IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application for resource consents by **TIGA MINERALS AND METALS LTD**
AND	
IN THE MATTER	of a submission by the
	COAST ROAD RESILIENCE GROUP INC

Statement of evidence of Tammy Ward and Chris J Cromey
For COAST ROAD RESILIENCE GROUP INC
Topic Dust

Dated: 29 January 2024

Coast Road Resilience Group Inc

Email:coastroadrg@gmail.com

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1. Introduction to the writers

1.1 **Tammy Ward**. My full name is Tammy Lynn Ward. I have a high school diploma and most of my working career has been in retail security in the United States before moving to New Zealand in 2001 to assist with managing a dive shop. I have also worked for New Zealand Customs and currently I am employed by the Nelson City Council as a Senior Resource Consents Administrator, having been there for the last 10 ½ years.

1.2 I am a member of the Coast Road Resilience Group Inc. (CRRG). I have been asked by the CRRG to provide lay witness evidence in relation to dust. I am not an expert in this matter and this report is not intended as expert evidence. I have prepared this statement of evidence for the CRRG in relation to this application.

1.3 I am familiar with the TiGA application site because I have lived in Barrytown for the last 2 years.

1.4 This statement of evidence focuses on matters of dust and dust dispersion. In preparing this statement, I have reviewed the following documents:

- TiGa RC Application AEE Final and all of the application's attachments; all of the Amendment to Application documents; and all of the Request for Information documents
- GDC and WCRC s42A Officer Reports
- Statement of Evidence – Graeme Ridley (sediment control and stormwater management)
- Statement of Evidence – John Berry (company)
- Statement of Evidence – Kate McKenzie (planning)
- National Environmental Standard for Air Quality 2004 (NESAQ)

- West Coast Regional Council – Regional Air Quality Plan 2002 (WCRC AQP)
- Ministry for the Environment – Good Practice Guide for Assessing & Managing Dust 2016 (MfE)

1.5 In addition to providing this statement in support of the CRRG, I also lodged a personal submission in relation to the TiGA Minerals and Metals Ltd application.

1.6 My full name is **Christopher James Cromey**. I have a MSc (Eng) Water Resources Technology and Management, 1992-1993, University of Birmingham, and experience in the field of lagrangian (particle tracking) modelling - the dispersion of waste particles from marine and freshwater fish farms. I have published 17 papers in the scientific literature with 6 of these as first author: published works have 1600+ citations.

1.7 I am a member of the Coast Road Resilience Group Inc. (CRRG) and have provided lay witness evidence in relation to dust, specifically the modelling of potential dust particle emissions from the proposed activities. I am not an expert on dust management or in dust particle modelling - the following sections are not intended as expert evidence.

1.8 I have prepared this statement of evidence for the CRRG in relation to this application. I have lived on the Barrytown Flats close to TiGa application site since 2017.

1.9 In preparing this statement of evidence, I have reviewed the following documents:

- TiGa RC Application AEE Final and all of the application's attachments; all of the Amendment to Application documents;
- GDC and WCRC s42A Officer Reports
- Statement of Evidence – Graeme Ridley (sediment control and stormwater management)
- Statement of Evidence – John Berry (company)
- National Environmental Standard for Air Quality 2004 (NESAQ)
- West Coast Regional Council – Regional Air Quality Plan 2002 (WCRC AQP)
- Ministry for the Environment – Good Practice Guide for Assessing & Managing Dust 2016 (MfE)

1.10 In addition to providing this statement in support of the CRRG, I also lodged a personal submission in relation to the TIGA Minerals and Metals Ltd application.

2 What is Dust

2.1 Webster's dictionary describes dust as 'fine particles of matter (as of earth); the particles into which something disintegrates. The Oxford dictionary describes it as 'fine, dry powder consisting of tiny particles of earth or waste matter lying on the ground or on surfaces or carried in the air'. In brief, dust is particulate matter on the ground or in the atmosphere. Particulate Matter, or PM, is the term used to describe very small solid, liquid or gaseous particles in the air which may include dust, dirt and soot.

2.2 Particulate matter can be measured in Micrometres (Microns). A micrometre is one thousandth of a millimetre and invisible to the naked eye. A sheet of paper is approximately 100 micron thick, and a human hair is about 30-200 microns (Figure 1). Microns are the measurement used to partly assess how PM will behave in the atmosphere.

2.3 PM10 is the term used to describe particles that are 10 micrometers or smaller and can be inhaled[1]into the lungs. Very fine particles, known as PM2.5, pose the greatest risk to human health.

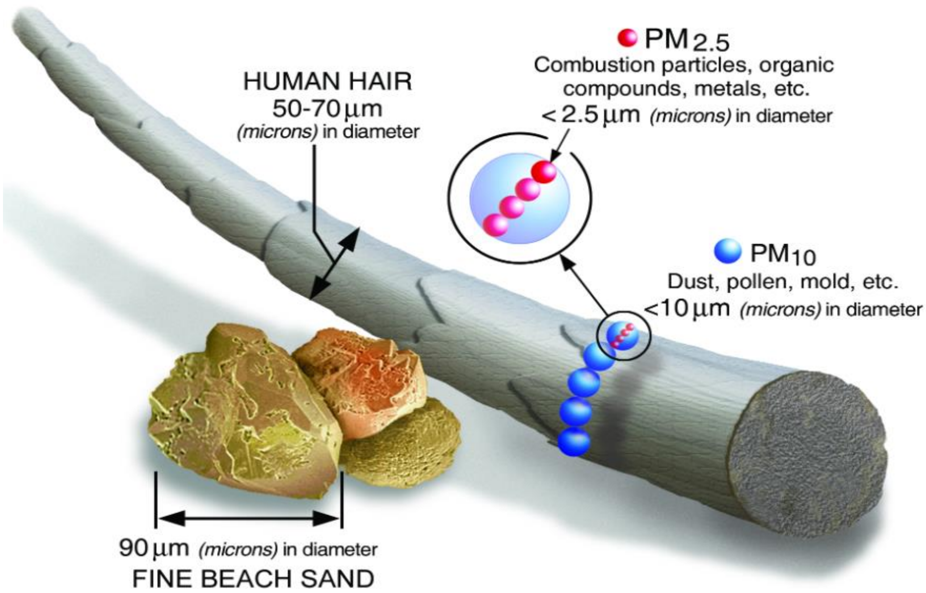


Figure 1: Comparisons for PM particles

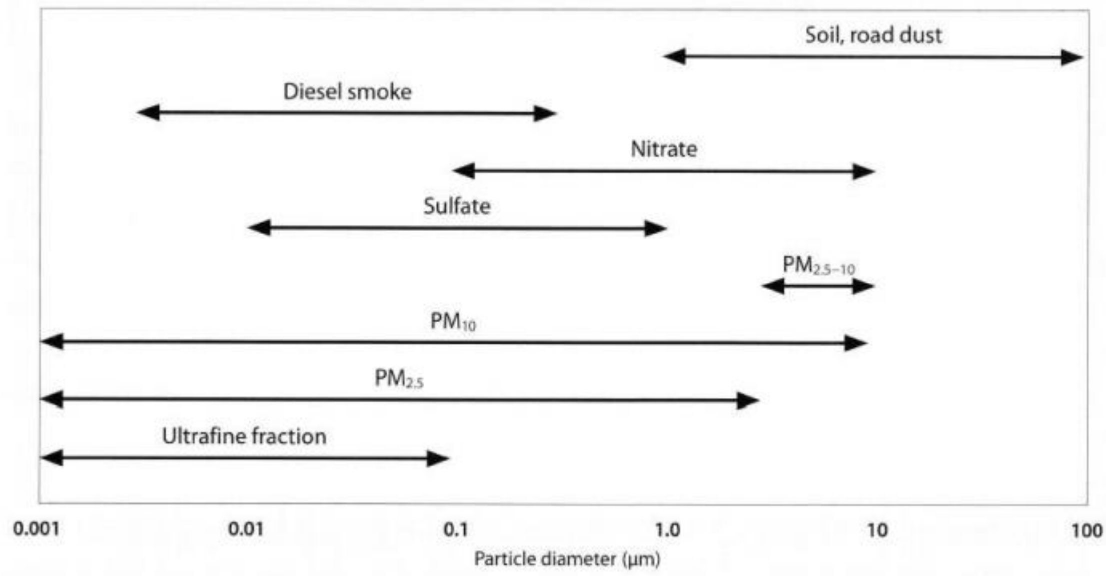
2.4 Based on this, it stands to reason that dust can sometimes be seen in the air if there is an accumulation of enough of the particles, but most often dust is noticed (rather than seen) once it lands on surfaces.

2.5 The National Environmental Standard for Air Quality Regulations 2004 (NESAQ) uses PM10 as the standard for ambient air quality in order to protect human health.

2.6 The Ministry for the Environment (MfE) Good Practice Guide for Assessing and Managing Dust[2] also gives a size comparison of common particulate matter components (Figure 2). This shows soil and road dust sitting between 1-100 microns in size.

[1]https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

[2]Ministry for the Environment. 2016. Good Practice Guide for Assessing and Managing Dust. Wellington: Ministry for the Environment



(Source: World Health Organisation, 2006)

Figure 2: Size range of airborne particles

2.7 The MfE guidance goes on to state that larger dust particles are generally responsible for nuisance effects as they are more obvious as deposits on clean surfaces, while smaller particles ($PM_{2.5}$ and PM_{10}) are known to cause adverse health effects.

2.8 The MfE guidance also clarifies that it is primarily concerned with assessing and managing nuisance effects for larger size fractions of dust due to its impact on visuals and amenity values. For smaller dust sizes such as PM_{10}, you must refer to the NESAQ.

2.9 We note that the WCRC s42A report, paragraph 78, states that NESAQ is not applicable here and while that may be true, the regulations do still set a minimum level of air quality to minimise impacts on human health. The air around Barrytown is not normally expected to be polluted and therefore does not need to be identified as an airshed for monitoring. If dust is discharged from the site, the expectation is that it will be dispersed enough to not be a concentration near to the levels of the NESAQ requirements. We question whether this is a reasonable assumption and if in fact there should be monitoring to ensure that is the case. Should monitoring determine that results are well below the regulated levels, then monitoring could be stopped. This would at least give residents in the area, and particularly those close to the activity, some additional peace of mind.

3 **Overview of Application to Discharge to Air**

3.1 TiGA have submitted an application to discharge contaminants to air, namely dust. The application states that there are dust and radiation monitors on the perimeter of the mine site since late 2022 and these will remain in place for the duration of the mining activities.

3.2 Dust sources would mainly be the result of stockpiling, earthworks and access roads. We were unable to find mention of other potential discharges such as emissions from heavy diesel machinery, generators or radioactive dust.

3.3 The application states that the West Coast Regional Council Air Quality Plan (WCRC AQP) lists mining and stockpiling as permitted activities with thresholds for dust management. The application states the rules for stockpiling require no dust beyond the property boundary; the rules for mining no offensive or objectionable dust emissions beyond the property boundary (refer to Chapter 10.4, rules 3 & 5)

3.4 Chapter 7 of the WCRC AQP relates to Dust.7.4 of the document refers to Policies, of which '*adverse effects of the deposition of dust will be avoided, remedied or mitigated by ensuring that any discharge of dust does not occur at a volume, rate or in a manner that could cause an offensive or objectionable effect, including… the soiling of property*'. This goes on to explain that '*The presence of deposited dust can result in a loss of amenities, inconvenience and disruption to outdoor activities*'.

3.5 Chapter 7 also describes the management of dust being often divided into two types: Deposited Dust (larger than PM20) and Suspended Dust (smaller than PM20). The AQP has adopted the air quality standard of PM10 for measurements of particles that are associated with adverse effects on human health.

3.6 7.4.3 is assessment criteria for offensive or objectionable discharges which states:
In assessing offensive or objectionable effects from discharges of dust, the Regional Council will take into account the following factors:

- *o Frequency of dust discharges;*
- *o Intensity of dust discharges;*
- *o Duration of dust discharges;*
- *o Offensiveness of the odour;*
- *o Extent of dust discharges (suspended and deposited);*
- *o Location of dust discharges.*

3.7 TiGA have applied for a discharge to air for dust emissions. The application's Assessment of Environmental Effects (AEE) has a brief statement of dust management measures and then refers you to the Dust Management Plan (DMP) in the application (Att K). The only other references we have been able to find in the application which are dust related are proposed conditions 27.1 and 27.2, which again refer to the DMP.

4. RMA – Purpose, Effects and Amenity

4.1 The purpose of the RMA as specified in section 5(1) is "*to promote the sustainable management of natural and physical resources*". Section 5(2)(c) provides for "*avoiding, remedying, or mitigating any adverse effects of activities on the environment*". Section 2 of the Act defines "**environment**" as including:
(a) *Ecosystems and their constituent parts, including people and communities; and*
(b) All natural and physical resources; and
(c) Amenity values; and
(d) The social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) or which are affected by those matters."

4.2 The term “**amenity values**” is also defined in section 2 of the Act. It means:

> “*those natural or physical qualities and characteristics of an area that contribute to people’s appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes*.”

4.3 Section 3 defines the meaning of **effect** to be

“*the term effect includes—*

(a) any positive or adverse effect; and

(b) any temporary or permanent effect; and

(c) any past, present, or future effect; and

(d) any cumulative effect which arises over time or in combination with other effects— regardless of the scale, intensity, duration, or frequency of the effect, and also includes—

(e)any potential effect of high probability; and

(f)any potential effect of low probability which has a high potential impact.

4.4 Our understanding of the above sections is that the environment includes the people and their appreciation of the natural characteristics of an area which provide an amenity value of pleasantness, aesthetic coherence, and cultural and recreational attributes. And that any adverse effects (4.3 a-f) are to be avoided, remedied or mitigated.

4.5 Earthworks, stockpiling and bunds are activities that have potential to create dust that could have adverse effects on the environment and amenity values.

5. Review of TiGa Dust Management Plan [DMP]

5.1 Part A.1 of the DMP starts with a purpose which is ‘*to manage, mitigate and monitor dust emissions during construction and mining*’ and its objective is ‘*to detail the best practicable option to avoid dust nuisance being caused by construction and mining works and to mitigate any such effects should they occur*’.

5.2 The DMP then lists a set of consent conditions, which do not appear to contain proactive measures to avoid dust issues but are rather just general conditions on how the overall site will operate each year and what reporting will be undertaken.

5.3 We have identified the following items which appear to relate directly to dust management:

a. Operate in accordance with the DMP

b. Vehicle speeds not to exceed 15km/hr

c. No offensive of objectionable discharge of dust beyond the boundary

d. Installation of meteorological equipment

e. Installation of 2 dust monitoring gauges and parameters of limits for exceedance and notifying the Council if this happens.

5.4 Part C gives an overview of dust sources and states a workplace survey and risk assessment review will occur on a scheduled 3 monthly basis (or more frequently if mine plans change) and will ensure ongoing validity and effectiveness of controls. We could not ascertain from the DMP who would be responsible for this review and reporting work.

5.5 Part C also states identified high risk areas for dust generation will be on daily shift plans and attended to throughout the shift.

5.6 All heavy mineral concentrate (HMC) stockpiles will be enclosed within buildings.

5.7 Part 3 is about background monitoring results which consists of a table (shown below) of 6 test results from the monitors on site. However, no analysis was given as to what the results actually mean. Our assumption is the results are showing milligrams of solids.

5.8 The DMP is relying on the particulate to be a certain weight in order to track it with the monitoring gauges and in some instances this may work, but there are likely to be much smaller particles that will be travelling in the air and these do not appear to have been considered.

5.9 Condition 28.3 states that 2 dust deposition gauges will be installed and shall not exceed 4g/m^2/30 days above background levels. This is the recommended trigger level for deposited dust in the MFE guidelines. The proposed locations of the monitors are noted below with green diamonds.

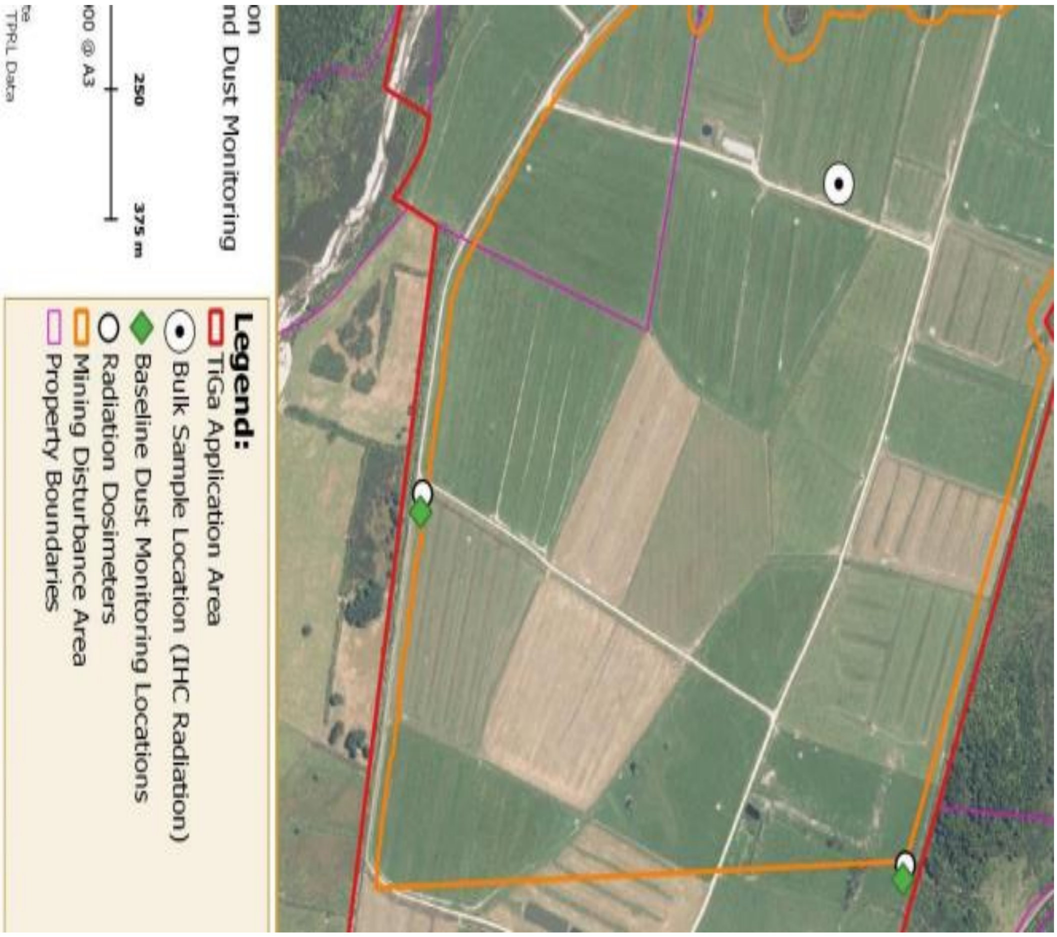


Figure 3: Dust and Radiation Monitoring Locations

5.10 The Applicant has provided background monitoring done over a period of months; Nov-Dec22 (36 days), Dec22-Jan23 (26 days) and Feb-March23 (34 days) in Figure 4 below. However the information provided is confusing. The term 'MG' is used in the last column, which leads to the assumption it is referring to milligrams, but there is no indication of whether this means it is a total amount collected, or corrected for the surface area of the dust collector. The results would better expressed as g/m^2/30 days so that the background level could have been compared to the MFE suggested trigger level in 5.9 above.

Sample ID	Laboratory Id	EGA-ISO4222-2 Install Date	EGA-ISO4222-2 Collect Date	EGA-ISO4222-2 Sampling Period DAYS	EGA-ISO4222-2 TotalInsol Solids MG LOR5.00
Cowans DM 1	WP23-11550-001	16/11/2022	21/12//2022	36	<5
Cowans DM 2	WP23-11550-002	16/11/2022	214/12/2022	36	<5
Cowans DM 1	WP23-11550-001	22/12/2022	17/01/2023	26	10
Cowans DM 2	WP23-11550-002	22/12/2022	17/01/2023	26	14
Barrytown DM!	WP23-1183.001	16/02/2023	22/03/2023	34	13
Barrytown DM2	WP23-11831..002	16/02/2023	22/03/2023	34	13

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Figure 4: Background monitoring results

5.11 Also included is a table of rainfall during the above sampling as below:

Station	Date	Amount (mm)	Deficit (mm)	Period per day (Hrs)	Frequency
23934	16/11/2022 – 21/12/2022	315.2	372.7	24	D
23934	22/12/22 - 17/01/2023	66.8	1608	24	D
23934	16/02/2023 -22/02/2023	307.8	1461.7	24	D

Figure 5: Total rainfall during sampling periods

Again, no analysis of the results is given so it is unclear if the table is showing an increase or decrease in moisture over the sampling period or what these figures may have been compared with to get deficit readings. We did find a reference to a rainfall table for Punakaiki in the ESCP (App J, 2.1) which states an approximate rainfall for the area is 2800mm/yr. When comparing this to the above table, the first and third readings are wetter than the average while the second reading is drier. We also note that the third line appears to have an incorrect date range.

5.12 The DMP should be considering all potential dust factors and good dust monitoring means size matters. Bay of Plenty Regional Council report, Mount Maunganui Dust Reporting[3] states:

> '*Dust particle size is an important factor in determining the way in which the dust moves through the air. It is also relevant for the possible environmental impacts, especially health effects. Particle sizes are normally measured in microns, and the size range of airborne particles is typically from less than 0.1 microns up to about 500 microns, or half a millimetre.*'

5.13 The report goes on to give an example of how far different size particles can travel. It states the following:

> '*In a 20 kph wind, the 100-micron particles would only be blown about 10 metres away from the source while the 10-micron particles have the potential to travel about a kilometre. Fine particles can therefore be widely dispersed, while the larger particles simply settle out in the immediate vicinity of the source. Bearing in mind that if suitable conditions prevail (such as strong winds, vehicle activity etc.) then this deposited material can get re-suspended and move in the direction of the prevailing wind to a new location, hence particles can travel much greater distances than given in the simplistic example stated above.*'

5.14 It should be noted that the DMP does not contain any wind analysis or even comments about the prevailing winds on the West Coast. Also, Section 4 of the DMP gives only brief comments about dust mobilisation, breaking it into three types;

- Creep – largest, heaviest particles remain stable or creep along the soil surface in winds of approximately 16km/h
- Saltation – the movement of medium sized particles in winds of approximately 21km/h. Accounts for 50-80% of soil movement. Wind causes particles to bounce but as they are too big to remain suspended they are carried short distances (1-10m), they fall to the ground and dislodge other particles to repeat the process. This type of mobilisation can create thick soil clouds which move with the wind.
- Suspension – the smallest particles picked up in winds above 21.6km/h and suspended causing visible dust clouds.

As more detail is lacking, one would have to make assumptions about the size of particles in each scenario, but it would seem reasonable that particles of <100 microns (as shown in Figure 1) could fit within the suspension movements. The potential for particle dispersion from dust point sources is summarised by Sairanen

[3]https://www.boprc.govt.nz/media/275611/mount_maunganui_dust_monitoring.pdf

&Pursio (2020)[4] as a few hundred metres for particles >30 micron and 200 – 500 metres for particles 10-30 microns.

5.15 The MfE guidance document (5.2.5) refers to material stockpiles. It states that these are subject to dust pick-up at winds in excess of about 5m/sec or 10 knots. A wind of 10 knots equates to approximately 18.5 km/h.

5.16 A check of the National Institute of Water and Atmospheric Research (NIWA) notes that the prevailing winds for the west coast are generally SW or NE but can have local variants[5]. With the addition of predicted El Nino changes this will bring more and possibly stronger westerly winds as well.

5.17 Figure 6 below is taken from the MetService and shows wind direction and maximum wind gust speed from 22 Dec 2023 – 5 Jan 2024 as taken from the Westport Airport. While we appreciate this is a different location from the Barrytown Flats, it highlights the fact that the winds come from variable directions and maximum gusts far exceed 18.5km/h. This would suggest that dust being generated on the site has a very high probability to travel further than anticipated.

5.18 It is noted here that the Applicant has submitted an amended version of the DMP (Evidence John Berry) which now mentions wind direction being primarily from the south west, with average annual speeds of 13.7km/h and monthly mean wind speeds of 16km/h for Westport. The information is taken from the same report we have referenced in 5.16 above. which was written in 2016. The report discusses wind and wind patterns along the west coast at that time. Mr Berry appears to have inferred that the information is a reflection of today's wind patterns and that speeds of >30km/h can occur in Barrytown but on an average of 2-3 days a month based on the NIWA tables in his evidence (pg 12 Amended DMP). The NIWA report does not mention Barrytown as a location and we are uncertain of how Mr Berry has come to this conclusion. Collectively, Figure 6 below is 15 days' worth of wind maximum wind gust speeds from Westport, with an average gust of 40 km/h and direction changing daily.

[4]Sairanen, M. and Pursio, S. (2020). Near field modelling of dust emissions caused by drilling and crushing. SN Applied Sciences 2:1188.

[5]NIWA West Coast Climatology 2016, pg 13https://niwa.co.nz/our-science/climate/publications/regional-climatologies/west_coast

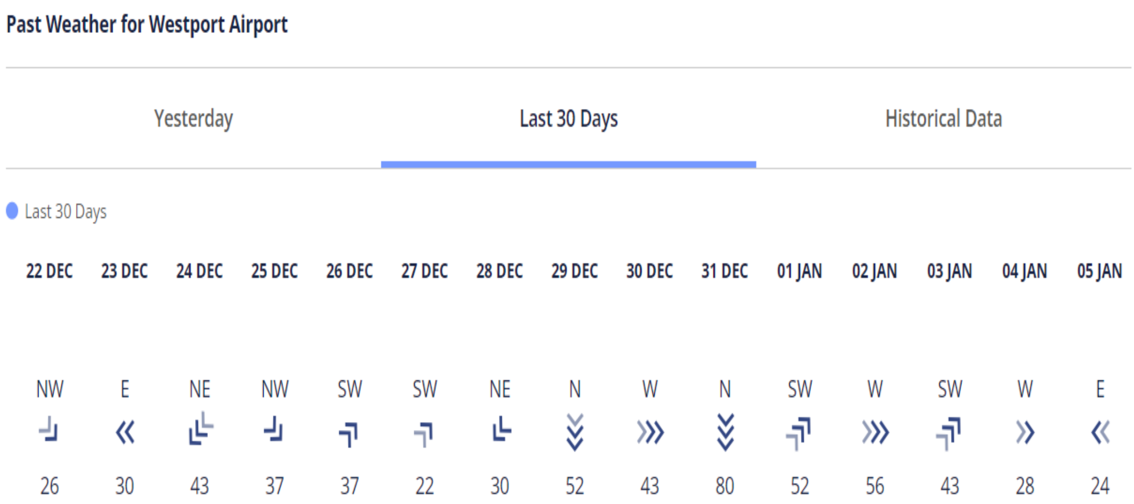

Figure 6: Maximum wind gusts and direction Westport aerodrome

5.19 Modelling of dust particle deposition (<100 micron) shows that depending on the particular location of the point source and the severity of the suspension event, two sampling locations may be inadequate. For instance, if we had an easterly wind, dust would be blown onto freshwater sources and the lagoons where there are no monitors. The application is lacking any research of the winds and potential weather of the area so as to more accurately determine what type of dust monitors are appropriate, and where the best placements of those monitors should be.

5.20 Of particular relevance to this, is a recent wind event at Westport. On the afternoons of the 1st and 2nd of January 2024, SW winds caused HMC to blow through the Westport streets. Hourly averaged wind speed and wind gust data measured at the Westport aerodrome, did exceed the threshold for wind suspension stated by the applicant (22 km/h). At the same time the HMC was reported as being blown through the streets of Westport, meteorological data measured on the Barrytown Flats nearby to the proposed site did show elevated SW wind speeds. The article in the Westport News, 3 January 2024[6], stated the HMC was stored at the wharf and winds deposited it along streets and properties in town. Contact was made with one of the affected properties on Palmerston Street. The property owner confirmed stockpiles were moved from the wharf shed and relocated to the old cement works, which is next to the river and approximately 100m SW of their property. Hourly average wind speeds, gust data and rainfall (mm) for Westport during this period were also obtained.

5.21 Based on this collective information, the event was most likely caused by a SW wind, which picked up HMC from the old cement works and carried it approximately 100m to be deposited on rooftops and gutters. It is noted here that the amended DMP (Evidence John Berry) states that '*there is potential for airborne sand to be generated at the site, but will likely not become suspended due to the size and mass of the particles.*' Mr Berry states that sand particles <45 micron will be removed and returned to the pit as slimes. However, as the example above clearly shows, >45 micron particles can travel great distances in the right conditions.

[6]Newspaper article; The News, Westport, Wednesday January 3, 2024

5.22 For dust monitor placement, MfE guidance suggests that *‘A minimum of two to four sites will usually be required for most diffuse dust sources. Considerably more sites will be needed if the activity is spread over a wide area, such as an open cast mine ’*[7]This would seem to be an important piece of guidance that has not been taken into consideration.

5.23 Part 5 of the DMP states sensitive receptors will have a minimum setback of 20m. Sensitive receptors are listed as residential houses and sensitive ecosystems. Additionally, native vegetation, CMA, wetlands and surface waterways near the project area are to be treated as sensitive and dust is to be avoided. Sairanen, M. and Pursio, S. (2020) (section 5.14), heavy mineral concentrate particle transport through Westport (section 5.20), and dust particle modelling at the proposed site described in this statement, suggest that dust particle transport on a scale of hundreds of metres is possible.

5.24 The DMP does not acknowledge other sensitive receptors which could be on surrounding properties, such as organic food gardens (submission 324), grazing pasture, nursery stock and water supplies (submission 197).As this is a rural area, most people collect rainwater from their rooves and other buildings. Dust travelling beyond the 20m setback could have a serious impact on these receptors as well and consideration should be given. It is noted here that the amended DMP (Evidence John Berry) states that

> ‘*Given the distance 200m or more to sensitive receptors, the bunding and planting, grassed paddocks between receptors…mitigation proposed will ensure dust will not be discharged beyond the application area.’*

In relation to dust potentially being blown onto Canoe Creek Lagoon he states

> *‘…grassed areas, planting and other vegetation are located between likely dust generation and these areas. This along with mitigation will ensure dust will not be discharged beyond the application site.’*

While established vegetation may prevent some dust reaching sensitive receptors, a large portion of plantings will be new and less effective. Dust may also be suspended at heights greater than vegetation.

5.25 Part 6 for mitigation measures offers the following for general mitigation and says these will be used ‘*as applicable across the project*’ (highlight for emphasis below):

Control
• Site personnel trained in dust management controls. • Monitoring of site conditions (weather/soil conditions) to anticipate and prevent dust effects. • Limiting operations which have the potential to cause high dust during high wind events. • Use of water cart and sprays to keep surfaces damp as required near sensitive receptors. A critical part of this control measure is identification of a sufficient water supply at the site for this purpose with adequate volume. .

[7]MFE Good Practice Guide for Assessing and Managing the Environmental Effects of Dust pg.28

They also state unsealed surfaces will be kept damp in areas near sensitive receptors. Considering the amount of open dust source area, this will require a large amount of water usage. They would have to keep the entire entrance to the site damp, as well as stockpiles, and any other areas that prove to be dust prone. What do they intend to do if there is not enough water?

5.26 Water is generally the best option for dust management, but if the areas are not kept consistently damp, the water won't have the desired effect. Environment Canterbury (ECan) suggests the following wetting parameters for effective dust control of open source areas[8], '*The minimum amount of water that you should have available on site is 5 mm/m²/day. Apply it incrementally so the ground surface remains moist.* '

5.27 Water trucks are the most common tool used to wet flat areas, but they may not be appropriate for wetting large bunds and stockpiles. Appreciating that the bunds are to be planted/grassed, but the stockpiles will not, the DMP is unclear on how these areas will be dust controlled in the interim.

5.28 ECan also makes other suggested control measures, such as adding wetting agents to the water. TiGA does not appear to have included any assessment of wetting agents. If these are being considered, then the DMP should be listing which agents are appropriate and how they will be safely applied and controlled so as not to contaminate sensitive areas.

5.29 Most of the dust monitoring is of a visual nature and the DMP states inspections will be done daily at a minimum. Weather forecasts will be checked daily from the meteorological weather station to be installed onsite. Proposed conditions of consent confirm the weather station is to be installed prior to commencement of site preparation and will log in real time and report agreed representative meteorological data for the site. However, there are no assessments of what will be required, or conditions within the DMP, to state what this agreed data should be.

5.30 The daily dust inspection monitoring has a tick box exercise for reporting as below. While this is supposed to be completed daily, there do not appear to be any conditions in the DMP providing instruction on when it is to be completed. Is it done once a day, once per shift, every 6 hours or just when the weather conditions are deemed likely to generate dust?

[8] https://esccanterbury.co.nz/project/dust-control/

SCOPE OF INSPECTION	Circle the relevant item	COMMENTS
Is there visible dust from site work activities, stockpiles, earthworks areas or haul roads?	Y N N/A	
Are haul roads visibly dry and need spraying with water truck?	Y N N/A	
Are any exposed earthworks or stockpile areasvisibly dry and need water spray?	Y N N/A	
Stockpile heights Dampened Stockpiles covered/stabilized where needed?	Y N N/A Y N N/A	
Are there any signs of dust going off site as a result of site activities? Land adjacent to the site to be inspected (including vegetation, residential properties and cars), and adjoining SH6 for the presence of dust deposits.	Y N N/A	
If wind speeds are strong are additional inspection and mitigation measures being put in place? (e.g. increase water application, restrictions on dusty activities)	Y N N/A	
Are watering systems (e.g. water carts, wheel wash) operating effectively to minimize dust?	Y N N/A	
Are trucks covered before entering or leaving the site?	Y N N/A	

While this can be a useful tool, visual checks can also be subjective. What one person deems as acceptable may not appear acceptable to someone else. Without parameters, how will staff know what is too much? Again, this seems to be a reactive way to control dust. Dust suppression should be an ongoing activity, not something that is dealt to once dust is noticed. In particular, the intensity and gusty nature of the easterly wind on the Flats is commonly not accurately forecast. Under certain conditions, this very dry wind easily exceeds the thresholds for dust particle suspension quoted by the applicant.

5.31 The DMP has a table of contingency measures (p15) consisting of 4 items. We note the first one says '*dust discharges cause deposition at sensitive receptors*'. The control is to '*stop activities…until mitigation is reviewed and additional mitigation is in place*'. However, if dust was being managed on a continuous basis, it seems unlikely to be deposited on sensitive receptors, except in extreme wind conditions, in which activities would be severely limited or stopped altogether anyway.

5.32 If equipment breaks/malfunctions (i.e. water truck), the control is to assess rainfall and wind and only stop work if particularly dry or windy conditions exist and repair as soon as practicable.

5.33 The contingency for high wind forecasts (above 20km/h) is to limit (not stop [our words]) activities that will generate dust downwind…additional visual inspection of exposed areas…assess need for additional controls such as increase of water application rates. As noted earlier in this report, winds above 18.5km/hr begin picking up dust particles.

5.34 Any visible dust discharges from stockpiles or uncovered soil will be dampened, covered or stabilized. Again, it would seem if there was a proper dust management regime in place, the stockpiles and exposed areas would remain damp enough to avoid or at least severely mitigate the occurrence of visible dust.

5.35 The DMP goes on to talk about dust inspections and monitoring and the frequency of those activities. Most items will be completed either daily or as conditions change. Again, the checks seem to be mostly visual and therefore subjective to the person doing the checking. While some things would be obvious, for instance if it is raining, other things may not be so obvious, such as a stockpile drying out in strong, winds with low humidity.

6. Overall Analysis of TiGA DMP

6.1 The TiGA DMP states its objective is to '*avoid dust nuisance being caused…and to mitigate any such effects should they occur*'. We found it to be largely a copy and paste of bits of information from a few pieces of legislation and industry standards.

6.2 The format of the document makes it hard to follow and it seems to have no depth of detail to assist someone on the ground to know what to do. It appears largely written as a reactive document, stating what they will do if dust occurs.

6.3 It will rely largely on visual monitoring of the site by individuals. This seems to be a very subjective way to manage dust control and does not state how often the visual monitoring will be undertaken, just that it will be done daily, and in some instances, as conditions change (p15/16 table).

6.4 The actual parameters of dust control seem quite limited. Some examples of this are:

- Use of water on dry areas. No other suppressant options are listed, and water use would be subject to a sufficient supply/volume being identified.

- Drop heights are to be minimised. No indications are given as to what the drop height maximum should be. This may be something that can't have a specific maximum or minimum put on it due to the loader capability and placement of trucks for loading, which means drop heights would be at the discretion of the loader operator.

Figure 7: Example photo drop height dust emission for emphasis

- Removal of vegetation and topsoil will be controlled and limited to the amount necessary for mining operations. The DMP notes 7.2 under

Methods of Operation that only 8 hectares disturbed at any one time. The Erosion Sediment Control Plan (ESCP) states (p12 point 11) '*The Project has committed to having a maximum area open at any one time of 8.0ha. This includes all the bund establishment and road access provisions. This has the effect of ensuring, including through site establishment phases, that progressive stabilisation is implemented, and the risk of sediment generation and discharges are greatly reduced. It is recognised that if greater than 8ha is required for a specific task that this will be for short duration periods only and only would occur with WCRC certification*.'

- The ESCP also refers hay/straw mulch, traditional grass sowing and polymer/soil binder products as options for soil stabilisation with 2 key purposes being dust suppression and erosion control. The DMP however, makes more generic suggestions such as keeping stockpile surfaces damp or covered in areas adjacent to sensitive receptors. Unpaved surfaces are kept damp, compacted where practical and where works are completed, grassing or sealing.

- Neither the ESCP nor the DMP list any appropriate soil binders that can be used.

- Limiting height and slope of stockpiles. The DMP has no heights listed but the revised Landscape & Visual Assessment states these will be 4.5m (refer 7.2-7.4).

6.5 We have compared the TiGA DMP with two other dust management plans, one specifically for mineral sand mining in Australia[9] and the other for earthworks in a residential area in New Zealand[10].

6.6 Both of these reports are much more detailed, and contain far more analysis of the issues of dust, than the TiGA DMP. The Australian example includes things such as mapping of sensitive receptors, wind analysis, a risk rating for different activities including wind erosion of stockpiles and even discussion about PM_{10} and $PM_{2.5}$.Thisexample is covering off the same type of activities that will occur here such as clearing of vegetation, excavation, stockpiling etc. and makes a risk assessment of each of these with parameters of control to be used for avoidance of PM_{10} exceedances.

6.7 We appreciate that the example we are referencing is in Western Australia and would presumably have even more dust impacts than the Barrytown site, but it would seem that as TiGA is an Australian mining company, they would have put more effort into creating an appropriate dust management planto address all possible issues with dust.

[9]Atlas Project Dust Management Plan June 2022
[10]EnviroCo Environmental Compliance, Dust Management Plan, 3D Hill Street July 2021

7. NIWA Predictions and Exposed Area Information

This year we are expecting weather patterns to turn from La Nina to El Nino, which will mean south-westerly to westerly winds[11] and may mean we have more rainfall.

As this is a prediction, we are in a 'wait and see' pattern. More rain may mean less dust effects from the activity, but should the rain not eventuate, dust could be a major problem.

Niwa has compared the soil moisture from 2022 to 2023 (Figure 10), currently showing much higher moisture levels for this area compared with the same time last year.

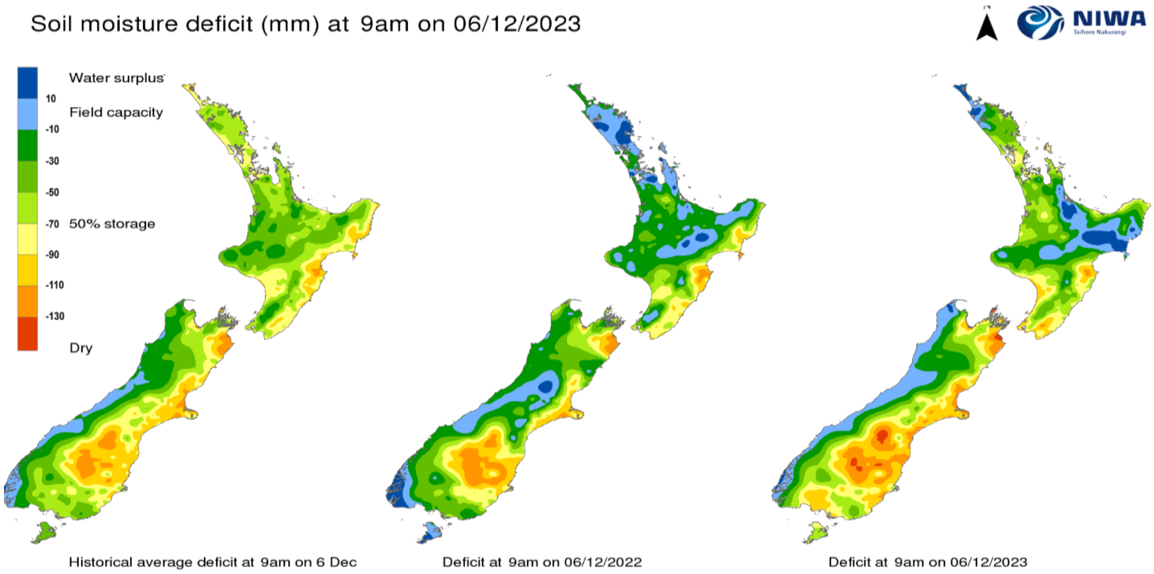

Figure 10 – NIWA soil moisture deficit

7.1 Many areas of the application site have been identified as potentially significant dust sources. The revised Landscape and Visual Assessment of Effects (LVA) in the application (Att C2) describes several of these.

7.2 Page 14 of the LVA describes the pre-mining preparation and in particular, the bund that will be created along SH6. This bund is proposed to be 1.8m high, 13m wide and 300m long, running parallel to the highway. The intention is to plant the bund for visual screening. However, until all of the plantings establish, the bund will be a very large area of excavated dirt that will quickly become dry and easily wind-blown.

7.3 Page 14 also describes the creation of the two Mine Water Facility ponds, with the excavated topsoil and waste being placed in the southern end of eastern stockpile bund 125m wide, 280m long and 4.5m high, consisting of approximately 135,000m^3 of material.

7.4 Additionally, two Clean Water Facility ponds will be excavated, and this topsoil and waste will create the northern end of the stockpile bund, again being 125m wide, 360m long and 4.5m high, and consisting of approximately 150,000m^3 of material.

[11] https://niwa.co.nz/news/2023-so-far-nzs-record-breaking-weather

7.5 The clearing of the mining area for machinery and vehicles states an additional 180,000m^3 of material will be used in the bunds once ore is extracted and stockpiled.

7.6 All of this excavation equates to approximately 8.4ha of total exposed land area and an unknown amount of stockpiled ore, which will be exposed to wind and could pose a serious dust issue for surrounding properties as well as water bodies.

7.7 These bunds are proposed to be hydroseeded with the southern end being planted to mitigate visual effects. Dust will likely be a factor until plantings become established.

7.8 The LVA also identifies that there will be a north ore stockpile, located to the west of the stockpile bund. This will contain the ore extracted from all of the pond excavations and the mining area. In response to a further information request from the Council, the applicant confirmed this stockpile will be no more than 4.5m in height (Further Info Response Att C1).

7.9 As previously stated in point 5.25, The minimum amount of water that you should have available on site is 5 mm/m^2/day for efficient dust suppression. Using this figure, if 3ha of the 8.4ha needed wetting, then you would need approximately 150m^3/day of water. By way of comparison, the requirement for a 300 head dairy cow herd is 28m^3/day, so wetting down of 3ha requires 5 times more water than the daily requirement of 300 head of dairy cattle[12].

8. Submissions

8.1 A number of the submissions in opposition to this application raised concerns over the potential for dust issues from the activity, see table below. As this is a rural area, it is common for people to grow their own food, have grazing areas for stock and to have fresh water sources as well as roof collection of rainwater for drinking. These can all be impacted by the accumulation of dust which can have health impacts.

Sub #	Issue Raised
142	Raises issues of possible dust impacting activities at the school and requests air monitoring equipment be installed to ensure compliance and safety.
175	May not be able to contain dust / frequent winds above 20km/h
188	States the application is unclear if dust will be properly managed
189	States the application is unclear if dust will be properly managed
197	Has concerns for dust to migrate onto their house/grazing pasture/nursery plant stock/planting blocks and water supply. States there is contradicting information about sealing of roads and no discussion of extreme winds of the area.

[12]Reasonable Stock Water Requirements. Guidelines for consent applications. Technical Report Dec.2007 Horizons Regional Council; Sections 2.1-2.2 pg. 8-10

324	Has concern for dust to be deposited on their organic farming

8.2 The DMP does not contain any analysis of the above potential effects or comments about potential health impacts.

9. Introduction to dust particle modelling

9.1 Relating to dust and the applicants Dust Management Plan (DMP), the GDC s42A officer's report recommends:

a. '*The DMP does not provide an assessment as to the level or extent of adverse dust effects on sensitive receptors, including the adjoining wetlands. This should be provided to understand any actual and potential dust effects.*' Point 215, p 49 in GDC s42A report.
b. '*Consideration should be given to mapping sensitive receptors in the DMP to assist with implementation and monitoring*.' Point 216a, p 49.
c. '*Please provide an assessment by a suitably qualified person as to the level and extent of adverse dust effects on sensitive receptors, including the adjoining wetlands*.' Point 8, p 100.

The s42A report also mentions the Ministry for the Environment's Good Practice Guide for Assessing and Managing Dust recommended level of 4g/m^2/30 days (Point 216b, p 49).

9.2 From the s42A recommendations, the important aspects appear to be:

a. the distance and direction that dust particles travel (the extent)
b. dust particle deposition rates (which determines the level of adverse effect)
c. whether the rate exceeds a trigger measured at the boundary (4 g/m^2/30 days)

9.3 The following points are relevant to these recommendations:

a. From a near-field modelling scientific paper of a mining operation: '*Large particles will deposit within few hundred of meters from the dust source, while particles of an intermediate size range (10–30 μm) are likely to travel up to 200–500 m*.'[13] In addition, the distance to the edge of the observed and predicted plume for PM_{10} (10 μm) in the cited paper is hundreds of metres.

b. The recent wind-driven suspension event of heavy mineral concentrate (HMC) from stockpiles in Westport already described in 5.20 is pertinent to dust management at the proposed site, because:

(i) it showed that HMC can be blown from stockpiles
(ii) it allows some assessment of the horizontal and vertical scale of particle transport
(iii) evaluation can be made of the wind conditions that caused the particles to move from the stockpiles

[13] Sairanen, M. and Pursio, S. (2020). Near field modelling of dust emissions caused by drilling and crushing. SN Applied Sciences 2:1188.

(iv) without effective dust management problems can occur.

Referred to as the 'Westport event' herein.

c. For the Westport event, the horizontal scale of HMC transport of 100 m referred to in 5.20, and the vertical scale of transport up onto local rooves, was useful information for the modelling.

d. Prior to undertaking the modelling, routine 'back of the envelope' calculations were made using information on dust particle sizes and settling (fall) velocities, locally measured wind speeds, and thresholds for wind-driven dust suspension events (the latter provided by the applicant). The dust particle size class 30–100 μm was found to be important as it can potentially be transported hundreds of metres. Calculations agreed with 9.3a.

e. Observed and modelled dust particle contour plots in Sairanen and Pursio (2020) show that towards the edge of the dust plume, the contours of concentration are close together. An observer or sampling location that is moved perpendicular to the main axis of dispersion, soon reaches the edge of the plume, and soon after that is no longer within the plume. Where contours are close together, monitoring may easily miss the plume, and the same is likely to apply to a dust deposition footprint. This difficulty in sampling in the right place relates to the s42A officer's report recommendation for a dust assessment by a suitably qualified person.

f. The dust deposition gauges, installed by the applicant to measure background dust deposition, may have limitations for monitoring during site operation. Specifically, the dust deposition gauges used: '*Deposition monitoring is a cheap and easy method for monitoring dust nuisance. However, the results can be difficult to interpret because of the poor time resolution of the method (typically 30 days). There is usually too much variation in weather conditions and other factors such as source emissions over this time to allow any sensible correlation with monitoring results*.'[14]

g. For the model input data, information on the location of diffuse and point dust sources was required, in particular in relation to proximity to sensitive receptors. In particular, it wasn't certain on the number and sizes of ore stockpiles, where they were expected to be, and how long they would be there for. There appeared to be many different potential sources of dust across the site, varying in size and location, but also uncertainty regarding how susceptible various areas might be to wind erosion.

h. It is of concern that previous sub-sections (a – e) above, suggest the spatial scale for particle dust transport of the size class < 100 μm could be hundreds of metres, which is more than the width of the proposed buffers.

[14] Good practice guide for air quality monitoring and data management 2009, section 5.1.4 Dust deposition.

10. Dust particle modelling at the TiGa application site – the approach taken

10.1 To try to understand and illustrate some of the concerns with regards to dust management at the proposed site, a published lagrangian (particle tracking) model[15] was modified (referred to as DustMod) and used to predict some scenarios. Scenarios predicted the transport of dust from point sources around the proposed site during windy periods.

10.2 Some crucial information was available which helped to inform the modelling, including local meteorological data, basic particle size information from the application and scientific literature, general information on potential point sources of dust, site layout, and a guideline threshold above which wind suspension events may occur.

10.3 DustMod was used to model dust particle transport for the <100 µm size fraction for a strong south westerly wind, around the same time as the Westport event. The model was also used to predict dust suspension for a strong pre-frontal NE wind. Both scenarios used locally measured 5 minute meteorological data.

10.4 The main point sources in the model were the ore stockpile areas and associated bunds, as the extreme ends of these areas are near to boundaries . In practice, bunds would vary in terms of their potential for dust erosion, and the ore stockpiles would vary in size and location.

10.5 DustMod was not used to model the heavy mineral concentrate because this is expected to be stored inside, or covered.

10.6 DustMod input data are given in the annex and governing equations for the original model here[15]. The model was concerned with particle suspension only, that is dust particles suspended from point sources when the wind gust exceeded the threshold. Particles were then transported horizontally according to mean wind speed plus a more variable random component to crudely represent the effect of turbulence (random walk model). The particles settled vertically according to their fall velocity, finer and slower settling particles taking longer to settle were transported further (a vertical random component was also applied). Final positions of dust particles were then compiled into a contour plot (g/m^2).

10.7 An unknown in the model is how much dust is suspended from each different source with each suspension event (i.e. emission rates), and this is known to be difficult to quantify[16]. This was overcome by increasing the amount available for erosion in each point source until the model predicted approximately 4 g dust/m^2/suspension event at the boundary, and then dust emission rates were broadly compared with published data to check they were acceptable. Bruce et al. (2021) also reverse model in this way, varying emission rates to compare modelled with observed dust emissions.

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[15] Cromey, C.J., et al. (2012). MERAMOD – a model for predicting the deposition and benthic impact of aquaculture in the Eastern Mediterranean. Aquaculture Environment Interactions, 2, 157–176.

[16] Bruce, J. et al. (2021) Relative efficiency of passive dust samplers: Progress towards coarse dust dispersion modelling. Atmospheric Environment 244, 117872.

10.8 In addition to 'suspension', the application dust management plan also mentions 'creep' and 'saltation'. The HMC that was reported to pass through the gutters at street level in the Westport event, could be imagined to be partly caused by saltation - particles bouncing along in short steps away from the stockpile. Neither creep nor saltation, mechanisms associated with coarse particles, were modelled with DustMod (particle resuspension (saltation) model[17] switched off).

10.9 DustMod predictions are unvalidated and are only intended to illustrate certain points relating to dust management. In terms of validity, the predictions perhaps lie halfway between a newly developed model untested or validated in any environment, and a validated near-field dust particle model.

11. What the model predictions of dust dispersion showed

11.1 For the strong SW wind, predictions of dust suspension from the ore stockpile areas and bunds (before grassing) showed that where the trigger level was reached at the boundary, dust deposition rates lower than the trigger level were predicted up to 400 m NE of the site boundary. i.e. the limit of the predicted dust deposition 'footprint' is not tens of metres, but on a scale of hundreds of metres from the source (Figure 11).

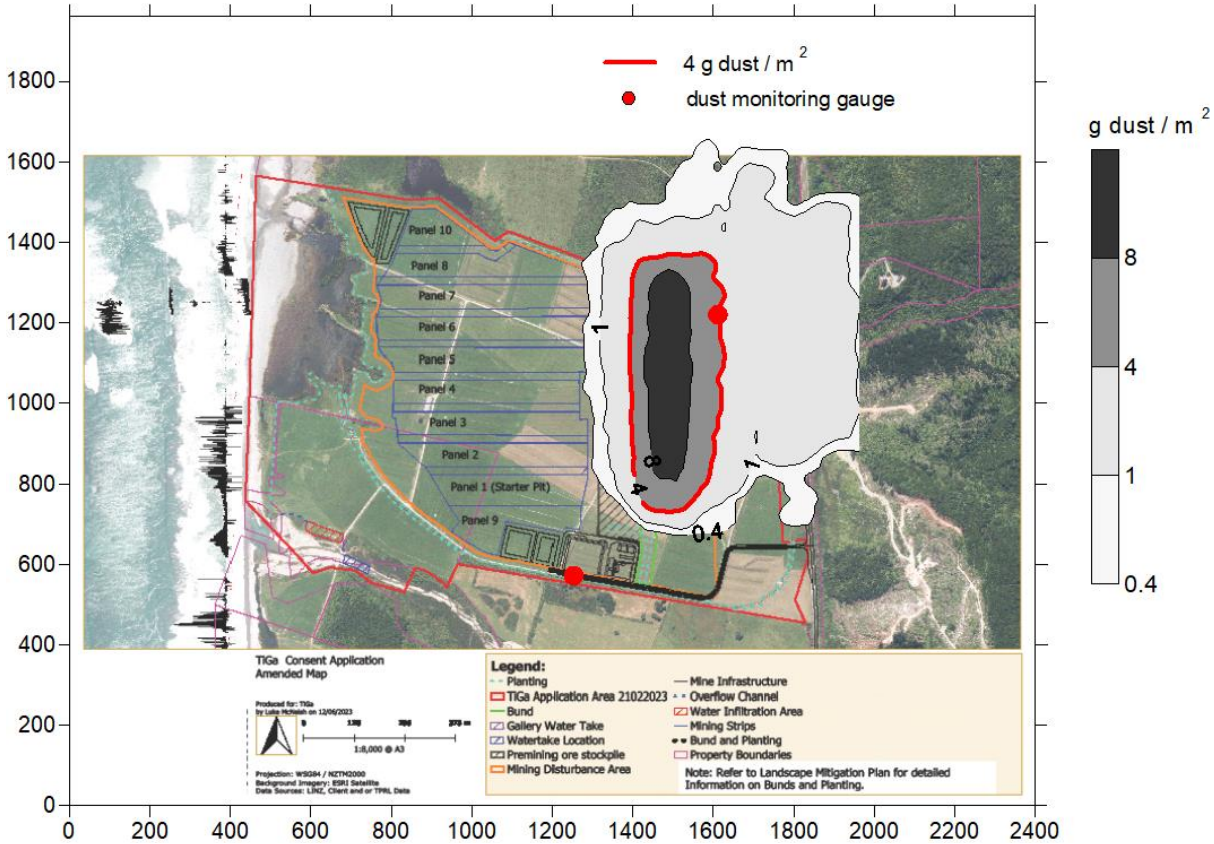

Figure 11. Predictions of dust deposition from the ore stockpile areas for one significant suspension event in a 30 day period caused by an afternoon of strong SW wind. The locally measured meteorological data were for the same period that caused the Westport event. A series of smaller

[17] Cromey, C.J. et al. (2002). Validation of a fish farm waste resuspension model by use of a particulate tracer discharged from a point source in a coastal environment. Estuaries, 25, 916-929.

suspension events over a 30 day period could illustrate a similar picture. 4 g dust/m^2 that deposits over a 30 day period, is a trigger level.

11.2 The above figure also highlights potential problems with dust monitoring. The background monitoring gauge location is shown, and a monitoring gauge placed in the same location during this event would have missed the maximum predicted deposition footprint by approximately 150 metres. It would have measured 4 g/m^2, compared to more than 8 g/m^2 at a different place along the boundary.

11.3 Using a smaller point source i.e. the northern part of the ore stockpile area, the model predictions illustrate similar concerns (Figure 12) – i.e. the extent of the footprint and also positioning dust monitoring equipment where it is not measuring maximum dust deposition rates at the boundary. Any point sources of dust in the model located near the northern boundary, even relatively much smaller ones, would likely highlight similar concerns.

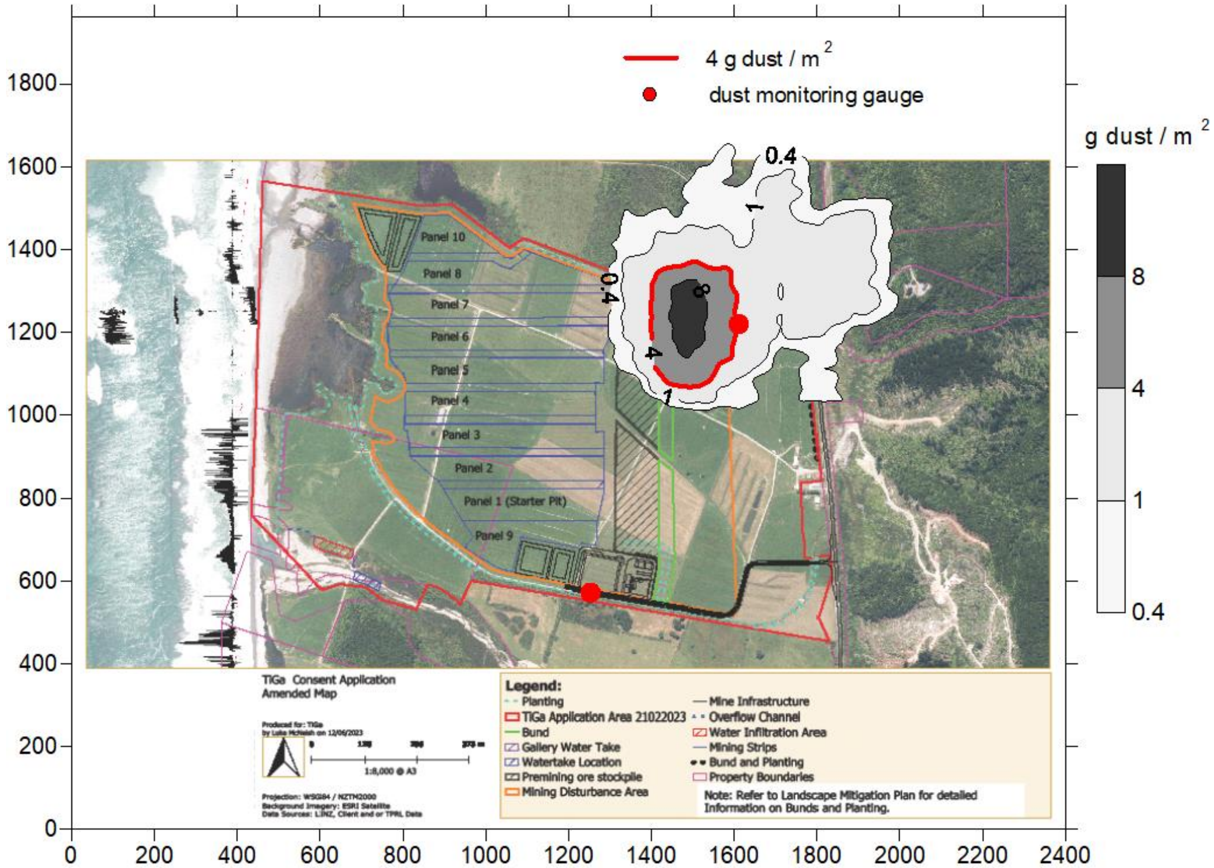

Figure 12. Predictions of dust deposition from the northern ore stockpile area only for one significant suspension event in a 30 day period caused by an afternoon of strong SW wind. The locally measured meteoroligcal data were for the same period that caused the Westport event. A series of smaller suspension events over a 30 day period could illustrate a similar picture. 4 g dust/m^2 that deposits over a 30 day period, is a trigger level.

11.4 The ore stockpile area and bunds are large features, with the extreme ends of these close to the boundary. There might be a period when large areas are recently exposed, and these appear to be large areas to have dust controls, particularly when the conditions for suspension events may develop fast.

11.5 For the pre-frontal NE wind, predicted dust suspended from the southern stockpile area and bunds (before grassing) was transported to the west of the proposed building location, over the ponds and southern boundary (Figure 13). This wind was stronger than the SW wind with more variable direction, with the limit of the deposition footprint at approximately 400 m. Any potential dust sources around the buildings, would add to the predicted deposition footprint for this wind.

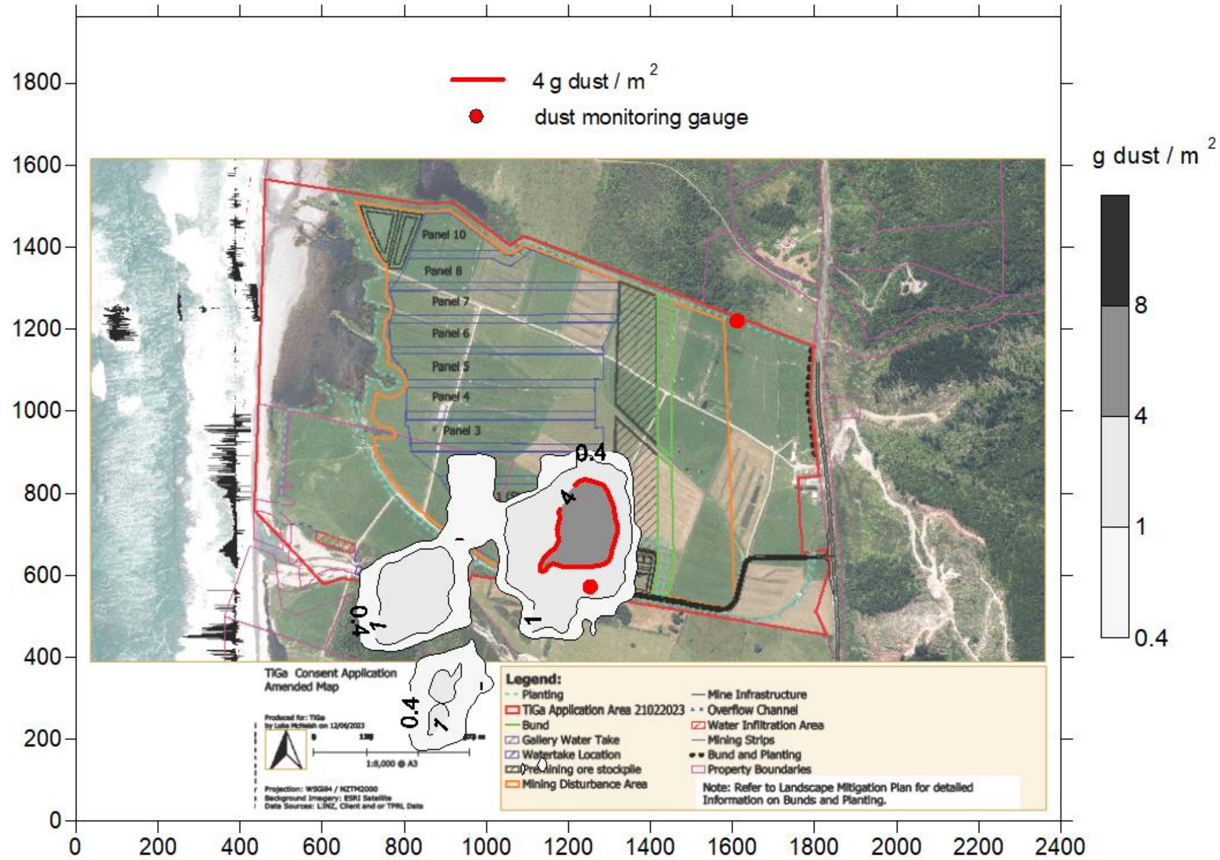

Figure 13. Predictions of dust deposition from the southern ore stockpile area only for one significant suspension event in a 30 day period for a pre-frontal NE wind. The locally measured meteorological data are an example of wind that can occur after some dry weather, but prior to rain. A series of smaller suspension events over a 30 day period could illustrate a similar picture. This prediction does not include potential dust suspension from working areas in the vicinity of the buildings, which would add to this dust deposition footprint. 4 g dust/m^2 that deposits over a 30 day period, is a trigger level.

11.6 Similarly for the SW wind scenarios, the background dust deposition gauge location would have missed the maximum predicted deposition at the boundary.

11.7 The scenarios use dust emission rates which are at the low end of some reported rates (see annex). The measured winds also were from a short sampling period and were only just above the suspension threshold (22 km/h) for some intervals. Higher emission rates and higher winds would result in higher predictions of deposition rates.

12. Conclusion and Recommendations

12.1 The TiGA DMP does not contain assessments of the winds and weather of the local area and does not discuss the effects of dust being dispersed over sensitive receptors, including neighbouring properties. Unvalidated dust particle modelling, illustrated that the fine particle dust fraction (<100 um) can be transported hundreds of metres from the source during strong SW and NE winds.

12.2 The DMP appears to be written with the assumption that the site is wet enough to largely negate the issue of dust, and in fact the application states '*consent is sought as a precaution in case of any dust emission occurring*'.

12.3 While there is a high water table in the area, and the mining is a wet process, once dirt is dug up and exposed to conditions which dry it out i.e. piling it in a bund so a warm dry wind can blow freely over it, it will eventually create dust.

12.4 The DMP states they intend to use 2 dust monitors for the entire site, yet there is no assessment of why they believe this is an adequate solution to dust monitoring. The modelling undertaken illustrates the difficulties with monitoring dust at the right place on the boundary.

12.5 Strong and gusty E winds with low humidity occasionally blow much harder than the SW and NE winds used in the model. Such an E wind, which is not usually forecasted accurately, could blow dust towards the lagoons potentially causing adverse effects.

12.6 The DMP relies heavily on visual checks by personnel each day, who may have differing opinions of what a dust discharge is.

12.7 Dust can happen at any moment in the right conditions. Proper dust management should be designed for specific sites and contexts for specific activities and should be a continuous process, not a check box exercise to complete at the start of a shift.

12.8 The DMP does not identify if there will be any radioactive component to any dust emissions. It contains a dust sampling process and talks about a risk assessment but does not include the parameters of that assessment, nor what an exceedance level actually is.

12.9 We note that the GDC s42A report (p100 point 8) recommends the applicant provide an assessment by a suitably qualified person, as to the level and extent of adverse effects of dust on sensitive receptors. This assessment is to include a comparison to the MFE guidance trigger levels and '*special characteristics of the dust (including but not limited to radiation levels) which would warrant a lower dust trigger level*'. We fully support this recommendation.

12.10 Additionally, page 49 of the s42Areport recommends the applicant address other areas of the DMP. This recommendation is also fully supported as it addresses some of the issues raised in this statement.

12.11 There are concerns around the lengthy list of consent conditions, which no doubt will undergo more revisions, but would ultimately need to be complied with. There is a lack of confidence that Councils have the capability to oversee these works successfully, as well as concerns around conditions that appear to be selfmonitoring. The importance of strict monitoring cannot be stressed enough and should not be left to the applicant.

Annex to Lay witness statement of factual evidence – Dust particle modelling

Input data/model component	Value	Data source/reference/notes	Foot note
Topgography	Flat	-	
Positional information, stockpile areas, etc.	Dimensions from application, relative distances between features in metres	Application	
Meteorological data			
SW	01/01/24 11:00-20:00	Measured locally and wind speed/gusts scaled by 1.5	1,2
NE	31/12/23 01:14-04:10	Measured locally; not scaled	3
Wind sampling interval	5 minute	-	
Height of wind vane above ground	3 m	-	
Wind threshold for suspension events	22 km/h	Applicant's Dust management plan	
Random walk model	$k_x, k_y = 0.1\ m^2\ s^{-1}$, $k_z = 0.001\ m^2\ s^{-1}$	Approximate (set to a low value precautionary)	4
Point sources	Northern and southern ore stockpile areas (stockpile/bunds (bare)/exposed surface areas) with maximum heights of 4.5 m	Application documentation	5
Particle fraction simulated in model	< 100 µm	Size fraction of interest (dust)	6
PM10, PM2.5	Excluded	Complex problem - model predictions indicate direction of transport for these fractions, but not intensity	
Particle settling velocity (% of emission in suspension event by mass)(approx. particle diameter size class)	16.8 cm s^{-1} (40 %) (65 µm) 7.8 cm s^{-1} (30 %) (45 µm) 3.5 cm s^{-1} (30 %) (30 µm)	Stokes' law	7
Particle transport mechanism simulated	Suspension: erosion, transport in air,	Modified particle tracking models developed and validated in	8,9

	deposition (no further erosion)	marine environment	
Dust erosion (emission) rates SW wind event Pre-frontal wind NE	17 – 21 g/m2 total for each event See table below	Reverse modelled to approximate trigger level at boundary See comparison below with published dust emission rates from mining activities	10,1 1,12
		Reverse modelled from trigger level at boundary	
Model trajectory evaluation precision	Particles transported 6 second ‘steps’, 0.001 m precision	Appropriate settings for spatial/temporal scale of predictions	
Model grid size (cell resolution)	2400 m by 2000 m (25 m by 25 m)	Encompasses area of interest – cell resolution adequate	13

Notes.

1. Westport event reported as afternoon of 02/01/24, but similar wind speeds/gusts/humidity on afternoon of 01/01/24 also (Westport aerodrome hourly data – NIWA). Used local measurements for windier of the afternoons which was 01/01/24 locally
2. Scaled by 1.5 to represent windier conditions at proposed sites as local measurements in sheltered location for SW wind
3. Measured pre-frontal wind data used as an example of strong NE pre-frontal winds that can occur; following dry spells, some pre-frontal winds are strong and gusty before rain
4. Intentionally set to low values so predictions are not influenced by uncertain parameters (higher values would tend to elongate predicted dust ‘footprint’ along main axis of wind causing event; higher values would also simulate effect of gustier conditions)
5. Particle initial conditions at point sources: random position horizontally, vertical height 4 m (which simulates particles eroding from top of stockpiles/binds and particles being lifted up in gusts from lower areas and slopes.
6. 10 % of sample < 100 µm, 5 % by mass of sample < 90 µm (PSD plot of mineral sand bulk sample in Att I Hydrological assessment). Shows that the particle sizes being modelled are present in some samples (heavy mineral concentrate not modelled as proposed to be under cover). Exposed bunds and surfaces/soils etc. likely to contain this fraction also.
7. Approximation of settling velocity
8. Standard lagrangian model governing equations used across different disciplines (DustMod model (inc. GUI and unused components) - 36 000+ lines code)
9. Creep and saltation not modelled – these are primary mechanisms for larger particles > 100 µm
10. Similar to reverse modelling the observed by varying emission rates (Bruce et al. 2021)
11. Avoided excessive variation and complexity in emission rate model parameters. Used a constant emission rate for a suspension event; pre-frontal wind scenarios approximately double the SW wind scenarios as mean wind speed and gust higher in pre-frontal wind

12. It was necessary to check that the amounts of dust eroded from the point sources were broadly within expected emission rates. Mass balances for the model are in the following table.

Point source	Scenario	Total period (hrs)	No. of 5 min time steps wind threshold exceeded	Total mass eroded (kg)	Planar areas (m^2)	Total mass eroded (g/m^2)	Emission rate ($g/m^2/s$)
Whole ore stockpile area/bunds (bare)	SW wind	8	41 (total = 3.42 hrs)	1687	79 000	21	0.002
Northern ore stockpile area/bunds (bare)	SW wind	8	41 (total = 3.42 hrs)	739	34 625	21	0.002
Southern ore stockpile area/bunds (bare)	Pre-frontal NE	2	15 (total = 1.25 hrs)	466	27 125	17	0.004

The largest predicted dust suspension event was the whole stockpile area/bund (bare), where 1687 kg were eroded from 7.9 ha. If there were 5 of these dust events in one year from that area, emission rate would be 1.06 tonnes dust/ha/yr. Published rates for estimations of dust emissions from mining for planning purposes were found to be in the range of 1.64 t/ha/yr (with dust controls) to 16.4t/ha/yr (without dust controls)[18]. 1.06 tonnes dust/ha/yr used in the model is at the low end of this range and so shows dust erosion rates from the stockpile areas/bunds (bare) were reasonable.

13. Particle inventory precision maintained until end of simulation, where grid cell summaries are contoured in Surfer for Windows™

[18] Bruce, J. et al. (2021) Relative efficiency of passive dust samplers: Progress towards coarse dust dispersion modelling. Atmospheric Environment 244, 117872 (references to European Environment Agency EMEP/EEA air pollutant emission inventory guidebook 2016)