Before the Board of Inquiry
Waterview Connection Project

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in the matter of: the Resource Management Act 1991

and

in the matter of: a Board of Inquiry appointed under s 149J of the Resource Management Act 1991 to decide notices of requirement and resource consent applications by the NZ Transport Agency for the Waterview Connection Project

Supplementary evidence of **Gavin Fisher (Air Quality)** on behalf of the **NZ Transport Agency**

Dated: 17 February 2011

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SUPPLEMENTARY EVIDENCE OF GAVIN FISHER ON BEHALF OF THE NZ TRANSPORT AGENCY

INTRODUCTION

1 My full name is **Gavin Westwood Fisher.** I refer the Board of Inquiry to the statement of my qualifications and experience set out in my evidence in chief (*EIC*) (dated 11 November 2010).

2 I repeat the confirmation given in that statement that I have read and agree to comply with the Code of Conduct for Expert Witnesses in the Environment Court.

PURPOSE OF SUPPLEMENTARY EVIDENCE

3 The purpose of this supplementary evidence is three-fold:

3.1 Introduce some further analysis that had been requested by submitters and the air quality experts during caucusing.

3.2 Report on the results of further caucusing held as a result of the further analysis. This caucusing was conducted on 15 February 2011 and involved Jayne Metcalfe (the Board's s42A expert), Janet Petersen (for Auckland Council) and myself.

3.3 Suggest some amendments to proposed conditions as a result of the further analysis.

4 This evidence is provided at this stage because much of the further analysis relies on complex dispersion modelling carried out by NIWA that was not available or completed at the time my rebuttal evidence was completed (3 February 2011). Model runs of the type used in this assessment are so detailed that they can take 20-22 days of computer run time to complete.

VENT MODELLING

5 Over the last few weeks there has been discussion, for various reasons, over the concept of lower the tunnel vents heights from 25m to 15m. This was assessed in preliminary modelling as early as 2008, and was also further assessed in the Assessment of Air Quality Effects (Technical Report G.1, Appendix K). Due to some changes in the overall Project design (such as updated traffic modelling), and in response to questions from submitters and caucusing experts, a new an updated modelling run was undertaken. This used the same methodology as in the main AEE, which modelled the vent height at 25m. That is (a) advanced Calpuff model, (b) detailed terrain, (c) meteorological datasets as supplied by and approved by the Auckland Council, and (d) detailed grid of effects in the area around the vents.

6 The latest modelling results (summarised in **Annexure A**) show that using 15m high vents, instead of 25m, results in very minor changes to the ground level concentrations of all the contaminants assessed (CO, NOx, PM_{10} and $PM_{2.5}$). The effects of the vent discharges are still very low, for all these contaminants, at all locations. Ground level concentrations do increase very slightly, very close to the vents (within 50m), but these concentrations are still only of the order of 1-1.5% of the limit values in the National Environmental Standards.

7 The concept has also been raised of having the northern vent located further east, across Great North Rd. This does not have any significant air quality effects, and does not create any new areas of sensitivity.

8 During the latest caucusing discussion, all of these outcomes relating to the vent emissions (as noted above) were generally agreed.

9 The concept has also been raised of having the northern vent split into three separate vents. In qualititative way, provided these are still 15m or more in height, the air quality effects are unlikely to be significantly different than those from a single vent. Full modelling of this has not been undertaken, as in order to do this, we would need full design information – such as heights, diameters, velocities, location and operational procedure. None of these are available.

10 Whilst three vents might have some utility from some perspectives, I personally can see no advantage from an air quality perspective. Such a design would (a) not produce any air quality benefits, (b) be complex to operate and assess, (c) present obvious engineering difficulties, (d) add cost, and (e) be harder to maintain.

FULL MODELLING

11 Again, in response to questions raised in evidence from submitters, another new full modelling assessment was carried out. In the original dispersion modelling presented in the AEE, the air quality effects were assessed at some 110 locations that were deemed "sensitive" receptors – schools, hospitals, residences very close to the roadway etc. This was a deliberate choice, by a team that included myself, on the basis that:-

11.1 These receptors were carefully chosen to show the worst possible air quality effects beyond the designation boundaries;

11.2 These models take a very long time to run, and selecting receptors cuts down on this time and allows more options to be assessed; and

11.3 The amount of data generated in the outputs of the models quickly becomes daunting, but we felt that using 110 specific locations would give the public (and reviewers) something more manageable to consider.

12 However following the lodgement of submitter evidence, it became necessary to provide modelling that covered the entire Waterview area in a finer scale mesh grid, in order to check that there were no locations that might have higher effects than showed up in the 110 receptors. Summary results of the full modelling are given in **Annexure B.**

13 These show that there are some areas where ground level concentrations of contaminants are higher than in the original modelling,[1] but these are invariably areas very close to the roadways, where there are no sensitive receptors and no residences. No new areas (say those away from roadways) were identified where contaminant concentrations would be higher than the peaks originally assessed.

14 As a result, my opinion is that the original conclusions contained in my evidence in chief (*EIC*), based on modelling results for some 110 specific sensitive receptors, still stand and remain valid. Paragraphs 11 and 12 from my EIC are copied below:-

> "*11. The results show that the Project will have an insignificant effect on both the local and regional air quality, over and above what might have occurred anyway without the Project. Indeed for many areas the Project results in better air quality than would occur otherwise. The small changes that do occur are mainly as a result of a re-distribution of traffic*."
>
> "*12. Air quality standards and guidelines are met everywhere. There are a few specific locations where one Auckland Regional air quality target for $PM_{2.5}$ is not met – but the contribution of the Project to this is insignificant, the main cause of the exceedence being domestic wood burning."*

SEPARATION DISTANCES

15 Following further analysis (already presented in my rebuttal evidence),[2] the experts generally agree that there will be no residences left too close to the proposed new or altered motorway routes.

16 The analysis identified just two houses that were within 20m of the roadway and not acquired by NZTA (17A Marewa Street and 10 McCormick St). They will be acquired, probably in the next financial year.

17 Finally, the separation distance analysis also showed that currently there are a number of houses close the roadway in this area (and throughout Auckland). Specifically, along SH16 around the Te Atatu Interchange, as of today, I identified several houses that were only 10-15 metres from the road, and the closest was just 7.5m. Following the implementation of the Project, there will be no houses closer than 20m. This represents a

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[1] Given throughout the main assessment contained in Technical Report G.1, Air Quality.

[2] Rebuttal evidence Gavin Fisher at paragraphs 31-39 and Annexure C.

significant improvement in living conditions for the occupants of these houses.

PROPOSED CONDITIONS

18 Ms Metcalfe and Ms Petersen had expressed a desire to see a more formalised system for assessing and reviewing the air quality monitoring, and in particular a protocol for addressing any issues arising.

19 The NZTA has already committed to providing regular monitoring reports on its public web site that can be reviewed and commented on by anyone (see proposed Operational Air Quality condition OA.4).

20 Rather than introduce a new review clause within the proposed Operational Air Quality conditions (OA.1 to OA.7), I feel that the current proposed Social condition SO.1 already covers this issue to some extent. It reads:

> SO1 In addition to the Community Liaison Group established pursuant to Condition PI.5, the NZTA shall establish an Education Liaison Group (including representatives from local schools, kindergartens, childcare facilities, Unitec Institute of Technology, the Ministry of Education and Housing New Zealand Corporation), to provide a forum through which:
>
> (a) Relevant monitoring data can be provided (e.g. air quality monitoring);
>
> (b) Notice can be provided of when particularly noisy activities will occur in close proximity to schools and education facilities, to enable the opportunity to identify any potential conflict with particular sensitive periods, and the requirement for specific mitigation strategies (e.g. rescheduling of construction activities where practicable);
>
> (c) Particular concerns can be raised by educational facilities or parents, discussed and potentially addressed.
>
> The Education Liaison Group shall be established at least 2 months prior to construction commencing and shall have regular meetings (at least three monthly) throughout the construction period. The Education Liaison Group shall continue to meet for at least 12 months following the completion of the Project (or less if the members of the Education Liaison Group agree), so that ongoing monitoring information can continue to be disseminated.

21 If this is not considered strong enough, some wording changes in proposed Public Information condition (PI.6) should suffice. That condition identifies what the Community Liaison Groups (*CLGs*) shall be provided the opportunity to review and comment on. The change might be simply to include in condition PI.6(f) wording as follows: "Publicly available results of

environmental monitoring as required by the designation and/or these consents (e.g. air monitoring)".[3]

22 One other small change to proposed condition OA.1 requested by Ms Metcalfe and Ms Petersen has now been incorporated (added words are underlined), as follows:

> OA.1 The vent used to discharge emissions in the tunnels shall discharge vertically into air at a minimum height of 15m above the ground and shall not be impeded by any obstruction that decreases the vertical efflux velocity.

Tunnel portal emissions

23 There is one outstanding air discharge condition – not yet agreed by Ms Metcalfe and Ms Petersen. This relates to the tunnel portal emissions, particularly in relation to when the ventilation fans might be allowed to be turned down or off.

24 I need to re-iterate that it is a central design feature of the tunnel ventilation system that it is capable of operating with no portal emissions. And if required to do so, this is how the tunnel will be operated. However it has become apparent that at times when there are few vehicles in the tunnel, this is a waste of resources. I understand the ventilation fans can take up to 11MW of electricity at full bore. I estimate this to be around $10M a year even at a discounted electricity rate of 10c KW/hr. Reducing this even by 20-30% is very attractive, and saves public funds.

25 In addition, I understand that the NZTA does wish to keep its environmental footprint from this Project as low as possible. Electricity production has a carbon footprint, and it runs counter to NZTA policy to cause unnecessary greenhouse gas emissions by running the ventilation fans if they are not needed.

26 So running the fans at lower power, or even off, for at least some of the time can have wider environmental benefits, and reduce public expenditure – as long as this does not lead to any adverse local effects.

27 There are several ways of running the tunnel ventilation system:

27.1 Not allowing the ventilation fans to be turned off ever. This is viable, but carries a very large cost penalty and is an inefficient use of resources at times when there might only be a few vehicles in the tunnel, requiring no significant ventilation.

27.2 Using a process that relies on time of day for when fans might be allowed to be turned down or off – such as only at night when traffic

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[3] I understand the NZTA also proposes to amend proposed condition PI.5 so as to provide for regular meetings of the CLGs up to 24 months post-construction so that ongoing monitoring information can continue to be disseminated.

volumes are low. This is a very simple process allowing the fans to be turned down only between 11pm and 7am, and was earlier proposed by me during caucusing. My view is, supported by detailed modelling, that this is a very workable condition. This was not agreed by the other experts during caucusing.

27.3 Using a process that relies on traffic counts – such as allowing the fans to be off when the traffic count was low enough. This option has not been pursued for several reasons, such as being operationally difficult and not being strongly related to emissions (i.e. 10 large diesel vehicles might have greater emissions than 100 smaller petrol vehicles).

27.4 Using a process that relies on monitoring the in-tunnel air quality at, or near, the portals – and having the fans turned on at times when this exceeded some limit. This was suggested by Ms Metcalfe and Ms Petersen during caucusing.

27.5 Using a process of monitoring the air quality immediately outside the portal, to ensure that relevant air quality standards or guidelines are not exceeded due to air coming out of the portals at times when the fans were off.

28 I support this last option for ambient air quality monitoring outside the portals. It is also favoured by the NZTA, for the simple reason that it provides an ultimate backstop, and a very direct measure, for showing that any contaminants emitted from the portals are not having an adverse environmental effect.

29 However, the Board's expert and the Auckland Council expert prefer the in-tunnel monitoring condition. Their argument appears to be that this method is more akin to the commonly applied "source" monitoring conditions used in industrial air discharge consents, and would give them some assurance that the actual emissions from the portals are quantified and controlled.

30 However, in my view the ambient monitoring condition is superior. Thus I support the current form of the NZTA's proposed Operational Air Quality condition OA.7 which seeks to ensure that any portal emissions "leakage" due to fans being turned down does not lead to an exceedence of the 1 hour NO_2 standard. It reads as follows:

> OA.7 The tunnel ventilation system shall be designed and operated to ensure that any air emitted from the tunnel portals does not cause the concentration of nitrogen dioxide (NO_2) in ambient air to exceed 200 micrograms per cubic metre, expressed as a rolling 1 hour average, at any point beyond the designation boundary that borders an air pollution sensitive land use.

31 In my opinion, this condition has a considerable environmental benefit over the alternatives discussed earlier. Quite simply, it is strictly "effects

based". It does not rely on understanding the complex relationship between what is going on in the tunnel and what happens in ambient air outside the tunnel. It commits the NZTA to ensuring that the air quality standard for NO_2 in the immediate vicinity of the tunnel portal is met – even if the tunnel's contribution to any exceedence is minor.

32 There are several problems with the alternative preferred by Ms Metcalfe and Ms Petersen – i.e. a condition set on in-tunnel monitoring:

32.1 There is <u>already</u> going to be monitoring of CO, NOx (and visibility) inside the tunnel.[4] These will located at each end, about 50m in from the portal. This is part of the operational requirements to manage health and safety. This monitoring is an essential part of the operational management system for the tunnel, and is a standard approach used around the world, on well established and defined criteria. The tunnel design experts have advised me of the impracticality – from their viewpoint – of combining an "operational" system with and "environmental compliance" system. This might seem on the face of it not an unreasonable task, but their concerns are strong.

32.2 If a new in-tunnel system was to be used, there is further problem in that where might it be sited? The air quality along the tunnel will vary, and what is measured will be affected by it location. This is a complex factor that is difficult to determine. Overseas guidelines on this issue are not readily available as each tunnel tends to have its own features. It would be easy make an inappropriate choice. For in-tunnel air quality management, the monitors are sited about 50m from the portal, but this does not necessarily give accurate data on what might actually be coming out of the portal.

32.3 Finally, as it turns out, there is a high degree of compatibility between the in-tunnel health and safety systems and the requirements for ensuring no adverse effects outside the portals. The operational in-tunnel system is designed to never allow certain levels of contaminants to occur (for NO_2 this is 1 ppm, equivalent to 1,400 $\mu g\ m^{-3}$). To achieve this, they will operate with a significant buffer, by way of the fan power. That is, they will preferentially operate the fans to keep this parameter at about 10-20% of its maximum value (140-280 $\mu g\ m^{-3}$). My preliminary assessment, supported by portal emissions modelling, of a maximum criterion for portal NO_2 concentrations that would ensure no significant effects outside the portals was 300 $\mu g\ m^{-3}$. Thus, if the fans are operated in a manner to satisy the in-tunnel health and safety requirments, they

[4] This has been confirmed in conversations with the ventilation design engineers (Tom Ireland and Derek Edwards from Aurecon on 15 February 2011), and will be detailed in the Tunnel Operations Management Plan. In addition, it is well known standard practice for road tunnels.

will also more than satisfy the requirement for no adverse effects outside the tunnel.

32.4 Put simply, the concentrations of contaminants that might leak out the portal will probably never reach levels that cause adverse effects, because the fans will be being used already to maintain fundamental health and safety conditions inside the tunnel.

33 Thus in my opinion the proposed external monitor, via proposed condition AO.7 above, is the preferred method and I support its use.

34 This portal monitoring will have the following features:-

34.1 It will need to operate continuously with some feedback to the fans controllers (although once some operational experience is gained this will be more of a checking function than an operational one).

34.2 It is only proposed to have one extra monitor, located within 50m of the southern portal. The modelling assessment has shown that portal effects at the southern portal are greater than those at the northern, by about 20-30%, mainly due to its more sheltered environs. As indicated above, its function will be more of a checking one, than a controlling one, since the in-tunnel operational ventilation requirements will always kick in before this ambient control requirement.

34.3 The portal monitoring system will be run to all the requirements specified in conditions for the other ambient monitors (OA.3).

35 In my view, based on all the modelling and analysis on portal emissions, and also based on experience and monitoring results from some Australian tunnels (presented in my rebuttal evidence, Annexure E), the ventilation system will be run operationally in such as way that emissions from the portals will not lead to adverse effects. The portal air quality monitor is simply being put there to demonstrate this definitively.

OFFSETS

36 The concept of offsets has been raised at several stages. It was raised by submitters, by the Board s42A reviews and in expert caucusing. In particular, there was considerable discussion in the expert caucusing, as detailed in the caucusing report[5]. It was left then as an "unresolved" issue, but my attempts to resolve this are reported below.

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[5] Expert Caucusing Joint Report to the Board of Enquiry – Topic Air Quality, 28 January 2011, paras 26 and 43-49.

37 Whilst not opposed to the general concept of offsetting vehicle emissions, I have pointed out in some detail already the infeasibility of doing this for this Project[6].

38 During the latest caucusing (15 February), and in the spirit of open discussion, I discussed with Ms Metcalfe and Ms Petersen a possible means of progressing their concerns in regard to adopting an offset programme. Whilst we made some progress on some of the technical aspects of this, it has subsequently become apparent that the issues around such a programme are substantially wider than can be resolved just between air quality experts. As noted in my rebuttal evidence[7], there are issues around policy, economics, planning, legislation, social effects and the wider aspect of the NZTA's functions which extend well beyond this particular project (i.e. issues have national implications).

39 Thus, I have to reiterate my position, as an air quality expert. While offsetting emissions can be beneficial for air quality, they have to be developed in a much wider context to ensure their efficacy. There are many details that would need to be examined in a process that could take several years and require the input from a wide range of people. Thus, in my opinion, the concept of offsets is premature and inappropriate for the Waterview Project.

ADDITIONAL CAUCUSING

40 The initial expert caucusing that was reported on 28 January 2011, contained a number of "unresolved" issues. Some of these have been covered above, but there were some others, and some were inter-related. These issues were discussed in the second caucusing on 15 February, and here I report on the outcomes not explicitly addressed above, and relate this back to the specific sections in the caucusing report.

41 **Monitoring evaluation**[8]. The experts sought a more formalised process for evaluating monitoring results. This has been addressed through modifications to proposed conditions PI.5 and PI.6 discussed earlier.

42 **Background concentrations and modelling methods[9].** The experts did not agree on some detailed technical methodologies for assessing background concentrations and conducting the modelling. Agreement was given on the contingent basis that if an offset plan was developed these matters were insignificant. Whilst I still maintain that the methodologies used have been robust and appropriate, Ms Metcalfe and Ms Petersen may

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6 Rebuttal evidence of Gavin Fisher paras 55-62.

7 Ibid.

8 Caucusing Report, para 28.

9 Caucusing Report, paras 13 and 16.

not still agree. No further work has been done on these issues, and in my opinion, none is needed.

43 **Separation distances[10].** Considerable further analysis have been given in my rebuttal evidence, and further analysis has been presented above in this evidence. In summary, the main issue was concern that houses might end up too close to the road after the Project is complete. I believe we have shown that this is not the case.

44 **Monitoring conditions[11].** Ms Metcalfe and Ms Petersen sought additional monitors, and longer periods. In summary, the NZTA has now committed to installing a new portal emissions monitor (as covered above). This will result in three ambient monitoring stations – Cowley St, Alan Woods Reserve and southern portal. In addition, data will be available on request from the two in-tunnel monitors.

45 On the matter of the period of monitoring, I still maintain that 2 years is perfectly adequate to assess the effects of the Project. I would note here also, that in my dealings with the NZTA, they have generally been very proactive in establishing and running air quality monitors when and where they are needed. I believe that if the 2 years of monitoring were to indicate any issues with non-compliance associated with the Waterview Project, NZTA would react effectively with programmes of monitoring, study and analysis to address these.

Gavin Fisher

17 February 2011

[10] Caucusing Report, paras 27 and 50-54.

[11] Caucusing Report, paras 28 and 55-61.

ANNEXURE A:

FULL MODELLING OF 15M VENT OPTION

Scope
NIWA has completed the modelling run assessing the effects of the 15m high vent option (vs. the 25m option). While full results are available, only a summary set is presented here.

Methodology
Calpuff was used with the original full featured datasets and terrain files, as were applied previously. The vent buildings are the same size (10m high), but the vent discharge point has been lowered from 25m to 15m above local ground level.

Results
The summary results are shown below, just for:-

- Two indicator parameters – 1 hour NOx and 24 hour PM_{10}
- The 2016 year (everything is lower for 2026)
- The top 20 receptor points (based on NOx).

These results show:-

- Ground level concentration increments due to vent emissions are very small.
- The differences at these receptors (and at all other places) are variable and minor.

Discussion
The results are perhaps non-intuitive. It might be expected that a lower height discharge would naturally result in higher ground level concentrations – but that is obviously not a universal outcome here.

Plumes behaviour is very sensitive both to weather factors and to building wake and downwash effects. Both are important here. For instance the plume is being very much affected by the local weather factors regardless of its initial emission height (another simplified analysis has shown that even ranging it from 5m to 50m still does not have a very significant effect). In addition, the turbulence created around the vent buildings helps to disperse the plume – resulting in slightly higher concentrations close to the vent for 15m releases, but lower ones further out.

Different trends for the two cases examined are due to one (NOx) being over just 1 hour, and the other (PM_{10}) being over 24 hours.

These results are consistent with those presented in the AEE report[12] which were for an earlier modelling result conducted in 2008, when stack heights were being evaluated.

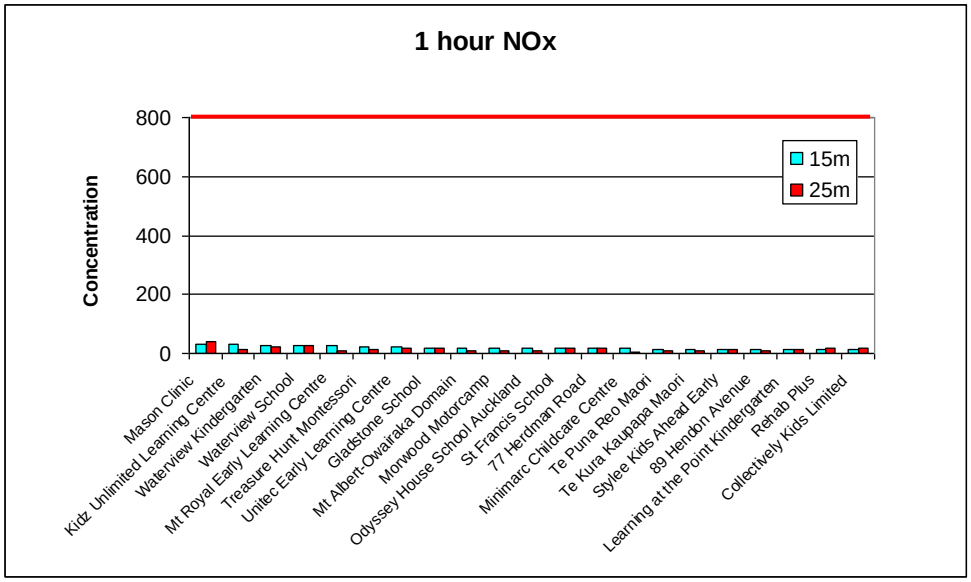
[12] Main AEE Report G.1. Appendix K

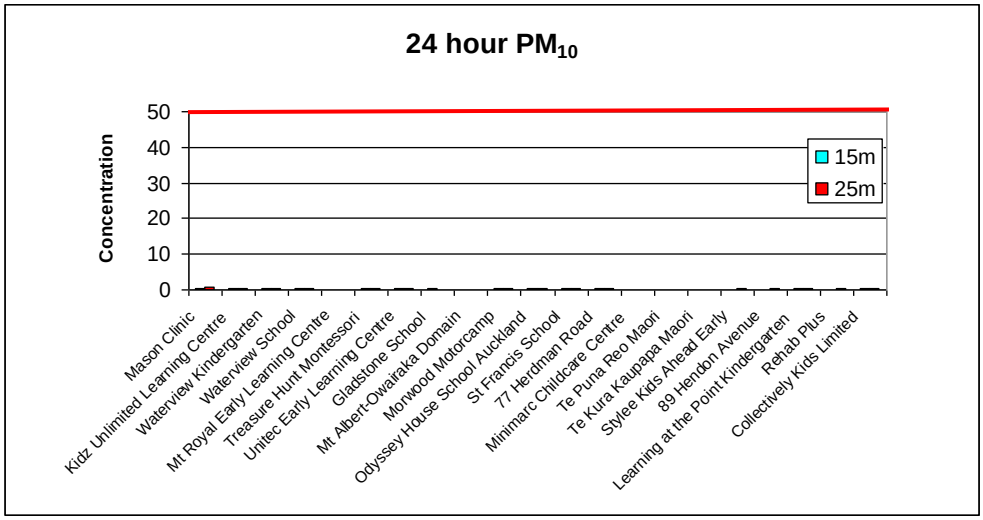
Summary

There is no adverse air quality effect for vent emission at either 25m or 15m heights. The ground level effects are very small for either option. Differences that do show up are small and have no particular consequence, positive or negative. Using a 15m vent height is perfectly acceptable from an air quality effects viewpoint.

Relative to Standards and Guidelines

Firstly, the results are plotted on a scale relative to the relevant guideline or standard (red lines on the graphs). There is a standard for PM_{10} (50 $\mu g\ m^{-3}$), but there is no standard or guidelines for NOx. The guideline for 1-hour NO_2 is 200 $\mu g\ m^{-3}$, but the NOx to NO_2 conversion has not been undertaken. A relatively conservative value of 25% is used (giving an indicative guideline of 800 $\mu g\ m^{-3}$). For most of Auckland, especially at the higher urban concentrations caused by vehicle emissions, it is generally around 15%.

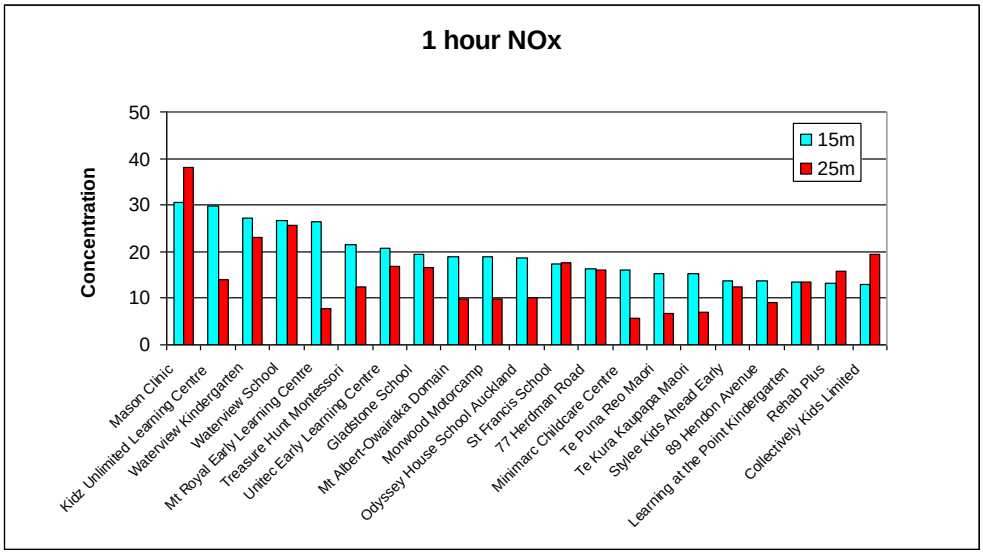


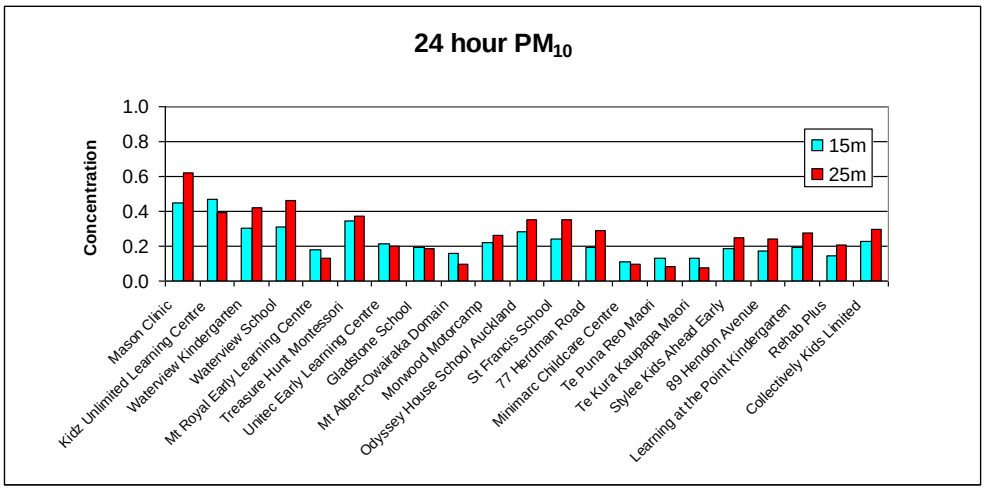


These results confirm that the incremental effects due to the vent emissions are very small.

15m vs. 25m vent heights

The previous charts do not show well the difference between the two vent height options. There are repeated below with finer scales.





These results show that there is a variable difference in effect between the two heights. For some locations the effects are slightly higher for 15m (blue bars), but for many they are lower.

The effects tend, in general, to be lower for receptors further out, and slightly higher for those closer to the vents. These differences are very small and would almost certainly be undetectable in any form of ambient monitoring. For instance the absolute accuracy of PM_{10} monitoring is at best +/- 2.5 $\mu g\ m^{-3}$. The differences here are of the order of 0.2 $\mu g\ m^{-3}$ at most, and would thus lie below the measurement "noise" of the monitor.

ANNEXURE B:

MODELLING ENTIRE GRID RESULTS

Scope
NIWA has completed the modelling run using a full grid scheme to highlight complete effects. These are summarised here in a number of plots, along with some additional analysis.

Methodology
Calpuff was used with the original full featured datasets and terrain files, as were applied previously. However in these runs a full 100m x 100m grid was used. Grid points that fall within 13m of a road edge were eliminated (assessing the concentrations on, or too near, the roads will bias the picture, and there are no sensitive locations within this zone.)

Results
The summary results are shown below, just for:

- 1 Hour NOx
- 24 Hour PM_{10}
- 24 Hour $PM_{2.5}$.

These results show:

- Ground level concentrations due to emissions associated with the Project are not large, and much as predicted in the AEE.

- The patterns of higher values are very much as expected, with higher levels around busy roadways, particularly the western part of SH16 and the southern part of the SH20 section near Mt Roskill.

- Background values are not shown here, but it is expected that there will be no standards exceedences. The $PM_{2.5}$ target will continue to be exceeded in 2016, as it was in 2006.

Summary
There results give more detail than has been presented in the AEE (which had results for some 100 specified receptors). These results are for some 7,200 grid points. They generally confirm the picture given in the earlier air quality assessments, although there are a few locations that might have slightly higher concentrations. These are invariably grid points that are very close to busy roadways.

Overall the concentrations are not significantly higher, and even for the worst receptor, added to the worst background, the concentration level will not exceed standards.

The guideline (Regional Air Quality Target) for $PM_{2.5}$ is already exceeded, and will continue to be exceeded – due to other sources – whether the Waterview Project goes ahead or not.

NOx (surface roads only)

Figure 1. 1 Hour NOx. 2016. Do minimum. (μg m^{-3})

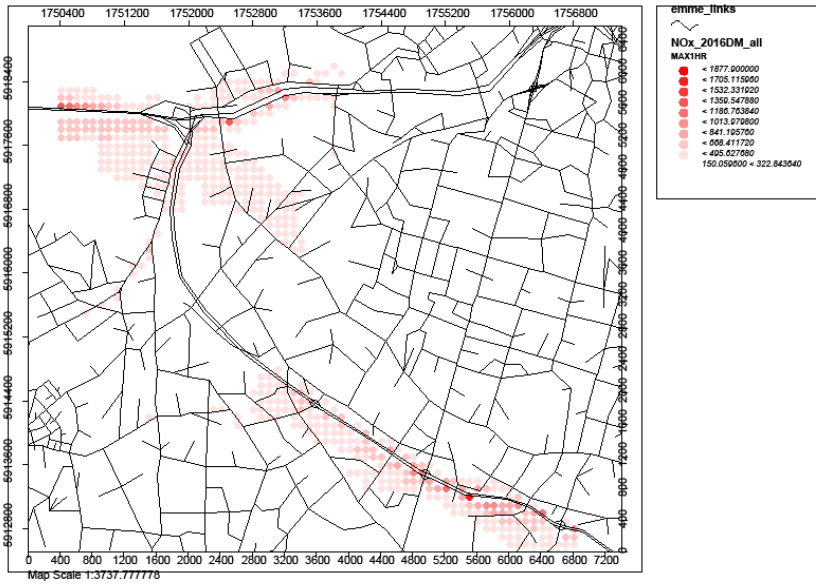
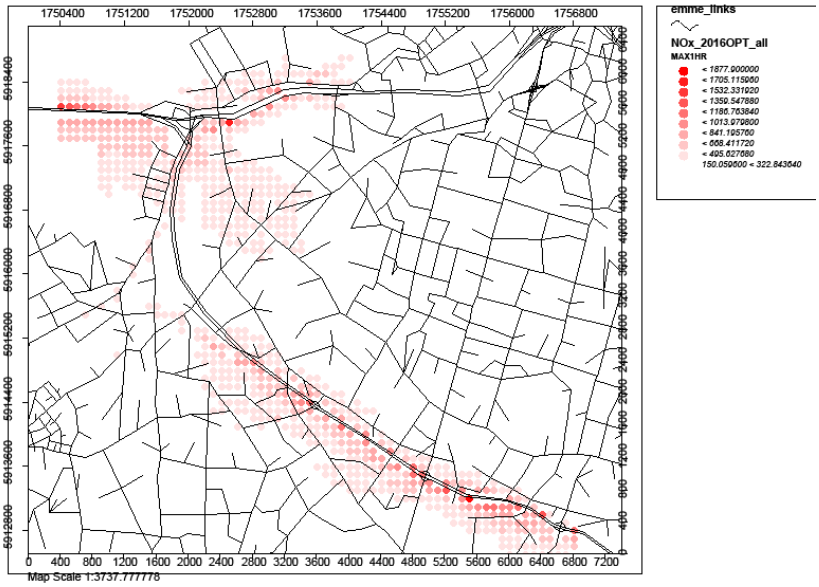


Figure 2. 1 Hour NOx. 2016. With project. (μg m^{-3})



The differences between these are very small, but there are some increased effects along the southern part of the route. **[Cannot read the key – needs to be larger]**

$PM_{2.5}$ (surface roads only)

Figure 3. 24 Hour $PM_{2.5}$. 2016. Do minimum. ($\mu g\ m^{-3}$)

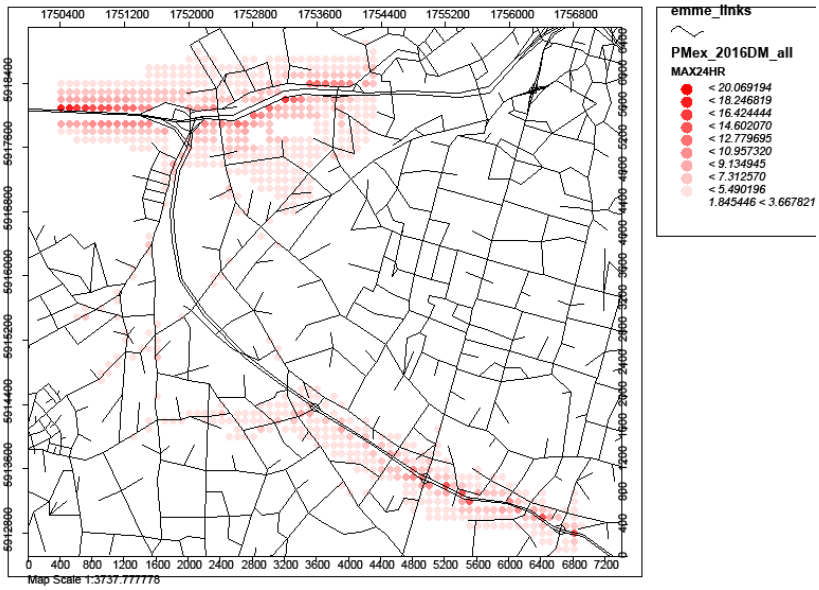
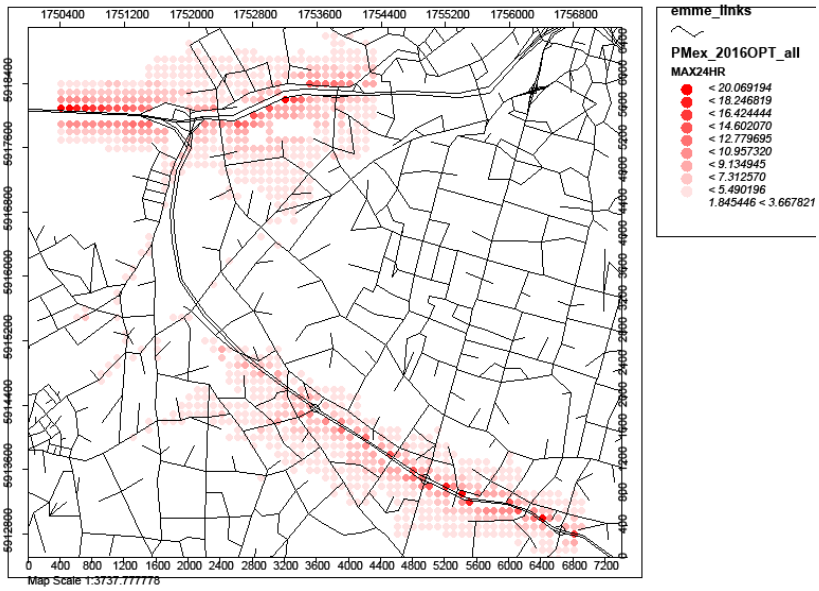


Figure 4. 24 Hour $PM_{2.5}$. 2016. With project. ($\mu g\ m^{-3}$)



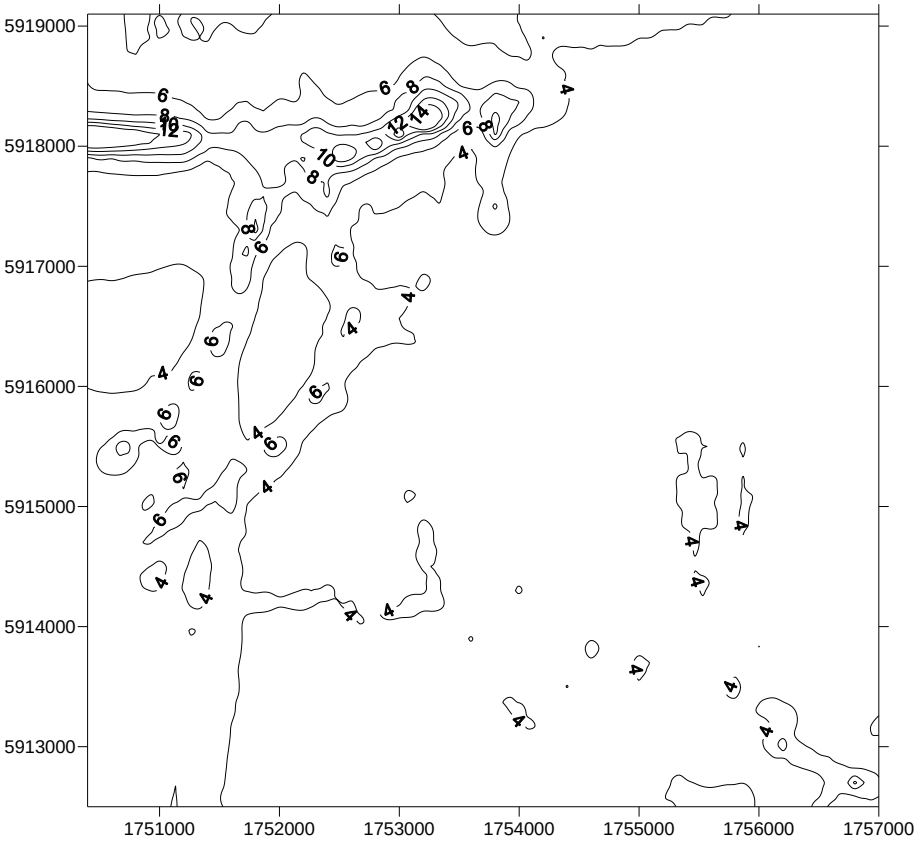
As with NOx, the differences for $PM_{2.5}$ are small.

PM_{10}

A more in depth analysis has been conducted on PM_{10} effects. Figures 5, 6, and 7 below show only the effects due to the local traffic and do not include cumulative estimates (if these are added they would be around 30-35 $\mu g\ m^{-3}$, depending on the location.) The base map has been omitted, but the scales and extent are the same as in Figures 1-4.

Firstly, Figure 5 below shows the pattern for PM_{10} concentrations in the baseline year of 2006.

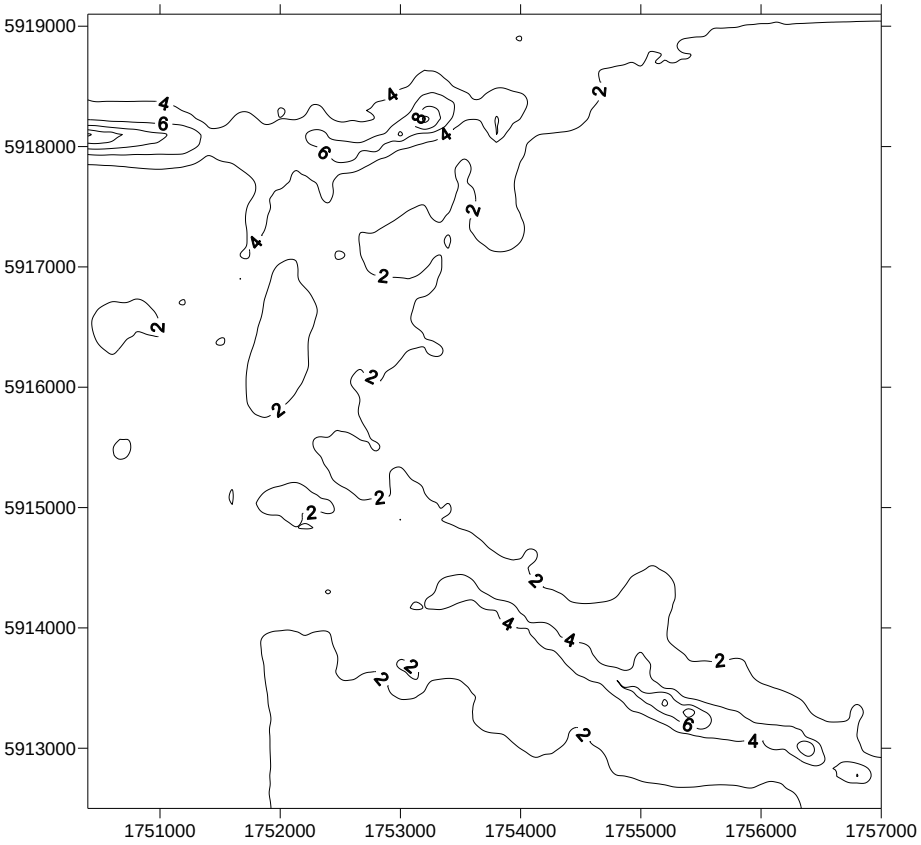
Figure 5. 24 Hour PM_{10}. 2006. ($\mu g\ m^{-3}$)



This shows that effects generally follow the busy road, especially SH16. The peak concentration value is 21.5 $\mu g\ m^{-3}$.

Next, in Figure 6 the case is shown for the 2016 year, without the Project.

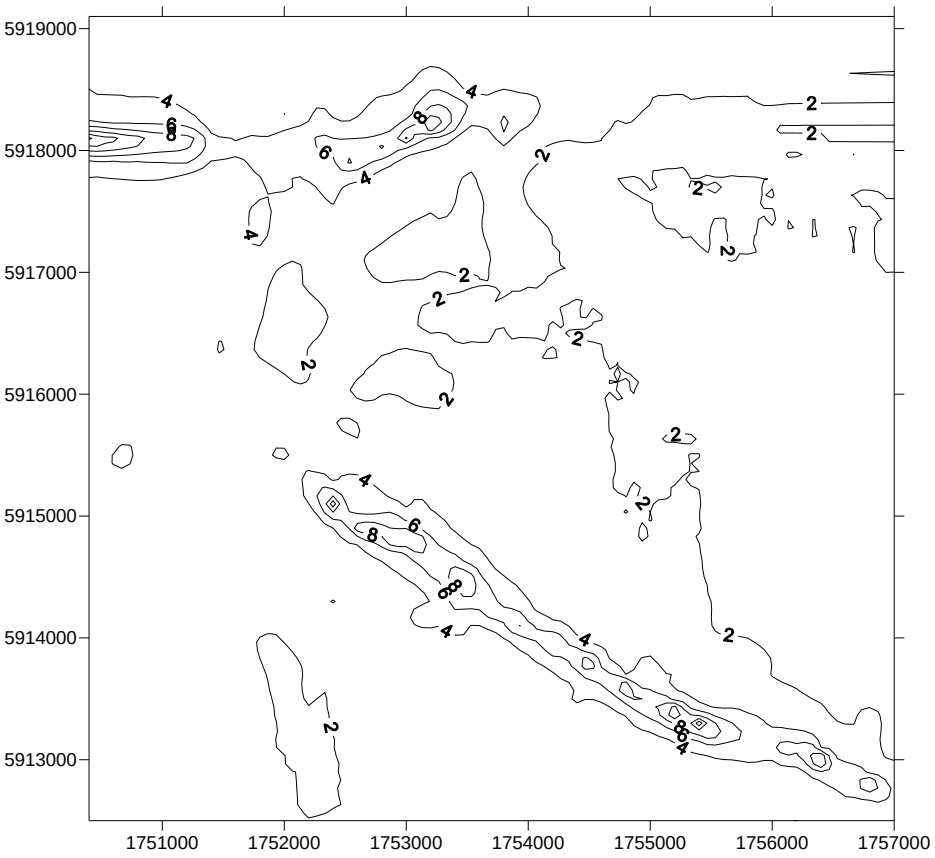
Figure 6. 24 Hour PM_{10}. 2016. Do minimum. ($\mu g\ m^{-3}$)



The shows generally slightly reduced effects (the peak concentration is 12.4 $\mu g\ m^{-3}$), but with a different pattern, due to the growth in traffic around the southern parts, near Mt Roskill.

Finally, the case is shown in Figure 7 for the 2016 year with the Project completed.

Figure 7. 24 Hour PM_{10}. 2016. With project. ($\mu g\ m^{-3}$)



This shows a minor increase, especially in the main route around Mt Roskill. The peak concentration is 14.4 $\mu g\ m^{-3}$.

Finally, the data are presented numerically, for the top 50 concentrations (ranked by 2016 "with project").

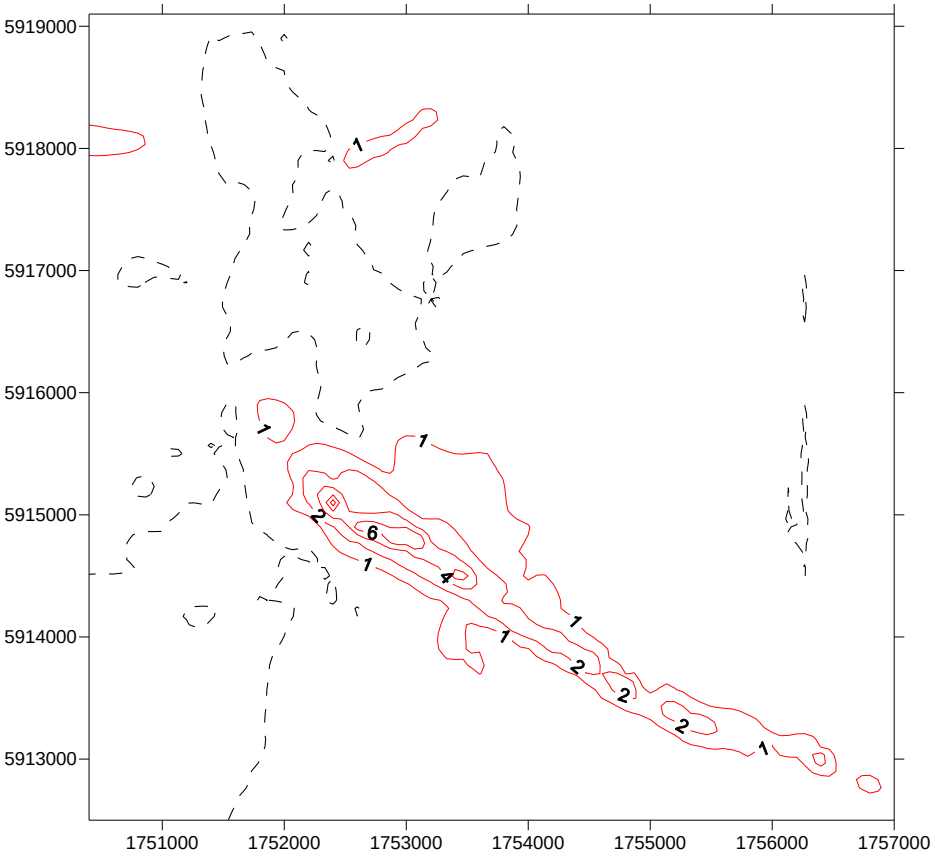
Table 1. Ranked concentrations of maximum 24 hour PM_{10} ($\mu g\ m^{-3}$)

PM10		2006	2016DM	2016OPT
X	Y	MAX24HR	MAX24HR	MAX24HR
1750400	5918100	21.0	12.4	14.4
1750500	5918100	19.8	11.7	13.4
1755200	5913400	2.7	9.7	13.3
1755400	5913300	3.0	9.6	13.2
1753200	5918200	21.5	11.7	12.9
1750600	5918100	18.7	11.0	12.6
1756400	5913000	4.0	9.1	12.3
1750700	5918100	17.6	10.4	11.7
1752400	5915100	3.2	2.0	11.2
1754800	5913600	2.7	6.3	10.8
1750800	5918100	16.6	9.7	10.8
1753100	5914800	3.2	2.1	10.8
1752700	5914900	2.7	2.1	10.8
1752900	5914800	2.7	2.2	10.7
1754500	5913800	3.1	6.5	10.6
1753000	5918100	16.2	8.5	10.3
1753500	5914500	3.0	3.1	10.1
1753400	5914500	3.0	3.0	9.9
1750900	5918100	15.4	9.0	9.9
1755500	5913200	2.6	7.7	9.9
1753300	5918200	16.2	8.7	9.5
1751000	5918100	14.1	8.3	9.3
1753500	5914400	2.7	4.7	9.2
1756800	5912800	4.2	7.4	9.1
1752600	5914900	2.7	2.0	9.1
1753900	5914100	2.6	5.7	9.0
1751100	5918100	13.5	8.1	9.0
1752800	5918000	14.0	7.3	8.8
1754900	5913500	3.1	6.5	8.7
1751200	5918100	13.0	7.8	8.7
1752800	5914900	3.1	2.1	8.6
1752500	5917900	14.5	7.2	8.6
1755200	5913300	2.5	6.5	8.3
1753100	5914700	3.0	2.4	8.3
1756100	5913100	4.7	6.4	8.0
1753000	5914900	3.1	2.0	8.0
1751300	5918100	11.8	7.1	7.8
1754200	5914000	2.9	4.9	7.8
1753400	5914600	3.2	2.5	7.7
1753500	5914300	2.7	6.0	7.7
1756300	5913100	3.5	5.7	7.6
1755000	5913400	2.9	6.3	7.6
1752600	5917900	12.3	6.3	7.6
1752900	5914900	3.0	2.1	7.6
1753700	5914200	2.5	4.8	7.4

This shows that for a number of locations, there are ups and downs, but peak values are still low, below 14.4 $\mu g\ m^{-3}$ (the standard for PM_{10} is 50). All of the higher values are within a few tens of metres of the roadways – the western part of SH16, and the route through Mt Roskill.

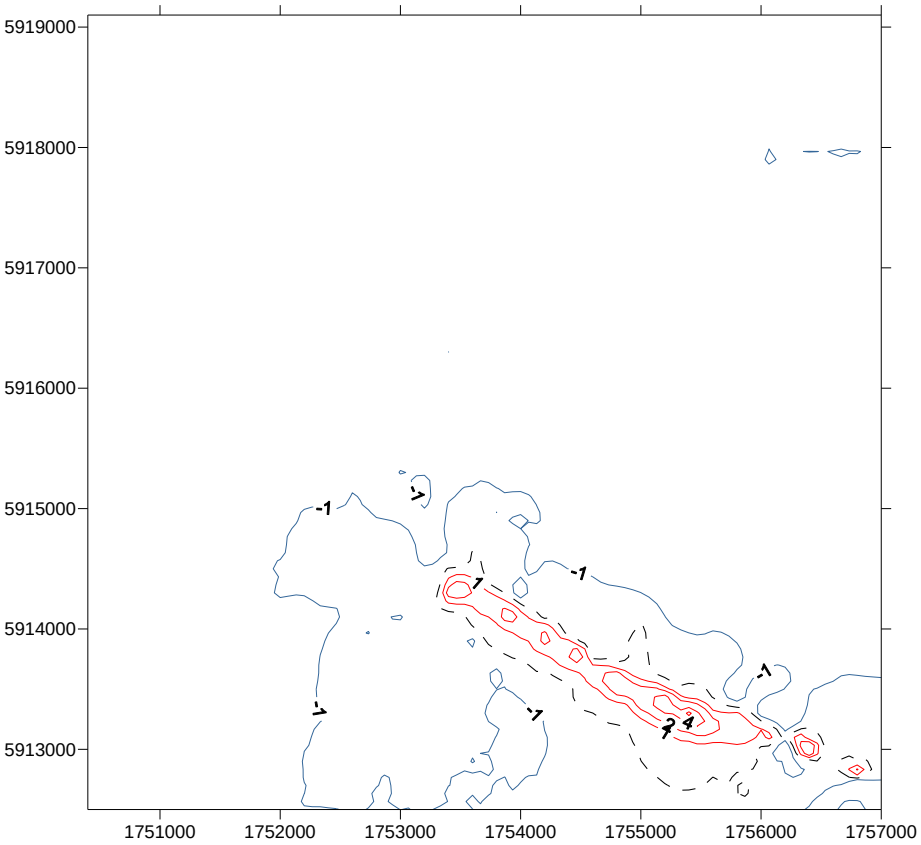
A further analysis is done examining the differences between the various scenarios. The red lines represent an increase, the dashed line no change, and the blue lines a decrease.

Figure 8. Difference between "Do minimum" and "With project". (μg m^{-3})



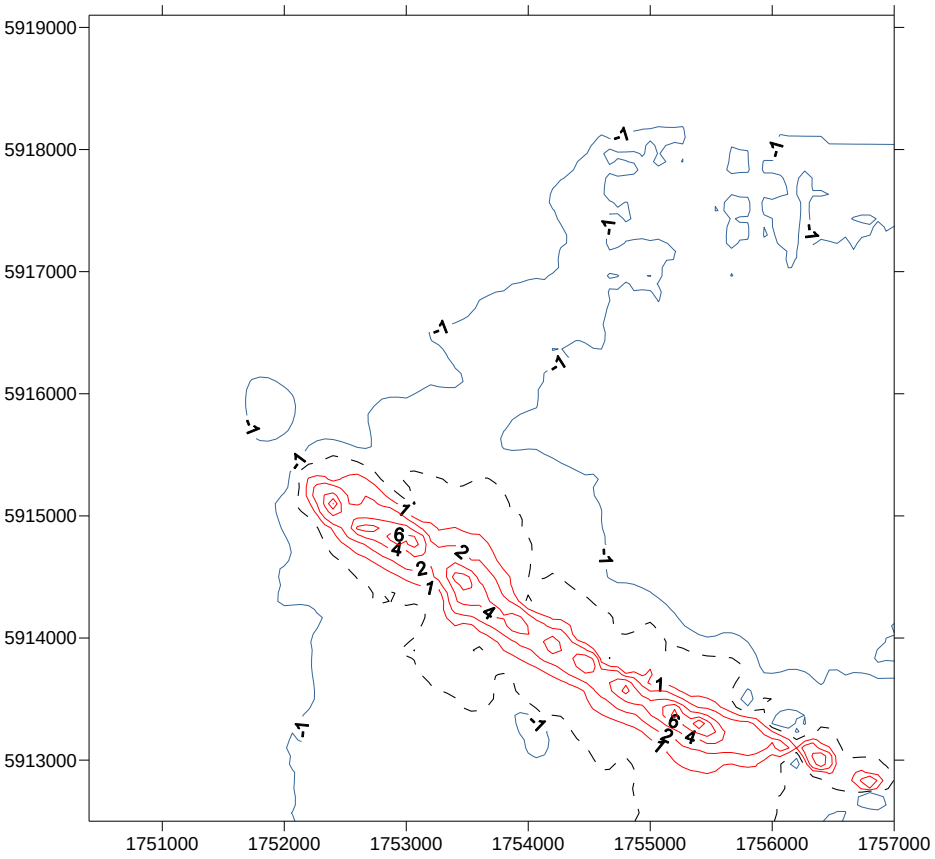
This shows that the completion of the Project will result in some small increases in 24 hour PM_{10} along the route through Mt Roskill. The largest of these (9.2 μg m^{-3}) occurring near the location of the current intersection of Maioro St and Richardson Rd.

Figure 9. Difference between "2006" and "2016. Do minimum". (μg m^{-3})



This shows the increases that are expected to occur anyway, regardless of the Project going ahead. The largest of these is 7.0 μg m^{-3}, occurring at the intersection of Richardson Rd and Dominion Rd.

Figure 10. Difference between "2006" and "2016. With project". (μg m^{-3})



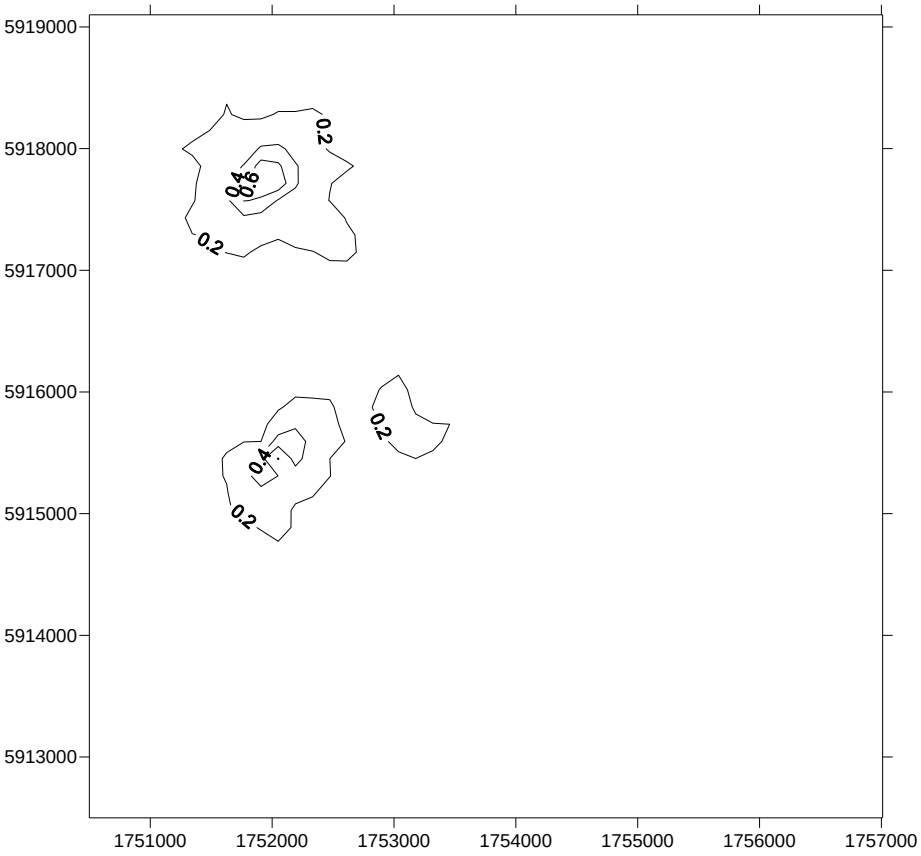
This shows the effect of the Project over the 'do nothing' scenario. There are large areas with a slight benefit (concentrations falling by around 1.0 μg m^{-3}), along the southern part there are some slight increases, the largest (10.6 μg m^{-3}) occurring at the location of the current intersection of Maioro St and Richardson Rd. Not that this increase seems large, but, along with several other grid point, it is at a location which is currently not very near to a road, but will be adjacent to the new Waterview Connection route.

Vents

For completeness, the effects due to the vents should be added into the above analysis. These are shown below, for the case of 24 hour PM_{10} from 15m vents.

Although the base map is not shown, this map is on the identical scale and size of the previous ones showing PM_{10} effects from the roadways.

Figure 11. 24 hour PM_{10} from 15m vents, 2016. ($\mu g\ m^{-3}$)



These concentrations are very low – with maximum value of 0.62 $\mu g\ m^{-3}$ just at the northern end of the Unitec campus. These values added to the roadway effects are almost trivial, and to the general background (of 30-35 $\mu g\ m^{-3}$) are completely inconsequential.