximately 840m, almost the full width of the 900m wide mining pit. Any localised mud or clay pockets encountered in the mining face are unlikely to extend throughout the full depth of the face and any elevated layers of higher fines content will be diluted by the lower fines content of the surrounding material.

48. I disagree with Dr Barbara that the information about the particle size distribution of sediments is uncertain and inadequate for the purposes of assessing the effects of the sediment plume. In my opinion the original and worst-case sediment plume modelling scenarios presented provide a sound basis for understanding the magnitude and effects of the sediment plume against the background conditions. I also observe that the increases in suspended sediment concentration and deposition associated with the worst-case model result could have been inferred from the original results with appropriate scaling and consideration of time variation in source levels.

49. The proposed discharge conditions are informed by the assessment of impact and provide the confidence that the mining operations will not result in any significant periods of mining operations when the rate of release of slowly settling fines into the sediment plume is outside the levels assessed.

EVIDENCE OF JORIS JORISSEN

50. I agree with Mr Jorissen at his paragraph 16 that no new information has been supplied by TTR with regards to the characteristics of the seabed material proposed to be extracted by the mining operation. However, I note that the proposed discharge conditions (see paragraphs 24 and 25 above) make it clear how TTR will run the mining operation.

51. A programme of advance grade control drilling will inform decisions on the depth of mining and where areas of seabed material should be avoided because of high fines content or low ore content (see section 2.3.3.1 of the Impact Assessment). Over the course of a full operational day with the crawler operating at a depth of 5m, the seabed area mined by the crawler would be about 20,000m^2. In the course of a full operational week it would be about 140,000m^2. The grade control drilling is proposed to be undertaken at 100m centres on a grid with sampling undertaken at 1m intervals in the vertical. At 100m spacing each drill location is representing 10,000m^2 of seabed. For a 5m mining depth there would be 5 relevant samples covering the material removed. On average, for each week of mining at full operational rates there would be 70 in-situ samples obtained in advance for the area that the crawler was operating within.

SUBMISSION OF KAREN PRATT

52. On page 53 of her submission Ms Pratt raises a concern that the agitation effect of the cutter head of the crawler has not been considered as a source term.

53. In my 2016 evidence (paragraphs 46 to 53) I included a section on other sources of material from the mining operation. I did not discuss loss of fines from the action of the cutterhead of the crawler. I agree that a few percent of the material in the mining face will be released into the surrounding waters by the cutting operation. The amount of fines that this represents will be a few percent of the fines content of the material being mined; which is a similar level of effect to the fines I suggested might be released from the seabed by the movement of the crawler over the seabed (paragraph 50 of my 2016 evidence). I maintain my earlier opinion (paragraph 53 of my 2016 evidence) that additional sources of fine sediment releases from the operations are

insignificant compared to the fine sediment discharge from the Integrated Mining Vessel. I observe that compliance with condition 4(d), based upon in-situ sediment sampling before mining, effectively addresses any concerns related to losses of fines arising from the operation of the crawler.

CONDITIONS

54. I have discussed the importance of the discharge conditions in my evidence and shown how they should give confidence with regards to the magnitude of the sediment plume arising from the mining.

CONCLUSIONS

55. I have reviewed my previous evidence and the submissions outlined above and my views are unchanged.

56. I consider that the quantification of the sources and rates of fine material arising from the mining operation and the settling and resuspension properties of the fine material are the best available information to inform the far-field dispersion modelling.

57. I consider that the use of the near-field sediment dispersion modelling to understand the physical processes associated with the discharge back to the seabed from the IMV provides the best available information to consider the trapping potential of the mining lanes.

58. I am of the view that the outputs from these investigations provide a suitable basis for the related assessments of far-field dispersion, and the environmental or other effects of sediment dispersion.

Dr Michael Dearnaley

23 January 2023