



EMISSIONS MONITORING – SYDNEY HARBOUR TUNNEL

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Table 1: History of Revisions

Revision	Date	Issued to	Changes
R0	20/11/2023	J. Quarta	Initial report release
R1	21/11/2023	J. Quarta	Updated EPL reference.



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Accreditation number: 19703



EXECUTIVE SUMMARY

Assured Environmental (AE) conducted air emissions monitoring at Sydney Harbour Tunnel Ventilation Facility. Sampling was performed on 24th and 25th October 2023 in accordance with New South Wales Environment Protection Licence (number 4062). The sampling was performed on two release points, North-bound and South-bound ventilation outlets.

The relevant conditions are taken from condition L2.2 of EPL 4062 (revision date: 7-Aug-2023) and presented in the table below.

Based on the comparison presented, the results of the monitoring undertaken has demonstrated compliance with the release limits provided in the site EPL for all parameters tested. The decision rule is based on the results obtained at the time of monitoring, without regard for measurement uncertainty limits. *Results are reported at dry, 273.15 °K and 101.325 kPa (STP), unless otherwise indicated.*

Table 2: Summary of Emissions – Sydney Harbour Tunnel Ventilation Outlet

Parameter	Unit of measure	Test result PM	Test result PM	Licence limit
Site	-	Syd Harbour Tunnel	Syd Harbour Tunnel	-
Source	-	Northbound	Southbound	-
Date	dd/mm/yyyy	24/10/2023	25/10/2023	-
Time start	hh:mm	13:44	6:21	-
Time end	hh:mm	16:51	9:28	-
Exhaust air velocity	m/sec	22.95	28.70	-
Exhaust air temperature	°C	25.0	25.0	-
Exhaust air absolute pressure	mbar	1003	997	-
Exhaust air moisture content	% v/v	0.98	0.95	-
Exhaust air density	kg/Nm ³	1.29	1.29	-
Exhaust air volume flow	Nm ³ /sec-dry	122	152	-
Nitrogen Oxides (NO _x as NO ₂)	mg/Nm ³	0.77	0.47	25
- Emission rate	g/sec	0.094	0.072	-
Carbon Monoxide (CO)	mg/Nm ³	1.78	1.990	40
- Emission rate	g/sec	0.217	0.302	-
Total Particulate Matter - PM	mg/Nm ³	0.215	0.462	1.1 [1]
- Emission rate	g/sec	0.026	0.070	-
VOCs - detectable species				
Formaldehyde	mg/Nm ³	< 0.005	< 0.005	-
Formaldehyde emission rate	g/sec	< 0.0006	< 0.0007	-
Acetaldehyde	mg/Nm ³	< 0.005	< 0.005	-
Acetaldehyde emission rate	g/sec	< 0.0006	< 0.0007	-
TVOC (as n-propane)	mg/Nm ³	1.67	0.912	4
TVOC emission rate	g/sec	0.203	0.138	-
Benzene	mg/Nm ³	0.0035	< 0.0017	-
Benzene emission rate	g/sec	0.0004	< 0.0003	-
Toluene	mg/Nm ³	0.2200	0.0782	-
Toluene emission rate	g/sec	0.0267	0.0119	-
Ethyl Benzene	mg/Nm ³	0.0190	< 0.0038	-
Ethyl Benzene emission rate	g/min	0.0023	< 0.0006	-
m+p-Xylene	mg/Nm ³	0.0140	0.0142	-
m+p-Xylene emission rate	g/sec	0.0017	0.0022	-
o-Xylene	mg/Nm ³	0.0047	0.0047	-
o-Xylene emission rate	g/sec	0.0006	0.0007	-
1,3-butadiene	mg/Nm ³	< 0.0012	< 0.0012	-
1,3-butadiene emission rate	g/sec	< 0.0001	< 0.0002	-

[1] – Special averaging time 1 means: 1 hour, or the minimum sampling period specified in the relevant test method, whichever is the greater.



TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
1 INTRODUCTION	7
2 MONITORING METHODOLOGY	8
2.1 OVERVIEW	8
2.2 SAMPLING METHODOLOGY	8
2.3 SAMPLE LOCATION	10
2.4 TEST EQUIPMENT	13
3 MEASUREMENT UNCERTAINTY	14
4 TEST RESULTS	15
5 CONCLUSION	17
6 QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)	18
7 GLOSSARY OF TERMS	19
8 APPENDIX	20
8.1 INFRASTRUCTURE APPROVAL – EF20/104	20
8.1 CONDITION L2.2 OF EPL 4602	21
8.1 CONDITION M2.2 & 2.3 OF EPL 4602	22
8.1 SAMPLE METHOD SUMMARIES	23
8.1.1 Velocity, Volume Flow Rate & Temperature (USEPA Method 2)	23
8.1.2 Gas Molecular Weight (USEPA Method 3)	23
8.1.3 Moisture Content (USEPA Method 4)	23
8.1.4 Total Solid Particles	23
8.1.5 Speciated VOCs – USEPA Method 18/USEPA TO-15	24
8.1.6 Speciated VOCs – USEPA Method 18 (Aldehydes & Ketones)	24

LIST OF TABLES

TABLE 1: HISTORY OF REVISIONS	2
TABLE 2: SUMMARY OF EMISSIONS – SYDNEY HARBOUR TUNNEL VENTILATION OUTLET	4
TABLE 3: TEST METHODS	8
TABLE 4: ANALYSIS PERFORMED BY	8
TABLE 5: SAMPLING COMMENTS	9
TABLE 6: SAMPLE LOCATION SUMMARY	12
TABLE 7: SAMPLE UNCERTAINTY	14
TABLE 8: SAMPLING INFORMATION	15
TABLE 9: VOC TEST RESULTS	16
TABLE 10: SAMPLING DATA QA/QC CHECKLIST	18
TABLE 11: LABORATORY DATA QA/QC CHECKLIST	18
TABLE 12: DEFINITIONS	19
TABLE 13: CONDITION A2.1 OF INFRASTRUCTURE APPROVAL	20



LIST OF FIGURES

FIGURE 1: SAMPLE LOCATION IMAGES	10
FIGURE 2: SYDNEY HARBOUR TUNNEL STACK LOCATION	11
FIGURE 3: MANUAL SAMPLE EQUIPMENT	13



1 INTRODUCTION

Assured Environmental Pty Ltd (AE) was appointed by Ventia Pty Ltd to sample and analyse source emissions in accordance with the Environmental Protection Licence (EPL) 4062 on the Ventilation Stack Outlet Southbound and Ventilation Stack Northbound release points.

Sampling was conducted by AE on 24th and 25th October 2023.

Sampling and analysis was performed for the following parameters:

- Solid particles – total;
- Carbon monoxide;
- Oxides of nitrogen (presented as NO₂);
- Volatile organic compounds (speciated and total).

AE was responsible for the collection and analysis of samples, unless otherwise indicated. The samples were recovered and stored in the appropriate manner until their return to the laboratory where the samples were prepared and analysed according to the methodologies listed in this report.



2 MONITORING METHODOLOGY

2.1 Overview

AE personnel made contact with the nominated site representative and confirmed that the facility was operating normally. At this time, all site access permits were arranged and the previously prepared draft sampling plan for the day was agreed with the client.

The following sections provide a summary of the specific locations utilised and methodologies used for the monitoring.

2.2 Sampling Methodology

All sampling and analysis were carried out in accordance with the listed requirements in Table 3, along with AE's scope of NATA (ISO:17025) in relation to this monitoring.

The methodology adopted for this project is based on the requirements of the Licence and with reference to the 'Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales' document.

Any specific comments about the sampling and analysis have been documented where required. A brief description of the test methods is presented in the Appendix.

Table 3: Test Methods

Parameter	NSW EPA TM	Reference Test Method	NATA accreditation	Analysis by	Notes
Sample location	TM-1	AS4323.1	Yes	1	nil
Velocity	TM-2	USEPA Method 2	Yes	1	nil
Volumetric flow rate	TM-2	USEPA Method 2	Yes	1	nil
Dry gas density	TM-23	USEPA Method 3	Yes	1	nil
Molecular weight	TM-23	USEPA Method 3	Yes	1	nil
Temperature	TM-2	USEPA Method 2	Yes	1	nil
Moisture	TM-22	USEPA Method 4	Yes	1	nil
Solid particles – total	TM-15	AS4323.2	Yes	1	a
Carbon monoxide	TM-32	USEPA Method 10	Yes	1	nil
Oxides of nitrogen	TM-11	USEPA Method 7E	Yes	1	nil
Volatile organics	TM-34	USEPA Method 18	Yes	2	b
Formaldehyde	TM-34	USEPA Method 18	Yes	2	c

Table 4: Analysis Performed By

Note	Company	Work Performed	NATA ID	Report Number
1	Assured Environmental	Sampling & analysis	19703	15253
2	Envirolab Services	Sample analysis	2901	336213



Table 5: Sampling Comments

Note	Comment
PM (a)	To achieve a lower limit of detection (common for traffic tunnel sources), filters and sample rinses were analysed using a 6-point (0.001mg) balance. Sample weighing was performed inhouse by Assured Environmental (NATA ID. 19703).
VOCs (b)	<p>A single Summa™ canister sample for speciated Volatile Organic Compounds must include, but is not limited to, Benzene, Toluene, Xylenes, 1,3-Butadiene, Formaldehyde and Acetaldehyde.</p> <p>As the source contains essentially ambient air, a site specific sample spike recovery was not performed.</p> <p>Single samples were collected using Summa canisters over a period of 1-hour during peak traffic period.</p> <p>Total volatile organic compounds is reported as n-propane equivalent following NSW EPA 'Methods for the Sampling and Analysis of Air Pollutants' – <i>Calculation of VOCs as n-propane equivalent on a mass basis.</i></p>
Formaldehyde (c)	Formaldehyde and Acetaldehyde collected separately using a suitable solid sorbent tube at the same time as the Summa canister/s

2.3 Sample Location

The Sydney Harbour Tunnel is a twin-tube road tunnel in Sydney, Australia. The tunnel provides a vehicular crossing of Sydney Harbour to alleviate congestion on the Sydney Harbour Bridge. It is one of two tunnels under the harbour, the other being a set of rail tunnels for the Sydney Metro. The Sydney Harbour Tunnel section is vented through a ventilation facility known as the Ventilation stack outlets southbound and northbound.

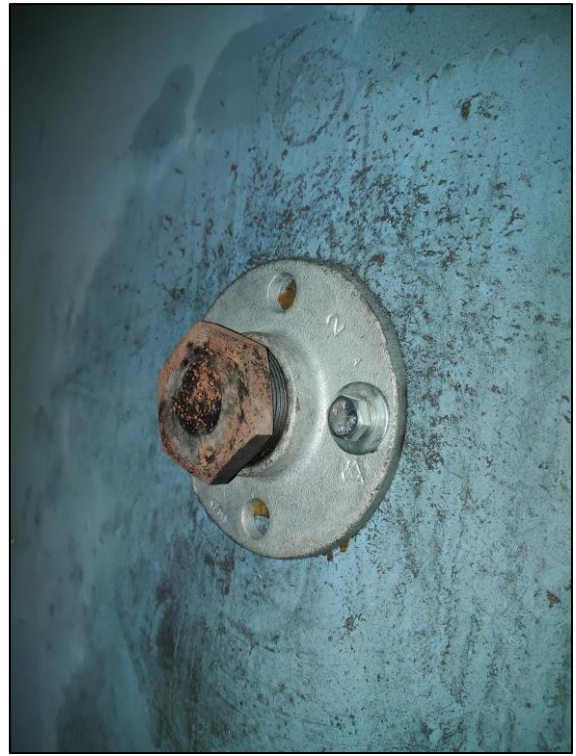
Access to the sampling locations is via ladders, the sample access points are located approximately 20 meters above ground level.

The sample points at the Ventilation Stack Outlet Southbound & Northbound contain five 55mm BSP sampling ports positioned along one face of the duct shown in Figure 1. Due to these small sampling ports, it is not possible to insert standard sampling probes.

The figures and tables below provide information of each sample location and site details.



Inside ventilation facility



Example of sampling port

Figure 1: Sample location images

* Existing north and southbound sampling ports are 55 mm diameter. The recommended requirement for isokinetic sampling ports is 100 mm internal diameter.

The sampling position was evaluated in accordance with AS 4323.1 to determine the total number sampling points, based on the cross-sectional area and effective distance from disturbances. It is noted that given the design of the structure and required exhaust duct size, meeting each requirement of the method is not possible. The assessment is summarised in the following tables and figures.

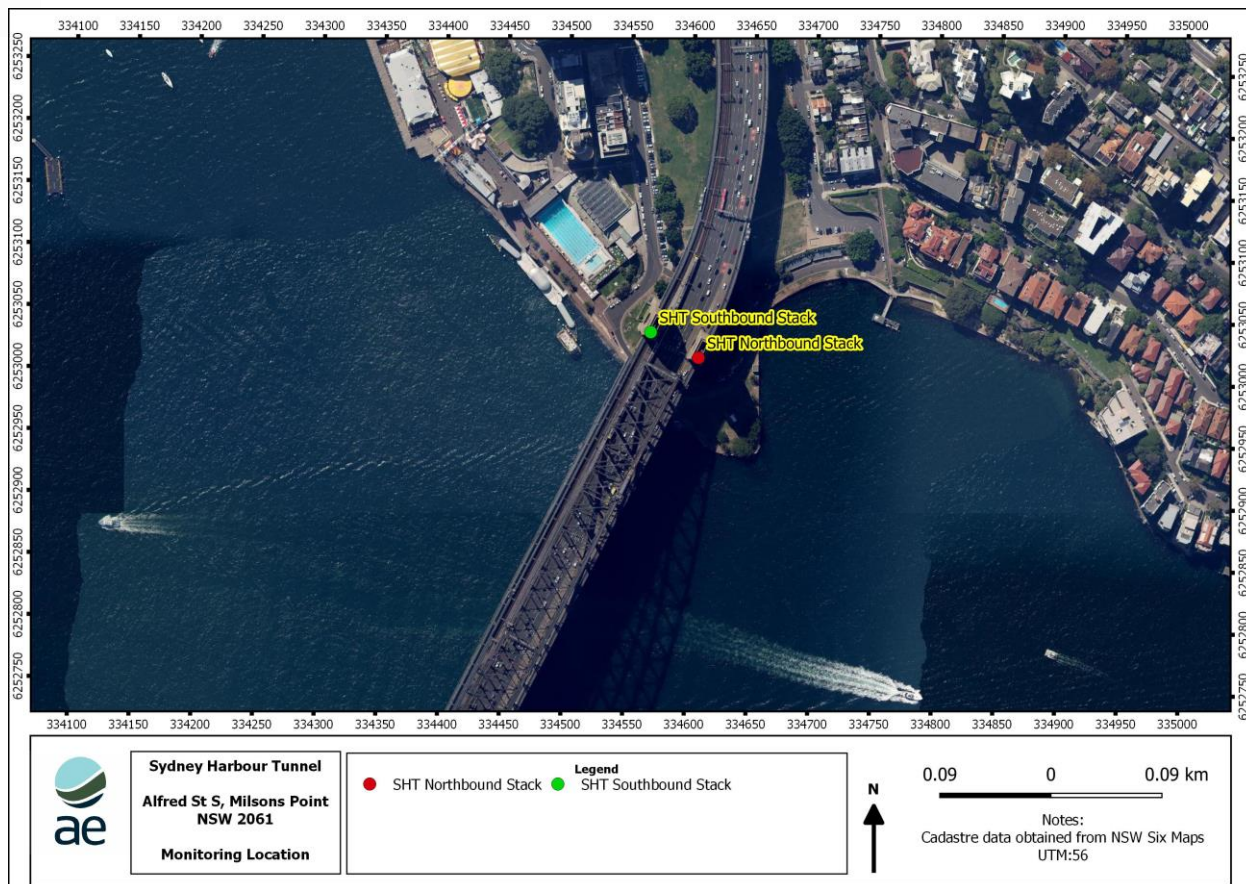


Figure 2: Sydney Harbour Tunnel stack location

Table 6: Sample Location Summary

AS4323.1	Sample location	Northbound	Southbound
	Description	Tunnel Ventilation Facility	Tunnel Ventilation Facility
	Stack coordinates	UTM 56s:	UTM 56s:
	m	334615.09 m E	334583.00 m E
	Easting	6253047.38 m S	6253072.94 m S
	Stack Exit point from ground (m)	~40	~40
	Stack Shape	RECTANGULAR	RECTANGULAR
Ideal Sampling Plane Assessment			
	Stack Diameter (m)	2.31	2.31
	Stack Cross Section Area (m ²)	5.91	5.91
	Distance to upstream disturbance (m) (from disturbance)	1.87	1.87
	Upstream Diameters (D)	0.81	0.81
	Distance to downstream disturbance (m) (from disturbance)	5.00	5.00
	Downstream diameters (D)	2.16	2.16
4.2.2 Table 1	Meets Requirements AS4323.1 Table 1	No	No
Non-deal Sampling Plane Assessment			
	Assessment required?	No	No
	Total traverse point factors	1.27	1.27
Non-conforming Sampling Plane Assessment			
4.2.2(a)	Gas flow in same direction	Yes	Yes
4.2.2(b)	Gas flow steady & evenly distributed (cyclonic or swirl <15°)	Yes	Yes
4.2.2(c)	Temperature difference between points <10%, and each point <10% of average	Yes	Yes
4.2.2(d)	Ratio of highest to lowest differential pressure & ratio highest to lowest velocity	3.7 1.9	1.8 1.3
4.2.2(e)	Minimum differential pressure	15.50	45.60
	Gas temperature above dewpoint	Yes	Yes
Sampling Plane Type			
4.2.2, 4.2.3, 4.2.4	Sampling plane type	Non-conforming	Non-conforming
	Alternative sampling plane available?	No	No
Number of Sample Points Adopted			
	Port size (mm)	55	55
	Port Thread Type	BSP	BSP
	Number of traverses	5	5
	Number of points per traverse	5	5
	Total number of traverse points	25	25
	Flow & temperature compliance check	Yes	Yes

2.4 Test Equipment

The sampling equipment was transported to site and specifically setup at the test location. Sampling was performed using isokinetic probes, filters and impingers for, with a constant flow sampling arrangement for Method 18.

Equipment used during the course of the testing is sourced from Apex instruments and Monitor Labs industry leaders in the supply of source testing equipment.

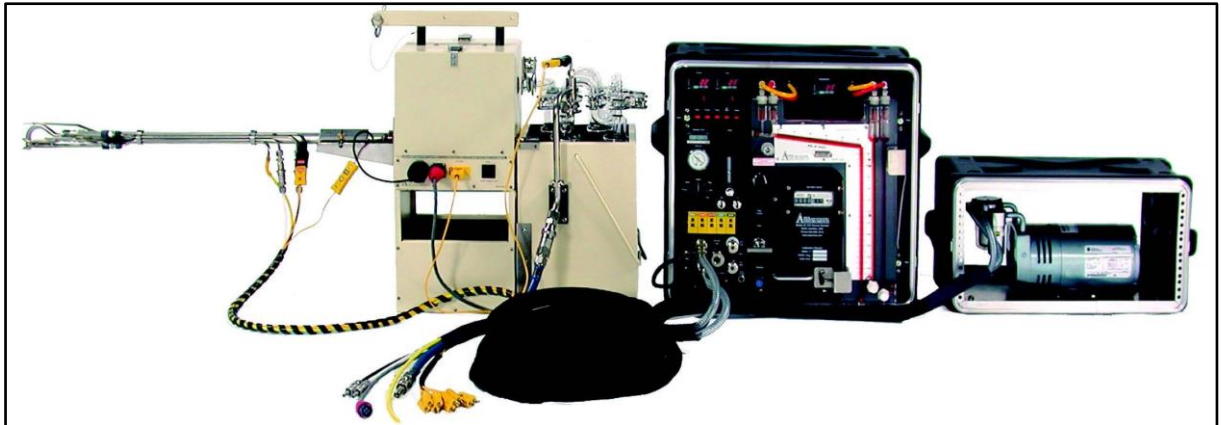


Figure 3: Manual Sample Equipment



3 MEASUREMENT UNCERTAINTY

There is an inherent uncertainty associated with any scientific measurement, including stack emissions monitoring. The measurement uncertainty can be controlled with strict adherence to the reference methodology along with utilising appropriate calibration standards with corresponding acceptable uncertainty reports.

Many source sampling methods do not outline exact procedures for establishing direct measurement uncertainty. In the absence of a defined procedure, the uncertainty budgets presented are based on estimations using ISO-GUM method.

Each individual source and test may have a unique associated uncertainty assigned, due to factors such as the stack sample location in relation to the positioning requirements of AS4323.1, stack temperature, water vapour content and sample analysis.

The table below outlines the estimated uncertainties associate with reports presented within this report.

Table 7: Sample uncertainty

Parameter	Reference method	Limit of measurement	Unit of measure	Uncertainty ^a ± %
Velocity	USEPA Method 2	3.0	m/sec	10
Temperature	USEPA Method 2	1.0	°C	5.0
Moisture content	USEPA Method 4	0.5	%-vol	5.0
Solid Particles – total	AS4323.2	0.06	mg/sample	15
Formaldehyde & Acetaldehyde	USEPA Method 18	0.002	mg/sample	15
VOC's	USEPA Method 18	0.002	mg/Nm ³	15
Carbon monoxide	USEPA Method 10	0.01	mg/Nm ³	10
Oxides of nitrogen	USEPA Method 7E	0.02	mg/Nm ³	10

^a At 95% confidence coefficient and a coverage factor of 2.

4 TEST RESULTS

Table 8: Sampling Information

Source Data			
Client		Ventia Pty Ltd	Ventia Pty Ltd
Site		Sydney Harbour Tunnel	Sydney Harbour Tunnel
Sample Point		Northbound	Southbound
Reference Method		AS4323.2 - ISOKINETIC	AS4323.2 - ISOKINETIC
Test Parameters		PM	PM
Process conditions		Exhaust Fan 15 Forward	Exhaust Fan 15 Forward
Historical Data & Hardware Information - Manual Sample			
Run Start Date	dd-mm-yyyy	24/10/2023	25/10/2023
Project ID		15253	15253
Run ID		-1	-4
Run Start Time	hh:mm	13:44	6:21
Run Stop Time	hh:mm	16:51	9:28
Console Serial Number		SN937	SN935
Meter Calibration Factor		1.028	1.079
Orifice Coefficient	(DH@)	48.11	42.46
Pitot Tube Coefficient		0.84	0.84
Actual Nozzle Diameter	mm	4.43	3.16
Stack Test Data			
Actual Sampling Time	minutes	188	188
Average Meter Temperature	°C	29	24
Average Stack Temperature	°C	25	25
Barometric Pressure	mb	1005	1002
Stack Static Pressure	mm H ₂ O	-18.5	-44
Absolute Stack Pressure	mb	1003	997
Sample Volumes			
Actual Meter Volume	m ³	3.583	2.587
Standard Meter Volume	Nm ³	3.223	2.355
Moisture Content Data			
Water vapour concentration	%	1.0	1.0
Stack Gas Density Analysis Data			
Dry Gas Molecular Weight	kg/Nm ³	1.29	1.29
Dry Gas Molecular Weight	g/g-mole	28.84	28.80
Wet Stack Gas Molecular Weight	g/g-mole	28.73	28.70
Volumetric Flow Rate Data (at Sample Plane)			
Average Stack Gas Velocity	m/sec	22.95	28.70
Equivalent Stack Diameter	m	2.31	2.31
Stack Cross-Sectional Area	m ²	5.914	5.910
Upstream distance (from disturbance)	m	1.87	1.87
Downstream distance (from disturbance)	m	5.00	5.00
Actual Stack Flow Rate	m ³ /min	8,142	10,200
Wet Standard Stack Flow Rate	Nm ³ /min-wet	7,385	9,190
Dry Standard Stack Flow Rate	Nm ³ /min-dry	7,312	9,100
Percent of Isokinetic Rate	%	90.2	104.0
Particulate Matter (PM) Concentration			
Total Mass of Particulates	g	0.00069	0.00109
Stack PM Concentration	mg/Nm ³	0.215	0.462
Particulate Emission Rate	g/min	1.5756	4.2100
Instrumental Analyser - Historical Data & Hardware Information			
Analyser serial number, make & model	value	AE009 Trailer 2	AE006 Trailer 1
Analyser Run Start Time	hh:mm	13:06	5:18
Analyser Run Stop Time	hh:mm	17:37	10:12
Analyser Total Sampling Time	hh:min	4:31	4:54
Instrumental Analyser Raw Data Averages			
Oxides of Nitrogen	ppm	0.38	0.23
Carbon Monoxide	ppm	1.43	1.59
Nitrogen Oxides (USEPA Method 7E - instrumental analyser)			
Nitrogen Oxides (NOx as NO ₂)	mg/Nm ³	0.77	0.47
Nitrogen Oxides (NOx as NO ₂)	g/min	5.7	4.3
Carbon Monoxide (USEPA Method 10 - instrumental analyser)			
Carbon Monoxide (CO)	mg/Nm ³	1.78	1.99
Carbon Monoxide (CO)	g/min	13.0	18.1
OTHER ANALYTES (VOC's ,Acetaldehyde& Formaldehyde)			
Formaldehyde	mg/Nm ³	< 0.0049	< 0.0049
Formaldehyde emission rate	g/min	< 0.0357	< 0.0447
Acetaldehyde	mg/Nm ³	< 0.0049	< 0.0049
Acetaldehyde emission rate	g/min	< 0.0357	< 0.0447
TVOC (as propane)	mg/Nm ³	1.6689	0.9121
TVOC (as propane) emission rate	g/min	12.201	8.300
Benzene	mg/Nm ³	0.0035	< 0.0017
Benzene emission rate	g/min	0.0250	< 0.0159
Toluene	mg/Nm ³	0.2200	0.0782
Toluene emission rate	g/min	1.6000	0.7112
Ethyl Benzene	mg/Nm ³	0.0190	< 0.0038
Ethyl Benzene emission rate	g/min	0.1400	< 0.0345
m&p xylene	mg/Nm ³	0.0140	0.0142
m&p xylene emission rate	g/min	0.1000	0.1294
o xylene	mg/Nm ³	0.0047	0.0047
o xylene emission rate	g/min	0.0350	0.0431
1,3-Butadiene	mg/Nm ³	< 0.0012	< 0.0012
1,3-Butadiene emission rate	g/min	< 0.0088	< 0.0110

Table 9: VOC test results

Speciated VOC's	Units	Northbound	Southbound
Propylene	mg/m ³	0.002	< 0.001
Dichlorodifluoromethane	mg/m ³	< 0.003	< 0.003
Chloromethane	mg/m ³	< 0.002	< 0.002
1,2-Dichlorotetrafluoroethane	mg/m ³	< 0.004	< 0.004
Vinyl chloride	mg/m ³	< 0.001	< 0.001
1,3-Butadiene	mg/m ³	< 0.001	< 0.001
Bromomethane	mg/m ³	< 0.002	< 0.002
Chloroethane	mg/m ³	< 0.001	< 0.001
Ethanol	mg/m ³	0.082	0.288
Acrolein	mg/m ³	< 0.013	< 0.013
Trichlorofluoromethane(Freon 11)	mg/m ³	< 0.003	< 0.003
Acetone	mg/m ³	1.737	0.622
Isopropyl Alcohol	mg/m ³	0.107	0.137
1,1-Dichloroethene	mg/m ³	< 0.002	< 0.002
1,1,2-Trichlorotrifluoroethane	mg/m ³	0.008	< 0.004
Methylene chloride(Dichloromethane)	mg/m ³	0.114	0.030
Carbon Disulfide	mg/m ³	< 0.017	< 0.017
trans-1,2-dichloroethene	mg/m ³	< 0.002	< 0.002
MTBE	mg/m ³	< 0.002	< 0.002
1,1- Dichloroethane	mg/m ³	< 0.002	< 0.002
Vinyl Acetate	mg/m ³	< 0.002	< 0.002
MEK	mg/m ³	< 0.016	< 0.016
Hexane	mg/m ³	0.004	0.002
cis-1,2-Dichloroethene	mg/m ³	< 0.002	< 0.002
Ethyl Acetate	mg/m ³	< 0.002	< 0.002
Chloroform	mg/m ³	< 0.003	< 0.003
Tetrahydrofuran	mg/m ³	< 0.002	< 0.002
1,1,1-Trichloroethane	mg/m ³	< 0.003	< 0.003
1,2-Dichloroethane	mg/m ³	< 0.002	< 0.002
Benzene	mg/m ³	0.003	< 0.002
Carbon tetrachloride	mg/m ³	< 0.003	< 0.003
Cyclohexane	mg/m ³	0.002	< 0.002
Heptane	mg/m ³	< 0.002	< 0.002
Trichloroethene	mg/m ³	< 0.003	< 0.003
1,2-Dichloropropane	mg/m ³	< 0.003	< 0.003
1,4-Dioxane	mg/m ³	< 0.002	< 0.002
Bromodichloromethane	mg/m ³	< 0.004	< 0.004
Methyl Methacrylate	mg/m ³	0.002	< 0.002
MIBK	mg/m ³	< 0.022	< 0.022
cis-1,3-Dichloropropene	mg/m ³	< 0.002	< 0.002
trans-1,3-Dichloropropene	mg/m ³	< 0.002	< 0.002
Toluene	mg/m ³	0.218	0.078
1,1,2-Trichloroethane	mg/m ³	< 0.003	< 0.003
Methyl Butyl Ketone	mg/m ³	0.003	< 0.002
Dibromochloromethane	mg/m ³	< 0.005	< 0.005
Tetrachloroethene	mg/m ³	< 0.004	< 0.004
1,2-Dibromoethane	mg/m ³	< 0.004	< 0.004
Chlorobenzene	mg/m ³	< 0.003	< 0.003
Ethylbenzene	mg/m ³	0.019	< 0.004
m- & p-Xylene	mg/m ³	0.014	0.014
Styrene	mg/m ³	< 0.002	< 0.002
o-Xylene	mg/m ³	0.005	0.005
Bromoform	mg/m ³	< 0.006	< 0.006
1,1,2,2-Tetrachloroethane	mg/m ³	< 0.004	< 0.004
4-ethyl toluene	mg/m ³	< 0.003	< 0.003
1,3,5-Trimethylbenzene	mg/m ³	< 0.003	< 0.003
1,2,4-Trimethylbenzene	mg/m ³	0.005	0.004
1,3-Dichlorobenzene	mg/m ³	< 0.003	< 0.003
Benzyl chloride	mg/m ³	< 0.003	< 0.003
1,4-Dichlorobenzene	mg/m ³	< 0.003	< 0.003
1,2-Dichlorobenzene	mg/m ³	< 0.003	< 0.003
1,2,4-Trichlorobenzene	mg/m ³	< 0.004	< 0.004
Naphthalene	mg/m ³	< 0.003	< 0.003
Hexachloro-1,3-butadiene	mg/m ³	< 0.006	< 0.006



5 CONCLUSION

Assured Environmental performed air emissions monitoring for Ventia Pty Ltd on 24th and 25th October 2023, in accordance with the New South Wales Environmental Protection Licence (EPL) number – 4062. In reference to condition L2.2 of EPL 4062;

- Solid particles for both ventilation points was below 1.1 mg/Nm³.
- Carbon monoxide for both ventilation points was below 40 mg/Nm³.
- Nitrogen oxides for both ventilation points was below 25 mg/Nm³.
- VOCs as n-propane for both ventilation points was below 4 mg/Nm³.

Based on the comparison presented, the results of the monitoring undertaken has demonstrated compliance with the release limits provided in the site EPL for all parameters tested. The decision rule used is based on values obtained during testing without regard to uncertainty limits.



6 QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

Assured Environmental operates within a quality system based upon the requirements of ISO17025. Our quality system defines specific procedures and methodologies to ensure any project undertaken by Assured Environmental is conducted with the highest level of quality given the specific confines of each project. The overall objective of our QA/QC procedures is to representatively sample and accurately analyse components in the gas streams and therefore report valid measurements of emission concentrations.

To ensure representativeness of field work, our quality procedures target:

1. Correct sampling locations
2. Sample time
3. Frequency of samples and
4. Method selection & adherence

To ensure representativeness of lab work, our quality procedures target:

1. Sample preservation
2. Chain of custody (COC)
3. Sample preparation and
4. Analytical techniques

Assured Environmental maintains strict quality assurance throughout all its sampling programs, covering on-site 'field work' and the analytical phase of our projects. Our QA program covers the calibration of all sampling and analytical apparatus where applicable and the use of spikes, replicate sample and reference standards. The test methodologies used for this project are outlined in the methods section of this document. Field test data has been recorded and calculated using direct entry into Microsoft Excel spreadsheets following the procedures of the appropriate test methods. Determination of emission concentrations has been performed using the same Microsoft Excel spreadsheets which are partially supplied as an attachment to this report. More detailed information can be supplied upon request.

QA/QC checks for this project will use validation techniques and criteria appropriate to the type of data and the purpose of the measurement to approve the test report. Records of all data will be maintained. Complete chain of custody (COC) procedures has been followed to document the entire custodial history of each sample. The COC forms also served as a laboratory sheet detailing sample ID and analysis requirements.

Table 10: Sampling data QA/QC checklist

Sampling Data QA/QC Checklist	Comment
Use of appropriate test methods	Yes
'Normal' operation of the process being tested	Yes – as instructed by client
Use of properly operating and calibrated test equipment	Yes
Use of high purity reagents	Yes
Performance of leak checks post sample (at least)	Yes

Table 11: Laboratory data QA/QC checklist

Laboratory Data QA/QC Checklist	Comment
Use of appropriate analytical methods	Yes
Use of properly operating and calibrated analytical equipment	Yes
Precision and accuracy comparable to that achieved in similar projects	Yes
Accurate reporting	Yes

7 GLOSSARY OF TERMS

The following terms and abbreviations may be used in this report:

Table I2: Definitions

Symbol	Definition
<	The analytes tested for was not detected; the value stated is the reportable limit of detection
Am ³	Gas volume in cubic metres at measured conditions
AS	Australian Standard
BH	Back half of sample train (filter holder and impingers) (referred to during sample recovery)
°C	Degrees Celsius
CARB	California Air Resources Board methods
dscm	dry standard cubic meters
EPL	Environmental Protection Licence
FH	Front half of sample train (probe and filter holder) (referred to during sample recovery)
g	Grams
kg	Kilograms
Lower range	The sum of a list of a particular group of compounds, where only those individual congeners/compounds that are detectable in the sample have been included in the total. Results below the limit of detection have not been included, assumed to be 0.
m	Metres
m ³	actual gas volume in cubic metres as measured
mbar	Millibars
Medium range	The medium range of a particular group of compounds represents half of all the limit of detection values, plus the lower range result.
mg	Milligrams (10 ⁻³ grams)
min	Minute
ml	Millilitres
mmH ₂ O	Millimetres of water
Mole	SI unit that measures the amount of substance
N/A	Not applicable
ng	Nanograms (10 ⁻⁹ grams)
Nm ³	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa)
NMI	National Measurement Institute
NM VOC	Non methane volatile organic compound
NR	Not required on this occasion
ppb	Parts per billion
ppm	Parts per million
PQL	Practical quantitation limit
sec	Second
Sm ³	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa) and corrected to a standardised value (e.g. 15% O ₂)
STP	Standard temperature and pressure (0°C and 101.3 kPa) & dry
Upper range	The upper range of a particular group of compounds represents the sum of all positive detections, plus the full limit of detection values.
USEPA	United States Environmental Protection Authority

8 APPENDIX

8.1 Infrastructure Approval – EF20/104

Table 13: Condition A2.1 of Infrastructure Approval

Pollutant	Units of measure	Frequency ⁶	Method ¹
Solid Particles	µg/m ³	Quarterly	TM15
PM ₁₀	µg/m ³	Quarterly	OM-5
PM _{2.5} ⁵	µg/m ³	Quarterly	OM-5
CO	mg/m ³	Continuous	CEM-4
VOC	mg/m ³	Continuous	CEM-8
Speciated VOC ³	mg/m ³	Annual	OM-2
PAH ⁴	µg/m ³	Annual	OM-6
Parameter	Units of measure	Frequency	Method ¹
Flow rate	M ³ /s	Continuous	CEM-6
Moisture	%	Continuous	TM-22
Temperature	K	Continuous	TM-2
Other	Units of measure	Frequency	Method ¹
Sampling locations	NA	NA	TM-1

- Note:
- ¹ NSW EPA, 2001, Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales
 - ² Standards Australia, 2001, AS3580.9.8-2001, Methods for the Sampling and Analysis of Ambient Air – Determination of Suspended Particulate Matter – PM₁₀ Continuous Direct Mass Method using Tapered Element Oscillating Microbalance Analyser
 - ³ Must include, but not limited to; Benzene, Toluene, Xylenes, 1,3-Butadiene, Formaldehyde and Acetaldehyde
 - ⁴ Must include, but not limited to; 16 USEPA priority PAHs, namely; Naphthalene, Phenanthrene, Benz(a)anthracene, Benzo(a)pyrene, Acenaphthylene, Anthracene, Chrysene, Indeno(1,2,3-cd)pyrene, Acenaphthene, Fluoranthene, Benzo(b)fluoranthene, Dibenz(a,h)anthracene, Fluorene, Pyrene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene.
 - ⁵ Appropriately modified to include size selective inlet for PM_{2.5} or as otherwise approved by the Director-General.
 - ⁶ Frequency of monitoring can be varied with approval from the Director-General.



8.1 Condition L2.2 of EPL 4602

L2.2 Air Concentration Limits

POINT 2,3

Pollutant	Units of measure	100 percentile concentration limit	Reference conditions	Oxygen correction	Averaging period
Carbon monoxide	milligrams per cubic metre	40	Dry, 273K, 101.3 kPa		1 hour
Nitrogen Oxides	milligrams per cubic metre	25	Dry, 273k, 101.3kPa		1 hour
Solid Particles	milligrams per cubic metre	1.1	Dry, 273k, 101.3kPa		1 hour, or the minimum sampling period specified
volatile organic compounds as n-propane equivalent	milligrams per cubic metre	4.0	Dry, 273k, 101.3kPa		1 hour



8.1 Condition M2.2 & 2.3 of EPL 4602

M2 Requirement to monitor concentration of pollutants discharged

M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:

M2.2 Air Monitoring Requirements

POINT 2,3

Pollutant	Units of measure	Frequency	Sampling Method
Carbon monoxide	milligrams per cubic metre	Every 6 months	TM-32
Nitrogen Oxides	milligrams per cubic metre	Every 6 months	TM-11
Solid Particles	milligrams per cubic metre	Every 6 months	TM-15
Speciated organic compounds	milligrams per cubic metre	Every 6 months	TM-34
volatile organic compounds as n-propane equivalent	milligrams per cubic metre	Every 6 months	TM-34

Environment Protection Authority - NSW
Licence version date: 7-Aug-2023

Page 9 of 18

Section 55 Protection of the Environment Operations Act 1997

Environment Protection Licence



Licence - 4062

M2.3 For the purpose of the Table above, Speciated Organic Compounds must include, but are not limited to, Benzene, Toluene, Xylenes, 1,3-Butadiene, Formaldehyde and Acetaldehyde
Note: The frequency of the monitoring will be reviewed in two years.

M3 Testing methods - concentration limits

M3.1 Monitoring for the concentration of a pollutant emitted to the air required to be conducted by this licence must be done in accordance with:

- any methodology which is required by or under the Act to be used for the testing of the concentration of the pollutant; or
- if no such requirement is imposed by or under the Act, any methodology which a condition of this licence requires to be used for that testing; or
- if no such requirement is imposed by or under the Act or by a condition of this licence, any methodology approved in writing by the EPA for the purposes of that testing prior to the testing taking place.

Note: The *Protection of the Environment Operations (Clean Air) Regulation 2022* requires testing for certain purposes to be conducted in accordance with test methods contained in the publication "Approved Methods for the Sampling and Analysis of Air Pollutants in NSW".



8.1 Sample Method Summaries

8.1.1 Velocity, Volume Flow Rate & Temperature (USEPA Method 2)

Gas velocity and volume flow rate were determined in accordance with USEPA Method 2 – Determination of stack gas velocity and volumetric flow rate (type-s pitot tube). Velocity profiles were obtained across the sampling location using a calibrated S-type pitot tube, a Testo digital manometer, a type K thermocouple, and a Fluke thermocouple indicator.

Positions for velocity pressure and temperature measurement were determined in accordance with AS4323.1. Gas velocity and volume flow rate was then calculated in accordance with USEPA Method 2.

8.1.2 Gas Molecular Weight (USEPA Method 3)

A gas sample is extracted from a stack by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analysed for percent CO₂ and percent O₂.

8.1.3 Moisture Content (USEPA Method 4)

A measured volume of stack gas was bubbled through a series of chilled impingers each containing 100mls of water and then drawn through a silica gel tube in accordance with US EPA Method 4 - "Determination of Moisture Content in Stack Gases".

The total change in volume of water in the impingers and the weight change of the silica gel tube were used to calculate the percentage moisture in the stack.

8.1.4 Total Solid Particles

Monitoring for solid particles was conducted in accordance with Australian Standard 4323.2 - 1995 "Stationary Source Emissions, Method 2: Determination of Total Particulate Matter - Isokinetic Manual Sampling - Gravimetric Method".

Stack gas was withdrawn isokinetically through a nozzle, which had a sharp and tapered leading edge. Particulate matter was collected on a pre-weighed quartz filter located in a holder downstream of the nozzle. Gases were then conditioned (for removal of moisture) and finally metered for flow rate and sample volume.

The weight change of the filter was determined using an AnD electronic balance (with a current NATA endorsed certification), and this figure used to calculate the concentration of particulate matter.



8.1.5 Speciated VOCs – USEPA Method 18/USEPA TO-15

This method applies to ambient concentrations of VOCs above 0.5 ppb-v and typically requires VOC enrichment by concentrating up to one litre of a sample volume.

TO-15 was developed for the sampling and the analysis of VOCs in ambient air. Samples are collected in a certified passivated steel canister that is evacuated to approximately -30 inches Mercury. Samples may be collected either as grab samples or as temporal samples, sampling times from less than one minute to greater than 24 hours, by using a flow restricting device.

The atmosphere is sampled by introduction of air into a specially prepared stainless-steel canister (Summa canister). A pump ventilated sampling line is used during sample collection to ensure sample from the source being tested is delivered undiluted to the canister. After the air sample is collected, the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to the laboratory for analysis.

The sample is released by thermal desorption and carried onto a gas chromatographic column for separation and analysis via a high-resolution gas chromatograph (GC) coupled to a mass spectrometer.

8.1.6 Speciated VOCs – USEPA Method 18 (Aldehydes & Ketones)

Sampling and analysis for formaldehyde and acetaldehyde (Ethanal) was conducted using aldehydes & ketones DNPH sorbent tubes, the USEPA Method 18 adsorbent tube approach was used as a guide. A measured volume of stack gas was drawn through a DNPH adsorption tube, trapping aldehydes & ketone present in the gas. Samples were analysed using Carbonyls determined by derivatisation with DNPH and subsequent HPLC analysis.