Before Independent Commissioners Appointed by the Canterbury Regional Council and Selwyn District Council

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| In the matter of | The Resource Management Act 1991 |
| And | |
| In the matter of | Applications by Fulton Hogan Limited for all resource consents necessary to establish, operate, maintain and close an aggregate quarry (Roydon Quarry) between Curraghs, Dawsons, Maddisons and Jones Roads, Templeton |

SECOND JOINT WITNESS STATEMENT OF:

(1) DEBORAH RYAN;
(2) ROGER CUDMORE;
(3) CHARLES KIRKBY; AND
(4) LOUISE WICKHAM.

AIR QUALITY – PARTICULARLY $PM_{10}$

DATED: 9 DECEMBER 2019

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## Introduction

1. This Joint Witness Statement (JWS):

   (a) Relates to a reconvened expert conference in relation to Fulton Hogan Limited's proposal to establish, maintain and close the Roydon Quarry; and

   (b) Reports on the outcome of the second expert conference between the four air quality experts[1] who have filed evidence in this matter.

2. The first JWS of the air quality experts dated 14 November 2019 clarified key operational details for the proposal and noted:

   (a) the applicant proposed a maximum throughput of 725,000 tonnes per year (t/yr); and

   (b) Mr Cudmore had assessed a throughput of 600,000 t/yr.

3. The air quality experts note that the application document submitted to Canterbury Regional Council and Selwyn District Council in November 2018, proposed an average throughput of 600,000 to 700,000 t/yr.[2]

4. During the first week of hearing the Commissioners received a supplementary statement from Ms Wickham dated 21 November 2019 in which she provided updated estimates of annual $PM_{10}$ emissions based on a throughput of 750,000 t/yr.[3] The Commissioners directed further conferencing to address the following matters:

   (a) Whether each air quality expert agrees or disagrees with Ms Wickham's assessment of the predicted annual emissions of $PM_{10}$ (t/yr) from the proposed Roydon Quarry.

   (b) If an air quality expert disagrees with Ms Wickham's assessment then that expert is to provide a detailed alternative assessment (using the same general format as Ms Wickham) of the predicted annual emission of $PM_{10}$ (t/yr) from the proposed Roydon Quarry that clearly shows any differing assumptions that support their alternative assessment.

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[1] Deborah Ryan (witness for CRC); Roger Cudmore (witnesses for Fulton Hogan); Charles Kirkby (witness for Templeton Residents Association); Louise Wickham (witness for Canterbury District Health Board).

[2] Golder Associates (NZ) Ltd, (2018). Fulton Hogan Ltd Resource Consent Application to Establish 'Roydon Quarry', Templeton. Christchurch. November. at page 47.

[3] Maximum throughput advised by the applicant to air quality experts via email on 12 Nov.

(c) What scalar reduction of $PM_{10}$ emissions from the Yaldhurst study each expert considers to be appropriate with reasons.

5. The second expert conference was held on 2 December 2019 at the Christchurch office of Golder Associates with Ms Ryan and Ms Wickham attending remotely from Wellington and Auckland respectively. Mr John Hardie (Barrister and Mediator) facilitated the conference.

6. The experts involved have read Appendix 3 of the Environment Court Practice Note and confirm compliance with it.

7. In particular (and as set out in paragraphs 1(a) and (b) of Appendix 3) the witnesses understand:

   (a) the role of a JWS is to clearly record the issues agreed and not agreed, between them. Succinct reasons are to be captured in the JWS. This will assist all parties and the decision-makers in focussing on the matters that remain in dispute and the significance of them;

   (b) expert conferencing is not a forum in which compromise or a mediated outcome between the experts is anticipated. Unlike mediation, the “aim” is not resolution. Rather, the aim is clear identification of and narrowing of points of difference.

8. In order to address the Commissioners’ questions the following key assumptions were discussed. The design and site-specific information are important in $PM_{10}$ emissions calculations completed by the experts:

   - Travel distance/roading surfaces
   - Silt content for unsealed areas
   - Moisture content of topsoil
   - Gravel loading/ unloading emission control
   - Mr Cudmore’s emission reduction factor for product size

**9. Travel distance/roading surfaces**

9.1 Mr Cudmore has confirmed that the design of the road (for each of clean filling, and topsoil removal) is that the annual mean travel distance is 250 m each way. Of this 200 m is pea gravel/reject material (that is replaced and/or watered as required) and the remainder (50m) is a gravel quarry surface that is watered.

9.2 Mr Cudmore considers the distance between extraction areas and the mobile plant will be much shorter at an average would be 100 m over a year. This is because this plant would need to operate 250 m away from the northern, western and southern site boundaries and 500 m from the eastern site boundary.

**10. Silt content for unsealed areas**

10.1 Testing of Pound Road material (pit run) silt content is around 3%. Mr Cudmore considers this testing to be representative of the Roydon site and has conservatively assumed 4.8% silt content (based on US EPA for gravel quarry roads). The experts all agreed this is a reasonable assumption.

**11. Moisture content of topsoil**

11.1 Mr Cudmore has reviewed the Landcare soil maps for the site (https://smap.landcareresearch.co.nz/). These indicate soil moisture content varies between approximately 10% and 30%, with a lowest measurement just below 5%. Mr Cudmore therefore adopted 8% soil moisture as an appropriate annual average. The experts all agreed this is a reasonable assumption.

**12. Gravel loading/unloading emission control**

12.1 Mr Cudmore advised that for:

(a) Excavation: water will be applied if the excavated material is not damp; and

(b) Loading/unloading conveyors: water suppression will be used on conveyor transfer points including the conveyor hoppers.

**13. Mr Cudmore's emission reduction factor for product size for process plant**

13.1 Mr Cudmore advises for the Roydon quarry proposal, he estimated $PM_{10}$ emissions from the processing plant by using the US EPA emission factor for tertiary crushing with water control (that is for producing fine chip products) as there are no factors for production of coarse products as proposed for Roydon. To adjust the process plant emission factor so it would be applicable to a coarse production plant, he applied a further reduction by 80% (i.e. a five-fold reduction) to the US EPA emission factor. This was applied to account for the reduced $PM_{10}$ emissions from the proposed plant at Roydon compared to what typically occurs at the Yaldhurst quarry site (i.e. tertiary crushing to produce fine chip and sand products.

13.2 At Yaldhurst, the production of aggregates is focused on the asphalt, concrete and road chip sealing market. This means that 100% of stone quarried is primary, secondary and then tertiary crushed and screened to produce aggregate products in the range of 5 to 20mm and sand. Mr Cudmore understands that typically, five screens are needed for this overall process, three of which need to operated dry and cannot use water mist control because the screens for the fine products block up. Background documents to the US EPA emission factors for tertiary screening also mention this.

13.3 The proposed Roydon quarry will operate like the Fulton Hogan Pound Rd site – that is the processing plant would only produce coarse aggregate products which includes AP65, AP40 and AP20. This means that of the total annual production, only 50% or less is fed to the crusher. AP65 is the highest volume product that is produced, and this typically contains about 70% of stone that has not been through a crusher. AP40 is around 40% of the market and contains about 40% of stone that is not crushed. For fine chip and sand production at Yaldhurst, 100% of excavated stone is crushed.

13.4 The other coarse product streams also have significant fractions of stone that have not been crushed, as their specifications require 50% of their content to have a crushed face.

13.5 Therefore, for the Roydon proposal processing plant, approximately 50% of the excavated stones are crushed and down to 22 mm in size. This can be compared to the fine chip and sand production plants at Yaldhurst where 100% of the excavated stones are crushed and via three crushing stages to produce chip and sand products.

13.6 Therefore, Roydon has a 50% reduction in crushing and screening emissions from per tonne of material processed compared to fine chip/sand plants simply based on the fraction of material crushed in the incoming stream.

13.7 However, Mr Cudmore considers there is clearly further significant reduction in emissions per tonne of material processed when crushing and subsequent screening of material down to 22 mm size compared to processing down to fine chip and sand size range products via tertiary crushing.

13.8 Further quantifiable reduction in emissions also stems from the lower number of screens needed (only two further coarse product production versus five for fine chip production). Furthermore, the additional screens needed for fine product production cannot have direct water control of emissions otherwise this causes screen blockages.

13.9 Therefore, Mr Cudmore's view is that applying the same $PM_{10}$ US EPA emission factors for tertiary crushing and screening (kg/Tonne) to Yaldhurst and Roydon processing plants will grossly overstate the latter's emissions relative to Yaldhurst.

13.10 Mr Cudmore's 80% reduction of the USEPA specified controlled tertiary emission factor (relevant to fine chip and sand production) takes into account:

(a) the inherently lower potential for $PM_{10}$ from top/base coarse crushing and screening plant

(b) the lower number of crushers (2 vs 3) operated by top/base coarse plants

(c) the lower number of screens (2 vs 5) operated by top/base coarse plants

(d) the higher level of control (100% versus 40% water control of screens)

(e) the lower fraction of total material that is actually crushed (50% versus 100%)

14. The remaining air quality experts had differing views on Mr Cudmore's approach. These are detailed in the appendices but may be summarised as follows. Ms Ryan, Mr Kirkby and Ms Wickham consider the US EPA emission factors appropriate for a process to produce >20 mm aggregate, with the actual throughput, number of screens and crushers, and presence of emission control measures being central to the overall calculation.

### Summary of Roydon $PM_{10}$ emission estimates

15. Based on the above matters, the experts have considered their input assumptions for calculation $PM_{10}$ emissions from the Proposal. Annual $PM_{10}$ emissions are summarised in **Table 1** on a design throughput of 625,000 tonnes/year and **Table 2** (first year only).

16. Full details of assumptions and reasons for agreement, and disagreement by the experts are provided in Appendix A (Mr Cudmore), Appendix B (Ms Ryan), Appendix C (Mr Kirkby) and Appendix D (Ms Wickham).

**Table 1 Estimated Annual $PM_{10}$ Emissions:**

| | **LW** | **RC** | **DR** | **CK** |
|---|---|---|---|---|
| Assumed throughput (t/yr) | 625,000 | 625,000 | 625,000 | 625,000 |
| **Source** | **Annual $PM_{10}$ Emission Estimate (kg/yr)** | | | |
| Topsoil stripping (3.2 ha) | 239 | 174 | 174 | 196 |
| Wind erosion | 98 | 98 | 98 | 98 |
| Gravel loading/ unloading/ transfer | 461 | 328 | 328 | 461 |
| Gravel processing | 663 | 191 | 663 | 663 |
| Trucks/Loader on unsealed areas | 1,429 | 810 | 810 | 1,029 |
| **Total (t/yr)** | **2.9** | **1.6** | **2.1** | **2.4** |

**Table 2 Estimated Annual $PM_{10}$ Emissions: First Year**

| | **LW** | **RC** | **DR** | **CK** |
|---|---|---|---|---|
| Assumed throughput (t/yr) | 150,000 | | | 150,000 |
| **Source** | **Annual $PM_{10}$ Emission Estimate (kg/yr)** | | | |
| Topsoil stripping (5 ha) | 181 | | | 342 |
| Bund formation | 2,981 | | | 1,445 |
| Gravel processing | 159 | | | 329 |
| **Total (t/yr)** | **3.3** | | | **2.2** |

17. Mr Cudmore and Ms Ryan have not estimated the emissions for Year 1 because in their view emissions for Year 1 will be lower than the estimates for subsequent years. From a review of Ms Wickham's calculations, the majority of the emissions come from the travel by haul trucks. Ms Wickham assumes all of the movements occur on unsealed roads for a total distance each way of 500 m and a total distance per truck of 2 km. Mr Cudmore advises that as an average travel distance for the site seems high. Given the proposed mitigation measures to undertake the works outside of summer months and to pre-dampen bund materials, as required, Mr Cudmore and Ms Ryan consider that the emission factors used by Ms Wickham are unrealistically high.

18. Ms Wickham agrees that the travel distance per truck is relatively high. This is because the site is very large and unformed, with each truck travelling 500 m to the central processing area and then 500 m to each edge of the site to form the bund. Ms Wickham considers the emissions estimates to be reasonable, noting the calculations incorporate a 70% reduction factor for watering mitigation.

**Scalar Reduction between Yaldhurst and Roydon**

**Mr Cudmore**

19. Mr Cudmore considers that a reduction factor (to apply to measured air quality effects at Yaldhurst) is likely to be greater than 10 given the design differences of the Proposal compared to quarries operated at Yaldhurst.

20. Mr Cudmore has advised that the emissions for activities at Yaldhurst are estimated at 35.4 tonnes per year. Mr Cudmore indicated that there are sources of $PM_{10}$ at Yaldhurst that he has not accounted for in the Yaldhurst estimates and that he has generally applied factors that would not overestimate Yaldhurst emissions i.e. his estimate is at the low (conservative) end for Yaldhurst.

**Ms Ryan**

21. Given this basis for the Yaldhurst estimates and the range of estimates from the experts in Table 1, Ms Ryan agrees that in total mass emission terms, the ratio of emissions from Yaldhurst as compared to the Roydon quarry will be a factor of more than 10 times, with the estimates ranging from 12 to 22 times the emissions for Yaldhurst compared to Roydon (not accounting for the advised conservatism in the Yaldhurst mass emission estimate).

**Mr Kirkby**

22. Mr Kirkby considers that, despite the limitations of the approach, using $PM_{10}$ concentrations measured in the vicinity of the existing Yaldhurst quarries, with a suitable scaling factor, is an appropriate method to estimate potential off-site effects of the proposed Roydon Quarry.

23. However, a considerable degree of caution needs to be applied in deriving an appropriate scaling factor, because of the differences in layout of the two sites and the distances between the monitoring sites and the boundary of the Yaldhurst quarries.

24. While it has not been possible to verify Mr Cudmore's emission estimates for the Yaldhurst quarries, Mr Kirkby accepts that those estimates are likely to be reasonably representative.

25. Given a ratio of 14.5 between the estimated emissions from the Yaldhurst quarries and his estimates for the Roydon Quarry, Mr Kirkby considers that a factor of 10 is the maximum that could be applied (allowing for a reasonable margin of error in both estimates).

**Ms Wickham**

26. Ms Wickham reiterates the limitations of using a scalar approach in comparing Yaldhurst with the proposal:

    - The emissions estimates for Roydon do not include all sources;
    - None of the air quality experts have verified Mr Cudmore's emissions estimates for Yaldhurst. This limits confidence in comparisons of overall emissions; and
    - This approach will not address the highly variable nature of key sources, particularly those located at the edge of the site close to sensitive receptors.

27. However, in the absence of further information Ms Wickham suggests a scalar reduction of between five and seven for maximum increases in daily $PM_{10}$ may be appropriate.

**Signed 9 December 2019**

Roger Cudmore

Charles Kirkby

Deborah Ryan

Louise Wickham

## APPENDIX A PM$_{10}$ EMISSION ESTIMATES OF MR ROGER CUDMORE

**Points of Agreement with Mr Kirkby and Ms Wickham**

- Site specific silt content 4.8%
- Site specific moisture content 8%
- 84% reduction in PM$_{10}$ from wind erosion due to application of pea gravel to exposed areas

**Points of Difference**

1. For truck movement related emission estimates - Ms Wickham produces much higher values than myself and Mr Kirkby. The reasons for her higher estimates are as follows:

2. Myself and Mr Kirkby have applied 84% reduction in PM$_{10}$ due to application of reject gravel on the majority of internal roads surfaces - Ms Wickham does not agree with this reduction and treats the material as having no emission reduction benefits. I do allow for final sections of road (50 m) to not be covered in reject material and only assumed water control of dust at 70% reduction for these areas.

3. The key differences are driven by the assumed return distances to the mobile crusher from areas of excavation. Mr Kirkby and Ms Wickham both insist that average distances to and from the extraction area and the mobile plant are well in excess of the 250 m return trip distance that I have assumed. I consider this is realistic given constraints on where the mobile plant can operate and the need for extraction to be close by for this to be practical.

4. The other key difference in truck movement emissions relates to those associated with clean filling. Again, I have applied 84% reduction in PM$_{10}$ due to application of reject gravel on internal roads surfaces - Ms Wickham does not agree with this reduction and treats the material as having no emission reduction benefits. I also allow for watering to provide a further control of 70%. Overall these combined controls will achieve a 95% reduction over the uncontrolled emissions.

5. For material transfer related emission estimates - Ms Wickham and Mr Kirkby produce higher values than myself. The key reason for the higher estimates is that I assume 70% reduction in emissions due to use of water misters – Ms Wickham and Mr Kirkby do not agree with this reduction. I do not understand their rationale for this. I note that if the material is wet (as is expected then) then this already exerts a reduction in emission as calculated by the uncontrolled emission factor, and so it is still valid to applied the 70% control.

6. For the process plant, our calculations of emissions have moved closer together. However, there is still significant differences due to the reduction in emissions due to the type of products produced at Yaldhurst versus the Proposal. I have applied an 80%, which I consider conservative to account for the vastly lower emission potential of a top/base coarse plant versus one making fine chip sand product. This impacts on screening and crushing emissions per tonne of material. Ms Wickham appears to accept a 50% reduction for crushing emissions (based on material not put through a crusher) but she assumes no relative reduction for screening of product at Roydon versus Yaldhurst. Mr Kirkby had assumed an additional screening emission for Roydon that is not required, but I understand he has amended this in the final version.

7. The key point is that I have compared the relative emissions from each of the sites (Yaldhurst vs Roydon) to support the overall reduction factor and so have the absolute correct emissions for processes at Yaldhurst is not critical to this, what is critical is to consider the relative difference in emissions between the plant.

8. The following Table A1 provides a summary of Ms Wickham's and my own itemised emissions estimates for all general categories of $PM_{10}$ emission. To complement the above discussion, I provide final columns that outline the reasons for our numbers being different, where that occurs.

**Table A1: Comparison of $PM_{10}$ emission estimations for Roydon Quarry by Louise Wickham (LW) and Roger Cudmore (RSC) and reasons for differences**

| Activity | Unit | LW Value | RSC Value | Different Formula? | Different Input Values? |
|---|---|---|---|---|---|
| Production rate | Mg/year | 625,000 | 625,000 | | |
| | | | | | |
| **1.0 Overburden Stripping** | | | | | |
| 1.1 Topsoil removal* | kg/yr | 104 | 111 | No | Small difference in stripping depth (0.7 m vs 0.75 m) |
| 1.2 Loading of topsoil into trucks\loader* | kg/yr | 6 | 6 | No | No. |
| 1.3 Dumping of topsoil* | kg/yr | 6 | 6 | No | Ditto above |
| 1.5 Trucks carrying topsoil* | kg/yr | 123 | 49 | Very similar | Yes.<br><br>I have assumed 100 m of unpaved travel distance and remaining road surface to be reject material (consistent with the design). LW assumes 500 m of unpaved road travel distance, which is not consistent with the design. |
| ***Subtotal*** | ***kg/yr*** | ***239*** | ***174*** | | |
| | | | | | |
| **2.0 Wind erosion** | | | | | |
| **2.1 Dust pickup**<br>**(5 ha dust erosion prone area)** | **kg/yr** | **98** | **98** | No | No |
| | | | | | |
| **3.0 Gravel loading/unloading** | | | | | |
| 3.1 Excavation* | kg/yr | 106 | 61 | No | Yes. I have assumed 5% moisture for aggregate and LW assumes 8%.<br><br>I also assume 70% reduction for use of dust suppression water. Whereas LW assumes no further reduction due dust suppression water. |
| 3.1 Loading of gravel* | kg/yr | 106 | 61 | No | Ditto above |

| Activity | Unit | LW Value | RSC Value | Different Formula? | Different Input Values? |
|---|---|---|---|---|---|
| 3.2 Unload of gravel | kg/yr | 106 | 61 | No | Ditto above |
| Conveyor Transfer Points | kg/yr | 144 | 144 | No | No |
| ***Subtotal*** | ***kg/yr*** | ***461*** | ***328*** | | |
| | | | | | |
| **4.0 Gravel processing** | | | | | |
| 4.1 Screening (controlled) | kg/yr | 463 | 93 | No. | Yes. I have applied a reduction of 80% to the PM emission factor applied to screening emissions at Yaldhurst. This is to account for less screens, and less screening emission per tonne of production due to not crushing stone below 22 mm at Roydon. LW calculations assumed screening related emissions at Roydon will be the same as at Yaldhurst per tonne of production. |
| 4.2 Crushing (controlled) | kg/yr | 169 | 68 | No. | Yes. I have applied a reduction of 80% to the PM emission factor applied to crushing emissions at Yaldhurst. Reasons are provided in Section 12 of the main body of the JWS.<br>LW has applied a 50% reduction factor for crusher emissions |
| 4.3 Conveyor transfers (controlled) | kg/yr | N/A | N/A | No | LW and I have accounted for these emissions in Gravel/Loading Unloading emissions (Section 3 of this table). |
| 4.4 Truck loading - conveyor crushed* | kg/yr | 31 | 31 | No | No |

| Activity | Unit | LW Value | RSC Value | Different Formula? | Different Input Values? |
|---|---|---|---|---|---|
| ***Subtotal*** | ***kg/yr*** | ***663*** | ***191*** | | |
| | | | | | |
| **5.0 Trucks and cleanfill** | | | | | |
| 5.1 Trucks moving material to mobile plant | kg/yr | 326 | 154 | Yes. But LW applies a US EPA equation that accounts for reduction in annual emissions due to rainfall throughout the year. This makes a small 10% reduction. Otherwise the key emission equation is the same. | Yes.<br><br>I have assumed 100 m of unpaved travel distance and remaining road surface to be reject material (consistent with the design). LW assumes 500 m of unpaved road travel distance, which is not consistent with the design.<br>. |
| 5.2 Trucks bringing clean fill to site* | kg/yr | 714 | 268 | Ditto as above. | Ditto as above. |
| 5.3 Trucks dumping cleanfill* | kg/yr | 194 | 194 | No | No |
| 5.4 Loader pushing up cleanfill* | kg/yr | 194 | 194 | No | No |
| ***Subtotal*** | ***kg/yr*** | ***1428*** | ***810*** | | |
| | | | | | |
| **Total $PM_{10}$** | **T/yr** | **2.9** | **1.6** | | |
| Total $PM_{10}$ (< 500m from boundary) | T/yr | | 1.0 | | |
| | | | | | |

*This emission is assumed to be within 500 m of the airshed boundary
** A portion of this emission is assumed to be within 500 m of the airshed boundary (47 kg of the 98 kg) is assumed to be within 500 m of the airshed boundary.

## APPENDIX B PM$_{10}$ EMISSION ESTIMATES OF MS DEBORAH RYAN

### *80% reduction figure for the crushing and screening plant*

1. Ms Ryan agrees that it is appropriate to consider that only half of the annual throughput is crushed based on Mr Cudmore's advice; this is due to the nature of the material and the aggregate grades produced. Ms Ryan considers that any uncertainty about future aggregate grades produced can be addressed by conditions, given this is the basis on which the assessment of PM$_{10}$ has been made.

2. Ms Ryan disagrees with Mr Cudmore's stated reduction value of 80% on all crushing a screening plant because she considers this is not supported by the US EPA emission factors. In her review of the emission factor documentation for crushing plant, Ms Ryan found that the controlled emission factors for crushing and screening were the most appropriate factors to the level of crushing and screening undertaken at Roydon Quarry i.e. they were derived from measurements of tertiary cone crushers controlled with water sprays.

3. In particular, Ms Ryan notes that there are other emission factors provided for fine materials. Ms Ryan considers that it is not appropriate to adjust the USEPA emission factors based on comparisons with activities at Roydon with those at Yaldhurst quarries when undertaking the estimate for the Roydon quarry. Rather this difference should more appropriately be accounted for in the estimate of emissions provided for the sources at Yaldhurst, and the use of appropriate factors for processing fines materials or uncontrolled emission factors as applicable at that site. For these reasons, Ms Ryan's estimates for the crushing and screening plant only account for the factor of half the material being screened and otherwise accord with Ms Wickham's estimate

### *Emissions for P metal areas*

4. Mr Cudmore and Mr Kirkby have agreed that the Australian NPI emission factor is appropriate to use for wind erosion and the trafficked areas covered with reject material, an 84% reduction. Ms Ryan accords her estimate with that of Mr Cudmore on the basis that he has advised the areas that will be covered with reject material and how the site will operate, and Ms Ryan considers that Mr Cudmore has the best understanding of proposed operations at the Roydon site in practice. In particular, Mr Cudmore advised that conveyors would be used to transport material from the east to the mobile plant when required, rather than larger distances by truck.

5. Ms Ryan notes that a high level of maintenance on the reject areas will be needed to maintain the low levels of dust from trafficked areas as assessed by Mr Cudmore.

*70% reduction factor for control by watering*

6. Ms Ryan agrees with Mr Cudmore that a 70% reduction factor for watering can generally be applied to the relevant sources. This is because Mr Cudmore advised during conferencing that watering would be provided at transfer and operational areas, some fixed and some in the event that material becomes dry. Ms Ryan's view, given the assumed moisture accounted for in the emission estimates is conservative, i.e. at the low end of the range of the data provided, there is effectively additional watering already provided inherent in the material. Consequently, given that further additional watering will be undertaken as needed, then this represents an additional control that can reasonably be factored into the estimates in Ms Ryan's view.

**7.** Based on the above, Ms Ryan's estimates are as set out in Table 1.

## APPENDIX C PM$_{10}$ EMISSION ESTIMATES OF MR CHARLES KIRKBY

### Points of Agreement with Mr Cudmore

My updated estimates incorporate the following parameters advised by Mr Cudmore during conferencing 2 December 2019 and in subsequent emails:

- Maximum throughput 625,000 T/yr
- Site specific silt content 4.8%
- Site specific moisture content 8%

### Points of Difference

***Site preparation***

I note that Mr Cudmore has calculated emissions from soil disturbance on the basis of 3.2 ha rather than 2.2 ha. I have adopted this larger (more conservative) value.

***Travel distance assumptions***

Mr Kirkby considers that applying an emission factor of zero to gravelled areas is not sufficiently conservative. He accepts that this may be reasonable for newly covered areas (silt content effectively zero), but abrasion as a result of vehicle movements will immediately start to increase this.

Table 6 of the Australian NPI emission estimation technique manual for Fugitive Emissions v2.0 gives an emission reduction factor of 84% for wind erosion following the application of gravel to unsealed areas. In the absence of any other emission reduction factor for trafficked areas, Mr Kirkby considers this an acceptable substitute.

During the first 10-15 years of normal operations, the mobile plant cannot operate within the excavation area (must be at least 500m from the eastern boundary, and within the excavated pit – i.e. within the central processing area). Therefore, average distance travelled on gravel/reject material is 200m each way.

***Crushing and screening***

Mr Kirkby understands Mr Cudmore's reasoning for applying an emissions reduction factor for the production of basecourse (AP20, AP40 and AP65) at the site, but does not agree with the factor that he used.

Mr Jolly's evidence-in-chief specifically states that "aggregate which will be produced from Roydon quarry will be suitable to make good quality topcourse, basecourse and sub-base products" (para. 31). The manufacture of topcourse products (as noted by Mr Cudmore) is likely to generate significant proportions of fine particulate. In response to questions at the hearing, both Mr Stewart & Mr Jolly clarified that the product mix is now as stated by Mr Cudmore above. This should be confirmed by way of a condition.

Mr Kirkby has assumed that, on average, 50% of material will not require crushing, but it will all require screening etc.

***Gravel extraction and transfer***

The raw material is naturally damp – Mr Cudmore has used a figure of 8% moisture, conservatively derived from site-specific data. Because of the moisture content of the raw material, no additional water suppression is proposed in the extraction area. Any water suppression applied at conveyor loading and unloading points would be a replacement for moisture lost in transit. Therefore, application of an additional emission reduction factor for wet suppression is not appropriate.

## 1.0 Site Preparation

### 1.1 Topsoil removal by scraper

| | | | |
|---|---|---|---|
| Area excavated each year | 3.2 | ha | Updated in line with R Cudmore calculations (Attachment A) |
| | 22,000 | $m^2$ | |
| $PM_{30}$ EF | 0.029 | kg/Mg | Table 11.9-4 |
| Average depth | 0.7 | m | Stated value in evidence of Bligh & Jolly |
| Topsoil to remove | 15,400 | $m^3$ | |
| | 1.6 | $Mg/m^3$ | Updated from evidence of R Cudmore dated 6 Nov 2019 |
| | 24,640 | Mg | |
| $PM_{30}$ annual emission | 714.56 | kg | |
| Assume $PM_{10}$ | 10% | $PM_{30}$ | |
| **$PM_{10}$** | **104** | **kg** | |

### 1.2 Loading of excavated material into trucks

| | | | |
|---|---|---|---|
| Topsoil to load | 24,640 | Mg | |
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 8 | % | Moisture content, site specific |
| $PM_{10}$ EF | 0.00056 | kg/Mg | |
| **$PM_{10}$** | **6** | **kg** | |

### 1.3 Truck dumping of topsoil

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| **$PM_{10}$** | **6** | **kg** | |

### 1.4 Travelling by scraper

Not estimated

### 1.5 Travelling by haul trucks carrying topsoil to central processing area

| | | | |
|---|---|---|---|
| Topsoil to move | 24,640 | Mg/yr | |
| Truck capacity | 20 | tonnes | |
| No. trucks | 1,232 | trucks/yr | number of loads |
| 1 lb/VMT = | 281.9 | g/VKT | |
| s | 4.8 | % | Table 13.2.2-1 Sand and gravel, plant roads |
| W | 30 | tonnes | Updated from evidence of R Cudmore dated 6 Nov 2019 |

| | | | | |
|---|---|---|---|---|
| $PM_{10}$ | k | 1.5 | | |
| | a | 0.9 | | |
| | b | 0.45 | | |
| | $PM_{10}$ EF | 522 | g/VKT | |

| | | | | |
|---|---|---|---|---|
| | Annual $PM_{10}$ EF = E*((365-P)/365) | | | AP42 13.2.2 Unpaved Roads |
| Where: | Annual $PM_{10}$ EF = | size specific emission factor extrapolated for natural mitigation (g/VKT) | | |
| | E = | size specific emission factor ($PM_{10}$) | | |
| | P = | number of days per year with at least 0.254mm of precipitation | | |
| | P = | 31.6 | days >0.254 mm rain, Chch Aero 10-yr average 2008-2018 | |
| | $PM_{10}$ EF = | 477 | g/VKT | |

Assume these trucks travel 50 m each way over unsealed ground with watering @ 70% efficient emissions reduction, and 200m each way on pea gravel/reject material

| | | | |
|---|---|---|---|
| Assumed distance travelled | 100 | m | Unsealed, watered |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 86 | kg | |
| Watering control reduction | 70% | | NB: Need to include watering as condition of consent |
| Assumed distance travelled | 400 | m | Pea gravel / reject material, no additional watering |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 342 | kg | |
| Gravel mitigation | 84% | | NPI - fugitive |
| **$PM_{10}$** | **80** | **kg/yr** | |

**1.6 Topsoil stockpiles**

Not estimated

**2.0 Wind erosion of exposed areas**

**2.1 Dust pickup**

| | | | |
|---|---|---|---|
| TSP | 0.85 | Mg/ha/yr | Table 11.9-4 |
| | | | Updated from evidence of R Cudmore dated 6 Nov 2019 |
| | 2.45 | ha | with 84% reduction due to reject material as base grade |
| | 2.55 | ha | with 70% reduction due to watering |
| | 0.98 | T/yr | |
| Assume $PM_{10}$ | 10% | $PM_{30}$ | |
| **$PM_{10}$** | **98** | **kg/yr** | |

## 3.0 Gravel loading/unloading

### 3.1 Excavation

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 8 | % | As agreed in 2nd JWS |
| $PM_{10}$ | 0.0002 | kg/Mg | |
| | 625,000 | Mg/year | Advised by Fulton Hogan 13 Nov, refer JWS (Air) dated 14 Nov |
| | 106 | kg | |
| Watering control reduction | 0% | | NB: No watering during excavation as per AEE |
| **$PM_{10}$** | **106** | **kg/yr** | |

### 3.2 Loading of gravel into trucks/conveyor

Using same assumptions as above

| | | | |
|---|---|---|---|
| | 106 | kg | |
| Watering control reduction | 0% | | No watering during excavation as per AEE |
| **$PM_{10}$** | **106** | **kg/yr** | |

### 3.3 Unloading of gravel from trucks/conveyor

Using same assumptions as above

| | | | |
|---|---|---|---|
| | 106 | kg | Assumes any water suppression effectively replaces drying out of aggregate |
| Watering control reduction | 0% | | |
| **$PM_{10}$** | **106** | **kg/yr** | |

### 3.4 Conveyor transfer points (controlled)

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.000023 | kg/Mg | Table 11.19.2-1 |
| Assume | 10 | transfer points | |
| | 144 | kg | All material passes along conveyors |
| Material size reduction | 0% | | |
| **$PM_{10}$** | **144** | **kg/yr** | |

## 4.0 Gravel processing

| | | | |
|---|---|---|---|
| Maximum Throughput | 625,000 | Mg/yr | Advised by Fulton Hogan 13 Nov, refer JWS (Air) dated 14 Nov |

### 4.1 Crushing (controlled)

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.00027 | kg/Mg | Table 11.19.2-1 |
| | 2 | Crushers | |

| | | | |
|---|---|---|---|
| | 338 | kg | |
| Material size reduction | 50% | | Assume that 50% of production does not require crushing |
| **$PM_{10}$** | **169** | **kg/yr** | |

**4.2 Screening (controlled)**

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.00037 | kg/Mg | Table 11.19.2-1 |
| | 2 | Screens | |
| | 463 | kg | All material will need screening |
| Material size reduction | 0% | | |
| **$PM_{10}$** | **463** | **kg/yr** | |

**4.3 Truck loading - Conveyor crushed**

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.00005 | kg/Mg | Table 11.19.2-1 |
| **$PM_{10}$** | **31** | **kg/yr** | NB: No watering during loading as per AEE |

**5.0 Trucks/Loader on unsealed areas of site**

**5.1 Trucks moving material to mobile plant**

NB: No trucks to fixed plant (all by conveyor)

| | | | |
|---|---|---|---|
| | 158,400 | Mg/yr | Updated from evidence of R Cudmore dated 6 Nov 2019 |
| Truck capacity | 20 | tonnes | |
| No. trucks | 7,920 | trucks/yr | Truck loads |

Assume these trucks travel 50 m each way over unsealed ground with watering @ 70% efficient emissions reduction, and 200m each way on pea gravel/reject material - mobile processing plant by central processing area

| | | | |
|---|---|---|---|
| Assumed distance travelled | 100 | m | Unsealed, watered |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 378 | kg | |
| Watering control reduction | 70% | | Need to include watering as condition of consent |
| Assumed distance travelled | 400 | m | Pea gravel / reject material, no additional watering |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 1,512 | kg | |
| Gravel mitigation | 84% | | NPI - fugitive |
| **$PM_{10}$** | **355** | **kg/yr** | |

**5.2 Trucks bringing clean fill to site**

Approx. 30% vehicle movements entering site bring topsoil on gravelled roads

| | | | |
|---|---|---|---|
| Clean fill to move | 164,063 | tonnes | Assume cleanfill density = 1.4 tonnes/m³, |
| Truck capacity | 20 | tonnes | |
| No. trucks | 8,203 | trucks/yr | |

Assume these trucks travel 50 m each way over unsealed ground with watering @ 70% efficient emissions reduction, and 200m each way on pea gravel/reject material area

| | | | |
|---|---|---|---|
| Assumed distance travelled | 100 | m | Unsealed, watered |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 391 | kg | |
| Watering control reduction | 70% | | Need to include watering as condition of consent |
| Assumed distance travelled | 400 | m | Pea gravel / reject material, no additional watering |
| $PM_{10}$ | 0.48 | kg/VKT | |
| | 1,566 | kg | |
| Gravel mitigation | 84% | | NPI - fugitive |
| **$PM_{10}$** | **368** | **kg/yr** | |

**5.3 Trucks dumping clean fill**

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | kg/Mg | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 1 | % | Updated from evidence of R Cudmore dated 6 Nov 2019 |
| $PM_{10}$ | 0.0031 | kg/Mg | |
| | | | |
| Clean fill to move | 164,063 | Mg/yr | Calculated as in 5.2 above |
| $PM_{10}$ | 510 | kg/yr | |
| Watering control reduction | 70% | | Need to include watering as condition of consent |
| **$PM_{10}$** | **153** | **kg/yr** | |

**5.4 Loader moving clean fill around site**

| | | | |
|---|---|---|---|
| Using same assumptions as above | | | |
| $PM_{10}$ | 0.0031 | kg/Mg | |
| | | | |
| Clean fill to move | 164,063 | Mg/yr | Calculated as in 5.2 above |
| $PM_{10}$ | 510 | kg/yr | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **153** | **kg/yr** | Need to include watering as condition of consent |

## APPENDIX D PM$_{10}$ EMISSION ESTIMATES OF MS LOUISE WICKHAM

This appendix provides updated estimates of annual PM$_{10}$ emissions for a maximum throughput of 625,000 T/yr (**Table D-1**). It further provides an estimate of annual PM$_{10}$ emissions for the first year, including bund formation, as an indication of scale (**Table D-2**).

### Points of Agreement with Mr Cudmore

Ms Wickham's updated estimates incorporate the following parameters advised by Mr Cudmore during conferencing 2 December 2019 and in subsequent emails:

- Maximum throughput 625,000 T/yr
- Site specific silt content 4.8%
- Site specific moisture content 8%
- 84% reduction in PM$_{10}$ from wind erosion due to application of pea gravel to exposed areas

Ms Wickham supports Ms Ryan's recommendation that conditions be placed on throughput so that the activity in practice matches that assessed for the purposes of consenting.

### Points of Difference with Mr Cudmore

Ms Wickham has not incorporated additional mitigation factors, or the travel distances, assumed by Mr Cudmore for the reasons outlined below.

#### *Screening – no additional mitigation*

The US EPA emission factor for screening was based on emissions testing at five screening plants (US EPA, 2004).[4] Four of these plants crushed granite, and two crushed limestone about which (US EPA, 2004):

> *"Available data indicate that PM$_{10}$ and PM$_{2.5}$ emissions from limestone and granite processing operations were similar. Therefore, the emission factors developed from the emissions data gathered at limestone and granite processing facilities are considered to be representative of typical crushed stone processing operations."*

Ms Wickham's review of the emissions test data (references 1, 3, 7, 8 and 15 in US EPA, 2003)[5] supports emissions from limestone and granite screening being similar, with screening emissions from limestone screening being slightly lower than those for granite screening.

[4] US EPA, 2004. *AP-42 Compilation of Air Emission Factors. Mineral Products Industry. 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing.*
[5] United States Environmental Protection Agency, 2003. *Background Information for Revised AP-42 Section 11.9.2, Crushed Sonte Processing and Pulverised Mineral Processing*. Available at: https://www3.epa.gov/ttn/chief/ap42/ch11/bgdocs/b11s1902.pdf

All screens tested had water sprays to control emissions.

Whilst the $PM_{10}$ emission data was rated quality A, an overall emission factor rating of E was applied to the average annual $PM_{10}$ emission factor of 0.00037 grams per tonne of product screened due to there being only five plants tested. Ms Wickham considers this is a reasonable industry-representative emission factor for the $PM_{10}$ emissions likely to be produced from the screens at the Roydon site.

Ms Wickham does not agree with Mr Cudmore's adoption of additional emissions reduction for this estimate.

***Crushing – no additional mitigation***

The US EPA emission factor for tertiary crushing was based on emissions testing at five stone crushing plants (US EPA, 2004).[6] Two of these tertiary crushers were conical type crushers and the remaining three were cone crushers (as will be employed at Roydon). The crushers tested produced a range of stone products from 25 – 76 mm in diameter. This is slightly larger than Roydon, which will be producing product down to 22 mm in diameter.

Four of these plants crushed granite, and two crushed limestone. Ms Wickham's review of the emissions test data (references 2, 3, 7, 8 and 15 in US EPA, 2003) support emissions from limestone and granite crushing being similar, with emissions from limestone crushing being slightly lower than those for granite crushing.

All crushers tested had water sprays to control emissions.

Whilst the $PM_{10}$ emission data was rated quality A, an overall emission factor rating of E was applied to the average annual $PM_{10}$ emission factor of 0.00027 grams per tonne of product crushed due to there being only five plants tested. Ms Wickham considers this is a reasonable industry-representative estimate for the $PM_{10}$ emissions likely to be produced from the crushers at the Roydon site.

Ms Wickham does not agree with Mr Cudmore's adoption of additional 80% emissions reduction for this estimate.

Ms Wickham notes that emission factors are specified in grams per tonne of product throughput. Ms Wickham has therefore, incorporated a 50% reduction in overall throughput, based on Mr Cudmore's advice that only 50% of the excavated material is processed in the crusher. This has reduced the emissions estimate from this source by 50%.

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[6] US EPA, 2004. *AP-42 Compilation of Air Emission Factors. Mineral Products Industry. 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing.*

*__Comparison with Yaldhurst__*

Ms Wickham agrees with Mr Cudmore that the $PM_{10}$ processing emissions from Roydon will be less than those at Yaldhurst. This is because Yaldhurst has significantly higher throughput, more screens, and produces a finer (smaller diameter) product which requires more crushing.

However, Ms Wickham agrees with Ms Ryan that this comparison with Yaldhurst does not speak to the relevance, or otherwise, of the US EPA emission factors for Roydon. The US EPA factors are defined on a per tonne basis, for the specified type of process which are relevant to Roydon (e.g. crushing to >26 mm with water spray controls). There were no fine chip crushers used to develop the US EPA emission factors for crushing. Ms Wickham therefore agrees with Ms Ryan that these factors are appropriate for Roydon.

*__Travel assumptions__*

Mr Cudmore has assumed only 50 m each way of unsealed site travel distance, with the remaining 200 m each way being subject to an additional 84% reduction due to the use of pea gravel/reject material for formed haul roads. Ms Wickham is familiar with haul roads constructed using pea gravel from the Roads Metals site in Yaldhurst (refer photo below).

Ms Wickham considers these are still gravel roads and, as such, reasonably represented by the emission factor for trucks travelling on industrial haul roads, particularly when considering the additional assumption of a 70% emission reduction for watering.

Ms Wickham has not adopted the additional 84% reduction for <u>wind erosion</u>, to the emission factor for travel on gravel roads on site. This is because the 84% factor was an assumed reduction to be applicable to gravel laid on exposed ground to reduce $PM_{10}$ due to *erosion* (i.e. wind pickup).[7] Ms Wickham does not consider this reduction factor to be applicable to $PM_{10}$ being emitted from trucks travelling over gravel roads where the activity is the truck travel causing the emission, not wind pickup.

Ms Wickham therefore remains comfortable that applying the AP42 emission factor, with mitigation for typical site rainfall and watering mitigation (with 70% reduction), is reasonable for an assumed 250 m of average annual travel distance.

Ms Wickham acknowledges Mr Cudmore's advice regarding the location of the mobile plant. However, Ms Wickham considers 50 m travel each way to the mobile plant is insufficiently conservative and has instead assumed 150 m travel distance (300 m total). This has reduced her emissions estimate for this source.

***Other reduction assumptions***

Ms Wickham has assumed water sprays are **not** used for:

- Excavation
- Loading and unloading of gravel into trucks/conveyor/processing.

This is because the gravel is typically damp (8% moisture) and watering will not be needed (as repeatedly advised by the applicant in the original air quality assessment). This is consistent with the excavation and loading/unloading Ms Wickham has observed in practice at Yaldhurst (i.e. watering is not employed).

This is a point of disagreement with Mr Cudmore who has assumed that "watering as needed" attracts a 70% emissions reduction for all generated emissions.

Ms Wickham has assumed water sprays **are** used on:

- Conveyors;
- Crushing and screening plant;
- Exposed areas to avoid wind pick-up;
- All truck travel on unsealed areas;
- Handling of cleanfill (which has a much lower moisture content – 1%)

Ms Wickham reiterates her recommendation that these controls (i.e. hectares of exposed area, watering of emissions from these sources) should be reflected in conditions of consent.

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[7] Australian Government, 2012. *Emission Estimation Technique Manual for Fugitive Emissions*. Version 2.0 January. Available at http://www.npi.gov.au/resource/emission-estimation-technique-manual-fugitive-emissions. At Table 6.

## Table D-1 US EPA AP-42 $PM_{10}$ Annual Emission Estimates (Processing at Throughput of 625,000 t/yr)

### 1.0 Site Preparation

#### 1.1 Topsoil removal by scraper

| | | | |
|---|---|---|---|
| Area excavated each year | 3.2 | ha | Updated advice of R Cudmore 5 Dec 2019 |
| | 32,000 | $m^2$ | |
| $PM_{30}$ EF | 0.029 | kg/Mg | Table 11.9-4 |
| Average depth | 0.7 | m | Evidence of Mr Bligh and Mr Jolly |
| Topsoil to remove | 22,400 | $m^3$ | |
| | 1.6 | $Mg/m^3$ | Evidence of R Cudmore dated 6 Nov 2019 |
| | 35,840 | Mg | |
| $PM_{30}$ EF | 1,039 | kg | |
| Assume $PM_{10}$ | 10% | $PM_{30}$ | |
| **$PM_{10}$** | **104** | **kg** | |

#### 1.2 Loading of excavated material into trucks

| | | | |
|---|---|---|---|
| Topsoil to load | 35,840 | Mg | |
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 8 | % | Site specific parameter corrected 2 Dec 19 |
| $PM_{10}$ EF | 0.00017 | kg/Mg | |
| **$PM_{10}$** | **6** | **kg** | |

#### 1.3 Truck dumping of topsoil

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| **$PM_{10}$** | **6** | **kg** | |

**1.4 Travelling by scraper**

Not estimated

**1.5 Travelling by haul trucks carrying topsoil to central processing area**

| | | | |
|---|---|---|---|
| Topsoil to move | 35,840 | Mg/year | |
| Truck capacity | 20 | tonnes | |
| No. trucks | 1,792 | trucks/yr | |
| $PM_{10} = k(s/12)^a (W/3)^b$ | | lb/VKT | |
| 1 lb/VMT = | 281.9 | g/VKT | |
| s | 4.8 | % | Site specific parameter corrected 2 Dec 19 |
| W | 30 | tonnes | Evidence of R Cudmore dated 6 Nov 2019 |
| | 27 | tons | |
| $PM_{10}$ | | | |
| k | 1.5 | US EPA empirical constant | |
| a | 0.9 | US EPA empirical constant | |
| b | 0.45 | US EPA empirical constant | |
| $PM_{10}$ EF | 501 | g/VKT | |
| Annual $PM_{10}$ EF = E*((365-P)/365) | | | AP42 13.2.2 Unpaved Roads |

Where:

Annual $PM_{10}$ EF = size specific emission factor extrapolated for natural mitigation (g/VKT)

E = size specific emission factor ($PM_{10}$)

P = number of days per year with at least 0.254mm of precipitation

| | | |
|---|---|---|
| P = | 31.6 | days >0.254 mm rain, Chch Aero 10-yr average 2008-2018 |
| $PM_{10}$ EF = | 457 | g/VKT |

Assume these trucks travel 250 m each way over unsealed ground with watering @ 70% efficient emissions reduction

| | | | |
|---|---|---|---|
| Assumed distance travelled | 500 | m | |
| $PM_{10}$ | 0.46 | kg/VKT | |
| | 410 | kg | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **123** | **kg/yr** | NB: Need to include watering as condition (not currently included) |

### 1.6 Topsoil stockpiles

Not estimated

## 2.0 Wind erosion of exposed areas

### 2.1 Dust pickup

| | | | |
|---|---|---|---|
| TSP ($PM_{30}$) | 0.85 | Mg/ha/yr | Table 11.9-4 |
| | 2.54 | ha | 84% reduction due to pea gravel on exposed areas* |
| | 2.55 | ha | 70% reduction due to watering |
| $PM_{30}$ | 0.98 | t/yr | * Table 6, NPI Fugitive emissions |
| Assume $PM_{10}$ | 10% | $PM_{30}$ | |
| **$PM_{10}$** | **98** | **kg/yr** | |

## 3.0 Gravel loading/unloading

### 3.1 Excavation

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 8 | % | Updated 2 Dec 19 |
| $PM_{10}$ | 0.0002 | kg/Mg | |
| | 625,000 | Mg/year | |
| **$PM_{10}$** | **106** | **kg/year** | Assumes no watering during excavation as per AEE (8% moisture content) |

### 3.2 Loading of gravel into trucks/conveyor

Using same assumptions as above

| | | | |
|---|---|---|---|
| **$PM_{10}$** | **106** | **kg/year** | Assumes no watering during loading as per AEE (8% moisture content) |

### 3.3 Unloading of gravel from trucks/conveyor

Using same assumptions as above

| | | | |
|---|---|---|---|
| **$PM_{10}$** | **106** | **kg/year** | Assumes no watering during unloading as per AEE (8% moisture content) |

### 3.4 Conveyor transfer points (controlled)

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.000023 | kg/Mg | Table 11.19.2-1 |
| Assume | 10 | transfer points | |
| **$PM_{10}$** | **144** | **kg/year** | Controlled emission factor (assumes watering at source) |

## 4.0 Gravel processing

| | | | |
|---|---|---|---|
| Maximum Throughput | 625,000 | Mg/year | |

### 4.1 Screening (controlled)

| | | | |
|---|---|---|---|
| Screening Throughput | 625,000 | Mg/year | |
| $PM_{10}$ | 0.00037 | kg/Mg | Table 11.19.2-1 |
| | 2 | Screens | |
| **$PM_{10}$** | **463** | **kg/year** | Controlled emission factor (assumes watering at source) |

### 4.2 Crushing (controlled)

| | | | |
|---|---|---|---|
| Crusher Throughput | 312,500 | Mg/year | Assumes only 50% of total throughput goes through crusher |
| $PM_{10}$ | 0.00027 | kg/Mg | Table 11.19.2-1 |
| | 2 | Crushers | |
| **$PM_{10}$** | **169** | **kg/year** | NB: This is a controlled emission factor (assumes watering at source) |

### 4.3 Truck loading - Conveyor crushed

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.00005 | kg/Mg | Table 11.19.2-1 |
| **$PM_{10}$** | **31** | **kg/year** | Assumes no watering during loading (8% moisture content) |

## 5.0 Trucks/Loader on unsealed areas of site

### 5.1 Trucks moving material to mobile plant

NB: No trucks to fixed plant (all by conveyor)

| | | | |
|---|---|---|---|
| | 158,400 | Mg/year | Evidence of R Cudmore dated 6 Nov 2019 |
| Truck capacity | 20 | tonnes | |
| No. trucks | 7,920 | trucks/yr | |
| Assumed distance travelled | 300 | m | Assume 150 m each way |
| $PM_{10}$ | 0.46 | kg/VKT | AP42 13.2.2 Unpaved Roads, annualised for Chch (see above) |
| | 1,086 | kg | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **326** | **kg/yr** | NB: Need to include watering as condition (not currently included) |

### 5.2 Trucks bringing clean fill to site

| | | | |
|---|---|---|---|
| Clean fill to move | 208,333 | tonnes | Assumes one third of 625,000 t/yr |
| Truck capacity | 20 | tonnes | |
| No. trucks | 10,417 | trucks/yr | |
| Assumed distance travelled | 500 | m | 250 m each way |
| $PM_{10}$ | 0.46 | kg/VKT | AP42 13.2.2 Unpaved Roads, annualised for Chch (see above) |
| | 2,381 | kg | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **714** | **kg/yr** | NB: Need to include watering as condition (not currently included) |

**5.3 Trucks dumping clean fill**

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | kg/Mg | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 1 | % | Evidence of R Cudmore dated 6 Nov 2019 |
| $PM_{10}$ | 0.0031 | kg/Mg | |
| | | | |
| Clean fill to move | 208,333 | Mg/year | Assumes one third of 625,000 t/yr |
| $PM_{10}$ | 648 | kg/year | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **194** | **kg/yr** | NB: Need to include watering as condition (not currently included) |

**5.4 Loader moving clean fill around site**

| | | | |
|---|---|---|---|
| Using same assumptions as above | | | |
| $PM_{10}$ | 0.0031 | kg/Mg | |
| | | | |
| Clean fill to move | 208,333 | Mg/year | Assumes one third of 625,000 t/yr |
| $PM_{10}$ | 648 | kg/year | |
| Watering control reduction | 70% | | |
| **$PM_{10}$** | **194** | **kg/yr** | NB: Need to include watering as condition (not currently included) |

## Table D-2 US EPA AP-42 $PM_{10}$ Annual Emission Estimates (Site set up, throughput of 150,000 t/yr)

### 1.0 Site Preparation

#### 1.1 Topsoil removal by scraper

| | | | |
|---|---|---|---|
| TSP | 0.029 | kg/Mg | Table 11.9-4 |
| $PM_{30}$ | 0.029 | kg/Mg | The gravel is overlain by a shallow layer of superficial soils, typically in the vicinity of 0.5 to 1.0 m depth (Golders, 2018). At section 3.5. Page 9. |
| Average depth | 0.7 | m | Evidence of Mr Bligh and Mr Jolly |
| First stage | 5 | ha | First year, evidence of R Cudmore dated 6 Nov 2019 |
| | 50,000 | $m^2$ | |
| Topsoil to remove | 35,000 | $m^3$ | |
| | 1.6 | $Mg/m^3$ | Evidence of R Cudmore dated 6 Nov 2019 |
| | 56,000 | Mg | |
| $PM_{30}$ | 1624 | kg | |
| Assume $PM_{10}$ | 10% | $PM_{30}$ | |
| **$PM_{10}$** | **162** | **kg** | |

#### 1.2 Loading of excavated material into trucks

| | | | |
|---|---|---|---|
| Topsoil to load | 56,000 | Mg | |
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 8 | % | Site specific parameter corrected 2 Dec 19 |
| | 0.00017 | kg/Mg | |
| **$PM_{10}$** | **9** | **kg** | |

#### 1.3 Truck dumping of topsoil

| | | | |
|---|---|---|---|
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| **$PM_{10}$** | **9** | **kg** | |

### 1.4 Travelling by scraper

Not estimated

### 1.5 Travelling by haul trucks carrying topsoil

Not applicable - central processing area being excavated

### 1.6 Topsoil stockpiles

Not estimated

## 2.0 Bund Formation

### 2.1 Cleanfill handling

X-Area bund = 1/2 x (a + b) x h

| | | | |
|---|---|---|---|
| a | 1 | bund top width | |
| b | 15 | bund base | |
| h | 3 | bund height | |
| X-Area | 24 | $m^2$ | |
| Vol = X-Area x Length | | | |
| Length 1 | 1350 | Dawsons Rd | Ignore additional section |
| Length 2 | 1300 | Jones Rd | |
| Length 3 | 1350 | Curraghs Rd | |
| Length 4 | 1300 | Maddisons Rd | |
| Vol bund = | 127,200 | $m^3$ | |
| | 1.6 | $Mg/m^3$ | |
| | 203,520 | Tonnes to be brought in to form bund | |
| $PM_{10} = k \times 0.0016 \times (U/2.2)^{1.3} / (M/2)^{1.4}$ | | | AP42 section 13.2 Aggregate Handling |
| k | 0.35 | | AP42 section 13.2 Aggregate Handling |
| U | 3.9 | m/s | Mean wind speed, annual average Golders met set |
| M | 1 | % | Evidence of R Cudmore dated 6 Nov 2019 |
| $PM_{10}$ | 0.0031 | kg/Mg | |
| | 203,520 | Mg/year | Tonnes of bund to be formed |

| | | | |
|---|---|---|---|
| **$PM_{10}$** | 633 | kg/year | |
| Watering control reduction | 70% | | NB: Big assumption |
| **$PM_{10}$** | **190** | **kg/year** | |

**2.2 Loader forming bund**

| | | | |
|---|---|---|---|
| Not estimated | | | |

**2.2 Travelling by haul trucks carrying bund fill**

| | | | |
|---|---|---|---|
| | 203,520 | Tonnes to be brought in and formed into bund | |
| | 20 | T/truck | |
| | 10,176 | Trucks | |
| Distance each truck travels to central area | 1 | km | 500 m each way from site entrance to centre and back (road not sealed yet) |
| Distance each truck travels to bund | 1 | km | 500 m each way from centre to site edge and back |
| Total distance trucks travelled | 2 | km | |
| | 20,352 | VKT | |
| $PM_{10}$ | 457 | g/VKT | AP42 13.2.2 Unpaved Roads, annualised for Chch 32 days/yr rain >0.254 mm |
| | 9,305 | kg | |
| Watering control reduction | 70% | | NB: Big assumption |
| **$PM_{10}$** | **2,791** | **kg/year** | |

**3.0 Gravel processing**

| | | | |
|---|---|---|---|
| First year throughput | 150,000 | Mg/year | Assumed |

**3.1 Screening (controlled)**

| | | | |
|---|---|---|---|
| Screening Throughput | 150,000 | Mg/year | |
| $PM_{10}$ | 0.00037 | kg/Mg | Table 11.19.2-1 |
| | 2 | Screens | |
| **$PM_{10}$** | **111** | **kg/year** | Controlled emission factor (assumes watering at source) |

**3.2 Crushing (controlled)**

| | | | |
|---|---|---|---|
| Crusher Throughput | 75,000 | Mg/year | Assumes only 50% of total throughput goes through crusher |
| $PM_{10}$ | 0.00027 | kg/Mg | Table 11.19.2-1 |
| | 2 | Crushers | |
| **$PM_{10}$** | **41** | **kg/year** | NB: This is a controlled emission factor (assumes watering at source) |

**3.3 Truck loading - Conveyor crushed**

| | | | |
|---|---|---|---|
| $PM_{10}$ | 0.00005 | kg/Mg | Table 11.19.2-1 |
| **$PM_{10}$** | **8** | **kg/year** | Assumes no watering during loading (8% moisture content) |