Greater Wellington
Te Pane Matua Taiao

2 June 2023

File Ref: OIAPR-1274023063-2545

[redacted]

Tēnā koe [redacted]

Request for information 2023-128

I refer to your request for information dated 12 May 2023, which was received by Greater Wellington Regional Council (Greater Wellington) on 12 May 2023. You have requested the following:

"When I asked Twitter "when will Metlink fix their air", I was not expecting much in the way of response from Metlink. I have previously raised the issue of Wellington buses' poor air quality with Metlink, and the response I got back was that no, there were no HEPA filters, and that as Metlink wasn't legally required to do anything about its air quality, it wouldn't be doing anything.

I could potentially be interested in a meeting with a subject matter expert, but it would be helpful to know in advance what their field of expertise was, and whether that conversation was intended to be two-way? I would be willing to hear about what barriers Metlink is facing in improving its onboard air quality (and whether public health advocates can help with that). Is Metlink also willing to hear about why better indoor air quality on buses is needed?

If that doesn't sound workable, then an OIA would be an alternative. A more specific question would be:

When does Metlink plan to either

a) introduce sufficient air exchange to its bus and train air conditioning systems to keep CO2 levels below 800ppm, even at full bus/train capacity, and/or

b) update its bus and train air conditioning to systems with HEPA filters (with an effective plan for appropriate filter cleaning or replacement), adequate for full bus/train capacity, to reduce the risk of viral transmission between passengers, and between passengers and your drivers;

and if Metlink has no plans to do either of these, why not?

(N.B. Of the two of these, (a) would be preferable to help your drivers stay alert, but (b) would still be highly valuable for reducing virus transmission. (a) and (b) together would be even better, particularly for your drivers, as they would benefit from the greater alertness of the low CO2, while also being protected from viruses and long-term daily exposure to small particulate matter from road/traffic pollution. Passengers are of course also exposed to road/traffic pollution, but have a shorter total period of daily exposure than do drivers).”

Greater Wellington’s response follows:

Please see **Attachment 1** which contains a report on indoor air quality monitoring on Metlink buses which we believe you may find of interest.

Metlink follow advice on health setting standards

Metlink takes the health and safety of our passengers and front-line team seriously and seeks to comply with health and safety laws and guidelines to the best of our ability.

Metlink is not a health standard setting organisation. Metlink follows advice and guidance from the Ministry of Health, the Ministry of Transport and Waka Kotahi on health standards. Our bus fleet meets the current regulations for urban buses set by Waka Kotahi. Currently, there are no regulatory indoor air guidelines for carbon dioxide on public transport.

Metlink is advocating to Government, through the Ministry of Health, to develop a common set of indoor air quality standards for public transport in New Zealand.

Once in place, Waka Kotahi and public transport authorities across the country will be able to work to a consistent framework, with appropriate funding, procurement, testing and compliance.

Please see **Attachment 2** which contains a copy of our letter to the Ministry of Health on this matter. The Ministry of Health replied to our letter on 17 May 2023 acknowledging the letter and advised us that they would be taking some time to consider the findings of the report and the questions we raised.

We encourage you to make contact with the Ministry of Health to continue to advocate for health standards to be developed and applied to the public transport network.

If you have any concerns with the decision(s) referred to in this letter, you have the right to request an investigation and review by the Ombudsman under section 27(3) of the Local Government Official Information and Meetings Act 1987.

Please note that it is our policy to proactively release our responses to official information requests where possible. Our response to your request will be published shortly on Greater Wellington's website with your personal information removed.

Nāku iti noa, nā

Fiona Abbott
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Pilot study: indoor air quality monitoring on Metlink buses

2022/23

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The report may be cited as:

Mitchell T. & Logan, T. 2022. *Pilot study: indoor air quality monitoring on Metlink buses*. Greater Wellington Regional Council, Publication No. GW/ESCI-T-23-6, Wellington.

Contents

Executive summary

Indoor CO_2 levels are an indicator of ventilation effectiveness, ie, ability to exchange stale indoor air with 'fresh' outdoor air. The purpose of ventilation is to avoid the accumulation of indoor-generated contaminants and odours and to maintain human comfort levels. Since the pandemic, there has been increased attention on improving ventilation and indoor air quality to reduce the risk of transmission of current and future airborne respiratory illnesses.

This pilot aimed to improve understanding of air quality and effectiveness of ventilation inside urban buses. Indoor air was monitored by Air Matters Ltd on eight in-service Metlink buses during October 2022 to provide information on the levels of CO_2 from passenger respiration. Sustained and elevated levels of CO_2 were found on 22% of monitored trips indicating inadequate ventilation for the bus occupancy level, which may pose an increased risk of transmission of respiratory infections and affect passenger comfort levels.

It is recommended that options to improve ventilation on the upper level of electric double decker buses are investigated and tested. There is no national policy or regulation for acceptable CO_2 levels for public transport environment and no ventilation specifications in the *Requirements for Urban Buses*. Public health advice is required to determine whether measured CO_2 levels pose a risk to passenger health.

1. Introduction

Metlink buses transport around 57,000[1] people per day to their destinations. We want people's journeys to be as comfortable and safe as possible within our available resources and what is technically achievable. The latest Quality of life survey (2022[2]) found 41% of survey respondents in the Greater Wellington region did not feel safe from catching COVID-19 or other illness from public transport and 27% agreed that it was safe. Because of COVID-19, 33% of respondents reported using public transport less often and 4% reported using more often.

Since the pandemic there has been increased international attention on improving ventilation in shared indoor spaces to reduce the chances of transmitting airborne respiratory infections, such as COVID-19 and seasonal influenza, and to provide better indoor air quality. In NZ, the Ministry of Education provides guidance for ventilation and CO_2 levels in classrooms to improve learning outcomes and lower the risk of viral transmission[3].

In 2022, University of Auckland found high levels of CO_2 on buses compared to other publicly used indoor environments and highlighted concerns about increased risk of viral transmission (Rindelaub, 2022). In response to these concerns, Metlink initiated a pilot monitoring study to assess the levels of in-cabin CO_2 on a sample of Wellington buses. The monitoring was carried out in October 2022 by Air Matters Ltd, who have expertise in occupational indoor air testing. The findings of the testing are summarised in this report, with the full Air Matters Ltd report attached as Appendix 2.

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[1] Average daily bus passengers July 2022 to February 2023

[2] FINAL-QOL-8-City-Topline-Report_17-October-2022.pdf (qualityoflifeproject.govt.nz)

[3] https://temahau.govt.nz/covid-19/advice-schools-and-kura/ventilation-schools/ventilation-guidance

2. Background

2.1 Indoor ventilation requirements

The main source of indoor CO_2 is from exhaled breath. The NZ standard[4] for ventilation for acceptable indoor air quality recommends ventilation sufficient to keep CO_2 below 1,000 ppm (parts per million) for human 'comfort' levels. Indoor ventilation requirements are usually specified by the rate of *Air Change Per Hour* (ACH), ie, exchange of stale indoor air for 'fresh' outdoor air. Measuring ventilation directly is difficult, requiring specialised equipment and expertise. Therefore, measuring the sustained concentration of indoor CO_2 (arising from accumulation of exhaled breath) can be used as an indicator of ventilation effectiveness. Improving ventilation has been identified as one key mitigation for transmission of airborne infectious particles between people (World Health Organization, 2021; ASHRAE, 2022).

2.2 Ventilation on buses

Generally, buses in the Wellington public transport fleet either have opening windows for ventilation, or air conditioning with little or no fresh air entering as the air is recirculated within the cabin. Some air conditioning units installed on Wellington buses have no way of introducing fresh air (without modification), others have the ability, but this function is not activated. There is fresh air available via the windscreen demister system, which may help provide fresh air to the driver. Many, but not all, buses have an opening window next to the driver. Too much fresh air being introduced could overwhelm the capability of the air conditioning unit and/or cause condensation on the windows. Incidental air changes occur when opening/shutting of doors at bus stops and if the bus has opening windows at passenger discretion.

Requirements for heating, ventilation, and air conditioning (HVAC) listed in the *Requirements for Urban Buses* (Waka Kotahi, 2022) are limited to climate control, ie, maintaining a temperature of 20°C ± 2°C. The *Land Transport Rule Passenger Services 1999* states that if forced ventilation is the only means of ventilation, then the system must incorporate at least two fans capable of delivering within two minutes an air volume the same size as the passenger compartment (which equates to 30 air changes per hour). The air conditioning system for new urban buses with full climate control would struggle to achieve both ventilation requirements and maintain temperature specifications.

2.3 CO_2 monitoring to assess infection risk

Since the pandemic, numerous studies overseas and three primary schools in NZ (NIWA, 2022) have used CO_2 monitoring as an indicator of respiratory infection risk. The relative risk of viral transmission may scale with CO_2 concentration, as there is more chance of breathing in infectious particles, should a source be present. However, there is not a direct link between indoor monitored CO_2 levels and absolute infection risk, as risk of transmission depends on factors which vary independent of CO_2 concentration, for example,

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[4] NZS 4303:1990 Ventilation for acceptable indoor air quality

community transmission rates, which affect the probability that infected people may be present (Eykelbosh, 2021).

Using CO_2 monitoring to assess ventilation and/or infection risk has been mostly applied to indoor spaces that are regularly occupied by the same group of people (eg, offices and schools). Indoor guidelines that exist for CO_2 are generally based on 'steady-state' concentrations, ie, when an equilibrium is reached between occupant-generated CO_2 and the rate of air exchange. Public transport environments, where occupancy changes over relatively short periods, can lead to fluctuating CO_2 levels. It is noted that CO_2 monitoring may not be an effective tool for evaluating infection risk in spaces that are transiently occupied by different people (UK SAGE-EMG[5]).

Air Matters Ltd assessed CO_2 levels against traffic-light bands for risk of viral transmission developed by the *Australian Safe Indoor Air Working Group* (OzSAGE[6]) for bars, restaurants and shops opening following the removal of COVID-19 restrictions. OzSAGE noted that shared vehicles, including public transport, are not currently subject to effective regulation of ventilation levels and that national standards should be developed and implemented. Although, the applicability of OzSAGE guidelines to the public transport environment is uncertain, they are a useful reference point for comparing the tested vehicles. Sustained CO_2 levels above 1500 ppm have been recommended as an indicator of poor ventilation for indoor occupied workspaces (UK HSE Health and Safety Executive[7], UK SAGE-EMG[8]).

2.4 CO_2 monitoring to assess direct health effects

Breathing high levels of CO_2 can result in headaches, tiredness and impacts on cognitive performance. If such effects occur, they are generally reversible with fresh air. Consensus on appropriate health-based thresholds for short-term non-occupational indoor exposure to CO_2 is not available and existing evidence for impacts on health, wellbeing, learning outcomes and work performance is inconsistent (ASHRAE, 2022).

For occupational exposure, the NZ Workplace Exposure Standard for CO_2 is 5000 ppm (averaged over an 8-hr working day) and a short-term limit of 30,000 ppm (15-minute average).

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[5] EMG: Role of ventilation in controlling SARS-CoV-2 transmission, 30 September 2020 - GOV.UK (www.gov.uk)

[6] OzSAGE Safe Indoor Air (ventilation) recommendations. Version 1.02. 6 September 2021. https://ozsage.org/working_group/safe-indoor-air-ventilation/

[7] HSE Ventilation in the workspace. https://www.hse.gov.uk/ventilation/using-co2-monitors.htm#understanding

[8] EMG: Role of ventilation in controlling SARS-CoV-2 transmission, 30 September 2020 - GOV.UK (www.gov.uk)

3. Monitoring strategy

Air Matters Ltd installed two CO_2 sensors in each bus level (mid and back of the cabin). There were two monitors per single deck bus and four per double deck bus. Between 18-20 October 2022, eight in-service buses were monitored each day representing a total of 64 trips (Table 3.1). The monitors used were personal CO_2 meters (SAN-10), which use non-dispersive infrared (NDIR) technology.

Table 3.1: Buses monitored and their ventilation systems

Vehicle ID	Engine Type	Drivers' window	Opening windows	Air conditioning	Demist system with fresh air	Capacity Adults	Outside air from Air conditioning	Comment
3701	Electric DD	Yes	Yes	No	Yes	74	No	Fresh air via windows.
3710	Electric DD	Yes	Lower	Upper only	Yes	90	No	Fresh air via windows on lower deck, upper deck will require modification to achieve fresh air.
3523	EURO VI DD	No	No	Yes	Yes	102	No	Fresh air is possible
5083	EURO V DD	Yes	No	Yes	Yes	101	No	Up to 20% fresh air is possible
3433	EURO VI	No	No	Yes	Yes	75	No	Fresh air is possible
3452	EURO VI	No	No	Yes	Yes	75	No	Fresh air is possible
5738	Electric	Yes	No	Yes	Yes	75	Unknown	Up to 20% fresh air possible.
5747	Electric	Yes	No	Yes	Yes	75	Unknown	Up to 20% fresh air possible.

4. Key findings

4.1 Representativeness of sampled buses and passenger loadings

The eight buses selected for the study were a combination of bus types (DD electric, DD diesel, LV diesel and electric) operating on a variety of routes, including the bus corridor through the Golden Mile and outer suburbs of Wellington City. As such, the bus sample is broadly representative of the fleet operating in Wellington.

Buses were monitored during the morning and afternoon peaks to capture maximum passenger loadings. The maximum passenger numbers on the monitored buses were compared to the annual school term time distribution of daily maximum passengers recorded on each trip. Over half the monitored bus trips had maximum passenger loadings that were between the 75th and 100th percentile of typical maximum loadings in 2022.

4.2 CO_2 results

The CO_2 monitoring devices used in the study were 'personal' occupational health monitors and are therefore not optimised to measure indoor air quality but were considered the most practical devices readily available for the pilot study.

There were problems with readings from two devices drifting significantly from their calibrated value resulting in unrealistically low readings. Measurements below expected minimum outdoor CO_2 concentrations (413 ppm) were subsequently invalidated. Nevertheless, we have confidence in the monitoring data for showing general patterns and relationship between passenger occupancy and CO_2 levels.

4.2.1 Risk bands for viral transmission

Figure 4.1 shows the percentage of time monitored CO_2 levels (as a 30-second average) occurred in the OzSAGE relative risk banding levels for each vehicle monitored, including rest breaks and repositioning. Poor ventilation conditions, indicated by CO_2 above 1500 ppm, ranged from 0.3% of the time (Bus 5738) to 28% of the time (Bus 3433).

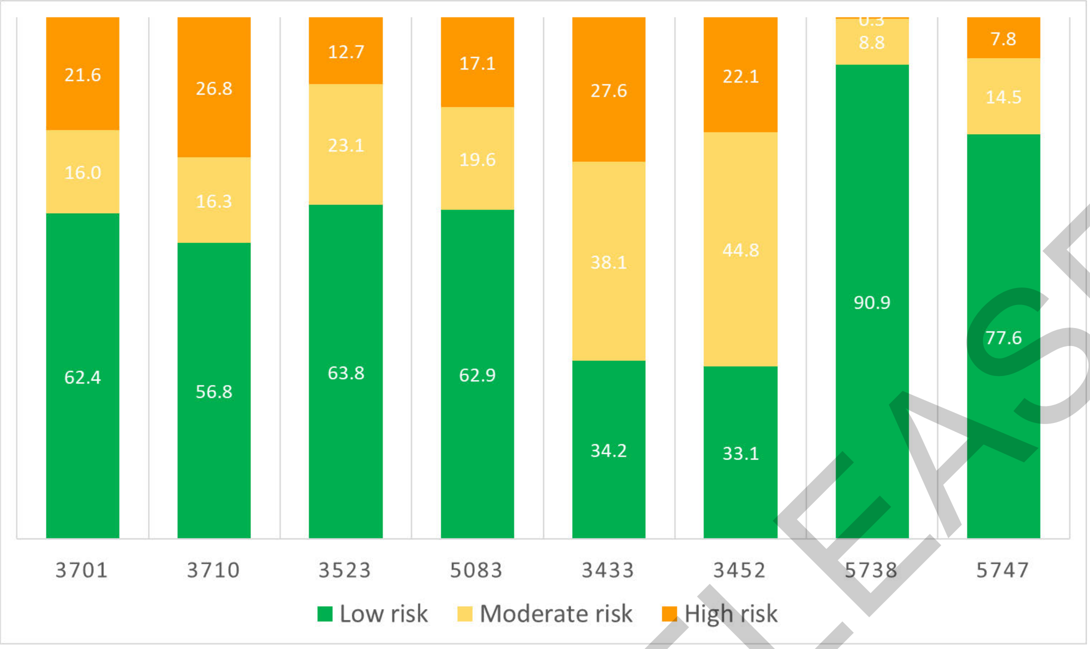

Figure 4.1: Percentage of time all CO_2 ppm (30 second averages) were in OzSAGE risk of viral transmission categories by vehicle tested. Includes rest breaks and bus repositioning. Low risk = < 800 ppm, Moderate risk = > 800 and < 1500 ppm, High risk = > 1500 ppm

Although it is not possible to use these CO_2 monitoring results to directly assess risks of respiratory infection transmission, the results suggest that measures to improve on-board ventilation should be further investigated and public health advice sought. It is noted that that ventilation provides a continuum of protection against infection risk, but there is no threshold level of ventilation for zero risk (NIWA, 2022).

4.2.2 CO_2 average by bus type and trip duration

GW Environmental Science averaged the CO_2 30-second data from the two sensors on each bus level and then aggregated the data by individual bus trips. Rest breaks and repositioning time were excluded so the analysis was focused on passenger exposure. A bus trip represents a segment of a route with specified bus stops. For example, trip 1160 (on Route 7) has 20 stops between Kingston and Wellington railway station. Total maximum passenger numbers for each route-trip were compared with 'typical' passenger occupancy during term in 2022.

Table 4.1. shows the double decker vehicle CO_2 monitoring results averaged for each route-trip combination and the percentile of maximum passenger loadings for the year. Typically, the upper decks recorded higher CO_2 levels than the lower deck, particularly for the electric buses. Table 4.2 shows the single deck vehicle CO_2 monitoring results for each individual route-trip and the percentile of maximum passenger loadings for the year. Across all monitored buses, there were 14 route-trips that had average CO_2 above 1500 ppm.

The summary distribution for all 30-second CO_2 readings by vehicle route-trip is attached in Appendix A1.

Table 4.1: Double deck vehicle route-trips. Route-trips where average CO_2 was greater than 1500 ppm are shaded orange.

Vehicle	Route	Trip	Duration	Departure	Stops (n)	Max pax	Max pax percentile*	CO_2 mean (ppm)	
								Lower deck	Upper deck
3701	7	1000	00:24:48	06:00	19	25	0.84	761	933
	HX	1020	00:09:40	06:25	2	8	0.92	736	1067
	39	1900	00:37:09	06:50	24	44	0.97	1005	2171
	7	1160	00:33:33	07:55	20	56	0.61	1613	3993
	1	1840	00:57:45	12:15	22	25	0.88	575	509
	7	1700	00:26:06	13:50	12	13	0.98	572	NA
3710	1	1010	00:58:26	05:40	32	28	0.83	1054	1167
	1	1180	01:19:04	07:05	32	80	0.89	2484	5756
	23	1100	00:43:01	08:40	26	27	0.77	1360	2871
	29	1140	01:01:38	10:14	12	12	0.71	629	1025
	29	1470	01:02:11	11:42	13	13	0.97	574	716
	29	1460	00:54:52	12:44	14	8	0.62	433	508
	29	1510	00:46:38	13:42	17	16	0.94	469	685
3523	1	1030	00:58:41	06:00	23	32	0.89	687	868
	24	1080	01:08:05	07:20	37	51	0.79	972	1166
	24	1110	01:02:55	08:23	21	18	0.67	617	775
	7	1790	00:29:45	15:15	18	26	0.32	625	785
	HX	1050	00:16:02	16:08	5	18	0.88	539	633
	7	1930	00:31:27	16:45	19	57	0.94	968	1306
	23	1350	00:40:26	17:44	18	34	0.8	691	897
5083	36	1120	00:55:18	08:00	26	105	1	2100	3026
	83	2090	00:42:45	09:20	12	10	0.29	821	708
	83	1200	01:15:36	11:05	21	37	0.95	842	726
	753	1010	00:21:55	15:26	2	62	0.56	1992	2243
	31x	1090	00:43:07	16:10	17	29	0.72	1189	1405
	36	1150	00:42:34	17:45	27	55	0.95	1199	1681

*The percentile of the 2022 daily maximum passengers onboard during the CO2 monitoring period

Table 4.2: Single deck vehicle route-trips. Route-trips where average CO_2 was greater than 1500 ppm are shaded orange.

Vehicle	Route	Trip	Trip duration	Departure	Stops (n)	Max pax	Max pax percentile*	CO_2 mean (ppm)
3433	24	1010	01:10:39	06:10	30	23	0.86	1252
	680	1000	00:28:34	07:50	16	47	0.87	1668
	24	1170	01:15:28	10:10	21	13	0.68	690
	24	1700	01:16:34	12:15	22	18	0.95	737
	24	1750	01:06:12	13:40	30	34	0.97	1443
	685	1010	00:38:58	15:15	16	33	0.68	2228
	7	1890	00:28:55	16:25	21	34	0.64	1679
	7	1960	00:30:02	17:05	13	10	0.79	987
	7	2030	00:36:46	17:35	23	56	0.86	2208
3452	HX	1000	00:09:51	06:10	2	5	0.78	761
	25	1030	00:27:43	06:48	11	7	0.59	768
	25	1080	00:31:47	07:35	21	26	0.35	1330
	25	1150	00:56:39	08:30	22	29	0.93	1660
	25	1220	00:32:38	09:30	15	12	0.66	1376
	17	1200	00:28:30	11:10	2	1	0.10	639
	17	1110	00:09:18	11:40	4	4	0.44	710
	17	1220	00:17:22	12:10	2	1	0.05	733
	17	1130	00:25:28	12:40	9	11	0.86	858
	17	1240	00:23:34	13:10	5	3	0.30	710
	17	1150	00:28:00	13:40	14	10	0.60	903
	17	1260	00:15:33	14:10	5	3	0.36	676
	7	1750	00:35:13	14:45	21	31	0.79	1298
	673	1010	00:29:44	15:40	9	33	0.49	2297
	19	1930	00:23:45	16:41	9	12	0.82	1525
	24	1420	01:12:38	17:15	26	24	0.69	1113
5738	2	1210	00:54:59	07:27	25	20	0.28	733
	2	1380	00:59:48	08:37	32	57	0.95	843
	2	1750	00:57:01	10:15	28	24	0.61	513
	2	2060	00:52:36	12:52	26	13	0.33	549
5747	2	1170	00:52:36	07:11	30	61	1	1389
	2	1320	00:58:54	08:15	31	72	1	1260
	2	1610	00:54:19	09:27	28	24	0.62	612
	2	1860	01:01:24	11:37	26	27	0.82	515
	2	2150	00:53:50	12:45	24	22	0.57	495
	2	2260	00:54:47	14:07	21	18	0.38	560
	2	2550	01:06:08	15:15	38	47	0.93	976
	2	2660	01:07:24	16:37	41	60	1	898
	2	2950	00:55:20	17:46	28	33	0.75	871

*The percentile of the 2022 daily maximum passengers onboard during the CO_2 monitoring period

4.2.3 Relationship between CO_2 and passenger occupancy

Passenger numbers onboard between bus stops were estimated using the difference between number of passengers alighting and passengers disembarking as recorded by snapper and gold card data. Although, in general CO_2 peaks temporally coincided with peaks in passenger numbers (Air Matters Ltd Appendix B: CO_2 time series graphs), there was considerable variability in the relationship between CO_2 and passenger numbers. Passenger numbers onboard and average CO_2 levels between each stop are shown for single deck buses (Figure 4.2) and by deck for double decker buses (Figure 4.3).

Figure 4.2 shows that on single deck buses average CO_2 levels above 1500 ppm between stops were found across the range of passenger numbers (0 to 72) except for bus 5738. Figure 4.3 shows at times high CO_2 concentrations between stops on the upper decks across the entire range of passenger numbers. The highest upper deck CO_2 concentrations were found on the two electric double decker buses (3701 and 3710). Although it was not possible to identify the spilt between passenger numbers on the upper and lower levels, the higher CO_2 concentrations found upstairs were probably due to the smaller upstairs cabin volume and slower decay rate of CO_2 (emitted by previous passenger) as there was less fresh air introduced upstairs compared to downstairs when bus doors open for passengers to board and disembark.

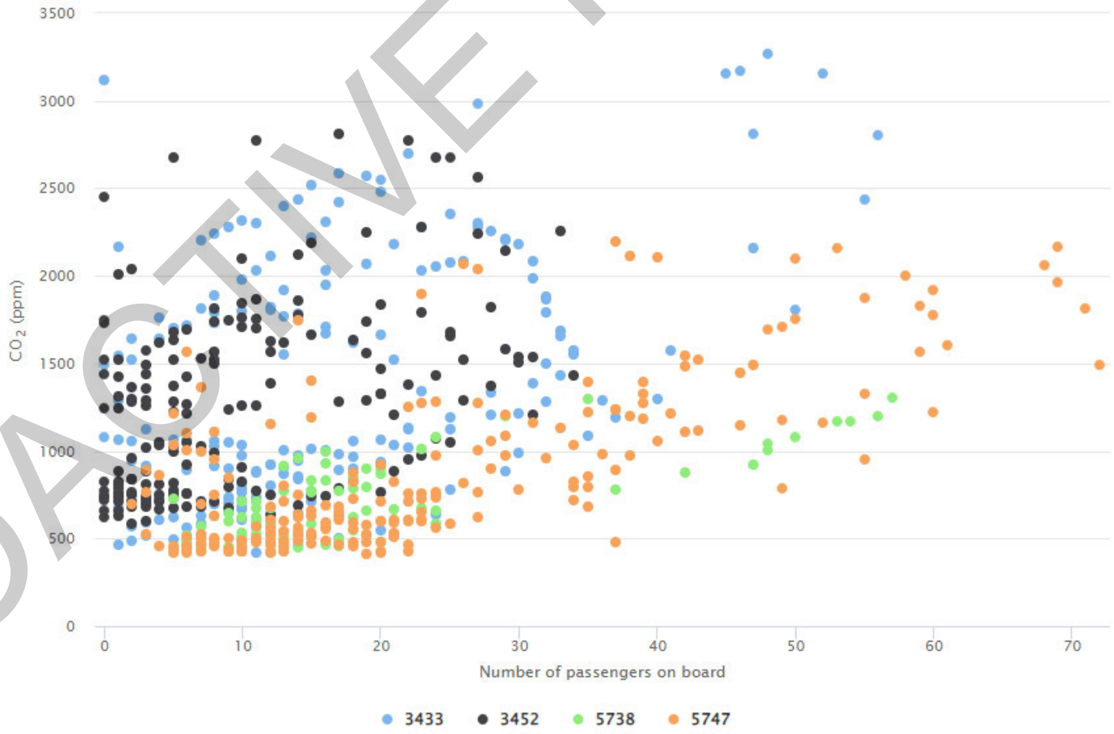

Figure 4.2: Single deck buses. Average CO_2 ppm vs number of passengers on board between bus stops by vehicle ID.

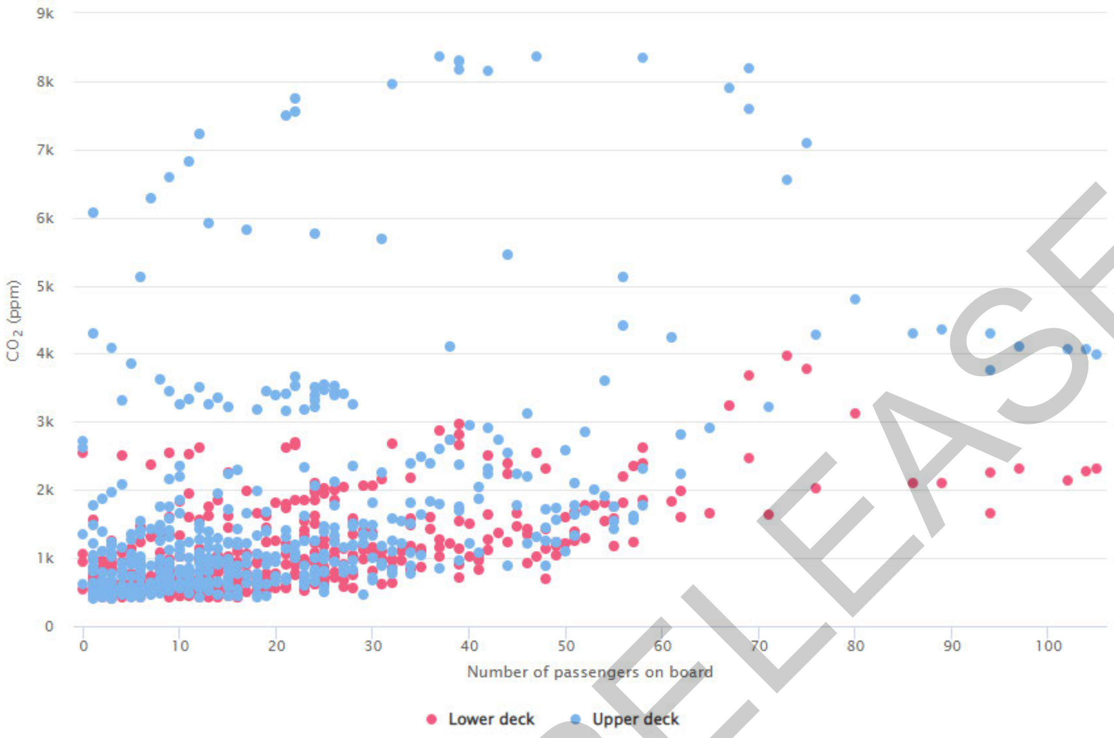

Figure 4.3: Double decker buses. Average CO_2 ppm vs number of passengers on board between bus stops by upper and lower deck.

4.2.4 Monitoring results summary

CO_2 concentrations are a function of many factors: passenger numbers, duration of the trip, CO_2 accumulated from previous passengers onboard, bus airflow and ventilation systems and potentially individual variations in passenger CO_2 generation rate.

The monitoring found that most buses experienced periods when CO_2 levels exceeded high risk guidelines for viral transmission, particularly the upper decks of double decker buses. Due to the small sample size, and inability to track any ventilation controls in use, this study was not able to identify reasons for differences in CO_2 concentrations between buses.

4.3 Direct health effects for passengers and drivers

The maximum average CO_2 concentration measured between two bus stops was 8404 ppm. At this level passenger comfort is likely to be affected. As there are no short-term non-occupational health guidelines for CO_2 exposure, further research and/or guidance from public health authorities is needed, particularly to assess whether there might be potential impacts on passengers with underlying vulnerabilities or health conditions.

When averaged over the entire day's monitoring (including re-positioning), CO_2 concentrations were well below the 8-hr and 15-minute Workplace Exposure Standard for occupational exposure to CO_2, designed to protect healthy adult workers. Driver exposure to CO_2 may be lower than in other areas on the bus due to driver control of personal air flow control settings and proximity to door opening. Personal monitoring is the best way to assess occupational exposure in this instance.

4.4 Outdoor air pollutants inside buses

Air Matters monitoring devices did not detect any traffic exhaust gases (ie, carbon monoxide and NOx) on board. GW Environmental Science carried out a very limited black carbon (ultrafine soot from combustion) monitoring trial on some buses and found varying levels of ultrafine combustion particulate most likely from traffic sources entering through open doors and windows. This has implications for increasing outdoor air intake along routes through highly trafficked areas which may increase the levels of polluted outdoor inside the bus but may also enhance air exchange which can flush out air pollutants that become 'trapped' inside the bus. More investigation and expert advice are required to understand this issue.

5. Recommendations

- Agree with Air Matters Ltd finding that priority should be given to understanding the factors influencing elevated levels of CO_2 on the upper levels of double decker buses.

- Investigate feasibility of improving ventilation on upper decks of double decker buses, and test effectiveness of any identified achievable modifications, such as adding fresh air through the air conditioning system.

- Seek advice from Ministry of Health on appropriate levels of CO_2 for public transport to protect health of all passengers.

Acknowledgements

Many thanks to the following GW staff, Tristan Elder for assisting with monitoring logistics, Hamish Clark for calculating passenger numbers between stops, Simon Cross for the historical passenger loadings by route and trip, and Jeremy Parry-Thompson and Harrison O'Sullivan-Moffet for carrying out on board black carbon monitoring.

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Appendix 1: CO_2 summary results by vehicle and route-trip

Table A1.1: Summary of distribution of CO_2 ppm 30-second measurements on double decker buses by route-trip, excluding bus repositioning and driver rest breaks.

Vehicle	Level	Route-Trip	Min	25th percentile	Median	Mean	75th percentile	Max
3701	Lower	7-1000	443	604	753	761	931	971
	Lower	HX-1020	528	586	762	736	892	937
	Lower	39-1900	507	786	1011	1005	1115	1623
	Lower	7-1160	1022	1131	1652	1613	2036	2272
	Lower	1-1840	413	509	554	575	637	761
	Lower	7-1700	425	502	547	572	630	775
	Upper	7-1000	522	763	917	933	1151	1366
	Upper	HX-1020	827	911	1088	1067	1210	1358
	Upper	39-1900	789	1355	2260	2171	2906	3514
	Upper	7-1160	1844	2492	3998	3993	5545	6064
	Upper	1-1840	415	456	484	509	580	647
	Upper	7-1700	NA	NA	NA	NA	NA	NA
3710	Lower	1-1010	464	957	1017	1054	1228	1454
	Lower	1-1180	455	1952	2565	2484	3000	4342
	Lower	23-1100	425	885	1382	1360	1815	2131
	Lower	29-1140	434	547	609	629	697	866
	Lower	29-1470	415	477	594	574	673	705
	Lower	29-1460	432	433	433	433	434	434
	Lower	29-1510	421	429	475	469	504	516
	Upper	1-1010	413	941	1214	1167	1386	1768
	Upper	1-1180	883	4586	6273	5756	7807	8405
	Upper	23-1100	1563	2441	2950	2871	3399	4421
	Upper	29-1140	538	857	1040	1025	1250	1542
	Upper	29-1470	535	616	719	716	810	878
	Upper	29-1460	455	495	504	508	527	576
	Upper	29-1510	419	558	681	685	818	912
3523	Lower	1-1030	414	572	626	687	814	990
	Lower	24-1080	421	833	872	972	1223	1504
	Lower	24-1110	451	539	585	617	701	804
	Lower	7-1790	417	525	629	625	740	781
	Lower	HX-1050	413	438	543	539	625	688
	Lower	7-1930	532	754	1043	968	1173	1314
	Lower	23-1350	443	561	618	691	842	982
	Upper	1-1030	541	654	826	868	1084	1252
	Upper	24-1080	561	680	1223	1166	1535	1833
	Upper	24-1110	550	696	754	775	881	968
	Upper	7-1790	416	606	793	785	991	1021
	Upper	HX-1050	538	556	598	633	710	804

Vehicle	Level	Route-Trip	Min	25th percentile	Median	Mean	75th percentile	Max
	Upper	7-1930	643	1023	1382	1306	1633	1780
	Upper	23-1350	523	674	863	897	1142	1264
5083	Lower	36-1120	1531	1825	2147	2100	2317	2812
	Lower	83-2090	641	722	801	821	927	1041
	Lower	83-1200	418	494	841	842	1095	1650
	Lower	753-1010	588	1503	2340	1992	2492	2719
	Lower	31x-1090	770	1024	1182	1189	1351	1570
	Lower	36-1150	604	919	1106	1199	1588	1805
	Upper	36-1120	429	1955	3573	3026	4105	4407
	Upper	83-2090	493	565	672	708	806	1152
	Upper	83-1200	428	524	742	726	892	1061
	Upper	753-1010	458	2150	2471	2243	2626	2722
	Upper	31x-1090	1040	1332	1416	1405	1518	1630
	Upper	36-1150	554	1172	1889	1681	2228	2403

Table A1.2: Summary of distribution of CO_2 ppm 30-second measurements on single deck buses by route-trip, excluding bus repositioning and driver rest breaks.

Vehicle	Route-Trip	Min	25th percentile	Med	Mean	75th percentile	Max
3433	24-1010	415	1077	1277	1252	1564	1814
	680-1000	438	935	1611	1668	2395	3121
	24-1170	435	579	704	690	806	928
	24-1700	415	551	751	737	933	1025
	24-1750	668	787	1483	1443	2043	2299
	685-1010	1305	2203	2301	2228	2420	2597
	7-1890	955	1495	1755	1679	1962	2093
	7-1960	881	913	984	987	1056	1132
	7-2030	1028	1679	2259	2208	2822	3309
3452	HX-1000	639	748	768	761	800	840
	25-1030	630	687	792	768	841	859
	25-1080	626	827	1371	1330	1816	1867
	25-1150	1208	1288	1623	1660	2026	2289
	25-1220	1255	1279	1363	1376	1466	1533
	17-1200	559	613	631	639	658	742
	17-1110	693	701	708	710	718	738
	17-1220	696	725	734	733	744	766
	17-1130	678	707	874	858	989	1043
	17-1240	683	694	707	710	720	760
	17-1150	748	767	914	903	1028	1067
	17-1260	584	589	690	676	747	772
	7-1750	661	760	1525	1298	1706	1786
	673-1010	866	1913	2608	2297	2773	2849
	19-1930	1240	1422	1600	1525	1641	1714
	24-1420	716	822	1003	1113	1423	1681
5738	2-1210	426	592	744	733	869	1025
	2-1380	432	624	786	843	1051	1333
	2-1750	415	442	472	513	574	690
	2-2060	424	485	566	549	597	667
5747	2-1170	429	863	1352	1389	1957	2185
	2-1320	419	712	1130	1260	1879	2233
	2-1610	413	529	619	612	716	765
	2-1860	413	446	493	515	587	648
	2-2150	424	463	479	495	519	621
	2-2260	416	502	555	560	634	671
	2-2550	422	714	959	976	1233	1536
	2-2660	413	469	733	898	1253	1889
	2-2950	420	631	817	871	1133	1292

Appendix 2: Air Matters monitoring report

GREATER WELLINGTON REGIONAL COUNCIL

AIR MATTERS REPORT 22214

Bus Cabin Carbon Dioxide Monitoring – Pilot Study

Assessment Date:	20/10/2022
Report Date:	16/12/2022

Report prepared for GWRC by Air Matters Limited.

Air Matters Report: 22214

Date: 16/12/2022

Status: FINAL

Sampling carried out by:

Nigel Goodhue

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Nigel Goodhue

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Occupational Hygienist

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Table of Contents

1. INTRODUCTION

Greater Wellington Regional Council (GWRC) engaged Air Matters Limited (Air Matters) to undertake a pilot study of carbon dioxide (CO_2) concentrations within a range of bus types used on the Wellington Region's public transport network. The monitoring was requested to provide an initial scientifically-based assessment of the transmission risk of airborne pathogens and passenger comfort levels. These monitoring results are intended to provide GWRC with an indication of risk, with the aim to prioritise measures to reduce the transmission of airborne pathogens within public buses. The monitoring was undertaken by Air Matters staff, on 18, 19th and 20th October 2022.

2. AIR QUALITY IN INDOOR AREAS & BUSES

Carbon dioxide has been used as an indicator of indoor air quality (IAQ) for centuries, with the first guidelines being developed in the nineteenth century. There are two aspects to consider when monitoring CO_2 to determine IAQ and potential health risks as described below.

Direct effects of Carbon Dioxide

Firstly, CO_2 can directly lead to adverse health effects at elevated levels. There are a range of exposure standards available for workplace indoor quality. For example, WorkSafe NZ's Workplace Exposure Standards (WES) for CO_2 are 5,000ppm averaged over an 8-hour shift and 30,000ppm averaged over a 15-minute period. Given WES are intended for persons in the workforce (healthy individuals) and over work timeframes, they are not likely to be appropriate for assessing the potential health effects on public transport.

Numerous studies, for example Zhang *et al* (2015) have assessed the effects of CO_2 on cognitive ability and provide a range of CO_2 levels where effects are observed during the exposure. Increased CO_2 levels are also associated with the feeling of 'stuffiness' or 'drowsiness' within an area which is likely also contributed to by variables such as elevated humidity and temperature.

Indicator of Air Quality

Secondly, CO_2 is used as a proxy for understanding the potential risk of transmitting pathogen containing aerosols. Provided the CO_2 is generated by human respiration, then elevated concentrations could indicate an increased risk of pathogen transmission. Since the COVID-19 pandemic, research and the use of CO_2 for this purpose has become more common. For example, the Ministry for Education has released guidance on appropriate CO_2 levels to minimise the risk of COVID-19 and other pathogen transmission within school classrooms.

The purpose of this study's monitoring is to understand the potential pathogen transmission risk. Therefore, the following sections are focused on determining appropriate CO_2 concentrations that may indicate an increased risk of pathogen transmission on public transport.

While passenger areas in buses are not typically described as indoor spaces, they are enclosed environments, and as such, the guidelines for CO_2 levels in buildings have been considered applicable for pathogen risk assessment purposes. A 2021 study from the University of Colorado suggests that "the relative risk of infection in a given situation has been shown to scale with the excess CO_2 concentrations" *(Peng & Jimenez 2021).* With the recent COVID-19 pandemic, the concentration of

CO_2 within an indoor space is being used as a threshold to determine the risk of pathogen transmission and it has become regularly reviewed and researched.

A 2020 publication by the Australian Institute of Refrigeration Air Conditioning and Heating recommends an orange indicator of indoor air quality (assumed to be moderate level of viral transmission risk) from 800 to 1000 ppm, and a red indicator at more than 1000 ppm CO_2 for school buildings (AIRAH guidance for school building COVID19 2020). In New Zealand, the Ministry for Education has recommended action levels in response to COVID-19 transmission risks when CO_2 levels within classrooms exceed 800 ppm (MoE, 2022).

OzSAGE (a multi-disciplinary network of Australian experts set up to provide advice on public health, health systems and policy matters relevant to COVID-19 control during the opening up of Australia) released a guidance document in September 2021, *Creating safe workplaces during the COVID-19 pandemic* and *Safe Indoor Air (Ventilation) Recommendations.* Within these guidance documents, OzSAGE recommends the following action limits:

For restaurants, bars and shops, CO_2 level should be considered as a surrogate for the relative risk of airborne infection. Action limits should be applied as per below:

1. *Below 800 ppm – indicates a low relative risk of infection;*
2. *Between 800 ppm to 1,500 ppm – indicates moderate relative risk of infection. Improvements should be made where practicable to increase the provision of fresh air into the indoor space;*
3. *Above 1,500 ppm – indicates a high relative risk of infection. Immediate improvements must be made to increase the provision of fresh air into the indoor space or air filters must be operational.*

While not specific to public transport, the principles of enclosed space ventilation, are applicable and these criteria were considered fit for purpose to evaluate the relative level of pathogen transmission risk within buses. This guidance does not provide any quantitative assessment on how the risk changes based on exposure time. However, it does note that the more amount of time spent in a venue increases the risk and given the guidelines have been developed for areas where short term occupancy (i.e. 15-120 minutes) is expected to occur they are considered by Air Matters to be appropriate for public transport. Further research may be required to identify if these levels are being used by public transport providers around the world.

3. SAMPLING STRATEGY & METHODOLOGY

Based on scoping discussions between GWRC and Air Matters, eight buses (four double decker and four single level) of varying models were selected for the CO_2 pilot study. The monitoring duration was established to run from before the morning passenger peak to after the afternoon peak. This was undertaken by installing the monitoring on the bus prior to their departure, and after their return, to depot.

Two monitoring locations ('mid' and 'back') per bus cabin were selected to account for potential variations in air quality. In double decker buses a total of four monitors where installed, two in the lower level and two in the upper level. The bus routes were chosen by GWRC in conjunction with the bus operators. The aim was to capture a range of routes, bus types and over times where they would experience maximum patronage. Table 1 illustrates the various bus types, routes, and departure and return times over the three days of monitoring.

Dedicated CO_2 monitors were installed on the buses (Personal CO_2 meters - SAN-10). The monitors were set to log at 30-second intervals and were calibrated prior to use and fresh air calibrated each morning (where practical) prior to installation. The calibration records are available on request, and the monitor details are presented in Table 2. Personal CO_2 gas monitors were selected as the most appropriate measurement devices for this pilot study for the following reasons:

- Robust construction and small size to minimise the risk of theft or vandalism.
- Long battery life which does not require mains power.
- The monitors are available in numbers allowing for multiple samples to be collected in a single day.

In addition to the dedicated CO_2 monitors, real-time data-logging gas monitors (Ventis Pro 4/5 and MX4) were deployed within buses to measure carbon monoxide (CO) and nitrogen dioxide (NO_2). Combustion gas was collected in tandem to ensure the CO_2 readings were not being affected by external influences. Combustion gases entering the bus, while posing a risk to passengers, would not contain any human-respired pathogens and therefore were not the subject of this study. The gas monitors were set to log at ten-second intervals and were calibrated prior to use. The calibration records are available on request, and the monitor details are presented in Table 2.

Table 1. Bus type and route details over the three days of monitoring

Bus Number	Bus Type	Shift Number(s)	Route	Depart depot	Return depot
18 October 2022					
5083	Diesel (DD)	W1541	36	7:37	18:44
5738	Electric	W1359 / W1380	2	6:58	14:00*
5747	Electric	W1357 / W1547	2	6:42	19:30
19 October 2022					
3452	Diesel (LV)	2102	1	5:38	18:26
3433	Diesel (LV)	2105	24	5:56	18:30*
3523	Diesel (DD)	2103	7	5:42	18:27
20 October 2022					
3710	Electric (DD)	2100	1	5:18	15:00
3701	Electric (DD)	2101	7	5:35	14:30*

*Estimated based on GPS data

Table 2. Gas Monitoring Equipment used during the monitoring

Make & Model	Serial no.	Calibration Date
Ventis Pro 4/5 (CO + NO_2)	20033WM-002	12 October 2022
	17083PN-010	12 October 2022
	17033E4-003	12 October 2022
	17060VU-015	14 October 2022
	17013NY-029	12 October 2022
	17083PN-004	14 October 2022
MX4 (CO + NO_2)	220326H-038	22 September 2022
	220326H-039	22 September 2022
SAN-10 (CO_2)	01817	22 August 2022
	02187	7 September 2022
	02491	
	02502	
	02508	
	02528	
	02532	
	02257	22 September 2022
Q-Trak 7575-X	7575X1634001	27 November 21

The monitors were deployed statically within the bus cabins near roof height due to the restricted availability of mounting locations and in response to concerns regarding vandalism. Example photographs of the sampling locations is presented in Appendix A.

In addition to the stationary monitors, Air Matters staff rode bus #5738on 18 October 2022 and bus #3710 on 20 October 2022 over the peak period to measure CO_2 using a hand-held Q-Trak monitor. Q-Trak monitors have a higher accuracy than the static monitors, however due to their size, battery life and cost it is not practical to deploy multiple Q-Trak's in stationary locations. The hand-held monitoring instrument was set to log at 10 second intervals and was used to validate the stationary CO_2 monitoring. To investigate whether ultrafine combustion particulate could be detected inside the bus, GWRC staff measured black carbon with a hand-held aethalometer (Aethlabs MA350) at the same time as Air Matters staff were undertaking their hand-held CO_2 measurements. The black carbon results will be reported separately by GWRC.

4. RESULTS

The results of the CO_2, CO and NO_2 monitoring undertaken on 18, 19 and 20 October 2022 are summarised by the following key points:

- Weather during the three days of monitoring was fine with low to moderate wind speeds and daily temperature ranges between 10-18 degrees Celsius.
- Carbon monoxide was below the detection limit on all deployed monitors and low (<1ppm) NO_2 was detected by some monitors. This indicates that there were little to no combustion gases entering the buses that would have any noticeable effect on the CO_2 reading;
- CO_2 across all buses reached levels that are considered moderate and high risk based on the criteria described in Section 1. A summary of the results is shown in Figure 1 for all buses and measuring locations. This graph presents the proportion of time each bus spent within each risk band (low, moderate, high) over its daily route.
- Highest peak CO_2 reading of >9,000ppm was recorded on Bus 3710 during the morning peak commute. The lowest peak was recorded on Bus 5738 reaching ~1,550ppm during the morning peak commute;
- Levels of CO_2 were very strongly correlated with passenger numbers;
- Generally, the CO_2 levels within a bus were spatially consistent and there was good temporal corelation between Back and Mid locations;
- In double decker buses significant variation was observed between upper and lower floors in the two Electric buses monitored on the 20th October;
- Data checks with the Q-Trak showed a reasonable agreement with the values of the nearest monitor located in the bus.
- Data from five of deployments dropped below ambient concentrations (415ppm) during periods of the monitoring. The reason for this drop is likely due to instrument drift. Despite this drift at ambient concentrations, peaks in the data across monitors within the same buses corelated well. Consequently, this potential drift at ambient levels is not expected to affect the interpretation of results of this pilot study.

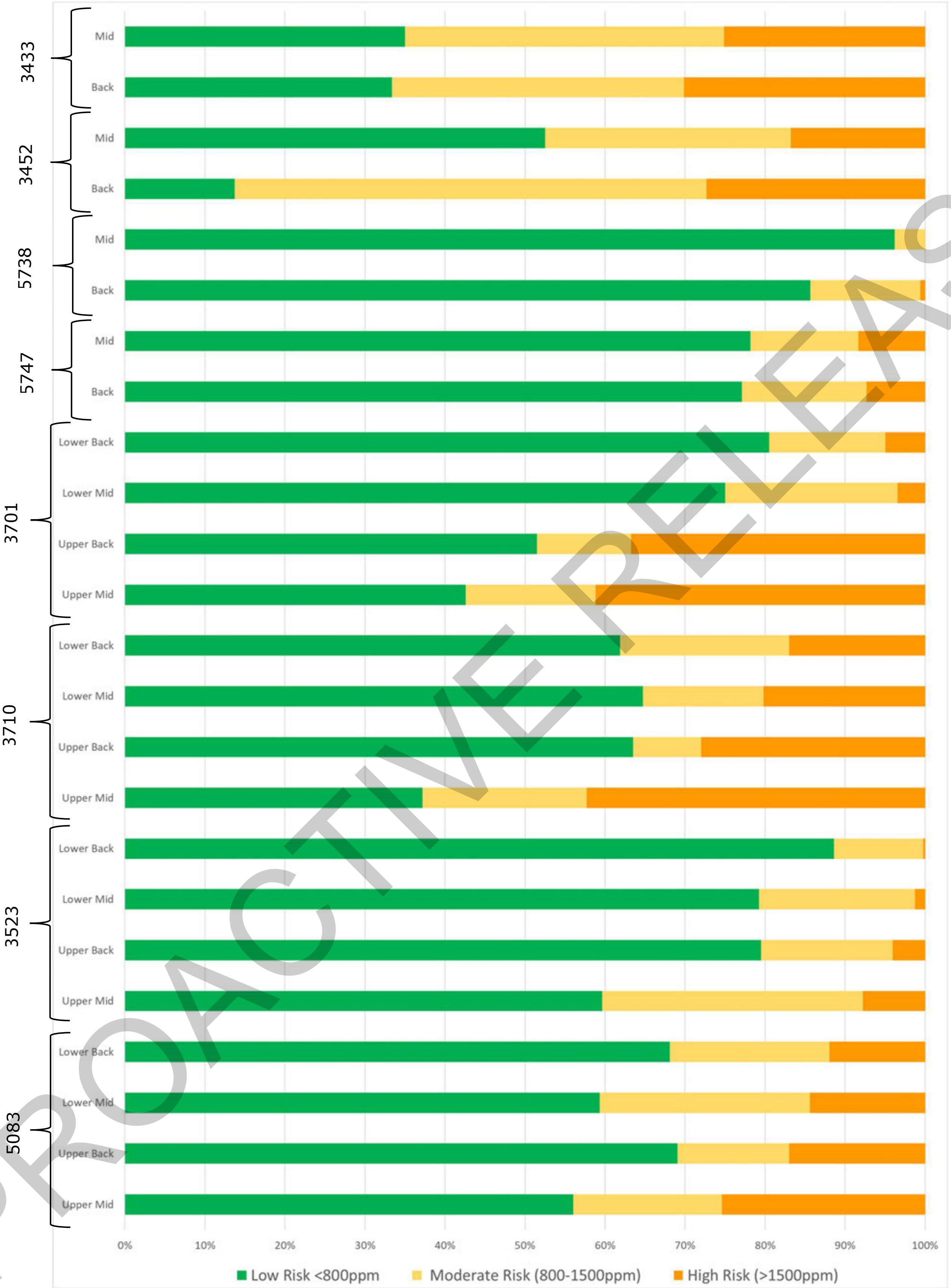

Figure 1. Air Quality risk banding shown as a percentage of time for each bus's daily route. Information on the Y axis is the various bus numbers and position of the monitor in each bus.

5. DISCUSSION

The following discussion is based on data collected over single bus runs. There are a range of factors that may influence CO_2 concentrations and pathogen transmission within a bus that could not be controlled in this pilot study. Consequently, the findings in this study shouldn't be solely relied on when determining absolute risks. Nevertheless, the results of this study show that consistent elevated CO_2 concentrations occurred across a range of bus types, routes and passenger levels. Based on this, mitigation measures to reduce potential pathogen exposure risk across all bus types should be further investigated.

The "moderate relative risk" CO_2 guideline level (>800 ppm) was exceeded in all the monitored buses and the "high relative risk" (>1,500 ppm) was exceeded in all buses, although the duration ranged significantly between buses. For example, in the high relative risk category, Bus 5738 only exceeded levels for 0.3% of the time (averaged across its two monitors), whereas Bus 3433 exceeded for 27% of the time (averaged across its monitors).

There is a very strong cause and effect relationship between measured CO_2 levels and passenger loading information. Graphed over time (refer Appendix B), the correlation is very evident in that as passenger numbers on the bus increase, so too does CO_2 levels. While this pilot study does not include any quantitative analysis of controlling factors it is expected that a reasonable statistical relationship would exist between CO_2 and passenger numbers.

Spatial variability

In terms of the spatial variation of air quality there was a good correlation between monitors located on the same level of a bus. This indicates that air circulation within the buses is 'well mixed' which is a realistic assumption given the open space, high turbulence (people moving / bus doors opening) and recirculation of the buses air conditioning.

Bus 3701 and 3710 showed the most significant difference between the upper and lower levels with the lower level having notably lower concentrations of CO_2 (refer Appendix A: Figure 5 and 6). This contrasts with the two other double decker buses (3523 and 5083) which showed a much closer correlation between upper and lower levels (refer Appendix A: Figure 7 and 8). This may have been caused by variation in passenger numbers between the levels however this information was not recorded.

The author was on board 3710 throughout the morning peak and observed that the bus was at capacity (fully seated in the upper level and seated / standing in the lower level). Concentrations on the lower level may have been reduced due to improved ventilation and/or fresh air ingress from door openings. Bus 3701 was also fitted with manually opening windows, so it is possible that passengers on the lower level had opened one or more windows allowing better circulation of fresh air.

As no information on passenger loading between levels, air condition settings or window openings was recorded it is not possible to draw any conclusions for the observed difference. Given some of the highest CO_2 values were recorded on upper levels of double decker buses, understanding these controlling factors should be given priority if mitigations or further testing is planned.

Temporal variability

The data illustrates that CO_2 concentrations rise quickly with the influx of passengers but in most cases takes an extended period of time to dissipate back to ambient concentrations. For example, on Bus 3701 after all passengers have disembarked post morning peak the CO_2 concentration in the upper level takes over 180 minutes to return to below 800ppm. No information on the bus's status (running / air conditioning) is recorded to understand this better, and it has also been identified that some passenger loading information is missing from the supplied record.

Bus 3710 which was ridden by the author over the morning peak shows a significant drop in CO_2 on lower level when parked up for a 10–15-minute rest break (green arrow in Appendix 2: Figure 6), however the upper level, does not decrease at the same rate and remains above the high-risk threshold for an extended period of time. Information on the operation of the buses ventilation system during the rest break was not recorded, however the doors were left open.

The overall results suggest that the risk of airborne pathogen transmission within most of the monitored buses is high over peak periods, and mitigation is recommended to reduce the level of risk. Mitigative actions could include increasing the fresh air ventilation rate for the bus cabins, filtering the recirculated air within the buses or a combination of both. The effectiveness of particulate filters cannot be determined using CO_2 levels as a proxy of transmission risk because the filters only filter out particulates, not gases such as CO_2. The filters must be designed to remove appropriately sized particles, based on the size of virus and or other pathogenic particles. The level and type of filtration on the buses in this study was not recorded.

It cannot be overstated that the use of masks is also an important component to manage the risk of airborne virus transmission, but it should not be the only form of control.

6. CONCLUSION

The pilot study has successfully measured CO_2 concentrations across 8 bus types and various routes and passenger loadings. In all cases the monitoring has demonstrated that there is an elevated risk of pathogen exposure when travelling as a passenger on a bus if pathogenic particles are present.

Carbon dioxide levels correlated well with passenger numbers. Highest peaks and extended durations of elevated CO_2 levels were observed in the upper levels of double decker buses. Based on the gathered information, it is recommended that further mitigation to reduce pathogen exposure risk is investigated across all bus types.

If GWRC intend to trial mitigations by increasing the fresh air ventilation rate and wish to assess the effectiveness, then the following recommendations are made:

- Due to a high number of variables, an additional extended baseline should be established of CO_2 data across 3-4 days, within the same bus while controlling as many external variables as possible;
- Based on the pilot study results, there may not be the need to monitor the full range of bus types, and this should be determined by the potential mitigations and whether they can be equally applied to all bus types. As a minimum, sampling should still include both double decker and single decker buses.
- Collect information regarding how the buses ventilation systems operate and any external ventilation use (windows) by either recording or controlling its use (i.e. not able to be used);
- Continue to collect the high-resolution passenger numbers and bus timing information and on double decker buses include information of the patronage between upper and lower levels;
- Repeat the monitoring once mitigations are implemented and replicate the baseline survey as close as possible;

Carbon dioxide monitoring is not an appropriate method to measure the effectiveness of pathogen filtration within public transport as the pathogens will be filtered out, but carbon dioxide will not. If improved filtration is to be trialled, and its effectiveness measured, then an alternative methodology would need to be developed.

7. ACKNOWLEDGEMENTS

The author would like to thank staff at GWRC for assisting in organising the monitoring and logistics of this study. Thanks also to NZ Bus and Tranzurban for allowing access to the bus fleet and assisting with the installation and retrieval of the monitors.

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APPENDICES

APPENDIX A: EXAMPLE PHOTOS OF MONITORING LOCATIONS

Figure 1. Example of the monitoring installation (red circles) in upper level of Bus 3701.

Figure 2. Example of the monitoring installation (red circles) in lower level of Bus 3701. Note on double decker buses the mid monitors were located back-to-back due to the location of the stairwell.

APPENDIX B: CO$_2$ TIME SERIES GRAPHS

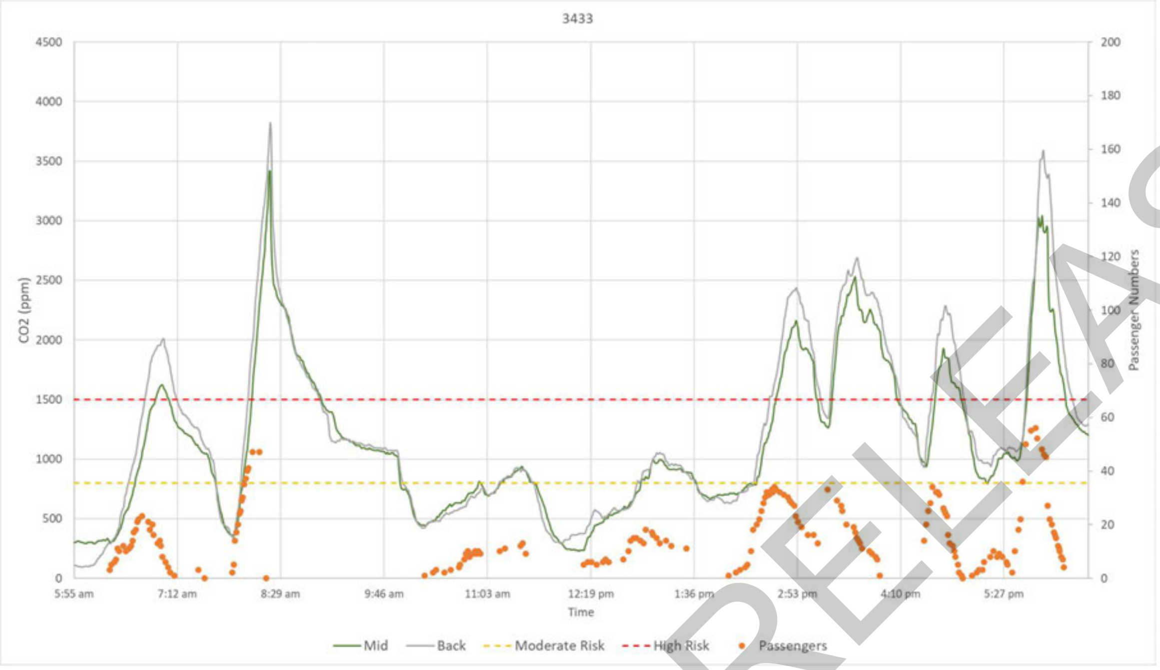

Figure 1. Bus 3433. Diesel (LV) monitored on 19 October 2022.

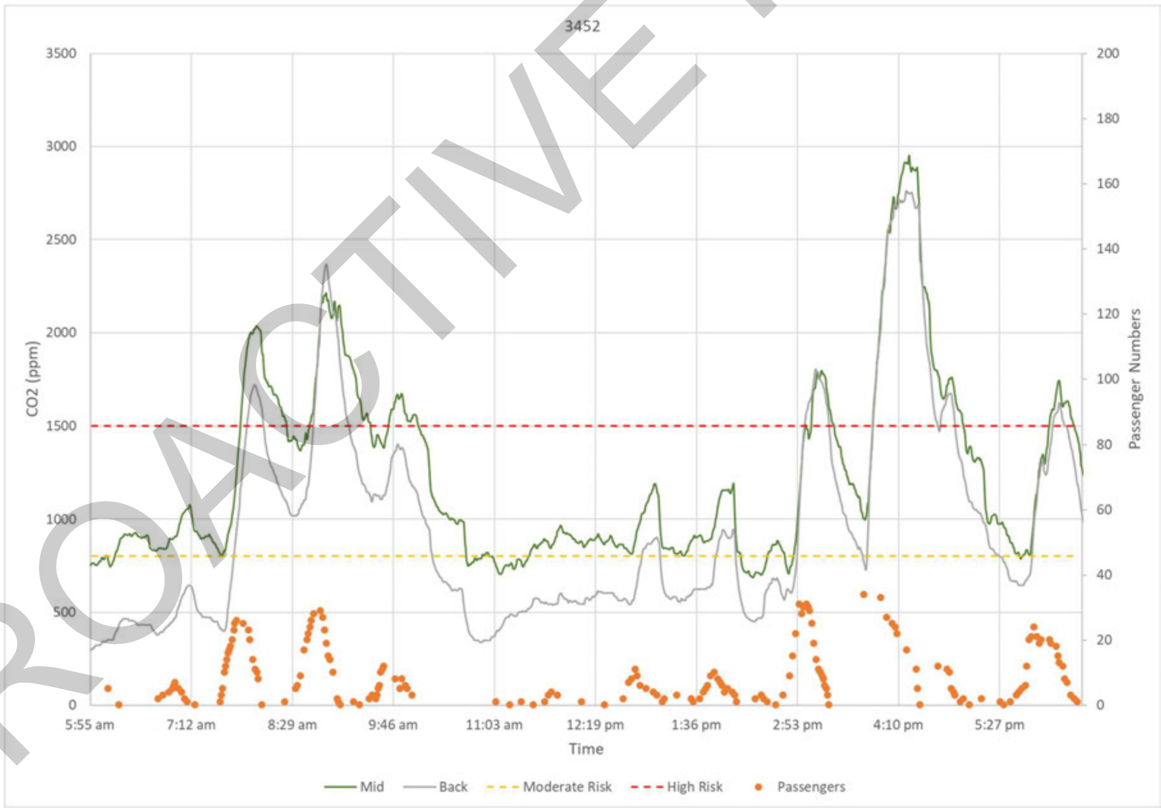

Figure 2. Bus 3452. Diesel (LV) monitored on 19 October 2022.

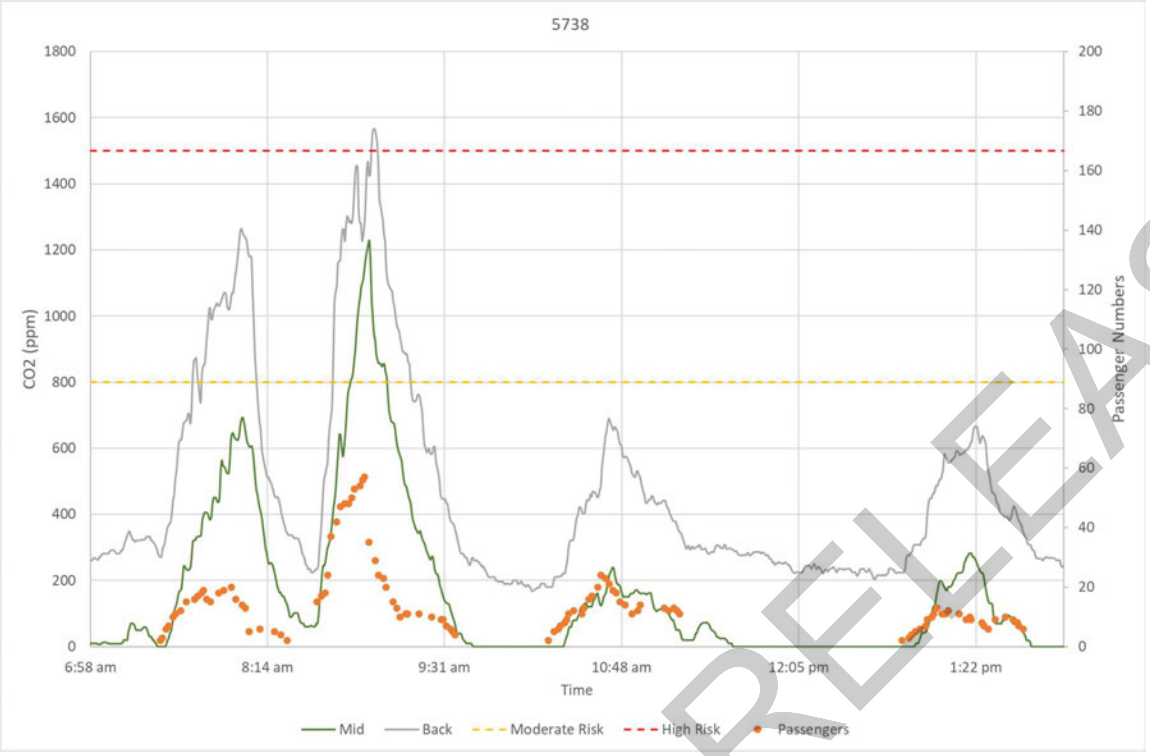

Figure 3. Bus 5738. Electric monitored on 18 October 2022. Note the Mid monitor's potential drift recording CO_2 concentrations of zero at times.

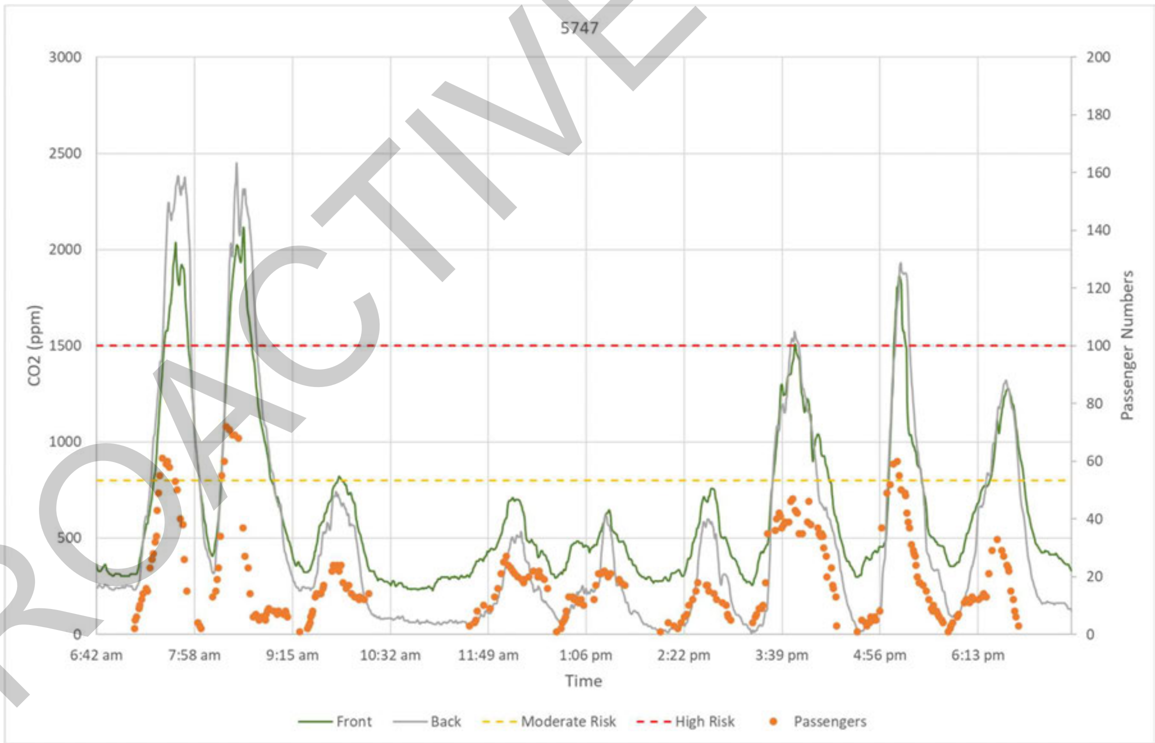

Figure 4. Bus 5747. Electric monitored on 18 October 2022.

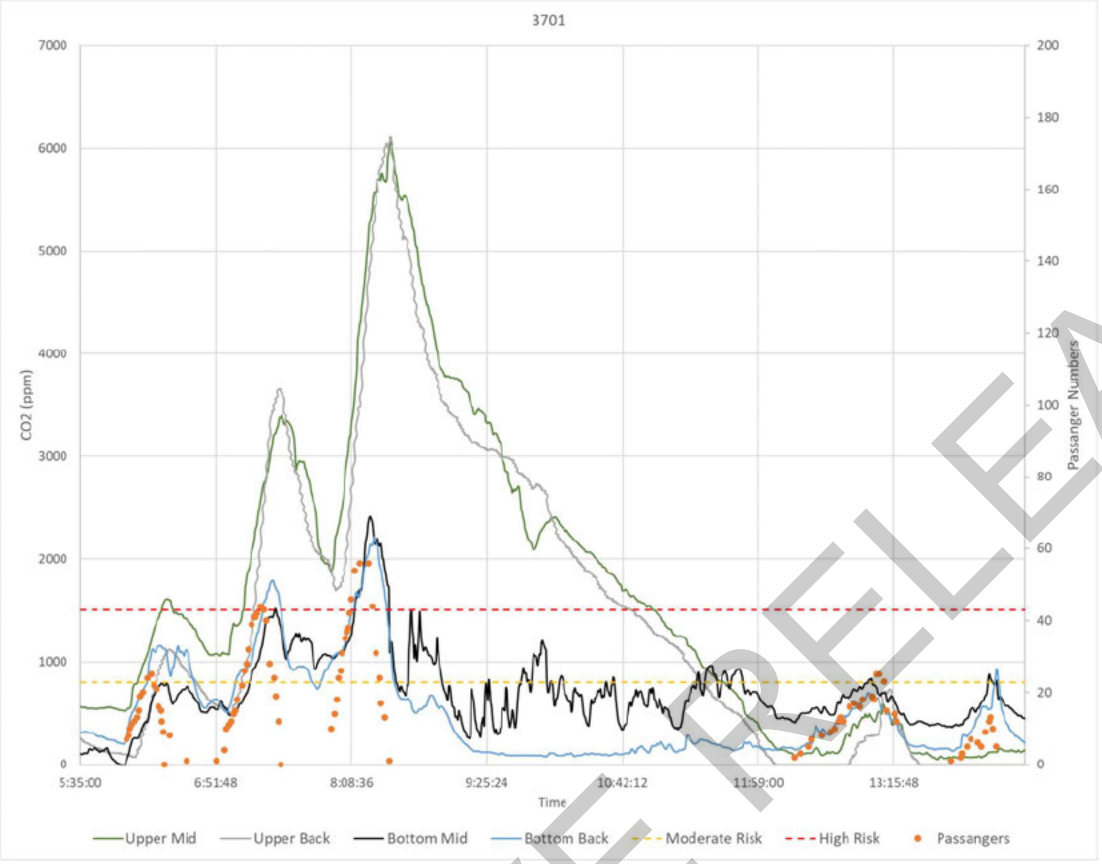

Figure 5. Bus 3701. Electric double decker monitored on 20 October 2022. Note the Upper Back monitor's potential drift recording CO_2 concentrations of zero at times.

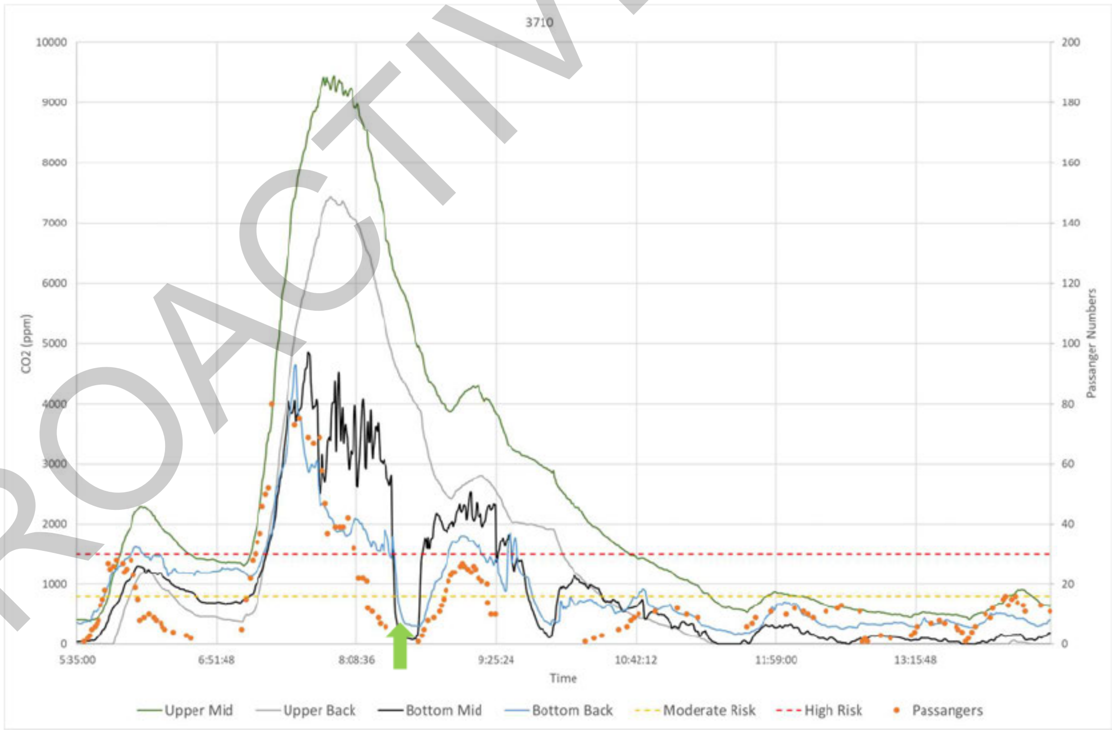

Figure 6. Bus 3710. Electric double decker monitored on 20 October 2022. Note Bottom Mid and Upper Back monitor's potential drift recording CO_2 concentrations of zero at times.

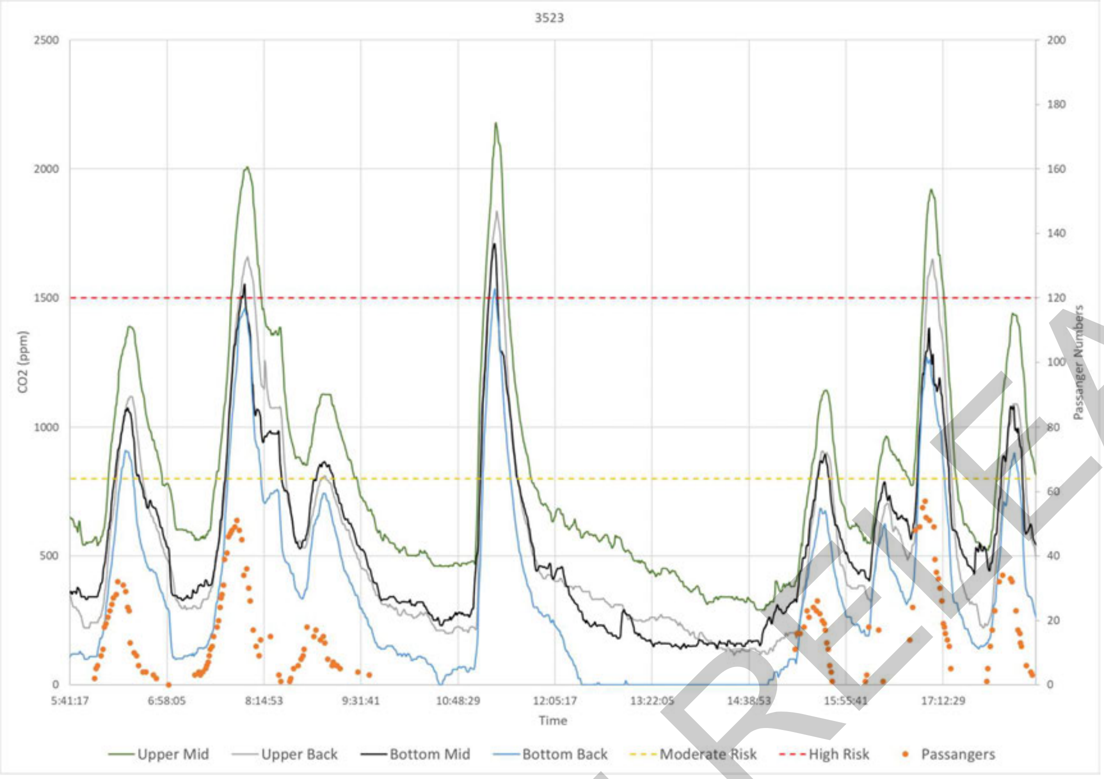

Figure 7. Bus 3523. Diesel double decker monitored on 19 October 2022. Note the Bottom Back monitor's potential drift recording CO_2 concentrations of zero at times. An increase in CO_2 between approximately 11am-midday is likely due to passengers however no passenger information was available over this period.

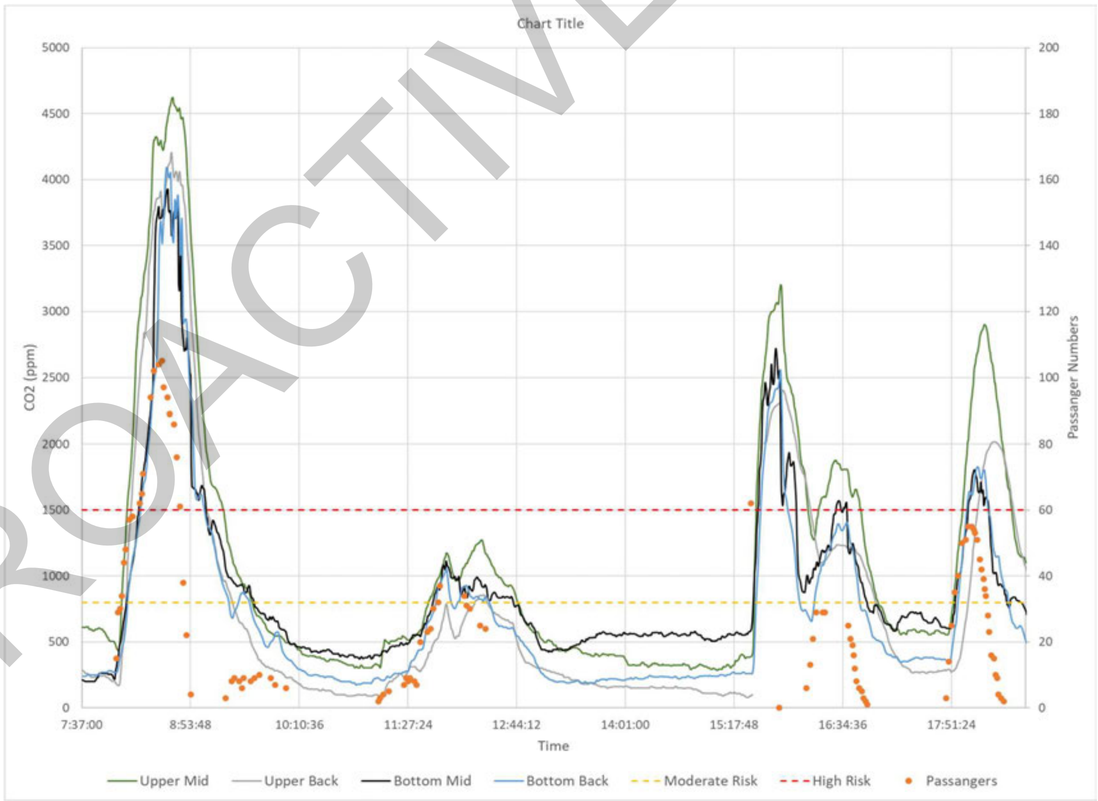

Figure 8. Bus 5083. Diesel double decker monitored on 18 October 2022. Note the gap in Upper Back CO_2 record from 15:31 – 15:39 when it is expected that the monitor was tampered with.

Greater Wellington
Te Pane Matua Taiao

metlink

By email

2 May 2023

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Public health risk of CO2 from passenger respiration on urban buses

Attached is a copy of an investigation report into levels of CO2 from passenger respiration on board a sample of Wellington buses. As you may be aware, there has been interest in the media regarding the perceived COVID health issues associated with elevated CO2 levels in buses.

As such, we commissioned the study to ascertain the potential for viral illness spread in buses using CO2 levels as a proxy for this risk. The CO2 monitoring was carried out for Greater Wellington by Air Matters Ltd, occupational health specialists. The monitoring confirms that during periods of high passenger occupation, CO2 levels become elevated. As such, we can infer the risk of spread of viral illness increases proportionately.

GWRC (Greater Wellington Regional Council) does not have expertise in public health, therefore we are seeking the following from MoH:

1. Confirmation that meeting the NZ Workplace Exposure Standard for CO2 (being 5000 ppm (averaged over an 8-hr working day) and a short-term limit of 30,000 ppm (15-minute average) generally provides sufficient health protection for passengers from direct health effects of CO2 exposure.
2. Advice as to whether there are any medical conditions that could be vulnerable to elevated CO2 levels and what threshold might apply.

3. Confirmation that the relevant control for the elevated risk of viral transmission remains mask wearing.

4. Advice as to whether there are any other recommendations to protect public health given these CO2 monitoring findings.

5. Advice as to whether there is an intention to provide guidelines for ventilation and CO2 levels in the public transport environment in the future.

We believe the issue of elevated CO2 on urban buses is not unique to the Wellington fleet and any changes to standards or policy settings for ventilation on public transport should be part of a national strategy.

Nāku noa, nā

Fiona Abbott
Metlink Manager Assets and Infrastructure
Greater Wellington Regional Council

Encl: Metlink pilot monitoring study onboard air quality