Aughinish Alumina Ltd.

Askeaton, Co. Limerick

IE Licence Reg. P0035-07

Additional reporting required in accordance with

Schedule E of IE Licence Reg. P0035-07

March 2025

Aughinish Alumina Ltd.

Industrial Emissions Licence
Register No. P0035-07

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1. Introduction

This document comprises additional reporting required in accordance with Schedule E of Aughinish Alumina Limited (AAL) Industrial Emissions Licence (P0035-07). Items covered in this report were previously submitted as part of the AER.

The report covers the period from the 1st January 2024 to the 31st December 2024.

2. Emissions

Summary information on all emissions, discharges and waste arising from operations at AAL has been submitted to the Agency via the Environmental Performance Reporting (EPR) on-line application. Monitoring data, summarised in the following sections, shows continued compliance with IE Licence Conditions and Emission Limit Values (ELV's).

2.1 Emissions to Air

There are 15 IE licensed air emission points at AAL. The primary sources of emissions to air in 2024 were the Gas Boilers (Emission Point Ref. A4-A, A4-B), Combined Heat and Power Plant (CHP) (Emission Point Refs. A3-A and A3-B), Calciners (Emission Point Ref. A2).

The remaining emission sources comprise bag houses, cyclone exhausts for control of particulate emissions from materials handling operations, and three diesel fired boilers for heating buildings.

2.1.1 HFO Boiler Emissions

The HFO Boilers (Emission Point Ref. A1) are now decommissioned are were not in operation in 2024, in accordance with Condition 5.13 of the IE licence.

2.1.2 Gas Boiler Emissions

Emissions from the gas boilers are summarised in Table 1 below as actual annual mass emissions (in kgs) for the licensed parameters during the 2024 reporting period.

Table 1: Mass Emissions to Air - Gas Boilers

Emission Point Ref. A4-A & A4-B – Gas Boilers	Mass Emission (Kgs) 2023	Mass Emission (Kgs) 2024	Licensed Mass Emissions (Kgs)
Nitrogen Oxides (as NO_2)	64,479	91,091	227,760
Carbon Monoxide	13,797	13,183	227,760

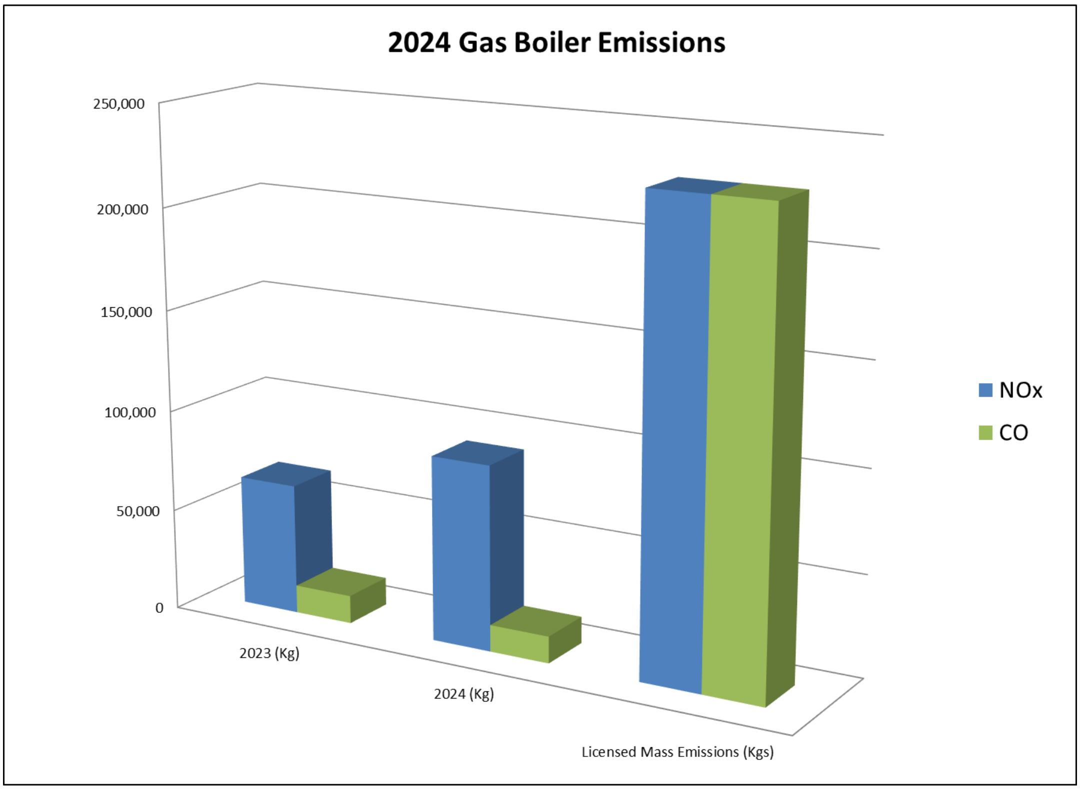


Figure 1: Gas Boiler Mass Emissions 2024

2.1.3 Calciner Emissions

Emissions from the calciners are summarised in Table 2 below as actual annual mass emissions (in kgs) for the licensed parameters during the 2024 reporting period.

Particulate mass emissions are based on the measured particulates, monitored as part of the IE Licence requirements, and estimated exhaust gas flow rates.

Table 2: Mass Emissions to Air - Calciners

Emission Point Ref. A2 – Calciner	Mass Emission (Kgs) 2023	Mass Emission (Kgs) 2024	Licensed Mass Emissions (Kgs)
Oxides of Sulphur (as SO_2)	0	0	7,029,024
Particulates	15,019	29,754	235,060
Nitrogen Oxides (as NO2)	380,473	468,362	878,628

Emissions of sulphur dioxide, particulates and nitrogen oxides from the calciners were significantly below licensed emission rates permitted for these parameters.

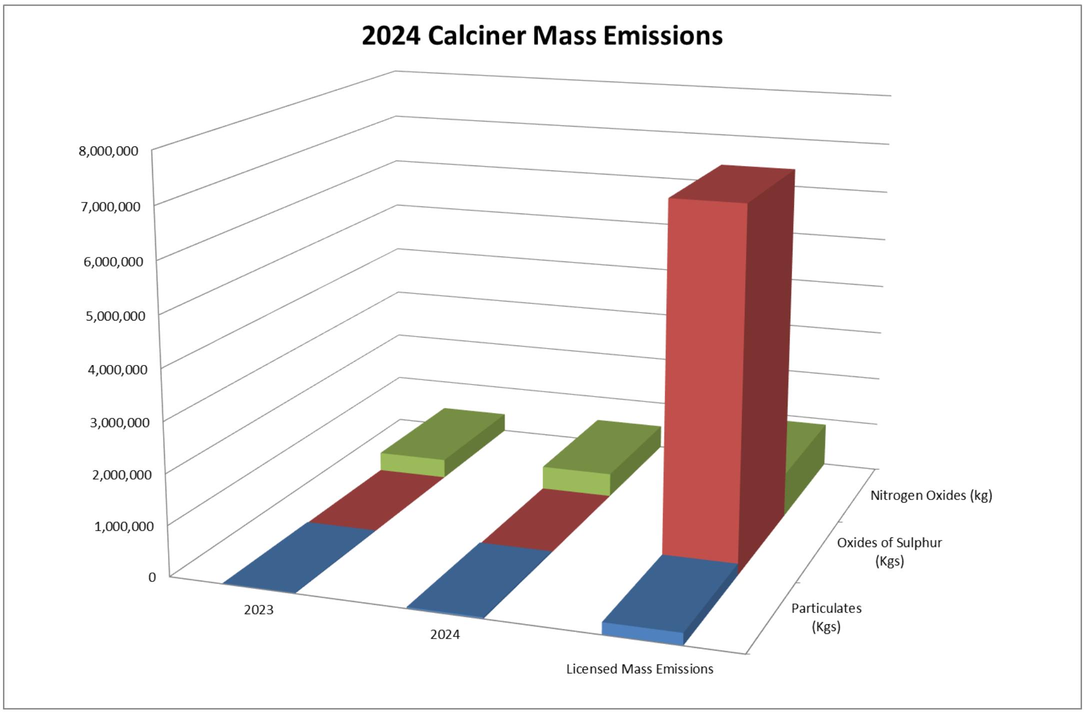


Figure 2: Calciner Mass Emissions 2024

2.1.4 CHP Emissions

Schedule C.1.2 of the IE Licence requires continuous monitoring of oxides of nitrogen (as NO_2) and carbon monoxide (CO).

The licence requirements for the CHP heat recovery steam generator stack are as outlined below:

- No 24-hour value shall exceed the emission limit value of 75 mg/Nm^3 for Nitrogen Oxides and 100mg/Nm^3 for Carbon Monoxide.
- No hourly value shall exceed twice the ELV.

The NO_2 and CO monitoring results for 2024 are shown in Table 3 below and are significantly below the licensed emission limit values.

Table 3: Mass Emissions to Air - CHP

Emission Point Ref. A3A & A3B – CHP	Mass Emission (Kgs) 2023	Mass Emission (Kgs) 2024	Licensed Mass Emissions (Kgs)
Nitrogen Oxides (as NO_2)	288,263	301,735	946,080
Carbon Monoxide	6,282	7,778	1,261,440

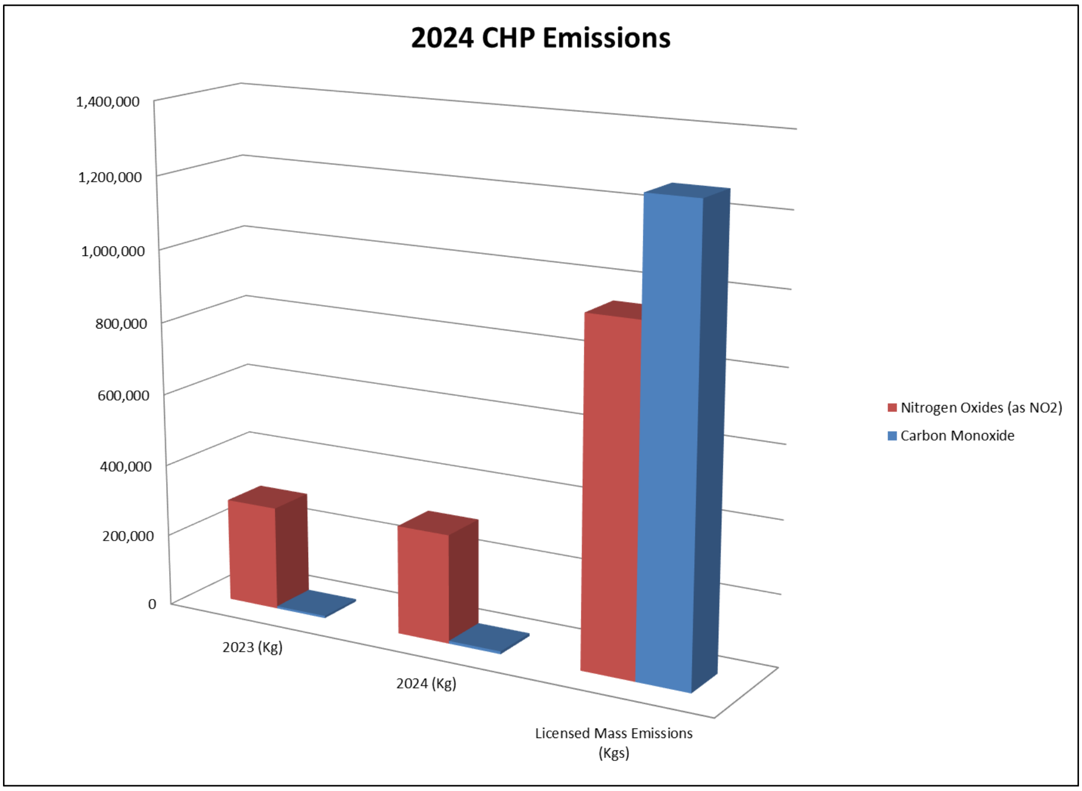


Figure 3: CHP Mass Emissions 2024

2.1.5 Other Emission Points (Dust Collection Units)

There are 9 other licensed process air emission points. These emissions are from dust collection units (DCUs) associated with bauxite and alumina handling and conveying operations at the plant.

Actual mass emissions of particulates from each of the licensed emission points are tabulated below and are based on average monitoring results and total hours of operation during 2024.

The combined actual annual mass emission of particulates from the licensed emission points was 3,496 kg during 2024, which is significantly lower than the permitted annual mass emission for the combined sources of 174,567kg.

In addition, each individual sample collected during the monitoring periods were significantly below the relevant emission limit value for that source.

Table 4: Summary of Particulate Emissions from Dust Collection Units

Emission Point Ref./Description		Mass Emission (kg) 2023	Mass Emission (kg) 2024	Licensed Emission (kg)
5	Transfer Tower 4 & 5 Exhaust Fan	1,865	1,036	51,757

Emission Point Ref./Description		Mass Emission (kg) 2023	Mass Emission (kg) 2024	Licensed Emission (kg)
6	Bauxite Crusher Scrubber Exhaust Fan	1,777	1,175	49,034
8	Transfer Tower 3 Scrubber Exhaust Fan	N/A	N/A	21,535
11	Alumina Loader Dust Fan FA49AL03 Outer	N/A	N/A	20,659
12	Alumina Loader Dust Fan FA49A Inner	469	540	9,682
16	Alumina Silo 1 Exhaust Fan FA12A017	1,010	221	6,570
17	Alumina Silo 2 Exhaust Fan FA12A018	115	444	6,570
18	Alumina Silo 3 Exhaust Fan FA12A019	121	26	4,380
19	Alumina Silo 1/2 Exhaust Fan FA12A020	138	54	4,380
Total		**5,496**	**3,496**	**174,567**

2.1.6 Emissions to Air Compliance Summary

Compliance with the relevant emission limit values (ELV's) for emissions to atmosphere is evaluated as follows for all active boilers, calciners and CHP emissions.

Gas Boiler Emissions

For gas boiler overall compliance is assessed in accordance with Condition 4.1.1:

- 100% of validated monthly average values shall not exceed 100mg/Nm^3 for NO_x & CO.
- 100% of validated daily average values shall not exceed 110mg/Nm^3 for NO_x & CO.
- 95% of validated hourly average values shall not exceed 200mg/Nm^3 for NO_x & CO.

The evaluation confirms that gas boiler emissions were fully compliant with all the parameters specified in Condition 4.1.1 of the IE Licence as summarised in Table 5 below.

Table 5: Evaluation of Compliance – Gas Boilers

Parameter	IEL ELV (mg/m3)	Actual 2024 (mg/m3)	Comment
A4-A (D Boiler) Monthly average NO_X	100%< 100	100%< 100	Compliant
A4-A (D Boiler) Daily average NO_X	100%< 110	100%< 110	Compliant
A4-A (D Boiler) Hourly average NO_X	95%< 200	100%< 200	Compliant
A4-B (E Boiler) Monthly average NO_X	100%< 100	100%< 100	Compliant
A4-B (E-Boiler) Daily average NOX	100%< 110	100%< 110	Compliant
A4-B (E-Boiler) Hourly average NO_X	95%< 200	100%< 200	Compliant
A4-A (D Boiler) Monthly average CO	100%< 100	100%< 100	Compliant
A4-A (D-Boiler) Daily average CO	100%< 110	100%< 110	Compliant
A4-A (D Boiler) Hourly average CO	95%< 200	99.99%< 200	Compliant
A4-B (E Boiler) Monthly average CO	100%< 100	100%< 100	Compliant
A4-B (E-Boiler) Daily average CO	100%< 110	100%< 110	Compliant
A4-B (E-Boiler) Hourly average CO	95%< 200	99.99%< 200	Compliant

Calciner Emissions

The requirements for Calciner particulate emissions as outlined in Condition 4.1.3 of the IE licence are as follows:

- No daily mean value shall exceed the ELV (50 mg/Nm^3)
- No hourly mean shall exceed twice the ELV (100 mg/Nm^3)
- 97% of hourly mean values shall not exceed 1.2 times the ELV (60mg/Nm^3)

An evaluation of the continuous monitoring data for 2024 is summarised in Table 6.

Table 6: Evaluation of Compliance – Calciners

Parameter	ELV (mg/m3)	Actual 2024 (mg/m3)	Comment
Daily Average Particulates	100% < 50	100% < 50	Compliant
Hourly Average Particulates	100% < 100	100% < 100	Compliant
Hourly Average Particulates	97% < 60	100% < 60	Compliant

In addition, for quarterly non-continuous monitoring of particulates and nitrogen oxides (as NO_2), individual results were fully compliant with the relevant ELV's for calciner emissions.

CHP Emissions

In accordance with Schedule C.1.2, continuous monitoring of Oxides of Nitrogen and Carbon Monoxide was assessed. A summary of evaluation of compliance of CHP emissions is presented in Table 7 below. In all cases, the emissions were compliant with the relevant ELVs.

Table 7: Evaluation of Compliance - CHP

Parameter	IEL ELV (mg/m^3)	Actual 2024 (mg/m^3)	Comment
A3-A (GT1) Monthly average NO_X	100%< 75	100% < 75	Compliant
A3-A (GT1) Daily average NO_X	100%< 82.5	100% < 82.5	Compliant
A3-A (GT1) Hourly average NO_X	95%< 150	100% <150	Compliant
A3-B (GT2) Monthly average NO_X	100%< 75	100% < 75	Compliant
A3-B (GT2) Daily average NO_X	100%< 82.5	100% < 82.5	Compliant
A3-B (GT2) Hourly average NO_X	95%< 150	100% < 150	Compliant
A3-A (GT1) Monthly average CO	100%< 100	100%< 100	Compliant
A3-A (GT1) Daily average CO	100%< 110	100%< 110	Compliant
A3-A (GT1) Hourly average CO	95%< 200	99.99%< 200	Compliant

Parameter	IEL ELV (mg/m^3)	Actual 2024 (mg/m^3)	Comment
A3-B (GT2) Monthly average CO	100%< 100	100%< 100	Compliant
A3-B (GT2) Daily average CO	100%< 110	100%< 110	Compliant
A3-B (GT2) Hourly average CO	95%< 200	100%< 200	Compliant

Dust Collection Units

Other particulate emissions are required to be sampled on a bi-annual basis.

All monitoring results for each of the emission points were fully compliant with the specified emission limit values set out in the IE licence.

2.1.7 Air Monitoring Parallel Measurements

In accordance with EN 14181, AAL conducted Annual Surveillance Tests (AST) on Gas Boilers (Emission Point Ref. A4-A and A4-B) and Combined Heat and Power Plant (CHP) (Emission Point Refs. A3-B) during 2024.

A QAL2 was completed for Combined Heat and Power Plant (CHP) (Emission Point Refs. A3-A) during 2024.

The AST and QAL2 reports are included as ***Attachment 1***.

2.1.8 Large combustion plant

The following units are classified as Large Combustion Plants (LCP) at AAL.

- A4-A D gas boiler
- A4-B E gas boiler
- A3-A Gas Turbine (GT) 1
- A3-B Gas Turbine (GT) 2

The total operating hours, total energy input and the total annual emissions are outlined in the tables below for the large combustion plants onsite.

Table 8: Total operating hours - LCP

Emission Point Reference	Total operating hours
A4-A	8397
A4-B	8491
A3-A	8374
A3-B	6726

Table 9: Total energy input - LCP

Emission Point Reference	Total energy input (TJ)
A4-A	1764.76
A4-B	1784.57
A3-A	6409.02
A3-B	5147.79

Table 10: Total annual emissions - LCP

Emission Point Reference	NO_X (Tonnes)	SO_X (Tonnes)	Dust (Tonnes)
A4-A	47.17	0	0
A4-B	44.10	0	0
A3-A	162.65	0	0
A3-B	138.55	0	0

2.2 Emissions to Water

AAL has two licensed discharges of treated effluent to the Shannon Estuary as follows:

Table 11: Licensed Discharges to Water

Licence Reference	Receiving Water	Characteristics
W1-1	Shannon Estuary	Treated Industrial (Process) Effluent
Sanitary Effluent	Shannon Estuary	Treated Sanitary Effluent

Discharges of treated industrial (process) and sanitary effluents to the Shannon Estuary are made at an outfall point close to the AAL Marine Terminal. Both discharges are sampled continuously for both flow and pH, and for other parameters at daily, weekly, quarterly and bi-annual frequencies, as specified in Schedules C.2.1 (Control of Emissions to Water) and C.2.2 (Monitoring of Emissions to Water) of the IE Licence.

2.2.1 Process Effluent (W1-1)

Treated process effluent is discharged to the Shannon Estuary at emission point W1-1. Summary monitoring results for 2024 are tabulated in Table 12 below.

Screening for heavy metals, VOC's (Volatile Organic Compounds) and toxicity is also carried out and results are detailed in Sections 2.2.2, 2.2.3 and 2.2.4 respectively.

The data reported in Table 12 is for the 12 months of 2024. Figures for 2023 are included by way of comparison.

It is noted that annual mass emissions for all parameters during the reporting period were within licensed emission limit values (ELV's).

Table 12: Process Effluent (W1-1) Mass Emissions

Parameters	Mass Emissions (kg) 2023	Mass Emissions (kg) 2024	Licensed Emissions (kg)
Volume (m^3)	4,948,548	4,905,379	10,950,000
BOD	111,595	113,914	861,400
Suspended Solids	79,790	70,914	547,500
Oils Fats & Greases	14,846	14,716	164,250

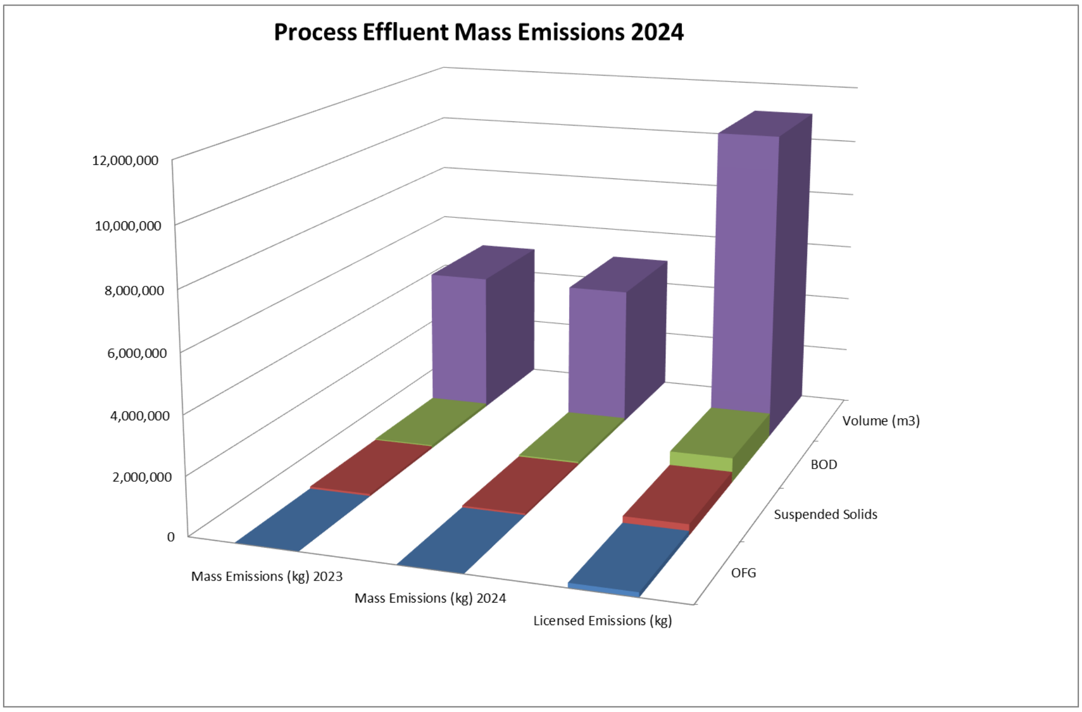


Figure 4: Process Effluent Mass Emissions 2024

2.2.2 Heavy Metal, Aluminium and Soda Analysis

AAL is required to analyse treated process effluent for heavy metals, aluminium and soda under IE Licence Schedule C.2.2 Monitoring of Emissions to Water.

Heavy Metals

Heavy metal analysis of the effluent discharged at emission point W1-1 was undertaken by Fitz Scientific Ltd. on a quarterly basis during 2024. Analytical results are shown in Table 13 below.

Table 13: Process Effluent (W1-1) - Heavy Metal Results

Parameter	Conc. (mg/l) Q1	Conc. (mg/l) Q2	Conc. (mg/l) Q3	Conc. (mg/l) Q4
As	0.0330	0.0450	0.0590	0.0640
Cd	0.0010	0.0010	0.0010	0.0010

Parameter	Conc. (mg/l) Q1	Conc. (mg/l) Q2	Conc. (mg/l) Q3	Conc. (mg/l) Q4
Cr	0.0500	0.0160	0.0170	0.0140
Cu	0.0060	0.0090	0.0260	0.0130
Hg	0.0017	0.0015	0.0004	0.0025
Ni	0.0030	0.0070	0.0080	0.0090
Pb	0.0010	0.0010	0.0010	0.0010
Zn	0.0090	0.0090	0.0090	0.0130
Ti	0.0050	0.0050	0.0050	0.0050
Fe	0.0420	0.0340	0.4900	0.3740
Mg	2.9000	5.4000	8.9000	7.9000

Aluminium & Soda

The results of the analyses for aluminium and soda are detailed in Table 14. The figure provided for each parameter is the average result for the 2024 monthly and quarterly monitoring intervals. 2023 data is provided for comparison.

Table 14: Process Effluent (W1-1) Soda & Aluminium Analysis

Parameter	Units	Annual Average 2023	Annual Average 2024
Aluminium	mg/l Al	2.90	2.37
Soda	g/l Na_2O	2.28	2.48

2.2.3 Effluent VOC Screen

Screening of industrial effluent (at W1-1) for VOC's is undertaken biannually as specified in Schedule C.2.2 of the IE Licence. Biannual sampling and analysis were undertaken in January and August 2024 with the results outlined in Table 15 below.

Table 15: Process Effluent (W1-1) - VOC Analysis

Date	Units	Test	Method	Result
04/01/2024	µg/l	VOC	USEPA 542.2	<1.0
14/08/2024	µg/l	VOC	USEPA 542.2	0.5

Note: Values denoted less than (<) are below the relevant threshold or limit of detection for that test

The VOC results are included as ***Attachment 2***.

2.2.4 Toxicity

Schedule B.2 (Emissions to Water) and Schedule C.2.2 (Monitoring of Emissions to Water) of the IE Licence requires biannual toxicity testing of the treated effluent. The ELV for toxicity is 5 Toxic Units (TU).

Samples of treated effluent (24 hour flow proportional composite samples) were collected and submitted to Enva Ireland, Cork for toxicity testing in January and July 2024.

The acute toxicity of each sample was analysed on suitable sensitive aquatic indicator species i.e. *Tisbe battagliai* and *Vibrio fischeri*.

The results (see Table 16) show that both effluent samples were compliant with the ELV for toxicity.

The toxicity testing certificates of analysis are included as ***Attachment 2.***

Table 16: Process Effluent - Toxicity Testing Results

Test Parameter	Q1 2024 Results (TU)	Q3 2024 Results (TU)	ELV (TU)
48h LC_{50} to *Tisbe battagliai*	<1.0	<1.0	5
30 min EC_{50} to *Vibrio fischeri*	<1.0	<1.0	5

Note: Values denoted less than (<) are below the relevant threshold or limit of detection for that test

2.2.5 Sanitary Effluent

Treatment of sanitary effluent is provided for by a proprietary biological effluent treatment plant, which comprises an activated sludge (aeration) stage and a settlement/clarification stage, prior to discharge. The system discharges to the industrial effluent discharge pipeline at a point upstream of the final discharge at W1-1.

Annual mass emissions are tabulated in Table 17 below. 2023 data is provided for comparison.

Table 17: Sanitary Effluent Mass Emissions

Parameter	Mass Emissions (kg) 2023	Mass Emissions (kg) 2024	Licensed Emissions (kg)
Volume (m^3)	21,006	23,538	87,600
BOD	76	161	2,190
Suspended Solids	109	125	3,066

The annual volumetric discharge mass emissions for all parameters were significantly below licence limits for the monitoring period.

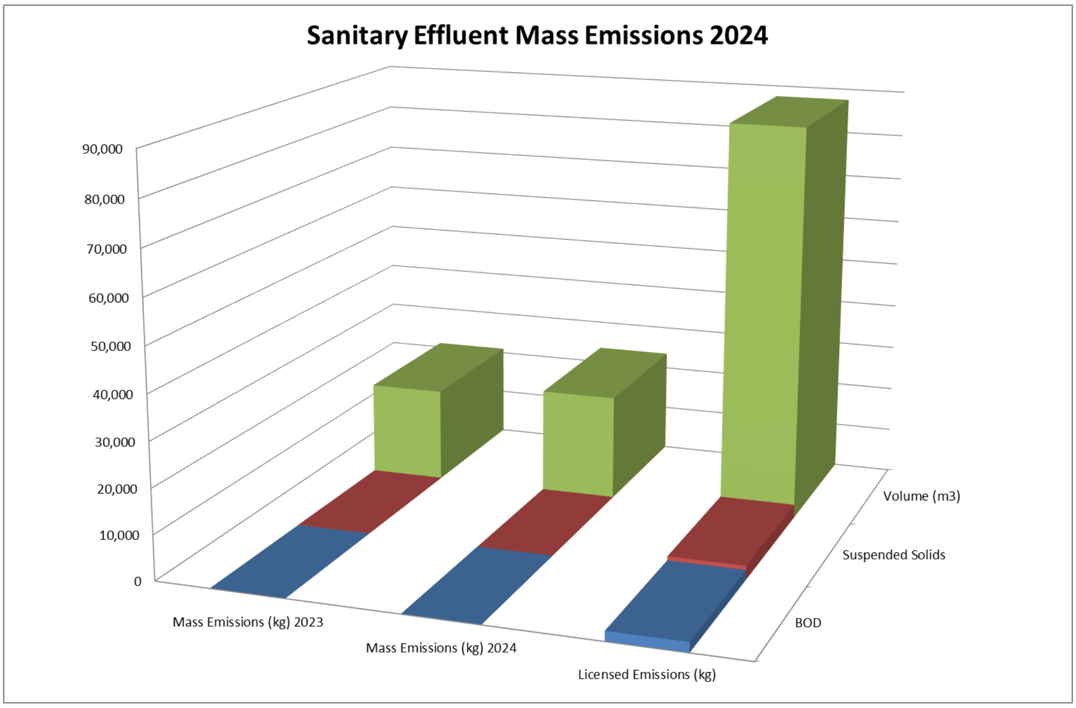


Figure 5: Sanitary Effluent Mass Emissions 2024

2.2.6 Surface Water Monitoring

Monitoring of surface water run-off from the site is undertaken at five discharge locations referred to as Surface Streams (SS).

Monitoring results for each emission point are summarised in Table 18 as the average value for the monitoring period.

Table 18: Surface Water Discharge Monitoring Results

Emission Point Reference	pH	Conductivity (µS/cm)	Na_2O (g/l)
Frequency	**Monthly**	**Monthly**	**Monthly**
SS 1	8.3	170	0.01
SS 2	8.5	177	0.01
SS 3	8.2	201	0.01
SS 4	8.3	188	0.01
SS 5	8.1	266	0.02

(Note: Results are numerical average of 2024 data)

2.2.7 Surface Water Monitoring at the BRDA

Monitoring of surface water run-off in the area of the existing BRDA is undertaken at three licensed locations – Mangan's Lough, the OPW Channel and Phase 2 West Robertstown Gate.

Results for each emission point are detailed in Table 19 and show the average value over the monitoring period. As the surface water in the area is subject to saline intrusion, the soda and conductivity values are subject to sodium interference owing to the presence of sodium salts in the brackish water.

Table 19: BRDA Surface Water Monitoring Results

Description	pH	Conductivity µS/cm	Soda (Na_2O) g/l
Mangan's Lough	7.4	1,634	0.36
OPW Channel	7.6	3,480	0.75
West Robertstown Gate	8.2	4,395	1.13

(Note: Results are numerical average of 2024 data)

2.2.8 Discharges to Water Compliance Summary

All discharges of treated process wastewater and sanitary effluent during the reporting period complied fully with the relevant emission limit values set out in the IE Licence.

3. Resource Consumption

3.1 Energy Consumption

Owing to the nature of the Bayer process used at AAL for alumina manufacturing and post extraction processing, energy represents the most economically significant impact to the process.

For this reason, the plant is designed with energy efficiency in mind. Heat recovery and power efficiency are two of the key process efficiency targets that receive close scrutiny.

Table 20: Energy Consumption 2022 – 2024

Source	2022 (MW)	2023 (MW)	2024 (MW)
Heavy Fuel Oil	1.5	1.8	0.0
Power (Electrical)	39.2	36.8	43.1
Diesel	0.3	5.1	0.3
Natural Gas	618.3	559.9	638.9
Total	**659.3**	**603.6**	**682.3**

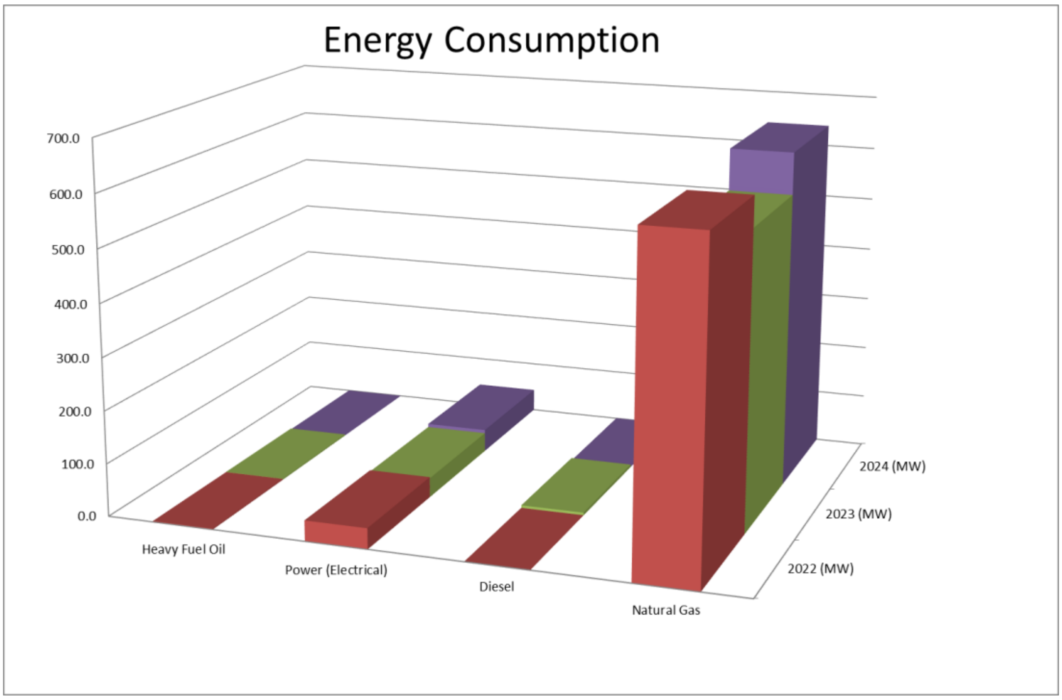


Figure 6: Energy Consumption 2022 – 2024

3.1.1 Energy Efficiency Report 2024

The 2024 energy efficiency report is provided as ***Attachment 3***.

- AAL successfully completed a vigilance audit by SGS of ISO 50001 standard in December 2024.
- AAL is also certified as high efficiency CHP through the Commission for Energy Regulation's scheme.
- The 2024 steam efficiency performance was 5.92 GJ/t.
- The 2024 power efficiency performance was 0.78 GJ/t.

3.2 Water Consumption

AAL receives potable water from Limerick City & County Council for process and domestic uses.

The bulk of the potable water is demineralised in the AAL water treatment plant for use in boiler steam generation. The balance of the potable water is used for process make-up, where process condensate (re-condensed water from the process) supply is not available, and also as domestic water.

Table 21: Water Consumption 2021 - 2024

Year	Total (m^3)
2024	5,093,007
2023	4,576,809
2022	4,648,767
2021	5,011,398

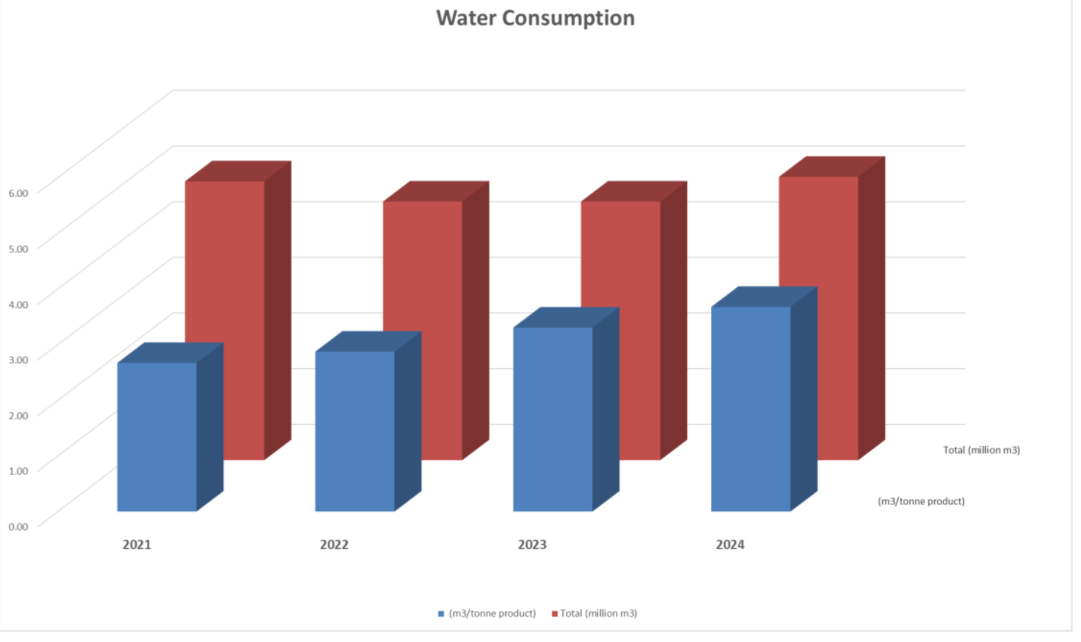


Figure 7: Water Consumption 2021 – 2024

3.3 Progress on Minimising Water Demand and Volume of Trade Effluent Discharges

AAL continually strives to improve the efficiency of its processes in order to reduce both the quantity of raw water consumed and waste effluent produced.

The water balance improvement program has enabled a sustained improvement in injection steam pick up and digestion temperature reduction, thereby reducing raw water consumption.

3.4 Raw Materials Efficiency and Waste Reduction

AAL continually strives to improve the efficiency of its processes in order to reduce the raw materials consumed and the waste produced.

Table 22 shows the volumes of raw materials consumed and waste produced for 2023 and 2024. The relative consumption for each parameter is calculated as the volume consumed per tonne of alumina hydrate produced.

Table 22: Raw Material Efficiency & Waste Reduction

Material	2023 Consumption	Relative Consumption (Volume/tonne alumina)	2024 Consumption	Relative Consumption (Volume/tonne alumina)
Alumina Produced (tonnes)	1,384,654	N/A	1,752,002	N/A
Bauxite Ore Consumed (tonnes)	3,662,347	2.6	4,443,059	2.5
Sodium Hydroxide (tonnes)	95,434	0.07	122,005	0.07
Sulphuric Acid (tonnes)	12,331	0.01	13,750	0.01
Water (m^3)	4,576,809	3.3	5,093,007	2.9
Waste (tonnes)	1,298,442	0.9	1,550,090	0.9
Energy (GJ)	604	13.7	682	12.3

4. Other Reports

This section contains additional information required under the various conditions of the IE Licence.

Monitoring data from ambient air quality and dust deposition are summarised.

Updates regarding the facility Closure, Restoration and Aftercare Management Plan (CRAMP), the Environmental Liabilities Risk Assessment (ELRA) and the costings and financial provisions associated with both are provided.

The BRDA Status Report in Section 4.6 contains details of the quantities of waste deposited and development works undertaken in the BRDA during the 2024 calendar year.

4.1 Leak Detection Monitoring System

In accordance with the IE Licence conditions, AAL is required to undertake annual groundwater monitoring for hydrocarbons in four monitoring boreholes (BH1- BH4) located in the underground fuel storage area.

The fuel storage area comprises three steel underground storage tanks (UST's), two of which were used for diesel and one for petrol. The two diesel UST's were decommissioned in 2005. The petrol UST was decommissioned in Q4 2019.

The results of groundwater monitoring carried out in 2024 are tabulated in Table 23 below.

Table 23: Borehole Groundwater Monitoring Results 2024

Borehole Ref.	Date	DRO* (µg/l)	PAH* (µg/l)
BH 1	04/03/24	<2	<0.2
BH 2	04/03/24	<1	<0.1
BH 3	04/03/24	2489	<0.1
BH 4	04/03/24	324	<0.1

**DRO – Diesel Range Organic hydrocarbons; PAH - Polycyclic Aromatic Hydrocarbons.*

4.2 Fugitive Emissions in the AAL Plant Area

AAL undertakes monitoring for fugitive dust emissions at thirty locations within the site perimeter.

The dust deposition gauges (labelled DG 1–28, 34 and 35) measure deposited particulate material, collected over a 30-day period in accordance with VDI Guidelines 4320 Part 2. In total, there are 21 deposition gauges located around the BRDA. The remainder are in the plant area.

Dust deposition measures the daily quantity of dust settling over a specified area (m^2) and is expressed as milligrams per square metre per day ($mg/m^2/day$).

Average results for 2024 are summarised in Table 24. Results are presented as mean annual rates for each location, together with the range of monthly data recorded throughout the year.

Table 24: Dust Deposition Rates (mg/m2/day) in 2024

Deposition Gauge No.	Average Deposition Rate (mg/m2/day)	Range (Min - Max) (mg/m²/day)	TA Luft Guideline Limit mg/m²/day
D.G. 1	20	2 - 39	350
D.G. 2	54	11 - 129	350
D.G. 3	27	6 - 53	350
D.G. 4	35	7 - 109	350
D.G. 5	33	4 - 81	350
D.G. 6	31	1 - 91	350
D.G. 7	35	11 - 68	350
D.G. 8	37	2 - 101	350
D.G. 9	34	6 - 74	350
D.G. 10	29	6 - 59	350
D.G. 11	30	17 - 71	350
D.G. 12	36	8 - 74	350
D.G. 13	30	7 - 100	350
D.G. 14	22	4 - 79	350
D.G. 15	22	6 - 82	350
D.G. 16	17	3 - 37	350
D.G. 17	27	10 - 55	350
D.G. 18	35	2 - 61	350
D.G. 19	53	9 - 111	350
D.G. 20	31	1 - 71	350
D.G. 21	32	9 - 102	350
D.G. 22	40	5 - 145	350
D.G. 23	23	2 - 47	350
D.G. 24	33	9 - 117	350
D.G. 25	33	5 - 95	350
D.G. 26	20	4 - 71	350
D.G. 27	37	17 - 99	350
D.G. 28	38	5 - 100	350
D.G. 34	35	1 - 154	350
D.G. 35	17	6 - 29	350

4.3 Ambient Air Quality Monitoring

A programme of ambient air quality monitoring (both on-site and off-site) is carried out by AAL in accordance with Conditions 5.8 and 6.18 of the IE Licence.

The parameters monitored as part of the ambient air quality monitoring programme are:

- Sulphur Dioxide
- Deposited Dust
- Particulate Matter below 10 µm (PM_{10})
- Particulate Matter below 2.5 µm ($PM_{2.5}$)

Results from the off-site ambient air quality monitoring programme are reviewed against the Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive 2008/50/EC as transposed into Irish legislation by the Air Quality Standard Regulations 2011 (SI 180/2011). On-site ambient air quality monitoring is also reviewed.

4.3.1 Ambient Air Sulphur Dioxide Monitoring

A summary of the ambient sulphur dioxide diffusion tubes results is tabulated in Table 25, along with a description of their locations.

All passive sulphur dioxide (SO_2) monitoring data was within AQS limits for 2024.

Table 25: Ambient Air SO2 Diffusion Tubes Monthly Results (µg/m^3)

Monitoring Location	Annual Mean (µg/m^3)	Min Result (µg/m^3)	Max Result (µg/m^3)	National Air Quality Standard Lower Assessment Threshold
Residential property (1)	1.5	1.3	1.6	<50µg/m^3 (Not to be exceeded more than 3 times per year)
Foynes Reservoir (9A)	1.9	1.3	4.4	

* Locations shown on ***Attachment 4*** Ambient Air Monitoring Locations Map
**CAFE threshold shown is lower assessment threshold for SO_2 (40% of 24-hour limit value)

4.3.2 Ambient Air Particulate Deposition

Particulate deposition is monitored at five off-site locations as part of the ambient air quality monitoring programme. Table 26 below shows a summary of the results for these monitoring locations during 2024.

All values were within the TA Luft guideline limit of 350mg/m^2/day.

Table 26: Ambient Air Mean Monthly Particulate Deposition Rates

Site No.	Dust Gauge Ref.	Average Deposition Rate (mg/m2/day)	Range (Min - Max) (mg/m²/day)	TA Luft Guideline Limit mg/m²/day
3	29	35	1 - 154	350
7	30	17	6 - 29	350
11	31	30	8 - 83	350
12	32	31	3 - 123	350
13	33	24	6 - 89	350

4.3.3 Ambient Air $PM_{2.5}$ & PM_{10} Monitoring Ambient Air Particulate Deposition

Monitoring of particulate matter below 2.5µm ($PM_{2.5}$) and below 10µm (PM_{10}) is carried out at 6 locations (2 on-site and 4 off-site) by AAL. The monitoring is carried out using Osiris Continuous Air Sampling Monitors. Table 27 (external) and Table 28 (internal) below show a summary of the results obtained for the 2024 monitoring.

Table 27: External Ambient Air Daily $PM_{2.5}$ & PM_{10} Monitoring Results 2024

Monitoring Location	Foynes	Ballysteen	LCC WTP	Fawnamore	CAFE Directive Limits
$PM_{2.5}$ Annual Mean µg/m³	6.3	6.1	6.6	5.8	20 µg/m³
PM_{10} Annual Mean µg/m³	10.0	9.3	12.7	8.3	40 µg/m³

Table 28: Internal Ambient Air Daily $PM_{2.5}$ & PM_{10} Monitoring Results 2024

Monitoring Location	SW of Plant	NE of Plant
$PM_{2.5}$ Annual Mean µg/m³	4.9	5.0
PM_{10} Annual Mean µg/m³	6.5	7.8

With reference to Schedule 3 of Air Quality Standard Regulations 2011 regarding location of sampling points, the AQS regulations do not apply to on-site ambient air monitoring.

In summary, the results of the off-site monitoring indicate the ambient air quality at off-site monitoring points is good (as defined by EPA ambient air monitoring programme) with all parameters monitored falling within the relevant targets/limits for those parameters.

4.4 Closure, Restoration and Aftercare Management Plan (CRAMP)

Condition 10 of the IE Licence requires that AAL maintains a detailed and fully costed Closure, Restoration and Aftercare Management Plan (CRAMP), which is adequate to assure the Agency that AAL is at all times capable of financing the environmental decommissioning and restoration of the AAL site after closure.

4.4.1 Update of CRAMP

At the request of the Agency, an updated CRAMP was submitted in 2024. AAL await approval of this CRAMP.

A revised Financial Provision has been agreed with the Agency.

4.5 Environmental Liabilities Risk Assessment (ELRA) Review

4.5.1 Update of ELRA

At the request of the Agency, an updated ELRA was submitted in 2024. AAL await approval of this ELRA.

A revised Financial Provision has been agreed with the Agency.

4.5.2 Statement of Measures in Relation to Prevention of Environmental Damage

The measures currently undertaken by AAL in relation to the prevention of environmental damage and possible remedial actions are detailed in the currently approved CRAMP and ELRA, as well as the revised CRAMP and ELRA submitted to the EPA in 2024.

4.6 Annual BRDA Status Report

The Bauxite Residue Disposal Area (BRDA) is classified as a Category A facility under the Extractive Waste Directive. The basis for this classification is the environmental sensitivity of the Special Area of Conservation lands and estuarine habitats adjacent to the BRDA. Operational information required under Schedule D of the IE Licence in respect of the BRDA is tabulated in Table 29 below. All areas are currently operational within the BRDA.

Table 29: BRDA Operational Status

Parameter	Details
BRDA name & Licence number	Aughinish Alumina Ltd. (BRDA) IE Licence Reg. P0035-07
BRDA location	Aughinish Island (National Grid Ref. 127300E, 152200N)
Reporting period	Jan 01 – Dec 31 2024
Owner and/or operator	Aughinish Alumina Ltd.
Area occupied by waste	168.5 hectares (94.5 ha Phase 1 BRDA, 74 ha Phase 2 BRDA)
Tonnage and composition of waste deposited in the preceding year	1,548,366 tonnes (See Table 30)
Methods of depositing	Pumping/Trucking
Time and duration of depositing	24 hours per day, 365 days per year
Total accumulated quantities of waste deposited	41,773,068 tonnes (Table 31)
Calculated remaining capacity	10,089,462 tonnes (Table 32)
Calculated final capacity of site	51,859,923 tonnes
Year in which final capacity of site is expected to be reached	2030
Stability checks undertaken	See Section 4.6.3
Results of monitoring programme	See Section 4.6.3
Summary of any monitoring non-compliances and corrective actions taken	No non-compliances in 2024
Summary of any development/remedial works carried out in the preceding year	See Section 4.6.8
Revisions to BRDA Operational Plan	See Section 4.6.7
Progress on restoration of completed cells	The construction of a closure demonstration area to assess capping options for the restoration / closure of the final BRDA surface.

4.6.1 BRDA Waste Composition and Tonnage Data

Information on current and projected waste disposal rates, together with a breakdown of waste types is tabulated below.

Table 30: BRDA Waste Composition & Tonnage 2024

Waste Stream	LoW Code	Jan – Dec 2024 Total (t)	As % of total waste deposited
Red Mud (dry)	01 03 09	1,417,945	91.58
Sand	01 03 99	117,095	7.56
Salt Cake (wet)	01 03 07	7,116	0.46
Process Waste (wet)	01 03 99	2,887	0.19
Lime Grits (wet)	01 03 99	3,268	0.21
Fluestack Residues (dry)	16 11 04	55	0.00
Total Waste		**1,548,366**	**100.00%**

Table 31: Accumulated Quantities of Waste to BRDA

Waste Stream	LoW Code	1983 – Dec 2024 (t)	As % of total waste deposited
Red Mud (dry)	01 03 09	37,464,812	89.69%
Salt Cake (wet)	01 03 07	537,022	1.29%
Process Waste (wet) (includes sand)	01 03 99	3,575,616	8.56%
Lime Grits (wet)	01 03 99	186,628	0.45%
Fluestack Residues (dry)	16 11 04	4,610	0.01%
Effluent Sludge A34 Clarifier (dry)*	06 05 03	4,380	0.01%
Total Waste		**41,773,068**	**100.00%**

(Note1: The data for all residues for 1983 - 1997 other than red mud are estimated based on pro-rata tonnages for the period 1997 to 2000)

* Material no longer generated.

Engineering estimates of the total occupied and remaining capacity of the BRDA have been updated to reflect recorded quantities of waste deposited at the facility during 2024 and take into account the residue deposited in both the Phase 1 BRDA and the Phase 2 BRDA commissioned since 2011 and are tabulated below.

Table 32: Estimated Capacity of BRDA

Period	MOM Note 1	Waste during period (t)	Accumulated waste (t)	Remaining capacity of BRDA (t)
1983 - 2014	R	26,868,179	26,868,179	27,475,746
2015	R	1,507,468	28,375,647	25,968,278
2016	R	1,514,519	29,890,166	24,269,311
2017	R	1,571,677	31,461,843	22,697,634
2018	R	1,493,710	32,955,553	21,203,924
2019	R	1,546,213	34,501,766	18,606,293 Note 2
2020	R	1,566,785	36,068,551	17,039,508
2021	R	1,528,158	37,596,709	14,263,214
2022	R	1,444,241	39,040,950	12,821,580 Note 3
2023	R	1,295,934	40,224,702	11,637,828
2024	R	1,548,366	41,773,068	10,089,462
2025	E	1,548,366	43,321,434	8,541,096

[1] MOM – Method of Measurement; R = Recorded (Measured); E = Engineering Estimate
[2] The remaining capacity based on topographical survey by drone in May 2019.
[3] Remaining capacity based on topographical drone survey in October 2021.

4.6.2 BRDA Containment Capacity

Containment capacity within the BRDA is developed by rockfill embankments constructed upstream on the hardened residue inside the BRDA perimeter. These embankments are constructed in stages, each stage increasing the elevation of the BRDA by 2 metres.

For Phase 1 BRDA, 100% of the perimeter is currently at Stage 10.

For Phase 2 BRDA, 80% of the perimeter is at Stage 6 and 20% at Stage 7.

The current IE Licence and planning permission permits the entire existing Phase 1 and Phase 2 BRDA perimeters to be raised to Stage 10.

4.6.3 BRDA Monitoring Programme

The 2024 Report on the BRDA stability monitoring programme is reported in the WSP 2024 Annual (Stability) Review, in compliance with Schedule C.7. Monitoring of the BRDA geotechnical instrumentation continued in 2024.

Monitoring of environmental conditions at the BRDA is undertaken on a routine basis through the collection of samples of groundwater from observation wells (OW's) and surface waters for analysis.

There are 30 dust deposition gauges at various locations around the site with a number of gauges at the perimeter of the BRDA. Monitoring results for the 2024 reporting period have been detailed in Section 4.2 (Fugitive Emissions in the AAL Plant Area).

4.6.4 Implementation of Golder Breakout Study Recommendations

In accordance with Condition 8.5.16, further progress for 2024 is listed as follows:

1. Ensure there is no excessive build up of pore pressures in the foundation or glacial fill materials due to leakage in accordance with the design criteria.
   To control pore pressure dissipation in the bauxite residue while perimeter stage raises are being constructed;
   - The stage raise is constructed in 2 x 1 m depth lifts a minimum of 3 weeks apart,
   - No bauxite residue is placed behind the new stage raise for a minimum period of 3 weeks following the construction of the upper 1m depth lift.
   - The excavation of the collector drain at the downstream toe of the newly constructed stage raise is not undertaken until placement of bauxite residue commences and not before a minimum of 3 weeks following construction of the upper 1m depth lift.

2. Ensure that the undrained shear strength of the bauxite residue forming the foundations for the upstream raise of the BRDA is monitored in accordance with the design criteria adopted;
   - Residue farming continued in the Phase 1 and Phase 2 BRDAs over the entire surface area and forming the foundations for the upstream raises of the BRDA to achieve its design criteria strength.
   - Continuous Penetration Testing (CPT) along with collection of MOSTAP undisturbed sampling, geonor shear vane testing and pore pressure dissipation testing of bauxite residue around the perimeters of Phase 1 and Phase 2 was undertaken in December 2023 and up to date mud shear strength calculated in Q1 2024.

3. Avoid water collecting in the Perimeter Interceptor Channel (PIC) by ensuring sufficient gradient in the channel on north east side of Phase 2 BRDA to allow water to migrate to lower sectors of the Perimeter Interceptor Channel;
   - PIC is formed and profiled with drainage stone to ensure gradient for flow of water. No water collecting.

4. Install and monitor the piezometers, inclinometers and settlement systems as the facility increases in elevation in accordance with the Risk Assessment recommendations;
   - A Physical Stability Monitoring Plan for the BRDA was updated by WSP Ireland Consulting Limited (WSP) as Engineer of Record in January 2024 following an assessment of the current AAL License (IEL P0035-07) and the 2018 Best Available Techniques (BAT) Reference Document for the Management of Waste from the Extractive Industries (BREF), in accordance with Directive 2006/21/EC (EUR 28963 EN). This Plan consists of scheduled installations and monitoring of geotechnical instruments installed within the facility along with a series of scheduled audits, inspections and conformance checks to assess the performance of the BRDA.

- An installation programme of piezometers was under taken in July 2024 where PY (10.5m) and PZ (17.3m) piezometers were relocated on dome of Phase 1 and P18B (10.5m) was installed on Phase 2.

5. Regularly inspect and undertake maintenance to ensure the integrity of the Sea Wall and conduct repairs as soon as possible if defects are identified;
   - In 2024 Sea Wall was regularly inspected, no maintenance works were undertaken.

4.6.5 Report on Annual BRDA Review

WSP Consulting Ireland Limited (WSP), formerly Golder, were commissioned by AAL to prepare this Annual Review Report for 2024 to facilitate licensee compliance with the conditions of Schedule C.7: Monitoring at the Bauxite Residue Disposal Area of the license (P0035- 07), namely the 'Annual Review' for the Bauxite Residue Disposal Area (BRDA).

This Annual Review Report 2024 summarises the quarterly monitoring results from the standpipe and Casagrande piezometers, the inclinometers and extensometers, the visual inspection of the facilities, observations made during a site inspection visit in February 2024 and assesses the stability of the BRDA, the inner and outer perimeter walls forming the perimeter interceptor channel (PIC), the storm water pond (SWP) and liquid waste pond (LWP).

At the end of 2024 the Phase 1 BRDA is at Stage 10 along all sectors.

At the end of 2024, 80% of the Phase 2 BRDA perimeter is at Stage 6 and 20% is at Stage 7 on the east of Phase 2.

The outer and inner perimeter walls of the PICs, the SWP and the LWP are performing in accordance with the design. A check on the stability of these structures was conducted on 04 & 05 February 2024. The visual inspection of the facilities indicated no signs of distress in the walls.

Data received from inclinometers, extensometers, and standpipes is satisfactory. The instruments are functioning well, and the indicated movements and water levels recorded are within the ranges to what is considered to be satisfactory performance and in accordance with design criteria.

Recommendations from the 2024 Annual BRDA Review to be progressed in 2025 include:

- Complete access improvement works to the Storm Water Pond
- Continue Cleaning of internal drainage channels as needed

4.6.6 Biennial Audit at the BRDA

WSP undertake both the Annual Review and the Biennial Independent Audit in accordance with the scope agreed by the Agency.

4.6.7 Revisions to BRDA Operational Plan

The Operational, Safety and Maintenance (OSM) manual was reviewed in September 2024 to ensure that all relevant information is up to date. The OSM is in compliance with Canadian Dam Association (CDA) guidelines and Extractive Waste BREF 2018.

4.6.8 BRDA Development/Remedial Works 2024

The notable developments/works in the BRDA during 2024 were:

- The construction of Stage 6 Perimeter Raise on east and west side Phase 2 BRDA
- The construction of Stage 7 Perimeter Raise on the south east side of Phase 2 BRDA.
- The construction of embankment for access in the centre of the BRDA.
- The construction of a closure demonstration area to assess capping options for the restoration / closure of the final BRDA surface.

There were no remedial works required in the BRDA during 2024.

4.6.9 Progress on Closure Planning and Re-vegetation of BRDA

IE Licence Condition 8.5.17 requires that AAL implements the recommendations in the relevant sub-sections of the Residues Solutions Report submitted to the Agency in July 2007. The subsections to be addressed are:

- Closure Planning
- Closure Re-vegetation
- Post-Closure Management
- Alternative Uses of Residue

Successful employment of the mud farming practice on the BRDA promotes carbonation of the red mud within the BRDA resulting in partial neutralisation to a stable pH of < 11.5.

AAL completed the development of a new 1,625m² closure demonstration cell and the cell was seeded in early autumn 2023. The purpose of the cell is to demonstrate the capping method of the bauxite residue disposal area on carbonated residue as per licence conditions 8.5.21 & 8.5.22. The exposed capping layer upon closure of the BRDA will consist of a seeded amended layer. The demonstration amended layer trials will experiment with various dosages of the proven composite ingredients of neutralised process residue, sand, gypsum and organic material. The trial will also experiment with the composition and depth of the capillary layer including whether its inclusion or exclusion measurably changes upward capillary movement. ***Attachment 6*** contains an overview outlining progress made to date throughout 2024.

The existing established closure demonstration trial cell is self-sustaining.

Enrich Environmental Limited are involved in works for the sampling, analysis and observation of remediated areas on the Bauxite Residue Disposal Area. ***Attachment 5*** contains details of the work conducted by Enrich in 2024 at the BRDA.

Since 2014, AAL has been involved in a number of research projects to identify and assess potential valorisation options for bauxite residue. AAL are currently working with academia and industry partners to research options, both at lab scale and pilot scale, for the use of bauxite residue, primarily in the area of low carbon construction applications, i.e. cement production, the production of concrete based product, e.g. pre-cast, floor screeds, grouts, and also geopolymers, as well as civil applications, such as road construction.

In 2025 AAL will complete trials (250t total) with an industrial partner in Ireland, for the pilot scale production and testing of concrete pre-cast products. This has been approved by the EPA by licensee return. It is AAL's ultimate intention to create a by-product for use in the aforementioned applications, with the aim of using our industrial waste, both to help decarbonise the cement and concrete sector, as well as diverting waste away from deposition at the AAL site.

4.6.10 BRDA Constructed Wetland Project

AAL continue to operate a constructed wetland within the BRDA. In 2013 AAL constructed and commenced operation of a 40 m^2 trial constructed wetlands effluent treatment area in collaboration with the University of Limerick and the International Aluminium Institute. This research demonstrates that a constructed wetland would be capable to render BRDA runoff suitable for discharge to the environment. The project continued to be a key research topic in 2024. ***Attachment 6*** contains an overview outlining progress made to date throughout 2024.

A multi-cell wetland system has been commissioned onsite. This more advanced system allows for further research into the potential for a wetland to render BRDA runoff suitable for discharge to the environment. This research project is being undertaken in collaboration with the University of Limerick. The cells have been constructed, with plants in place and the mixing/dosing system completed. This multi cell wetland system was operational in 2024 with leachate being fed through it. ***Attachment 6*** also includes an overview outlining progress on the multi cell wetland area throughout 2024.

4.6.11 BRDA Events 2024

There were zero incidents related to the BRDA which required notification to the Agency during 2024.

4.6.12 Implementation of Extractive Waste Management Plan

AAL is required under Condition 8.4.1 of the IE Licence to maintain an Extractive Waste Management Plan for the minimisation, treatment, recovery and disposal of extractive waste in accordance with Regulation 5 of the Waste Management (Management of Waste from Extractive Industries) Regulations, 2009. The Extractive Waste Management Plan was reviewed in 2023 with no updated required to the previous version that was approved by the EPA in 2018.

Extractive waste is treated and disposed to the on-site Bauxite Residue Disposal Area (BRDA) according to the Extractive Waste Management Plan. Waste materials suitable for internal road building within the BRDA are recovered for that purpose. Any other wastes for disposal within the BRDA are disposed following Agency approval on a case by case basis. These arrangements are detailed in the Extractive Waste Management Plan.

4.6.13 Emergency Planning for the BRDA

AAL's internal emergency response plan was last updated in March 2024 following a training exercise in accordance with condition 9.4.4.

A review of the External Emergency Response Plan was completed on site in March 2024. The Principal Response Agencies (LCCC, the HSE, Fire Service, An Garda

Siochana) and the EPA, as well as all the relevant personnel from AAL, were in attendance. The exercise included a visit to the BRDA and a desk top exercise. An updated External Emergency Response Plan was subsequently published by LCCC in October 2024.

4.7 Annual blasting report

Borrow pit operation works carried out in 2024 included drilling, blasting and crushing of rock. An EPA approved method statement for the operation of the borrow pit is in place outlining standard operating procedures, public information programme and channels of communication for residents, noise, vibration and air overpressure control methods, monitoring plan, pre-blasting checks for fauna for each blast, security and safety protocols and protocols for transport and handling of explosive.

Three blasts were undertaken on the following dates and times:

- 18^{th} of June, (13:30 hrs)
- 31^{st} of July, (14:00 hrs)
- 14^{th} of August, (14:00 hrs)

A record of the amount and type of explosive for each blast is maintained onsite. A total of 51,765m^3 of rock fill was extracted.

The monitoring conducted for each blast comprised:

- Vibration and air overpressure monitoring to comply with Schedule B.5 of IEL P0035-07 Limit Values.
- Vibration monitoring locations on the BRDA and above the GNI gas transmission pipeline.
- Pore pressure monitoring in the adjacent sector of the Phase 1 BRDA via strain gauge vibrating wire piezometers and by existing standpipe piezometers
- Settlement and lateral movement monitoring in the adjacent sector of the Phase 1 BRDA by inclinometers, extensometers and by observation via a site walkover before and after the blast.

Monitoring for the BRDA, the Gas Transmission Pipeline and the designated monitoring locations was carried out in accordance with Condition 5.12 of IEL P0035-07. All the monitoring data recorded (vibration, air overpressure, pore pressure, settlement, lateral movement and observation) were fully compliant with mitigation measures outlined in the Environmental Impact Assessment Report, Industrial Emissions License noise, vibration and air over pressure limit values and the Blast Vibration Assessment report response framework for blasting at the AAL Borrow Pit. The blasting has been assessed to have had no impact on the stability and the structural integrity of the BRDA and the Gas Transmission Pipeline.

Attachment 7 contains details of the Annual Blast Report prepared by WSP for the blasting activities conducted during 2024.

4.8 Progress on Bauxite Residue Neutralisation

During 2024, the process of industrial residue mud farming continued to be implemented in the BRDA.

As per the requirements of IE Licence Condition 8.5.20, AAL has documented the test method to be utilised to confirm neutralisation of the bauxite residue by mud farming.

The mud is sampled per cell and analysed for pH until target pH of <11.5 is achieved. Three samples per cell are taken and labelled with cell number, date and location. Samples may be taken following amphirolling and if required after harrowing. Once pH < 11.5 is achieved then no further sampling is required.

The quarterly composite analysis on “farmed red mud” as per condition 8.5.20 is listed in the 4 quarterly waste reports located in ***Attachment 8*** Waste Analysis 2024.

4.9 Public Awareness and Communications Programme

Copies of quarterly monitoring reports and annual environmental reports are retained at the main Reception/Security building at AAL. This documentation can be reviewed by any member of the public at all reasonable times.

Communications with our neighbours in 2024 included notifications in advance of all blasts at the onsite borrow pit, a Christmas greeting and a calendar with images of flora and fauna taken around the plant and on Aughinish Island.

Attachment 1
Air monitoring Parallel measurements report

2024

EN14181

AST REPORT

PREPARED FOR:

Aughinish Alumina Limited
GT2



Report Title	EN 14181 Annual Surveillance Test Report
Company address	Axis Environmental Services Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Contact Details	Phone: 061 324587, info@axisenv.ie
Report Commissioned by	Aughinish Alumina Limited
Facility Name	Aughinish Alumina Limited
EPA Licence Number	P0035-07
Licence Holder	Aughinish Alumina Limited
Stack Reference Number	GT2
Dates of the Monitoring Campaign	25-06-2024
Job Reference Number	AUALTC250624
Report Written By	Mr. Tim Casey
Report Approved by	Mark McGarry
Stack Testing Team	Mr. Tim Casey & Mr. Aaron Carway
Report Date	08-10-2024
Report Type	Annual Surveillance Test
Version	2
Signature of Approver	

Contents

All sampling and reporting are completed in accordance with Environmental Protection Agency Air Guidance Note 2 requirements.

Document Sign Off			
Document Number:	AUALTC250624		
Reason for Issue:	Annual Surveillance Test		
Issue Number:	2	**Date:**	08-10-2024
Originator:	**Signature:**	**Reviewer:**	**Customer:**
Tim Casey	[signature]	Mark McGarry	Aughinish Alumina
Document History:			
Report Revision Number	**Revision Date**	**Section Revised**	**Reason for Revision**
2	08-10-2024	4	Updated QAL 2 Function

1. Introduction

1.1 Summary Detail

AXIS environmental services Ltd were commissioned by Aughinish Alumina Limited, Aughinish West, Askeaton, Co. limerick to carry out an annual surveillance test and validation audit of the CEMS units installed on Emission Point GT2. The CEMS are installed to monitor:

- Oxides of Nitrogen (NOx as NO_2);
- Carbon Monoxide (CO);
- Oxygen (O_2).

1.1.1 Oxides of Nitrogen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

1.1.2 Oxygen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181. Under the Large combustion plant directive there is no requirement to complete QAL2 or AST for oxygen, therefore the application of a calibration function would need to be in agreement with the Agency. AG3 does request validation of oxygen.

1.1.3 Carbon Monoxide

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

The following table summarises the tests carried out and the equipment suitability:

Table 1.1: Calibration Function

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Variability Test Result	Pass	Pass	Pass
Calibration Function Validity	Pass	Pass	Pass
Calibration Function to be applied to Raw Data from AMS	y = 1.0071x + 0.8039	y = 1.0687x – 5.7705	y = 0.9835x-0.0098
Confidence Interval to be applied to AMS Results	20	10*	10
Recommended Function to Use	As above	As above	As above
Calibrated / Extended Range at Reference Conditions	0 to 50	0 to 20	0 to 15.2

Note: The calibration function, once applied, only remains valid as long as the QAL3 data remains within control limits. There can be no manual adjustments made to the CEMs other than those allowed to bring the settings back within the QAL3 control limits.

*EPA Guidance note AG3: Please note that the confidence intervals for CO and Volumetric flow have been modified in this revision of AG3 to 20%. This is to prevent a possible failure of the variability test during the QAL2/AST. These revised confidence intervals are not relevant for the validation of normal monitoring results. For normal compliance monitoring, the original confidence intervals stipulated in the Industrial Emissions Directive and your IE licence apply.

Table 1.2: Linearity and Test of Residuals

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Test of Residuals Max dc ,rel	1.80	1.84	0.82
Residuals Test Result Max dc ,rel <5%	Pass	Pass	Pass

1.2 Summary of Test Methods

Substance	Standard Reference Method	AG2 Compliant	INAB Accreditation
Oxides of Nitrogen	EN 14792	Yes	Yes – 408T
Carbon Monoxide	EN 15059	Yes	Yes – 408T
Oxygen	EN 14789	Yes	Yes – 408T

1.3 Deviations from Test Methods

Substance	Deviations from SRM or EN 14181	Impact on Results	Actions Required
Oxides of Nitrogen	None	None	None
Carbon Monoxide	None	None	None
Oxygen	None	None	None

2. Information Regarding Regulated Installation

2.1 Installation Information

Company Name	Aughinish Alumina Limited
Address	Aughinish West, Askeaton, Co. Limerick
Sector	Production of Inorganic Chemicals
Date of Last QAL2 / AST	August 2023

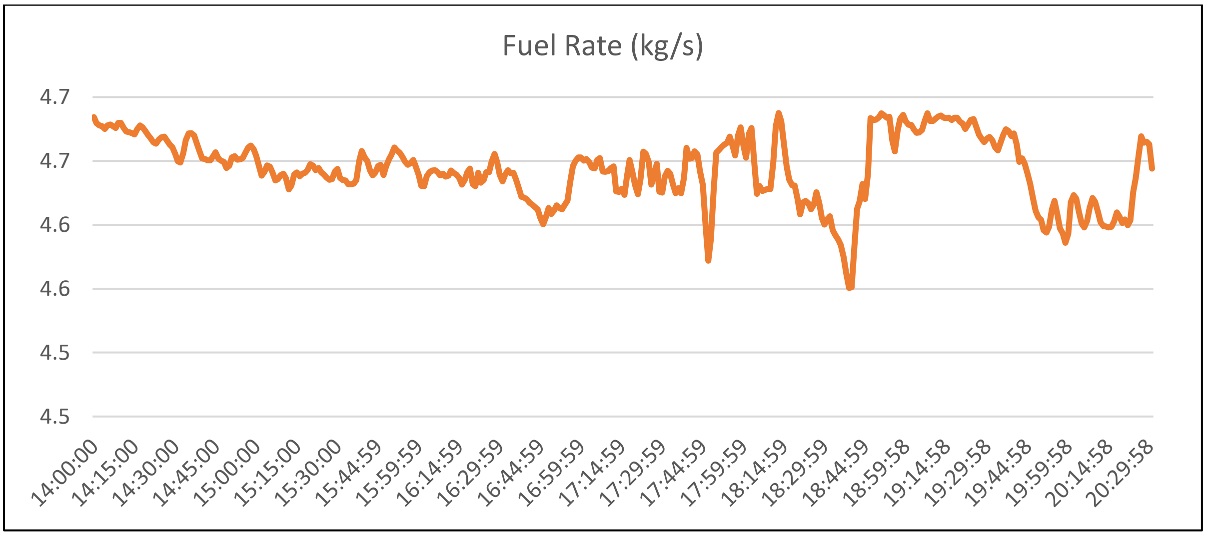
2.2 Emission Limit Values

Substance	Short Term ELV	Daily Average ELV	Uncertainty Requirement
Oxides of Nitrogen	-	50	20
Carbon Monoxide	-	100	10[3]
Oxygen	-	21[1]	10[2]

Note 1: Effective ELV AG3:2017 (Page 28);
Note 2: Uncertainty applied in AG3:2017 (Page 22);
Note 3: EPA AG3 does allow for an uncertainty of 20% to be applied to EN 14181 calculations;

2.3 Operational Information

Process	Description
Continuous or batch process	Continuous
Operating phases	No variation
Load	Fuel Consumption Rate kg/s
Expected variation of emissions	None
Influence of variation on sampling times	None
Other factors affecting monitoring results	None
Historical data checked beforehand	Yes
Parameters near zero	CO but reading normally
CEMs at or near zero	CO but reading normally



2.4 Type of Fuel

Fuel Type	Proportion Used during QAL2	Normal Fuels Used	Multiple Calibration Functions Required
Natural gas	100%	Natural Gas	None

2.5 Abatement

Abatement Types	Impact on Emissions
None	Not Applicable

2.6 Stack Arrangement

Parameter	Descriptions
Arrangement	Vertical Stack
Dimensions	Circular – 2.00m
Location of the ports	c. 40 meters above ground
Number of sampling ports	Numerous
Picture of the Emission Point	
Picture of the Platform	

2.7 Monitoring Platform and Provisions

Platform	Description
Safe Working Area	Yes
Clean Working Area	Yes
Sufficient Space to Work	Yes
Weather Protection	Yes – Located in the CEMS Hut at the base of the stack
CEMs	
Safe Access	Yes
Easy Access	Yes
Calibration Gases Used	Yes – 6141 Compliant
Tools Available	Yes
Spare Parts Available	Yes
Gases Introduced to Analyser	Yes
Gases Introduced to Line	Yes
Compliance with EN 15259	

2.8 Representative Sample

Sample Location	Description
Homogeneity Test Complete	There was no requirement for homogeneity as part of this assessment
Date of Homogeneity Test	-
Ratio High to Low Flow	<3:1 determined from previous report

2.9 CEMs Overview

Parameter	Brand	Model	Principle	QAL 1 Compliant	Location
Oxides of Nitrogen	Emerson	NGA 2000	Chemiluminescence	Yes	CEMS Hut
Carbon Monoxide	Rosemount / Emerson	NGA2000	Infra-Red	Yes	CEMS Hut
Oxygen	Rosemount / Emerson	NGA2000	Electrochemical cell	Yes	CEMS Hut

Parameter	CEMS Ranges	Wet or Dry Measurement	Horiba PG350 AMS Certified Range
Oxides of Nitrogen	0 – 200 mg/m^3	Dry	0 - 102.5[1] mg/m^3
Carbon Monoxide	0 – 75 mg/m^3	Dry	0 - 75 mg/m^3
Oxygen	0 – 25 %	Dry	0 - 25 mg/m^3

Note 1: as NO_2, this corresponds to approx. 0-67 mg/m^3 NO

2.10 Peripheral Determinands

Parameter	Recorded at CEMs
Temperature	Yes
Pressure	No
Water Vapour	No

2.11 Reference Conditions

Temperature	Pressure	Oxygen	Moisture
0 Deg C	101.3kPa	15%	0%

2.12 Sample Times

Run No	Date	NOx	CO	O2
1	25-06-2024	14:30 – 15:00	14:30 – 15:00	14:30 – 15:00
2	25-06-2024	15:30 – 16:00	15:30 – 16:00	15:30 – 16:00
3	25-06-2024	16:30 – 17:00	16:30 – 17:00	16:30 – 17:00
4	25-06-2024	17:30 – 18:00	17:30 – 18:00	17:30 – 18:00
5	25-06-2024	18:30 – 19:00	18:30 – 19:00	18:30 – 19:00
6	25-06-2024	19:30 – 20:00	19:30 – 20:00	19:30 – 20:00

3. Monitoring Campaign

3.1 Test Laboratory Technicians

Function	Name
Team Leader	Tim Casey
Technician	Aaron Carway

3.2 Standard Reference Methods

Substance	Standard Reference Method	Principle	Certified Range	Method Uncertainty	INAB Accreditation
Oxides of Nitrogen	EN 14792	Chemiluminescence	1.8 - 2050	<10%	Yes
Carbon Monoxide	EN 15059	NDIR	1.7 - 1250	<6%	Yes
Oxygen	EN 14789	Paramagnetic	0.1 – 26	<6%	Yes

3.3 Equipment Inventory

Type	Equipment Reference	Parameter
Horiba PG350	23EQ522	NOx, SO2, CO & O_2
Chiller Unit	24EQ512	Moisture Removal
40m Heated Line	22EQ510	-
Gas Blender	21EQ527	-
NO	24MG516	Calibration Gas Certified <2%
O_2	23MG502	Calibration Gas Certified <2%
CO	23MG512	Calibration Gas Certified <2%
Nitrogen	BOC	Certified Grade 99.9999%

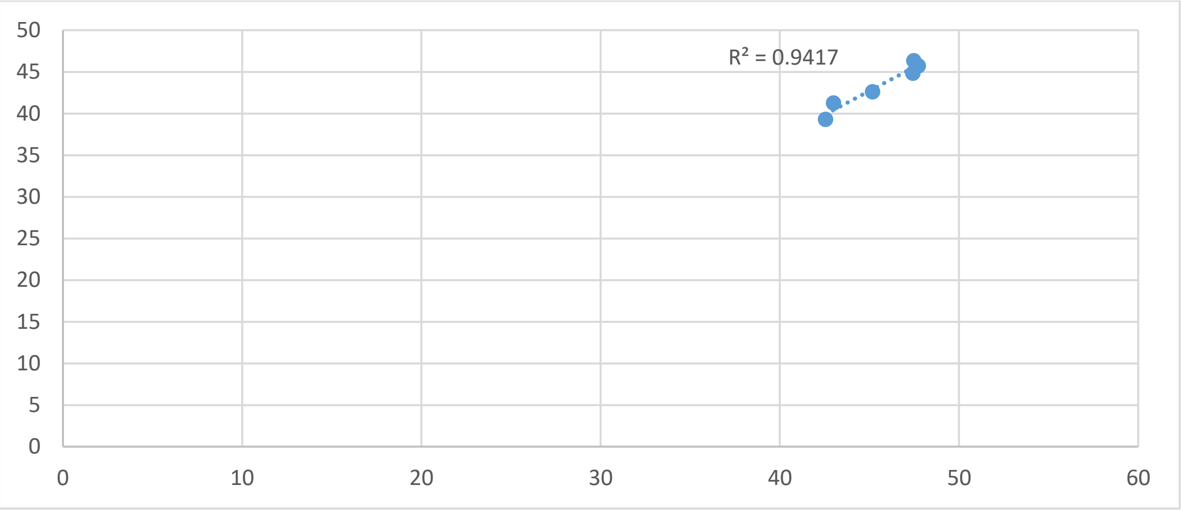
4. Calculation: Oxides of Nitrogen

4.1 Raw Data

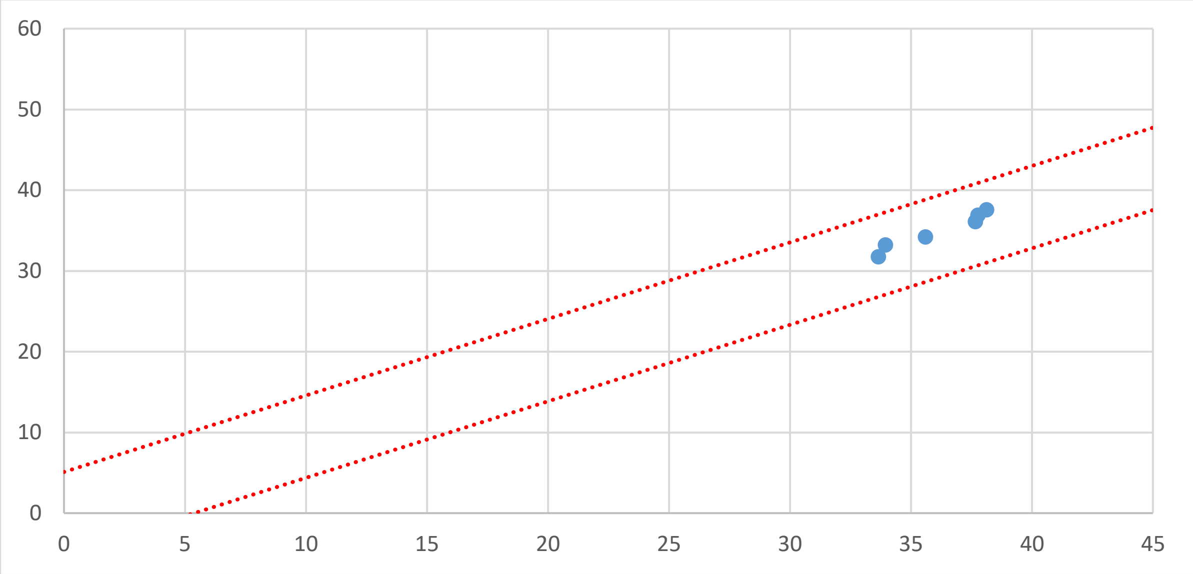
Parameter	Oxides of Nitrogen	
Reference O_2	15	
ELV	50	
CI (%)	20	
Calibration Function	y = 1.0071x + 0.8039	
Outliers	None	
Factor	2.053	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
14:30 - 15:00	47.48	46.33
15:30 - 16:00	47.72	45.73
16:30 - 17:00	47.42	44.84
17:30 - 18:00	45.18	42.60
18:30 - 19:00	42.56	39.30
19:30 - 20:00	43.00	41.26

y = bx + a	
b	1.0071
a	0.8039
Function	y = 1.0071x + 0.8039

Plot 4-1: SRM vs CEMs at AMS conditions



Plot 4-2: Reference SRM vs Reference CEMs



4.2 Outlier Assessment

Nitrogen Oxides					
Run	**AMS**	**SRM**	**Di**	**A**	**Outlier**
Time and Date	**x**	**y**		abs(Di-Davg)	
	ppm STP Dry	**ppm STP Dry**			**Yes / No**
14:30 - 15:00	23.13	22.6	-0.56	0.5219	No
15:30 - 16:00	23.25	22.3	-0.97	0.1074	No
16:30 - 17:00	23.10	21.8	-1.25	0.1756	No
17:30 - 18:00	22.01	20.8	-1.26	0.1766	No
18:30 - 19:00	20.73	19.1	-1.59	0.5100	No
19:30 - 20:00	20.94	20.1	-0.85	0.2329	No
Average			**-1.0788**		
Std Dev x 2			**0.7268**		

4.3 Calibration Assessment

Variability Test	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				0.9835		1.0071		
				-0.0098		0.8039		
14:30 - 15:00	47.48	46.33	13.61	13.38	13.63	38.13	37.59	-0.54
15:30 - 16:00	47.72	45.73	13.50	13.27	13.59	37.78	36.92	-0.85
16:30 - 17:00	47.42	44.84	13.53	13.29	13.57	37.66	36.10	-1.56
17:30 - 18:00	45.18	42.60	13.46	13.22	13.55	35.59	34.22	-1.38
18:30 - 19:00	42.56	39.30	13.48	13.25	13.60	33.66	31.76	-1.90
19:30 - 20:00	43.00	41.26	13.46	13.23	13.57	33.94	33.22	-0.72

Calibration Test	
Average D	1.16
$t_{0.95, n-1}$	2.015
SD	0.535
σ	5.102
N	6
I D I ≤	5.54
Test	Pass

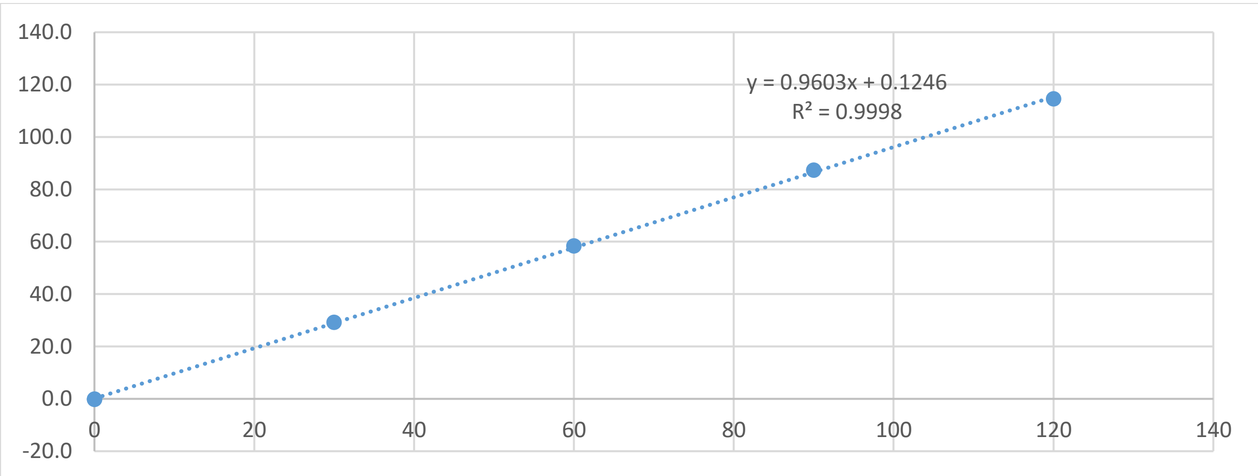
SD	0.5351
σ	5.1020
Kv	0.9329
1.5 x σ x Kv	7.1395
Test	Pass

$$|\bar{D}| \le t_{0,95,N-1} \frac{s_D}{\sqrt{N}} + \sigma_($$

$$s_D \le 1,5\ \sigma_0\ k_v$$

4.4 Linearity Assessment

			Nitrogen Monoxide Linearity Checks		
Effective Emission Limit Value			50	**mg/m³**	
Upper Range from CEMs to DCS			150	**ppm**	
Accuracy of the Cal Gas			<2	**%**	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	29.1	29.1	29.2	29.2
0%	0	-0.28	-0.3	-0.3	-0.3
40%	60	58.4	58.4	58.4	58.5
80%	120	114.5	114.4	114.5	114.5
60%	90	87.2	87.3	87.2	87.2
0%	0	-0.1	-0.1	-0.2	-0.2
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	29.1	28.933	-20.000	400.000
2	0.00	-0.3	0.125	-50.000	2500.000
3	60.00	58.4	57.742	10.000	100.000
4	120.00	114.5	115.359	70.000	4900.000
5	90.00	87.2	86.550	40.000	1600.000
6	0.00	-0.1	0.125	-50.000	2500.000
Average	50.00	48.14	Sums (?)	0.000	12000.000
			Slope	**B=**	**0.960**
			Offset	**A=**	**0.125**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-582.867	0.21	50	0.42	0.42
1	13.833	-0.40	50	-0.80	0.80
2	584.100	0.67	50	1.34	1.34
3	8012.200	-0.90	50	-1.80	1.80
4	3489.333	0.68	50	1.37	1.37
0	6.833	-0.26	50	-0.52	0.52
Sum	11523.433			Max	1.80



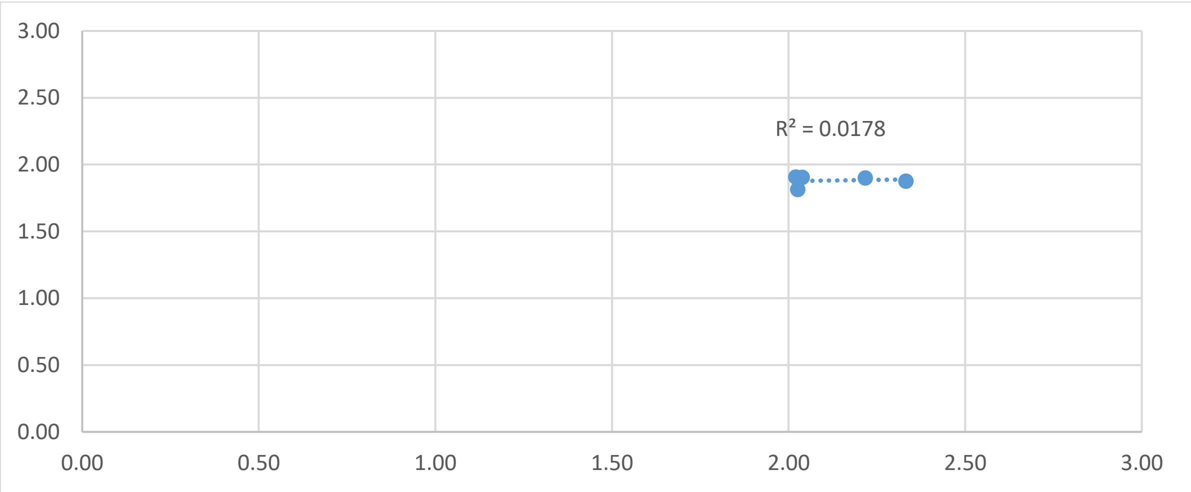
Max dc	1.80	<5%	Pass

5. Calculation: Carbon Monoxide

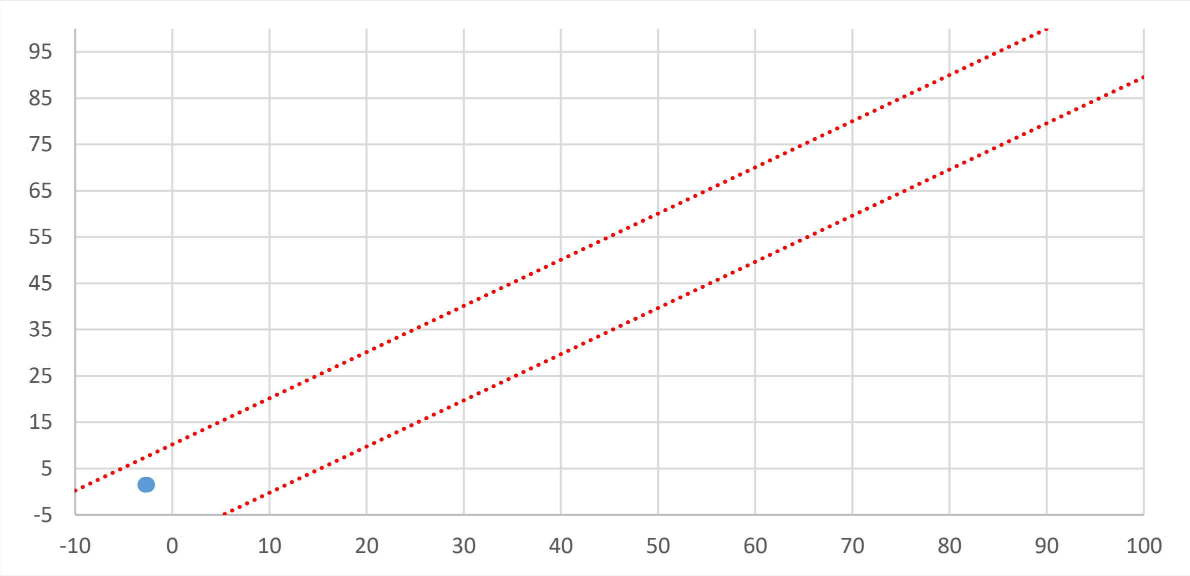
5.1 Raw Data

Parameter	Carbon Monoxide	
Reference O_2	15	
ELV	100	
CI (%)	20	
Calibration Function	y=1.0687x - 5.7705	
Outliers	None	
Factor	1.26	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
14:30 - 15:00	2.33	1.88
15:30 - 16:00	2.02	1.91
16:30 - 17:00	2.22	1.90
17:30 - 18:00	2.04	1.91
18:30 - 19:00	2.03	1.81
19:30 - 20:00	2.15	1.90
y = bx + a		
b	1.0687	
a	-5.7705	
Function	y=1.0687x - 5.7705	

Plot 5-1: Reference SRM vs Reference CEMs at AMS conditions



Plot 5-2: Reference SRM vs Reference CEMs



5.2 Outlier Assessment

Carbon Monoxide					
Run Time and Date	AMS x ppm STP Dry	SRM y ppm STP Dry	Di	A abs(Di-Davg)	Outlier Yes / No
14:30 - 15:00	2.33	1.9	-0.45	0.2082	No
15:30 - 16:00	2.02	1.9	-0.11	0.1344	No
16:30 - 17:00	2.22	1.9	-0.32	0.0684	No
17:30 - 18:00	2.04	1.9	-0.13	0.1135	No
18:30 - 19:00	2.03	1.8	-0.21	0.0345	No
19:30 - 20:00	2.15	1.9	-0.25	0.0058	No
Average			**-0.2468**		
Std Dev x 2			**0.2532**		

5.3 Calibration Assessment

Variability Test	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				0.9835		1.0687		
				-0.0098		-5.7705		
14:30 - 15:00	2.33	1.88	13.61	13.38	13.63	-2.5706	1.5233	4.09
15:30 - 16:00	2.02	1.91	13.50	13.27	13.59	-2.7918	1.5403	4.33
16:30 - 17:00	2.22	1.90	13.53	13.29	13.57	-2.6383	1.5310	4.17
17:30 - 18:00	2.04	1.91	13.46	13.22	13.55	-2.7611	1.5302	4.29
18:30 - 19:00	2.03	1.81	13.48	13.25	13.60	-2.7791	1.4656	4.24
19:30 - 20:00	2.15	1.90	13.46	13.23	13.57	-2.6739	1.5263	4.20

Calibration Test	
Average D	4.22
$t_{0.95, n-1}$	2.015
SD	0.086
σ	10.204
N	6
I D I ≤	10.27
Test	Pass

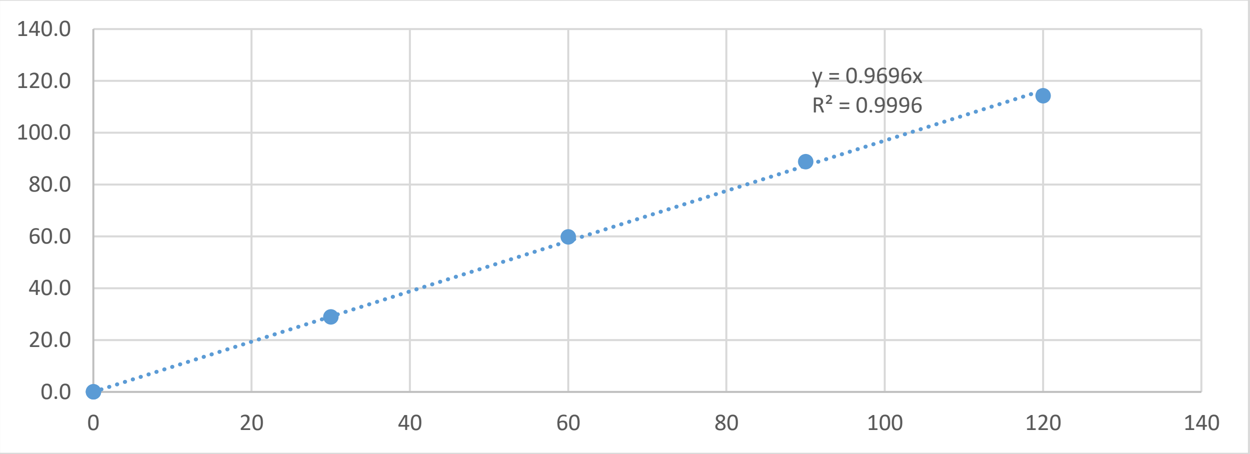
SD	0.0862
σ	10.2041
Kv	0.9329
1.5 x σ x Kv	14.2791
Test	Pass

$|\overline{D}| \leq t_{0,95,N-1}$

$s_D \leq 1{,}5\ \sigma_0$

5.4 Linearity Assessment

			Carbon Monoxide Linearity Checks		
Effective Emission Limit Value			100	mg/m³	
Upper Range from CEMs to DCS			150	ppm	
Accuracy of the Cal Gas			<2	%	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	29.0	29.1	29.0	28.9
0%	0	0.1	0.1	0.1	0.2
40%	60	59.9	59.8	59.9	59.9
80%	120	114.3	114.2	114.3	114.5
60%	90	88.9	88.9	88.8	88.9
0%	0	0.1	0.3	0.1	0.0
Gas Divider Point	**Actual y**	**Measured x**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	29.0	29.450	-20.000	400.000
2	0.00	0.1	0.542	-50.000	2500.000
3	60.00	59.9	58.358	10.000	100.000
4	120.00	114.3	116.175	70.000	4900.000
5	90.00	88.9	87.267	40.000	1600.000
6	0.00	0.1	0.542	-50.000	2500.000
Average	50.00	48.72	Sums (?)	0.000	12000.000
			Slope	**B=**	**0.964**
			Offset	**A=**	**0.542**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-580.000	-0.45	100	-0.45	0.45
1	-6.667	-0.41	100	-0.41	0.41
2	598.667	1.51	100	1.51	1.51
3	8003.333	-1.84	100	-1.84	1.84
4	3554.667	1.60	100	1.60	1.60
0	-6.667	-0.41	100	-0.41	0.41
Sum	11563.333			Max	1.84



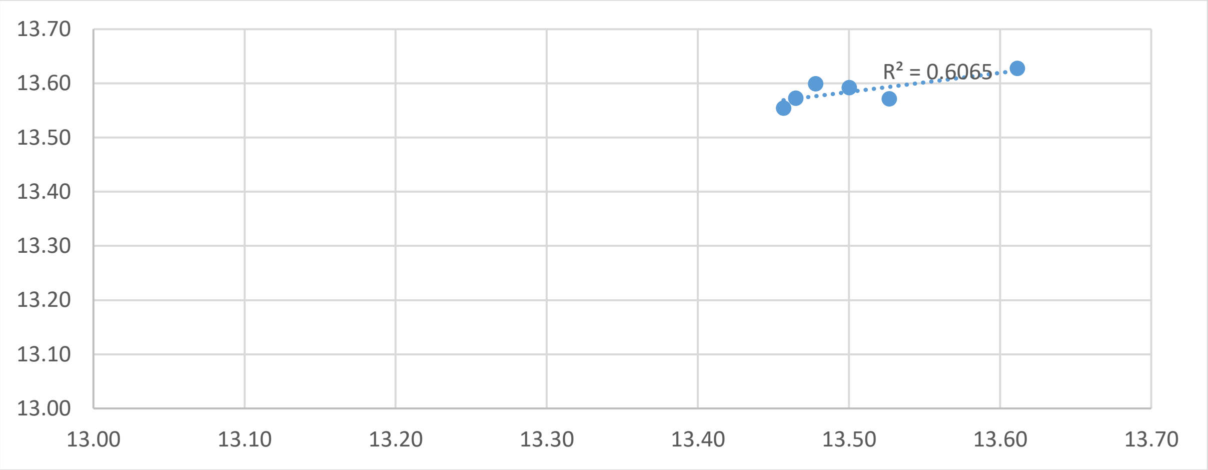
Max dc	1.84	<5%	Pass

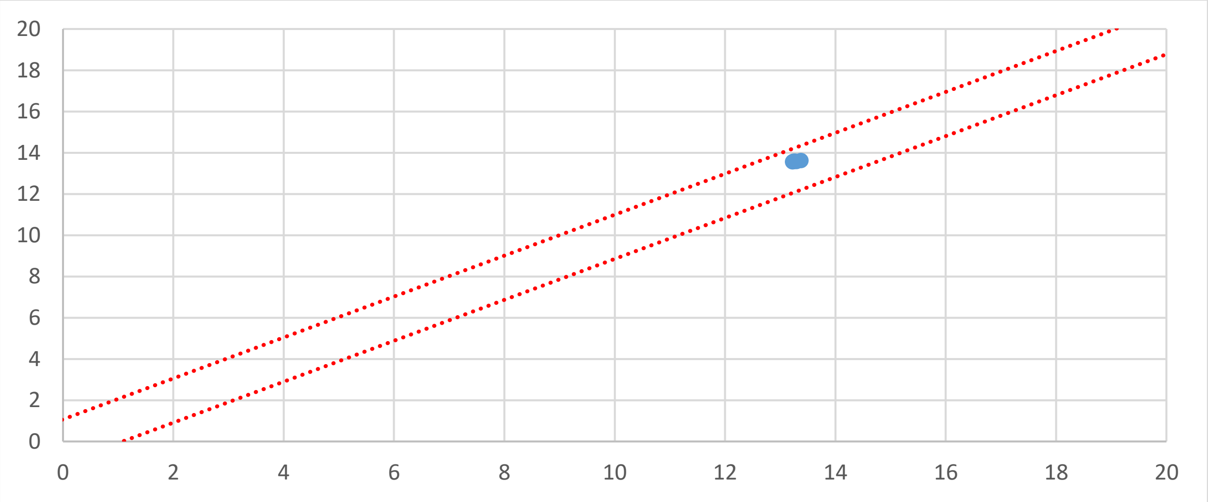
6. Calculation: Oxygen

6.1 Raw Data

Parameter	Oxygen	
Reference O2	15	
ELV	21	
CI (%)	10	
Calibration Function	y = 0.9835x-0.0098	
Outliers	None	
	xAMS (% Dry)	y SRM (% Dry)
14:30 - 15:00	13.61	13.63
15:30 - 16:00	13.50	13.59
16:30 - 17:00	13.53	13.57
17:30 - 18:00	13.46	13.55
18:30 - 19:00	13.48	13.60
19:30 - 20:00	13.46	13.57
y = bx + a		
b	0.9835	
a	-0.0098	
Function	y = 0.9835x-0.0098	

Plot 6-1: Reference SRM vs Reference CEMs





6.2 Outlier Assessment

Oxygen Run Time and Date	AMS x % Dry	SRM y % Dry	Di	A abs(Di-Davg)	Outlier Yes / No
14:30 - 15:00	13.61	13.63	0.02	0.06	No
15:30 - 16:00	13.50	13.59	0.09	0.01	No
16:30 - 17:00	13.53	13.57	0.04	0.04	No
17:30 - 18:00	13.46	13.55	0.10	0.02	No
18:30 - 19:00	13.48	13.60	0.12	0.04	No
19:30 - 20:00	13.46	13.57	0.11	0.03	No
Average			**0.0801**		
Std Dev x 2			**0.08**		

6.3 Calibration Assessment

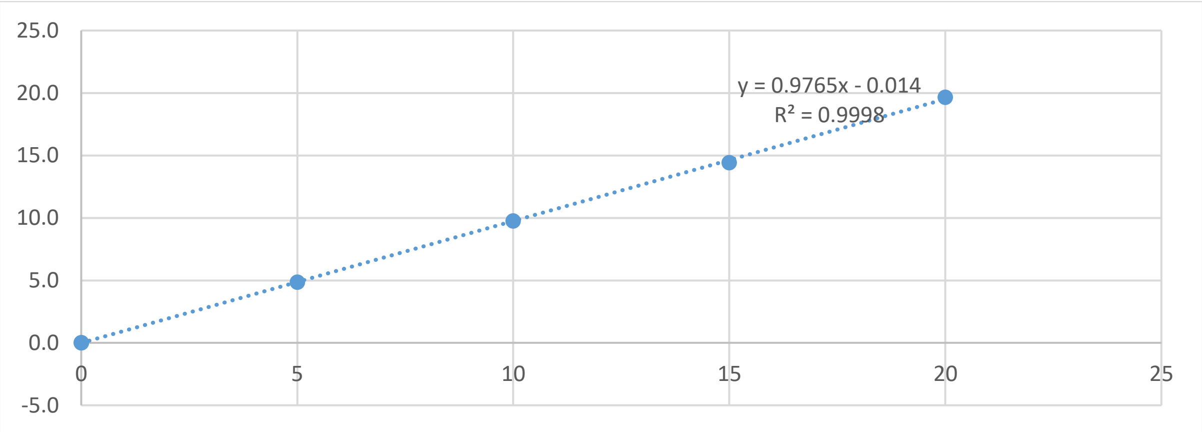
Variability Test	xAMS (% Dry)	y SRM (% Dry)	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
			0.9835		
			-0.0098		
14:30 - 15:00	13.61	13.63	13.3771	13.6278	0.25
15:30 - 16:00	13.50	13.59	13.2677	13.5926	0.32
16:30 - 17:00	13.53	13.57	13.2937	13.5715	0.28
17:30 - 18:00	13.46	13.55	13.2248	13.5542	0.33
18:30 - 19:00	13.48	13.60	13.2457	13.5995	0.35
19:30 - 20:00	13.46	13.57	13.2329	13.5726	0.34
Calibration Test				SD	0.0398
Average D	0.31			σ	1.0714
$t_{0.95,\ n-1}$	2.015			Kv	0.9329
N	6			σ x Kv x 1.5	1.4993
I D I ≤	1.1			Test	Pass
Test	Pass				

$|\overline{D}| \le t_{0,95,N-1}$

$s_D \le 1{,}5\ \sigma_0$

6.4 Linearity Assessment

		Oxygen			
		Linearity Checks			
Effective Emission Limit Value			21	%	
Upper Range from CEMs to DCS			25	%	
Accuracy of the Cal Gas			<2	%	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	5	4.9	4.9	4.9	4.9
0%	0	0.0	0.0	0.0	0.0
40%	10	9.8	9.8	9.8	9.8
80%	20	19.7	19.7	19.7	19.7
60%	15	14.4	14.4	14.4	14.4
0%	0	0.0	0.0	0.0	0.0
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	5.00	4.9	4.868	-3.333	11.111
2	0.00	0.0	-0.014	-8.333	69.444
3	10.00	9.8	9.751	1.667	2.778
4	20.00	19.7	19.515	11.667	136.111
5	15.00	14.4	14.633	6.667	44.444
6	0.00	0.0	-0.014	-8.333	69.444
Average	8.33	8.12	Sums (?)	0.000	333.333
			Slope	**B=**	**0.976**
			Offset	**A=**	**-0.014**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-16.193	-0.01	25	-0.04	0.04
1	-0.061	0.02	25	0.09	0.09
2	16.279	0.02	25	0.07	0.07
3	229.406	0.15	25	0.59	0.59
4	96.182	-0.21	25	-0.82	0.82
0	-0.128	0.03	25	0.12	0.12
Sum	325.485			Max	0.82



Max dc	0.82	<5%	Pass

7. Functional Tests

Parameter	Oxides of Nitrogen	Carbon Monoxide	Oxygen
AMS Manufacturer and Model	Rosemount / Emerson	Rosemount / Emerson	Rosemount / Emerson
Serial Number	4002504321218	4002504321218	4002504321218
Measurement Principle	Chemiluminescence	NDIR	Paramagnetic
QAL 1 Compliant	Yes	Yes	Yes
MCERTS / TUV Approved	Yes	Yes	Yes

Species	Measured Units	Measured Range	Measurement Conditions	Current QAL2 calibration function (if applicable)
NOx as NO_2	mg/m^3	0 – 25%	Dry	y = 1.0071x + 0.8039
Carbon Monoxide	mg/m^3	0 – 200 mg/m^3	Dry	y = 1.0687x – 5.7705
Oxygen	%	0 – 75 mg/m^3	Dry	y = 0.9835x-0.0098

Measurement Site and Installation

In-Situ & Extractive AMS	Y/N	Notes
Is there a safe and clean working environment that has sufficient space and weather protection?	Yes	The probes are located on an external sampling platform, ~30m above ground level. There is no shelter on the sampling platform.
Is there easy and safe access to the AMS?	Yes	Located at ground level inside dedicated enclosure hut.
Are tools, spares parts and reference materials available?	Yes	All available – Located in site stores
Are there facilities to introduce reference materials directly to the AMS as well as through the complete system (extractive only)?	Yes	Reference materials can be introduced into the instrument and into the sample system up to the probe assembly.

Reference Materials on site

Parameter	Concentration (mg/m^3 / %)	Cylinder Number	Cylinder Expiry	Certified Accuracy
Nitrogen Monoxide	79.8	245660SG	29-05-2028	0.9%
Carbon Monoxide	80.4	247330SG	18-03-2025	0.8%
Oxygen	20.9	-	-	-
Zero Gas	0	-	-	-

CEMS Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	79.8	-0.18	79.33	18
Carbon Monoxide	80.4	0	80.6	18
Oxygen	20.9	0.002	20.895	12

Sampling Line Leak Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	79.8	-0.16	78.91	23
Carbon Monoxide	80.4	0.2	80.6	22
Oxygen	20.9	0.004	20.874	15

Alignment and Cleanliness

In-Situ AMS	Y/N	Notes
Internal check of the AMS	N/a	N/a
Cleanliness of the optical components	N/a	N/a
Flushing of the air supply	N/a	N/a
Any obstructions in the optical path	N/a	N/a
Alignment of the measuring systems	N/a	N/a
Contamination control (internal check of the optical surfaces)	N/a	N/a
Flushing air supply	N/a	N/a

Extractive AMS

Extractive AMS	Y/N	Notes
Sampling probe	Yes	In good condition from visual inspection
Gas conditioning systems	Yes	In good condition from visual inspection
Pumps	Yes	In good condition from visual inspection
All connections	Yes	In good condition from visual inspection
Sample lines	Yes	In good condition from visual inspection
Power supplies	Yes	In good condition from visual inspection
Filters	Yes	Filters not removed to check
NOx converter efficiency (if applicable)	N/a	Verified during equipment service
Visual inspection of sampling train	Yes	In good condition from visual inspection

Linearity

Extractive	Y/N	Notes
During the calibration / linearity tests the applied concentrations should be logged onto the DAHS to prove the complete system. i.e. Concentration applied to the instrument is represented by the instrument output and identical to the value logged on the DAHS. DAHS logged values should be included in the instrument service report.	Yes	Complete
The linearity of the CEM response shall be checked using five different reference materials, including a zero concentration.	Yes	Complete
The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.	Yes	Complete
In case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration. The uncertainty must be ≤2%	Yes	Gas Dilution system used on ISO 17025 gases
The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of the range that is at least the short-term ELV. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference material shall be applied to the inlet of the CEM. (i.e. not down the line)	Yes	Applied at analyser at said concentrations.

Interference

Extractive	Y/N	Notes
NO	No	A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL1 and there is a failure of the QAL2 or AST which could be due to interferences.
CO	No	
O_2	No	

QAL3 Checks Zero and Span Drift Audit

Extractive	Y/N	Notes
NO	Yes	Successful zero and span check
CO	Yes	Successful zero and span check
O_2	Yes	Successful zero and span check

The test laboratory shall assess whether the operator has a QAL3 procedure in place, and whether the operator has applied this procedure. The evidence would comprise

(i) a documented procedure,
(ii) zero and span data,
(iii) control charts.

The company has all procedures and control charts in place.

Documentation

Extractive	Y/N	Notes
A plan of the AMS	Yes	We have been advised these are in place
AMS certification information	Yes	We have been advised these are in place
Manuals	Yes	We have been advised these are in place
Logbooks (Detailing problems with the AMS and corrective action taken)	Yes	We have been advised these are in place
Service Reports	Yes	We have been advised these are in place
QAL3 Documentation	Yes	We have been advised these are in place
Procedures for AMS maintenance, calibration and training	Yes	In place and up to date
Training records	Yes	We have been advised these are in place
Maintenance Schedules	Yes	We have been advised these are in place
Auditing plans and records	Yes	We have been advised these are in place

Report

Extractive	Y/N	Notes
Are there any faults that require corrective action	N	None detected

Works Completion

Name	Company	Date	Role
Tim Casey	AXIS Environmental Services	25-06-2024	Team Leader
Mark Byrnes	Aughinish Alumina	25-06-2024	Electrical Instrumentation

2024

EN14181

AST REPORT

PREPARED FOR:

Aughinish Alumina
Boiler E

Report Title	EN 14181 Annual Surveillance Test Report
Company address	Axis Environmental Services Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Contact Details	Phone: 061 324587, info@axisenv.ie
Report Commissioned by	Aughinish Alumina Limited
Facility Name	Aughinish Alumina Limited
EPA Licence Number	P0035-07
Licence Holder	Aughinish Alumina Limited
Stack Reference Number	Boiler E
Dates of the Monitoring Campaign	11-04-2024
Job Reference Number	AUGHMMG100424
Report Written By	Tim Casey
Report Approved by	Mark McGarry
Stack Testing Team	Mark McGarry / Tim Casey
Report Date	28-05-2024
Report Type	Annual Surveillance Test
Version	1
Signature of Approver	

Contents

All sampling and reporting are completed in accordance with Environmental Protection Agency Air Guidance Note 2 requirements.

Document Sign Off			
Document Number:	AUGHMMG100424		
Reason for Issue:	Annual Surveillance Test		
Issue Number:	1	**Date:**	28-05-2024
Originator:	**Signature:**	**Reviewer:**	**Customer Contact:**
Mark McGarry	Mark McGarry	Tim Casey	Aughinish Alumina
Document History:			
Report Revision Number	**Revision Date**	**Section Revised**	**Reason for Revision**

1. INTRODUCTION

1.1 Summary Detail

AXIS environmental services Ltd were commissioned by Aughinish Alumina Limited to carry out an Annual Surveillance Test and validation audit of the CEMS units installed on Emission Point Boiler E. The CEMS are installed to monitor:

- Oxides of Nitrogen (NOx as NO_2);
- Carbon Monoxide (CO);
- Oxygen (O_2).

1.1.1 Oxides of Nitrogen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

1.1.2 Oxygen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181. Under the Large combustion plant directive there is no requirement to complete QAL2 or AST for oxygen, therefore the application of a calibration function would need to be in agreement with the Agency. AG3 does request validation of oxygen.

1.1.3 Carbon Monoxide

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

The following table summarises the tests carried out and the equipment suitability:

Table 1.1: Calibration Function Data

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Variability Test Result	Pass	Pass	Pass
Calibration Function Validity	Pass	Pass	Pass
Calibration Function to be applied to Raw Data from AMS	Y = 0.9387x + 1.0677	Y = 0.9408x + 1.3712	Y = 0.9919x + 0.0632
Confidence Interval to be applied to AMS Results	20%	10%	10%
Recommended Function to Use	2023 QAL 2 Function	2023 QAL 2 Function	2023 QAL 2 Function
Calibrated / Extended Range at Reference Conditions	Valid Range 0 – 100 $mg.m^{-3}$	Valid Range: 0 – 104.5 $mg.m^{-3}$	0 – 20.90%

Note: The calibration function, once applied, only remains valid as long as the QAL3 data remains within control limits. There can be no manual adjustments made to the CEMs other than those allowed to bring the settings back within the QAL3 control limits.

Table 1.2: Linearity and Test of Residuals

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Test of Residuals Max dc ,rel	1.61	0.18	0.41
Residuals Test Result Max dc ,rel <5%	Pass	Pass	Pass

1.2 Summary of Test Methods

Substance	Standard Reference Method	AG2 Compliant	INAB Accreditation
Oxides of Nitrogen	EN 14792	Yes	Yes – 408T
Carbon Monoxide	EN 15059	Yes	Yes – 408T
Oxygen	EN 14789	Yes	Yes – 408T

1.3 Deviations from Test Methods

Substance	Deviations from SRM or EN 14181	Impact on Results	Actions Required
Oxides of Nitrogen	None	None	None
Carbon Monoxide	None	None	None
Oxygen	None	None	None

2. Information Regarding Regulated Installation

2.1 Installation Information

Company Name	Aughinish Alumina Limited
Address	Askeaton, Co Limerick
Sector	Production of Inorganic Chemicals
Date of Last QAL2 / AST	March 2023

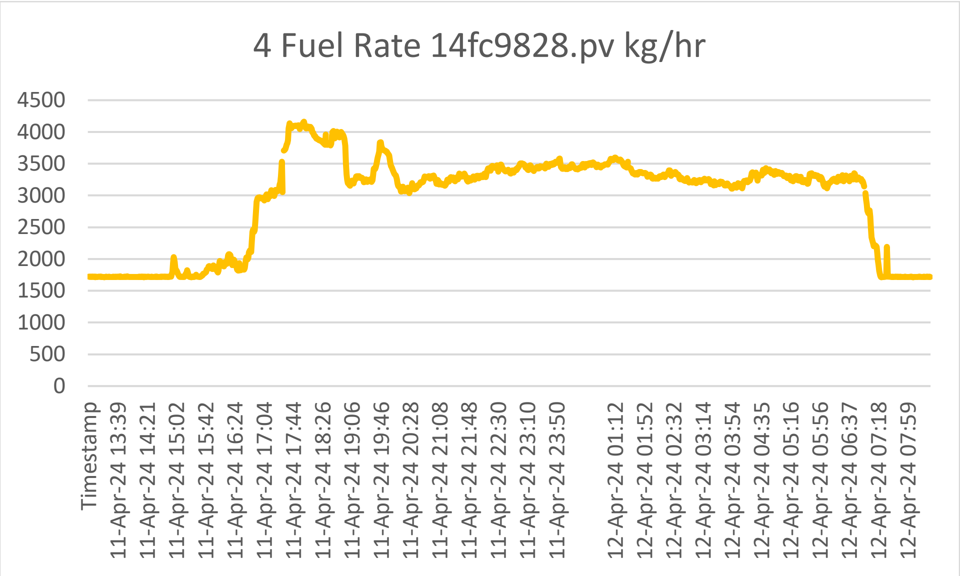
2.2 Emission Limit Values

Substance	Short Term ELV	Daily Average ELV	Uncertainty Requirement
Oxides of Nitrogen	-	100	20
Carbon Monoxide	-	100	20 Note 2
Oxygen	-	21 Note 1	10 Note 2

Note 1: Effective ELV as per EPA Guidance Note AG3:2017 (Page 28);
Note 2: Uncertainty applied in AG3:2017 (Page 22).

2.3 Operational Information

Process	Description
Continuous or batch process	Continuous
Operating phases	Variation in Load
Load	Fuel Rate 1720 to 4200
Expected variation of emissions	None
Influence of variation on sampling times	None
Other factors affecting monitoring results	None
Historical data checked beforehand	Yes
Parameters near zero	CO
CEMs at or near zero	CO



2.4 Type of Fuel

Fuel Type	Proportion Used during AST	Normal Fuels Used	Multiple Calibration Functions Required
Natural gas	100% natural gas	Natural Gas	N/a

2.5 Abatement

Abatement Types	Impact on Emissions
None	N/a

2.6 Stack Arrangement

Parameter	Descriptions
Arrangement	Vertical Stack
Dimensions	Circular – 2.17m
Location of the ports	c. 30 meters above ground
Number of sampling ports	Numerous
Picture of the Emission Point	
Picture of the Platform	

2.7 Monitoring Platform and Provisions

Platform	Description
Safe Working Area	Yes
Clean Working Area	Yes
Sufficient Space to Work	Yes
Weather Protection	Yes
CEMs	
Safe Access	Yes
Easy Access	Yes
Calibration Gases Used	Yes
Tools Available	Yes
Spare Parts Available	Yes
Gases Introduced to Analyser	Yes
Gases Introduced to Line	Yes
Compliance with EN 15259	The platform meets all criteria for platform installation.

2.8 Representative Sample

Sample Location	Description
Homogeneity Test Complete	No
Date of Homogeneity Test	N/a
Ratio High to Low Flow	<3:1

2.9 CEMs Overview

Parameter	Brand	Model	Principle	QAL 1 Compliant	Location
Oxides of Nitrogen	Rosemount / Emerson	NGA2000	Chemiluminescence	Yes	CEMS Hut
Carbon Monoxide	Rosemount / Emerson	NGA2000	NDIR	Yes	CEMS Hut
Oxygen	Rosemount / Emerson	NGA2000	Paramagnetic	Yes	CEMS Hut

Parameter	CEMS Ranges	Wet or Dry Measurement	Horiba PG350 AMS Certified Range
Oxides of Nitrogen	0 - 200 mg/m^3	Dry	0 - 102.5[1] mg/m^3
Carbon Monoxide	0 – 75 mg/m^3	Dry	0 - 75 mg/m^3
Oxygen	0 – 25 %	Dry	0 - 25 mg/m^3

Note 1: as NO_2, this corresponds to approx. 0-67 mg/m^3 NO

2.10 Peripheral Determinands

Parameter	Recorded at CEMs
Temperature	Yes
Pressure	No
Water Vapour	No

2.11 Reference Conditions

Temperature	Pressure	Oxygen	Moisture
0 Deg C	101.3kPa	3%	Dry

2.12 Sample Times

Run No	Date	NOx	CO	O_2
1	11-04-2024	13:00 – 13:30	13:00 – 13:30	13:00 – 13:30
2	11-04-2024	14:00 – 14:30	14:00 – 14:30	14:00 – 14:30
3	11-04-2024	15:00 – 15:30	15:00 – 15:30	15:00 – 15:30
4	11-04-2024	16:00 – 16:30	16:00 – 16:30	16:00 – 16:30
5	11-04-2024	17:00 – 17:30	17:00 – 17:30	17:00 – 17:30
6	12-04-2024	08:00 – 08:30	08:00 – 08:30	08:00 – 08:30

3. Monitoring Campaign

3.1 Test Laboratory Technicians

Function	Name
Team Leader	Mark McGarry
Technician	Tim Casey

3.2 Standard Reference Methods

Substance	Standard Reference Method	Principle	Certified Range	Method Uncertainty	INAB Accreditation
Oxides of Nitrogen	EN 14792	Chemiluminescence	1.8 - 2050	<10%	Yes
Carbon Monoxide	EN 15059	NDIR	1.7 - 1250	<6%	Yes
Oxygen	EN 14789	Paramagnetic	0.1 – 26	<6%	Yes

3.3 Equipment Inventory

Type	Equipment Reference	Parameter
Horiba PG350	23EQ522	NOx, CO & O_2
Chiller Unit	23EQ512	Moisture Removal
40 m Heated Line	22EQ510	-
NO	23MG510	Certified <2%
O2	Ambient Air	Certified <2%
CO	23MG512	Certified <2%
Nitrogen	-	Certified Grade 99.9999%
Gas Blender		-

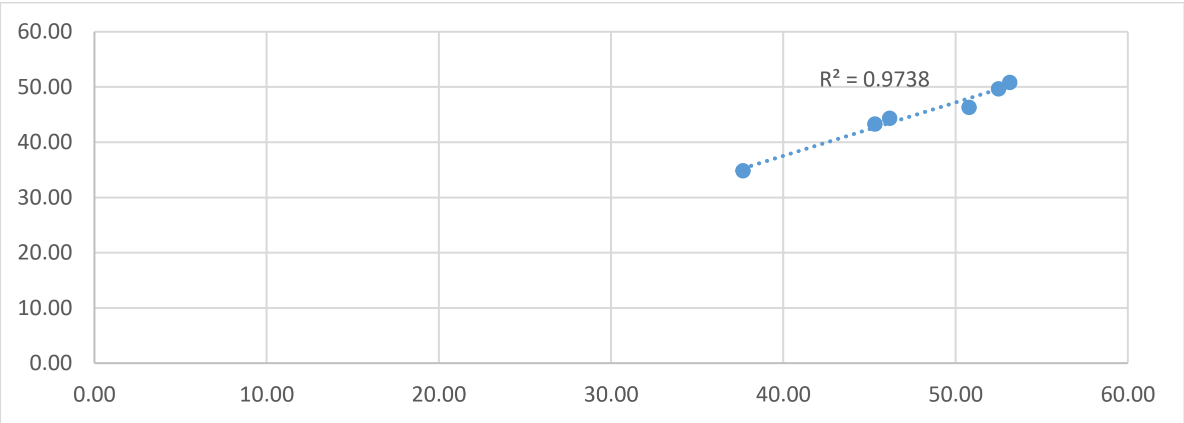
4. Calculation: Oxides of Nitrogen

4.1 Raw Data

Parameter	Oxides of Nitrogen	
Reference O_2	3	
ELV	100	
CI (%)	20	
Calibration Function	Y = 0.9387x + 1.0677	
Outliers	None	
Factor	2.053	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
11/04/2024 13:00 - 13:30	52.50	49.68
11/04/2024 14:00 - 14:30	50.79	46.32
11/04/2024 15:00 - 15:30	46.16	44.32
11/04/2024 16:00 - 16:30	37.67	34.84
11/04/2024 17:00 - 17:30	45.32	43.29
12/04/2024 08:00 - 08:30	53.14	50.81

y = bx + a	
b	0.9387
a	1.0677
Function	Y = 0.9387x + 1.0677

Plot 1: Reference SRM vs Reference CEMs



4.2 Outlier Assessment

Nitrogen Oxides					
	AMS	SRM	Di	A	Outlier
Time and Date	x	y		abs(Di-Davg)	
	ppm STP Dry	ppm STP Dry			Yes / No
11/04/2024 13:00 - 13:30	25.57	24.2	-1.38	0.0520	No
11/04/2024 14:00 - 14:30	24.74	22.6	-2.18	0.8514	No
11/04/2024 15:00 - 15:30	22.49	21.6	-0.90	0.4261	No
11/04/2024 16:00 - 16:30	18.35	17.0	-1.38	0.0517	No
11/04/2024 17:00 - 17:30	22.07	21.1	-0.99	0.3366	No
12/04/2024 08:00 - 08:30	25.88	24.8	-1.13	0.1924	No
Average			**-1.3240**		
Std Dev x 2			**0.9218**		

4.3 Variability Assessment

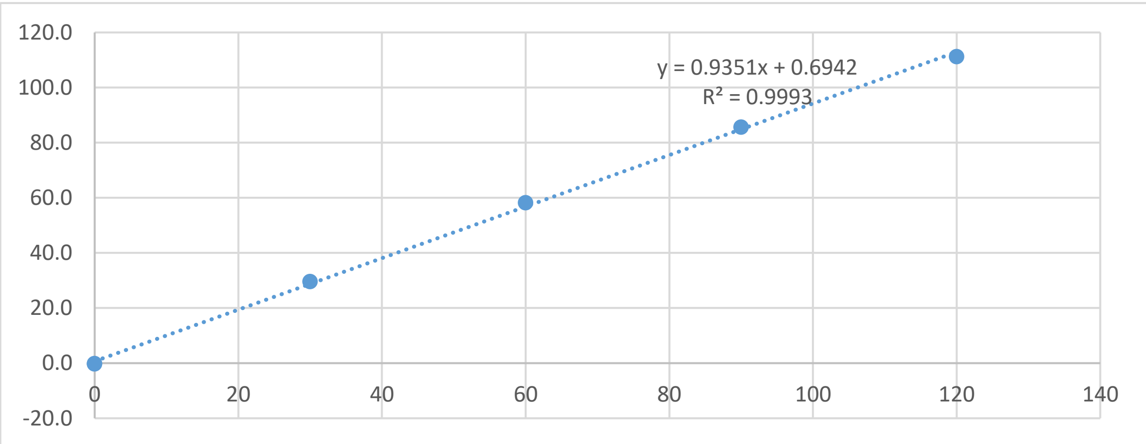
Variability Test	x AMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				0.9919		0.9387		
				0.063		1.0677		
1	52.50	49.68	8.62	8.61	8.61	73.3574	72.3463	-1.01
2	50.79	46.32	8.68	8.67	8.62	71.3526	67.5066	-3.85
3	46.16	44.32	8.54	8.54	8.48	64.2853	63.8934	-0.39
4	37.67	34.84	8.19	8.19	8.43	51.2925	49.9991	-1.29
5	45.32	43.29	5.84	5.85	5.81	51.8759	51.3590	-0.52
6	53.14	50.81	8.67	8.66	8.67	74.4999	74.4009	-0.10

Calibration Test	
Average D	1.19
$t_{0.95, n-1}$	2.015
SD	1.369
σ	10.204
N	6
I D I ≤	11.44
Test	Pass

SD	1.3695
σ	10.2041
Kv	0.9329
1.5 x σ x Kv	14.2791
Test	Pass

4.4 Linearity Checks

		Nitrogen Monoxide Linearity Checks			
Effective Emission Limit Value			100	mg/m³	
Upper Range from CEMs to DCS			150	ppm	
Accuracy of the Cal Gas			<2	%	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	29.7	29.8	29.6	29.7
0%	0	-0.14	-0.2	-0.2	-0.1
40%	60	58.3	58.3	58.3	58.3
80%	120	111.3	111.2	111.4	111.3
60%	90	85.7	85.8	85.7	85.6
0%	0	-0.1	-0.2	-0.1	-0.1
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	29.7	28.748	-20.0	400.0
2	0.00	-0.1	0.694	-50.0	2500.0
3	60.00	58.3	56.802	10.0	100.0
4	120.00	111.3	112.910	70.0	4900.0
5	90.00	85.7	84.856	40.0	1600.0
6	0.00	-0.1	0.694	-50.0	2500.0
Average	50.00	47.45	Sums (?)	0.0	12000.0
			Slope	**B=**	**0.935**
			Offset	**A=**	**0.694**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-593.933	0.95	100	0.95	0.95
1	7.000	-0.83	100	-0.83	0.83
2	582.900	1.49	100	1.49	1.49
3	7791.000	-1.61	100	-1.61	1.61
4	3427.733	0.84	100	0.84	0.84
0	6.833	-0.83	100	-0.83	0.83
Sum	11221.533			Max	1.61

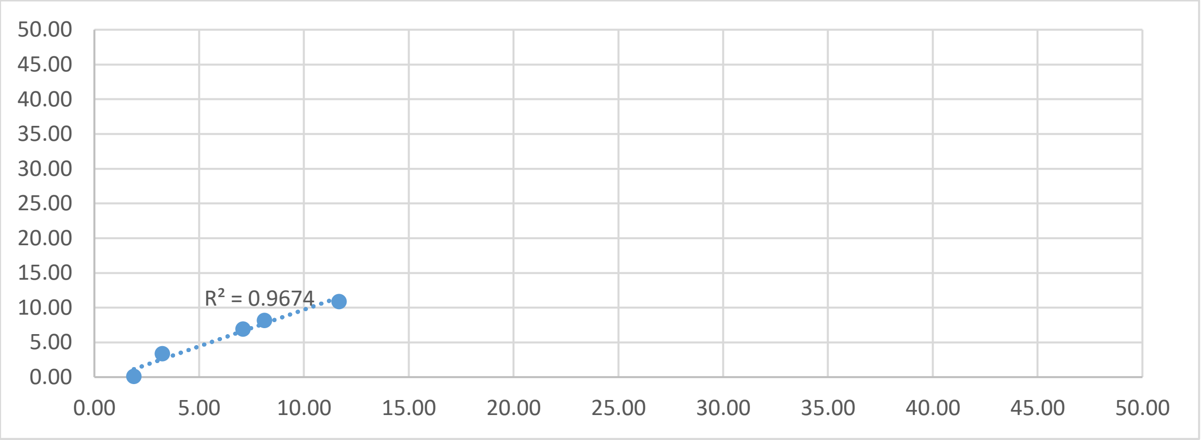


5. Calculation: Carbon Monoxide

5.1 Raw Data

Parameter	Carbon Monoxide	
Reference O_2	3	
ELV	100	
CI (%)	10	
Calibration Function	Y = 0.9408x + 1.3712	
Outliers	None	
Factor	1.26	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
11/04/2024 13:00 - 13:30	3.25	3.40
11/04/2024 14:00 - 14:30	7.10	6.94
11/04/2024 15:00 - 15:30	11.67	10.90
11/04/2024 16:00 - 16:30	8.11	8.18
11/04/2024 17:00 - 17:30	1.88	0.13
12/04/2024 08:00 - 08:30	3.35	1.96
y = bx + a		
b	0.9408	
a	1.3712	
Function	Y = 0.9408x + 1.3712	

Plot 5-1: Reference SRM vs Reference CEMs



5.2 Outlier Assessment

Carbon Monoxide					
Run	**AMS**	**SRM**	**Di**	**A**	**Outlier**
Time and Date	**x**	**y**		abs(Di-Davg)	
	ppm STP Dry	**ppm STP Dry**			**Yes / No**
11/04/2024 13:00 - 13:30	3.25	3.4	0.15	0.7917	No
11/04/2024 14:00 - 14:30	7.10	6.9	-0.16	0.4794	No
11/04/2024 15:00 - 15:30	11.67	10.9	-0.76	0.1253	No
11/04/2024 16:00 - 16:30	8.11	8.2	0.07	0.7136	No
11/04/2024 17:00 - 17:30	1.88	0.1	-1.75	1.1084	No
12/04/2024 08:00 - 08:30	3.35	2.0	-1.39	0.7510	No
Average			**-0.6393**		
Std Dev x 2			**1.5935**		

5.3 Variability Assessment

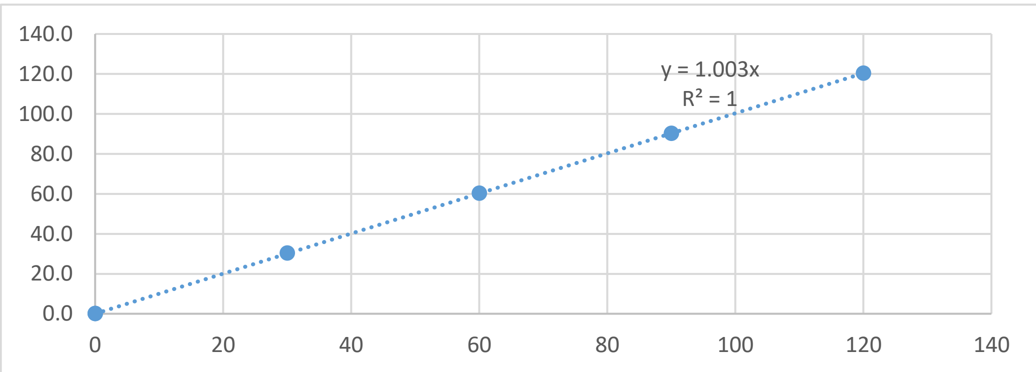
Variability Test	x AMS (mg/Nm³ Dry)	y SRM (mg/Nm³ Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				0.9919		0.9408		
				0.063		1.3712		
11/04/2024 13:00 - 13:30	3.25	3.40	8.62	8.61	8.61	6.4474	4.9499	-1.50
11/04/2024 14:00 - 14:30	7.10	6.94	8.68	8.67	8.62	11.7788	10.1070	-1.67
11/04/2024 15:00 - 15:30	11.67	10.90	8.54	8.54	8.48	17.8752	15.7154	-2.16
11/04/2024 16:00 - 16:30	8.11	8.18	8.19	8.19	8.43	12.6758	11.7456	-0.93
11/04/2024 17:00 - 17:30	1.88	0.13	5.84	5.85	5.81	3.7369	0.1587	-3.58
12/04/2024 08:00 - 08:30	3.35	1.96	8.67	8.66	8.67	6.6138	2.8694	-3.74

Calibration Test	
Average D	2.26
$t_{0.95, n-1}$	2.015
SD	1.153
σ	5.102
N	6
I D I ≤	6.14
Test	Pass

SD	1.1529
σ	5.1020
Kv	0.9329
1.5 x σ x Kv	7.1395
Test	Pass

5.4 Linearity Assessment

		Carbon Monoxide Linearity Checks			
Effective Emission Limit Value			100	**mg/m³**	80
Upper Range from CEMs to DCS			150	**ppm**	325
Accuracy of the Cal Gas			<2	**%**	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	30.3	30.4	30.3	30.3
0%	0	0.0	0.0	0.0	0.0
40%	60	60.3	60.3	60.4	60.2
80%	120	120.3	120.2	120.4	120.2
60%	90	90.2	90.3	90.1	90.3
0%	0	0.0	0.0	0.0	0.0
Gas Divider Point	**Actual y**	**Measured x**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	30.3	30.148	-20.000	400.000
2	0.00	0.0	0.088	-50.000	2500.000
3	60.00	60.3	60.209	10.000	100.000
4	120.00	120.3	120.331	70.000	4900.000
5	90.00	90.2	90.270	40.000	1600.000
6	0.00	0.0	0.088	-50.000	2500.000
Average	50.00	50.19	Sums (?)	0.000	12000.000
			Slope	**B=**	**1.002**
			Offset	**A=**	**0.088**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-606.667	0.18	100	0.18	0.18
1	0.000	-0.09	100	-0.09	0.09
2	603.000	0.09	100	0.09	0.09
3	8418.667	-0.06	100	-0.06	0.06
4	3609.333	-0.04	100	-0.04	0.04
0	0.000	-0.09	100	-0.09	0.09
Sum	12024.333			Max	0.18

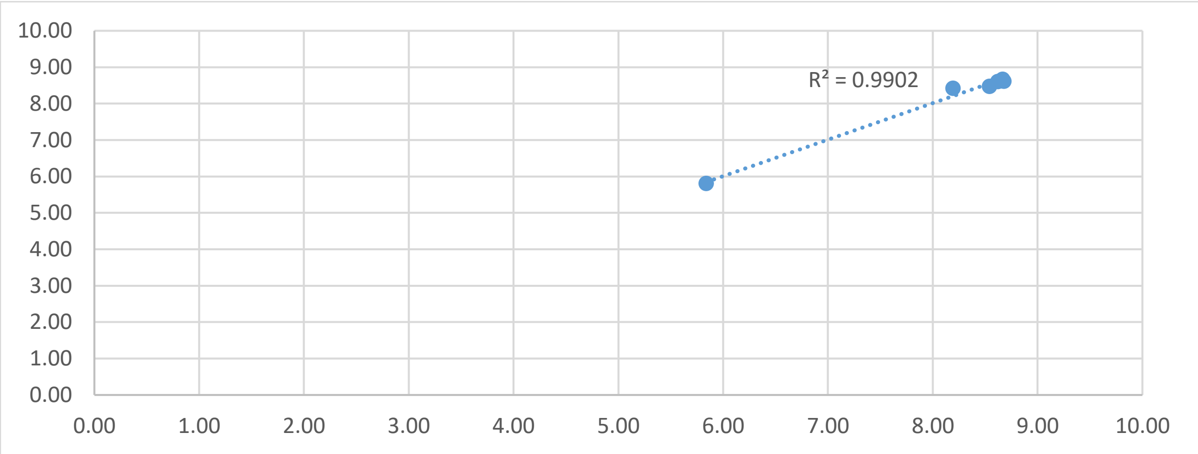


6. Calculation: Oxygen

6.1 Raw Data

Parameter	**Oxygen**	
Reference O_2	N/a	
ELV	21	
CI (%)	10	
Calibration Function	Y = 0.9919x + 0.0632	
Outliers	None	
	xAMS (% Dry)	y SRM (% Dry)
11/04/2024 13:00 - 13:30	8.62	8.61
11/04/2024 14:00 - 14:30	8.68	8.62
11/04/2024 15:00 - 15:30	8.54	8.48
11/04/2024 16:00 - 16:30	8.19	8.43
11/04/2024 17:00 - 17:30	5.84	5.81
12/04/2024 08:00 - 08:30	8.67	8.67
y = bx + a		
b	0.9919	
a	0.0632	
Function	Y = 0.9919x + 0.0632	

Plot 6-1: Reference SRM vs Reference CEMs



6.2 Outlier Assessment

Oxygen					
Run Time and Date	AMS x % Dry	SRM y % Dry	Di	A abs(Di-Davg)	Outlier Yes / No
11/04/2024 13:00 - 13:30	8.62	8.61	-0.01	0.03	No
11/04/2024 14:00 - 14:30	8.68	8.62	-0.06	0.08	No
11/04/2024 15:00 - 15:30	8.54	8.48	-0.06	0.07	No
11/04/2024 16:00 - 16:30	8.19	8.43	0.23	0.22	No
11/04/2024 17:00 - 17:30	5.84	5.81	-0.03	0.04	No
12/04/2024 08:00 - 08:30	8.67	8.67	0.01	0.01	No
Average			**0.0143**		
Std Dev x 2			**0.22**		

6.3 Variability Assessment

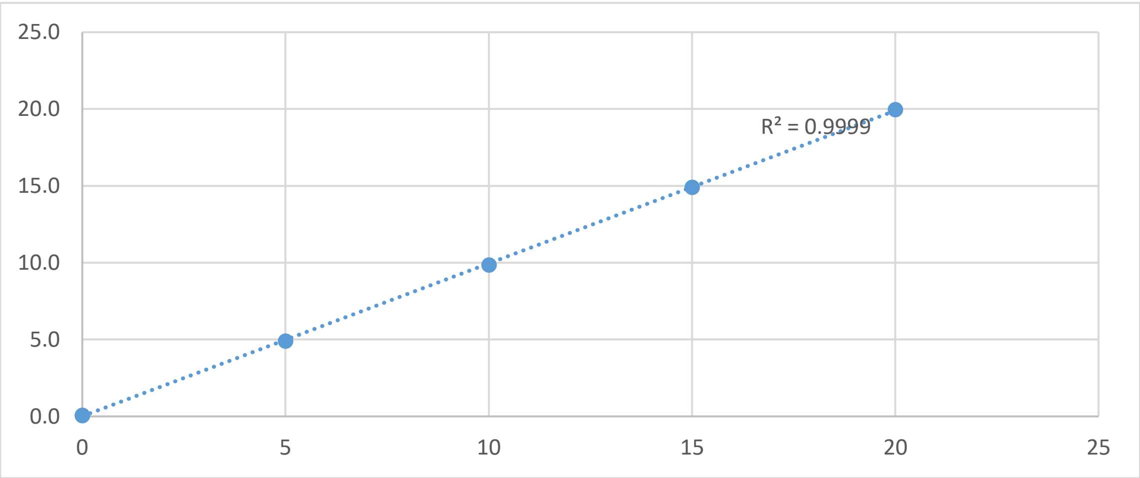
Variability Test	xAMS (% Dry)	y SRM (% Dry)	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
			0.9919		
			0.0632		
11/04/2024 13:00 - 13:30	8.62	8.61	8.6135	8.6086	0.00
11/04/2024 14:00 - 14:30	8.68	8.62	8.6718	8.6169	-0.05
11/04/2024 15:00 - 15:30	8.54	8.48	8.5362	8.4831	-0.05
11/04/2024 16:00 - 16:30	8.19	8.43	8.1884	8.4263	0.24
11/04/2024 17:00 - 17:30	5.84	5.81	5.8528	5.8118	-0.04
12/04/2024 08:00 - 08:30	8.67	8.67	8.6589	8.6747	0.02

Calibration Test	
Average D	0.02
$t_{0.95, n-1}$	2.015
N	6
I D I ≤	1.2
Test	Pass

SD	0.1120
σ	1.0714
Kv	0.9329
σ x Kv x 1.5	1.4993
Test	Pass

6.4 Linearity Assessment

		Oxygen			
		Linearity Checks			
Effective Emission Limit Value			21	**%**	
Upper Range from CEMs to DCS			25	**%**	
Accuracy of the Cal Gas			<2	**%**	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	5	4.9	4.91	4.91	4.91
0%	0	0.1	0.06	0.05	0.06
40%	10	9.9	9.85	9.85	9.85
80%	20	20.0	19.97	19.97	19.98
60%	15	14.9	14.91	14.91	14.91
0%	0	0.1	0.07	0.07	0.07
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	5.00	4.9	4.981	-3.333	11.111
2	0.00	0.1	0.010	-8.333	69.444
3	10.00	9.9	9.952	1.667	2.778
4	20.00	20.0	19.895	11.667	136.111
5	15.00	14.9	14.923	6.667	44.444
6	0.00	0.1	0.010	-8.333	69.444
Average	8.33	8.30	Sums (?)	0.000	333.333
			Slope	**B=**	**0.994**
			Offset	**A=**	**0.010**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-16.367	-0.07	25	-0.28	0.28
1	-0.472	0.05	25	0.19	0.19
2	16.417	-0.10	25	-0.41	0.41
3	233.022	0.08	25	0.31	0.31
4	99.400	-0.01	25	-0.05	0.05
0	-0.583	0.06	25	0.24	0.24
Sum	331.417			Max	0.41



Max dc	0.41	<5%	Pass

7. Functional Tests

Parameter	Oxides of Nitrogen	Carbon Monoxide	Oxygen
AMS Manufacturer and Model	Rosemount / Emerson	Rosemount / Emerson	Rosemount / Emerson
Serial Number	4007005222542	4007005222542	4007005222542
Measurement Principle	Chemiluminescence	NDIR	Paramagnetic
QAL 1 Compliant	Yes	Yes	Yes
MCERTS / TUV Approved	Yes	Yes	Yes

Species	Measured Units	Measured Range	Measurement Conditions	Current QAL2 calibration function (if applicable)
NOx as NO_2	mg/m^3	0 – 25%	Dry	Y = 0.9387x + 1.0677
Carbon Monoxide	mg/m^3	0 – 200 mg/m^3	Dry	Y = 0.9408x + 1.3712
Oxygen	%	0 – 75 mg/m^3	Dry	Y = 0.9919x + 0.0632

Measurement Site and Installation

In-Situ & Extractive AMS	Y/N	Notes
Is there a safe and clean working environment that has sufficient space and weather protection?	Yes	The probes are located on an external sampling platform, ~20m above ground level. There is no shelter on the sampling platform.
Is there easy and safe access to the AMS?	Yes	Located at ground level inside dedicated enclosure hut.
Are tools, spares parts and reference materials available?	Yes	All available – Located in site stores
Are there facilities to introduce reference materials directly to the AMS as well as through the complete system (extractive only)?	Yes	Reference materials can be introduced into the instrument and into the sample system up to the probe assembly.

Reference Materials on site

Parameter	Concentration (mg/m^3 / %)	Cylinder Number	Cylinder Expiry	Certified Accuracy
Nitrogen Monoxide	77.5	194931SG	01-06-2025	-
Carbon Monoxide	81.2	194931SG	01-06-2025	-
Oxygen	20.9	-	-	-
Zero Gas	0	S1684399FF	18-07-2027	99.998%

CEMS Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	77.5	0.1	77.5	37
Carbon Monoxide	81.2	0.2	81.2	18
Oxygen	20.9	0.0	20.9	3

Sampling Line Leak Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	77.5	0.1	77.3	40
Carbon Monoxide	81.2	0.2	80.6	18
Oxygen	20.9	0.2	20.89	6

Alignment and Cleanliness

In-Situ AMS	Y/N	Notes
Internal check of the AMS	N/a	N/a
Cleanliness of the optical components	N/a	N/a
Flushing of the air supply	N/a	N/a
Any obstructions in the optical path	N/a	N/a
Alignment of the measuring systems	N/a	N/a
Contamination control (internal check of the optical surfaces)	N/a	N/a
Flushing air supply	N/a	N/a

Extractive AMS

Extractive AMS	Y/N	Notes
Sampling probe	Yes	In good condition from visual inspection
Gas conditioning systems	Yes	In good condition from visual inspection
Pumps	Yes	In good condition from visual inspection
All connections	Yes	In good condition from visual inspection
Sample lines	Yes	In good condition from visual inspection
Power supplies	Yes	In good condition from visual inspection
Filters	Yes	Filters not removed to check
NOx converter efficiency (if applicable)	N/a	Verified during equipment service
Visual inspection of sampling train	Yes	In good condition from visual inspection

Linearity

Extractive	Y/N	Notes
During the calibration / linearity tests the applied concentrations should be logged onto the DAHS to prove the complete system. i.e. Concentration applied to the instrument is represented by the instrument output and identical to the value logged on the DAHS. DAHS logged values should be included in the instrument service report.	Yes	Complete
The linearity of the CEM response shall be checked using five different reference materials, including a zero concentration.	Yes	Complete
The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.	Yes	Complete
In case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration. The uncertainty must be ≤2%	Yes	Gas Dilution system used on ISO 17025 gases
The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of the range that is at least the short-term ELV. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference material shall be applied to the inlet of the CEM. (i.e. not down the line)	Yes	Applied at analyser at said concentrations.

Interference

Extractive	Y/N	Notes
NO	No	A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL1 and there is a failure of the QAL2 or AST which could be due to interferences.
CO	No	
O_2	No	

QAL3 Checks Zero and Span Drift Audit

Extractive	Y/N	Notes
NO	Yes	Successful zero and span check
CO	Yes	Successful zero and span check
O_2	Yes	Successful zero and span check

The test laboratory shall assess whether the operator has a QAL3 procedure in place, and whether the operator has applied this procedure. The evidence would comprise

(i) a documented procedure,
(ii) zero and span data,
(iii) (icontrol charts.

The company has all procedures and control charts in place.

Documentation

Extractive	Y/N	Notes
A plan of the AMS	Yes	We have been advised these are in place
AMS certification information	Yes	We have been advised these are in place
Manuals	Yes	We have been advised these are in place
Log Books (Detailing problems with the AMS and corrective action taken)	Yes	We have been advised these are in place
Service Reports	Yes	We have been advised these are in place
QAL3 Documentation	Yes	We have been advised these are in place
Procedures for AMS maintenance, calibration and training	Yes	In place and up to date
Training records	Yes	We have been advised these are in place
Maintenance Schedules	Yes	We have been advised these are in place
Auditing plans and records	Yes	We have been advised these are in place

Report

Extractive	Y/N	Notes
Are there any faults that require corrective action	N	None detected

Works Completion

Name	Company	Date	Role
Mark McGarry	AXIS Environmental Services	11-04-2024	Team Leader
Tim Casey	AXIS Environmental Services	11-04-2024	Technician
David Dillane	Aughinish Alumina	11-04-2024	Electrical Instrumentation

Report Title	EN 14181 AST Report
Company address	AXIS environmental services Ltd., Unit 3 Westlink Business Park, Clondrinagh, Ennis Road, Limerick, V94 K6XK
Stack Emissions Testing Report Commissioned by	Aughinish Alumina Ltd
Facility Name	Aughinish Alumina Ltd
Contact Person	Rory O Dwyer / Matt Butler
EPA Licence Number	P0035-07
Licence Holder	Aughinish Alumina Ltd
Stack Reference Number	GT1
Dates of the Monitoring Campaign	16-08-2023
Job Reference Number	AUGHTL18150823 – GT1
Report Written By	Mr. Tim Casey
Report Approved by	Mark McGarry
Stack Testing Team	Mr. Tim Casey, Mr. Niall Murray & Mr. Anderson Carneiro
Report Date	08-10-2024
Report Type	EN 14181 Compliance Report
Version	2
Signature of Approver	

Table of Contents

Report Date	08-10-2024	**Site Contact:**	Seamus Leahy / Rory O'Dwyer
Client:	Aughinish Alumina Limited	**Version No:**	2
Report Issued By:	Mark McGarry	**Signed:**	
Revision History			
Rev 1	Original Report		
Rev 2	Updated QAL2 Function		

1. INTRODUCTION

1.1 Summary Detail

Axis environmental services Ltd were commissioned by Aughinish Alumina Limited to carry out Annual Surveillance Test validation audit of the CEMS units installed on Emission Point Boiler D. The CEMS are installed to monitor:

- Oxides of Nitrogen (NOx as NO_2);
- Carbon Monoxide (CO);
- Oxygen (O_2).

1.1.1 Oxides of Nitrogen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

1.1.2 Oxygen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181. Under the Large combustion plant directive there is no requirement to complete QAL2 or AST for oxygen, therefore the application of a calibration function would need to be in agreement with the Agency. AG3 does request validation of oxygen.

1.1.3 Carbon Monoxide

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

The following table summarises the tests carried out and the equipment suitability:

Table 1.1: Calibration Function

Parameter	Oxides of Nitrogen as NO_2 NOx	Carbon Monoxide CO	Oxygen O_2
Variability Test Result	Pass	Pass	Pass
Calibration Function Validity Status	Pass	Pass	Pass
QAL 2 Calibration Function	y = 1.0594x – 0.1236	y = 1.0098x – 1.3759	y = 1.0014x - 0.0401
Recommended Function to Use	QAL 2 Function is valid	QAL 2 Function is valid	QAL 2 Function is valid
QAL 2 Calibrated Range at Reference Conditions	0 to 50	0 to 20	0 to 15.5

Table 1.2: Linearity and Test of Residuals

Parameter	Oxides of Nitrogen as NO_2 NOx	Carbon Monoxide CO	Oxygen O_2
Test of Residuals Max dc ,rel	0.19	0.65	0.07
Residuals Test Result Max dc ,rel <5%	Pass	Pass	Pass

1.2 Summary of Test Methods

Substance	Standard Reference Method	AG2 Compliant
Oxides of Nitrogen	EN 14792	Yes
Carbon Monoxide	EN 15058	Yes
Oxygen	EN 14789	Yes

1.3 Deviations from Test Methods

Substance	Deviations from SRM or EN 14181	Impact on Results	Actions Required
Oxides of Nitrogen	None	None	None
Carbon Monoxide	None	None	None
Oxygen	None	None	None

2. Information Regarding Regulated Installation

2.1 Installation Information

Company Name	Aughinish Alumina Limited
Address	Askeaton, Co. Limerick
Sector	Production of Inorganic Chemicals
Date of Last QAL2 / AST	August 2022

2.2 Emission Limit Values

Substance	Short Term ELV	Daily Average ELV mg/m^3 @ 15% O_2 Dry Gas	Uncertainty Requirement
Oxides of Nitrogen	-	50	20
Carbon Monoxide	-	100	20[3]
Oxygen	-	21[1]	10[2]

Note 1: Effective ELV
Note 2: Uncertainty applied in AG3:2017
Note 3: EPA AG3 allows for an uncertainty of 20 to be applied to EN 14181 calculations.

2.3 Operational Information

Process	Description
Continuous or batch process	Continuous
Operating phases	No variation
Load	75.8 – 78.5MW
Expected variation of emissions	None
Influence of variation on sampling times	None
Other factors affecting monitoring results	None
Historical data checked beforehand	Yes
Parameters near zero	CO but reading normally
CEMs at or near zero	CO but reading normally

2.4 Type of Fuel

Fuel Type	Proportion Used during AST	Normal Fuels Used	Multiple Calibration Functions Required
Natural Gas	100%	Natural Gas	No

2.5 Abatement

Abatement Types	Impact on Emissions
None	N/a

2.6 Stack Arrangement

Parameter	Descriptions
Arrangement	Vertical Stack
Dimensions	Circular – 2.00m
Location of the ports	c. 35 meters above ground
Number of sampling ports	Numerous
Picture of the Emission Point	
Picture of the Platform	

2.7 Monitoring Platform and Provisions

Platform	Description
Safe Working Area	Yes
Clean Working Area	Yes
Sufficient Space to Work	Yes
Weather Protection	Yes – At CEMS hut at base of stack
CEMs	
Safe Access	Yes
Easy Access	Yes
Calibration Gases Used	Yes – 6141 Compliant
Tools Available	Yes
Spare Parts Available	Yes
Gases Introduced to Analyser	Yes
Gases Introduced to Line	Yes
Compliance with EN 15259	The platform meets all criteria for platform installation.

2.8 Representative Sample

Sample Location	Description
Homogeneity Test Complete	There was no requirement for homogeneity as part of this assessment
Date of Homogeneity Test	-
Ratio High to Low Flow	<3:1 determined from previous report

2.9 CEMs Overview

Parameter	Brand	Model	Principle	QAL 1 Compliant	Location
Oxides of Nitrogen	Emerson	NGA 2000	Chemiluminescence	Yes	CEMS Hut
Carbon Monoxide	Rosemount / Emerson	NGA2000	Infra-Red	Yes	CEMS Hut
Oxygen	Rosemount / Emerson	NGA2000	Electrochemical cell	Yes	CEMS Hut

Parameter	Certified Range	Wet or Dry Measurement
Oxides of Nitrogen	0 – 200 mg/m^3	Dry
Carbon Monoxide	0 – 75 mg/m^3	Dry
Oxygen	0 – 25 %	Dry

2.10 Peripheral Determinands

Parameter	Recorded at CEMs
Temperature	Yes
Pressure	No
Water Vapour	No

2.11Reference Conditions

Temperature	Pressure	Oxygen	Moisture
273.15 Deg Kelvin	101.3 kPa	15 %	0%

2.12 Sample Times

Run No	Date	NO	CO	O2
1	16-08-2023	12:00 – 12:30	12:00 – 12:30	12:00 – 12:30
2	16-08-2023	13:00 – 13:30	13:00 – 13:30	13:00 – 13:30
3	16-08-2023	14:00 – 14:30	14:00 – 14:30	14:00 – 14:30
4	16-08-2023	15:00 – 15:30	15:00 – 15:30	15:00 – 15:30
5	16-08-2023	16:00 - 16:30	16:00 - 16:30	16:00 - 16:30
6	16-08-2023	17:00 – 17:30	17:00 – 17:30	17:00 – 17:30

3. Monitoring Campaign

3.1 Test Laboratory Technicians

Function	Name
Team Leader	Tim Casey
Technician	Niall Murray
Technician	Anderson Carneiro

3.2 Standard Reference Methods

Substance	Standard Reference Method	Principle	Certified Range	Method Uncertainty	INAB Accreditation
Oxides of Nitrogen	EN 14792	Chemiluminescence	1.8 - 2050	<10%	Yes
Carbon Monoxide	EN 15058	NDIR	1.7 - 1250	<6%	Yes
Oxygen	EN 14789	Paramagnetic	0.1 – 26	<6%	Yes

3.3 Equipment Inventory

Type	Equipment Reference	Parameter
Horiba PG350	ASLLK21EQ522	NOx, SO_2, CO & O_2
Chiller Unit	ASLLK22EQ509	Moisture Removal
40 m Heated Line	ASLLK22EQ510	-
NO	23MG506	Certified <2%
O2	23MG502	Certified <2%
CO	23MG506	Certified <2%
Nitrogen	BOC	Certified Grade 99.9999%

4. Calculations Oxides of Nitrogen

4.1 Oxides of Nitrogen (NO_x as NO_2)

Parameter	Oxides of Nitrogen	
Reference O_2	15	
ELV	50	
CI (%)	20	
Calibration Function	y=1.0594x - 0.1236	
Outliers	None	
Factor	2.053	
	xAMS (mg/Nm³ Dry)	y SRM (mg/Nm³ Dry)
1	39.96	37.21
2	39.47	37.05
3	42.42	37.70
4	41.70	36.60
5	43.02	37.50
6	42.71	37.38
y = bx + a		
b	1.0594	
a	-0.1236	
Function	y=1.0594x – 0.1236	

Variability Test	xAMS (mg/Nm³ Dry)	y SRM (mg/Nm³ Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				1.0014		1.0594		
				-0.0401		-0.1236		
1	39.96	37.21	13.84	13.82	13.78	35.1562	30.8292	-4.33
2	39.47	37.05	13.83	13.81	13.66	34.6880	30.2113	-4.48
3	42.42	37.70	13.78	13.76	13.43	37.0322	29.7747	-7.26
4	41.70	36.60	13.77	13.74	13.41	36.3289	28.8241	-7.50
5	43.02	37.50	13.73	13.71	13.37	37.3008	29.3947	-7.91
6	42.71	37.38	13.72	13.70	13.37	36.9682	29.2680	-7.70

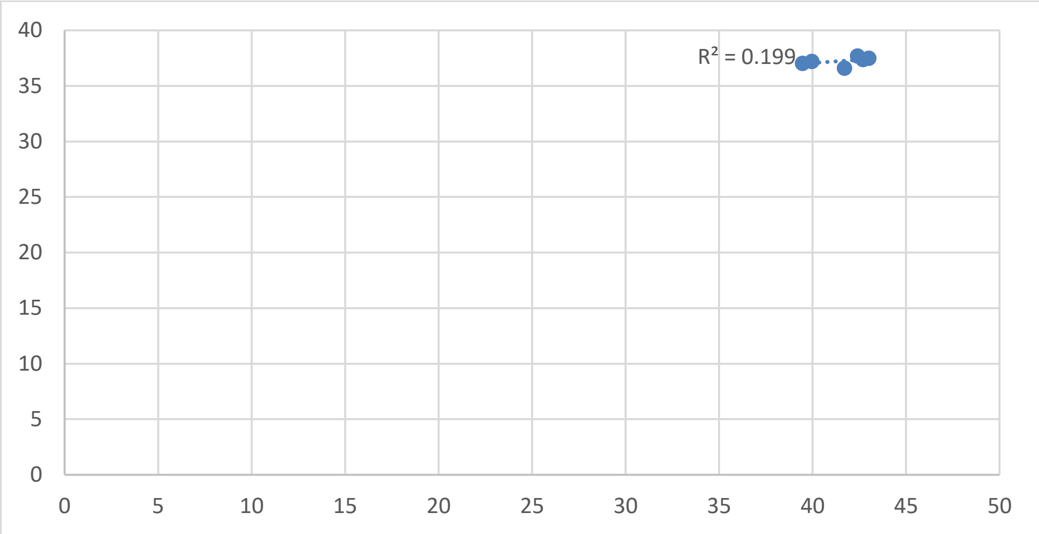
Calibration Test	
Average D	6.53
$t_{0.95, n-1}$	2.015
SD	1.662
σ	5.102
N	6
I D I ≤	6.60
Test	Pass

SD	1.6620
σ	5.1020
Kv	0.9329
1.5 x σ x Kv	7.1395
Test	Pass

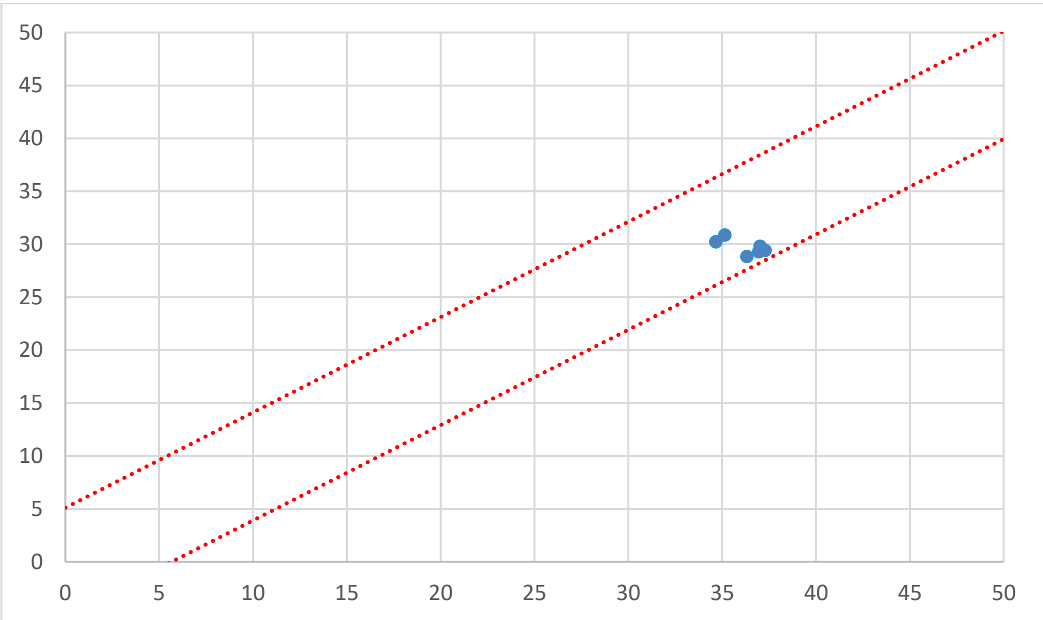
$$\left|\bar{D}\right| \le t_{0.95,N-1}\frac{s_D}{\sqrt{N}} + \sigma_0$$

$$s_D \le 1{,}5\ \sigma_0\ k_v$$

Plot 4-1: SRM vs CEMs



Plot 4-2: Reference SRM vs Reference CEMs

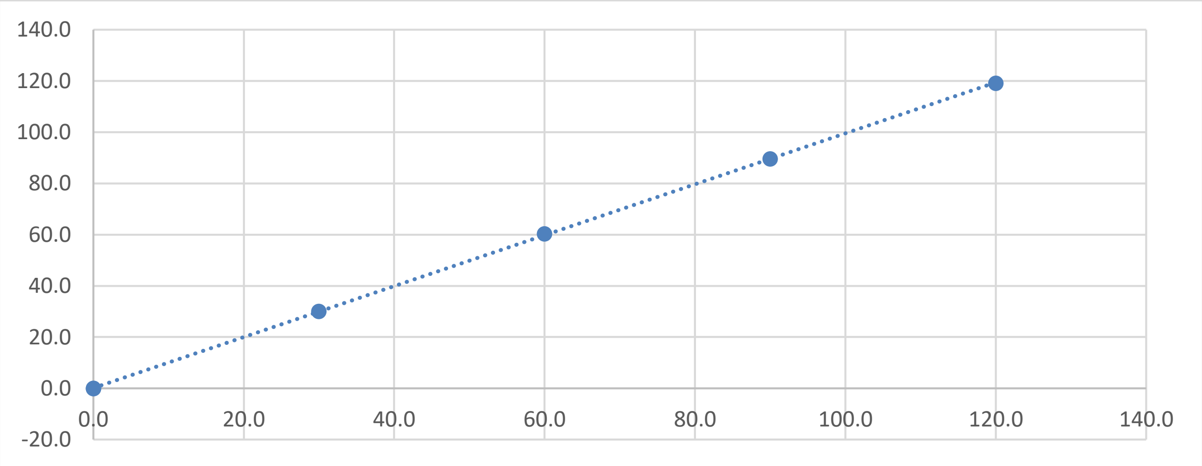


4.2 Outliers

Nitrogen Oxides					
Run	**AMS**	**SRM**	**Di**	**A**	**Outlier**
Number	**x**	**y**		abs(Di-Davg)	
	ppm STP Dry	**ppm STP Dry**			**Yes / No**
1	19.46	18.1	-1.34	0.7589	No
2	19.22	18.0	-1.18	0.9214	No
3	20.66	18.4	-2.30	0.2012	No
4	20.31	17.8	-2.48	0.3872	No
5	20.95	18.3	-2.69	0.5919	No
6	20.80	18.2	-2.60	0.5000	No
Average			**-2.0970**		
Std Dev x 2			**1.3314**		

4.3 Linearity Checks

		Nitrogen Monoxide			
		Linearity Checks			
Effective Emission Limit Value		100	**mg/m³**		
Upper Range from CEMs to DCS		150	**ppm**		
Accuracy of the Cal Gas		<2	**%**		
Check Point	**Expected Result**	**Yc**	**Test 1**	**Test 2**	**Test 3**
20%	30.0	30.0	30.01	30.04	30.00
0%	0.0	-0.05	-0.05	-0.04	-0.07
40%	60.0	60.3	60.30	60.27	60.28
80%	120.0	119.2	119.10	119.20	119.20
60%	90.0	89.6	89.63	89.53	89.61
0%	0.0	0.0	0.00	0.02	-0.02
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	30.0	29.950	-20.000	400.000
2	0.00	-0.1	0.124	-50.000	2500.000
3	60.00	60.3	59.776	10.000	100.000
4	120.00	119.2	119.428	70.000	4900.000
5	90.00	89.6	89.602	40.000	1600.000
6	0.00	0.0	0.124	-50.000	2500.000
Average	50.00	49.83	Sums (?)	0.000	12000.000
			Slope	**B=**	**0.994**
			Offset	**A=**	**0.124**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-600.333	0.05	308	0.02	0.02
1	2.667	-0.12	308	-0.04	0.04
2	602.833	0.22	308	0.07	0.07
3	8341.667	0.57	308	0.19	0.19
4	3583.600	0.40	308	0.13	0.13
0	0.000	-0.12	308	-0.04	0.04
Sum	11930.433			Max	0.19



5. Calculations Carbon Monoxide

5.1 Carbon Monoxide

Parameter	**Carbon Monoxide**	
Reference O_2	15	
ELV	100	
CI (%)	20	
Calibration Function	y = 1.0098x - 1.3759	
Outliers	None	
Factor	1.25	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
1	2.50	2.59
2	2.41	2.43
3	2.43	2.07
4	2.20	1.99
5	2.06	2.06
6	2.00	2.15
y = bx + a		
b	1.0098	
a	-1.3759	
Function	y = 1.0098x - 1.3759	

Variability Test	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				1.0014		1.0098		
				-0.0401		-1.3759		
1	2.50	2.59	13.84	13.82	13.78	0.9570	2.1476	1.19
2	2.41	2.43	13.83	13.81	13.66	0.8818	1.9773	1.10
3	2.43	2.07	13.78	13.76	13.43	0.8908	1.6347	0.74
4	2.20	1.99	13.77	13.74	13.41	0.6973	1.5632	0.87
5	2.06	2.06	13.73	13.71	13.37	0.5781	1.6153	1.04
6	2.00	2.15	13.72	13.70	13.37	0.5239	1.6871	1.16

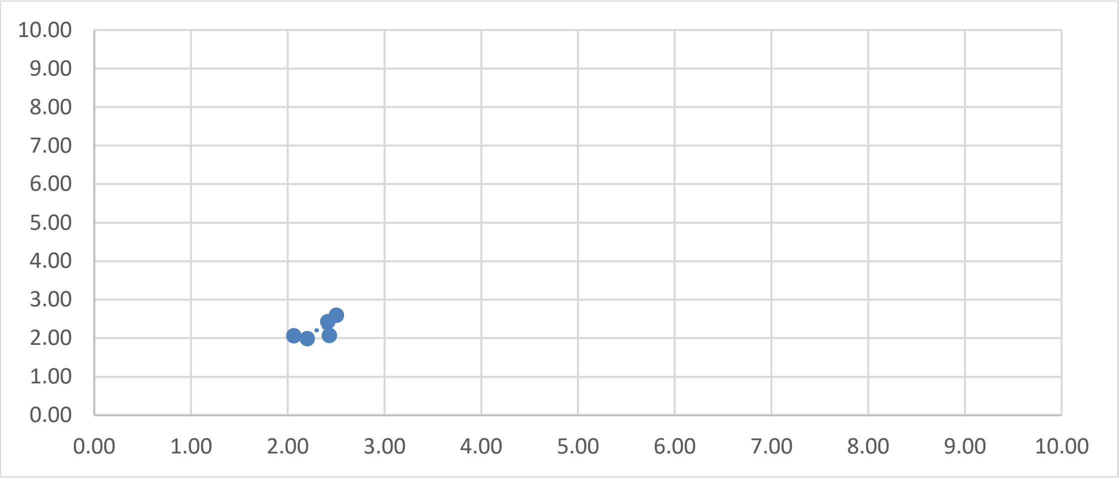
Calibration Test	
Average D	1.02
$t_{0.95, n-1}$	2.015
SD	0.176
σ	10.204
N	6
I D I ≤	10.36
Test	Pass

SD	0.1764
σ	10.2041
Kv	0.9329
1.5 x σ x Kv	14.2791
Test	Pass

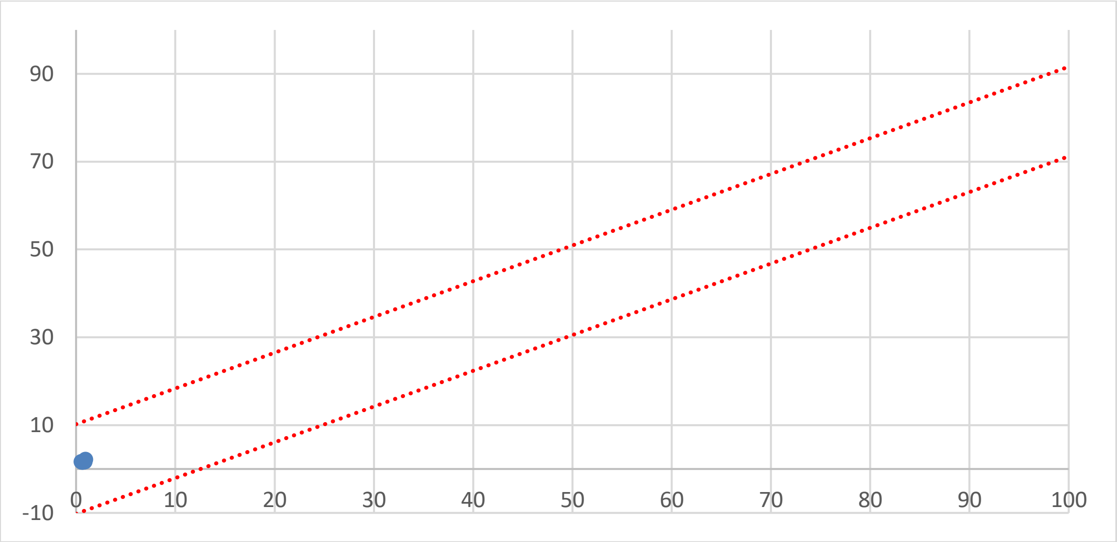
$$\left|\overline{D}\right| \leq t_{0,95,N-1}\frac{s_D}{\sqrt{N}} + \sigma_0$$

$$s_D \leq 1{,}5\ \sigma_0\ k_v$$

Plot 5-1: SRM vs CEMs



Plot 5-2: Reference SRM vs Reference CEMs



5.2 Outliers

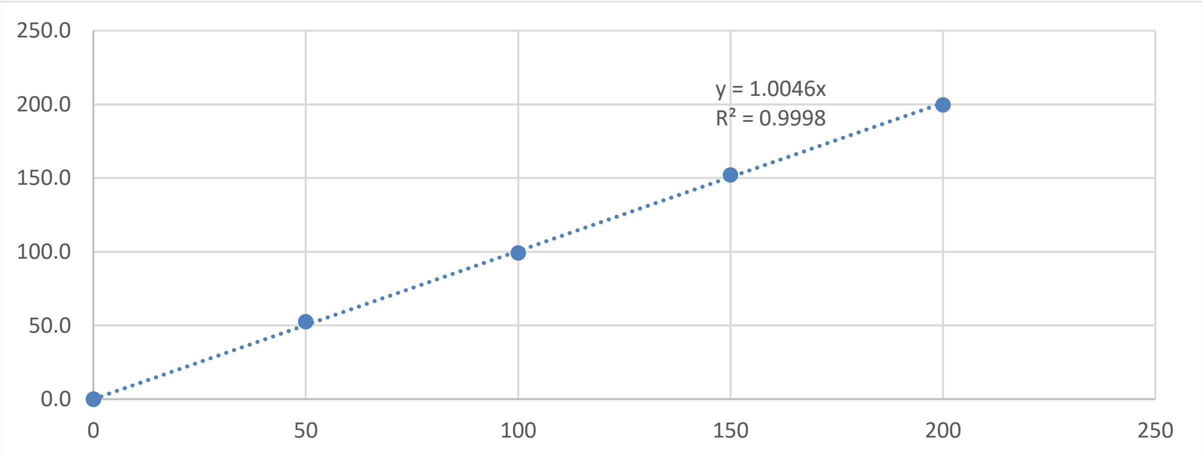
Run Number	AMS x ppm STP Dry	SRM y ppm STP Dry	Di	A abs(Di-Davg)	Outlier Yes / No
1	2.50	2.6	0.09	0.1436	No
2	2.41	2.4	0.01	0.0649	No
3	2.43	2.1	-0.36	0.3086	No
4	2.20	2.0	-0.21	0.1629	No
5	2.06	2.1	0.00	0.0524	No
6	2.00	2.2	0.16	0.2106	No
Average			**-0.0518**		
Std Dev x 2			**0.3936**		

5.3. Linearity Checks

Carbon Monoxide

Linearity Checks

Effective Emission Limit Value		100	**mg/m³**		
Upper Range from CEMs to DCS		250	**ppm**		
Accuracy of the Cal Gas		<2	**%**		
Check Point	**Expected Result**	**Yc**	**Test 1 4 x Response**	**Test 2 1 x Response**	**Test 3 1 x Response**
20%	50	52.7	52.7	52.7	52.7
0%	0	0.1	0.1	0.1	0.1
40%	100	99.3	99.3	99.4	99.3
80%	200	199.7	199.6	199.7	199.8
60%	150	152.3	152.3	152.2	152.3
0%	0	0.0	0.0	0.0	0.1
Gas Divider Point	**Actual y**	**Measured x**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	50.00	52.7	50.685	-33.333	1111.111
2	0.00	0.1	0.679	-83.333	6944.444
3	100.00	99.3	100.691	16.667	277.778
4	200.00	199.7	200.703	116.667	13611.111
5	150.00	152.3	150.697	66.667	4444.444
6	0.00	0.0	0.679	-83.333	6944.444
Average	83.33	84.02	Sums (?)	0.000	33333.333
			Slope	**B=**	**1.000**
			Offset	**A=**	**0.679**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-1756.889	2.02	100	2.02	2.02
1	-9.444	-0.68	100	-0.68	0.68
2	1655.500	-0.69	100	-0.69	0.69
3	23298.333	-0.70	100	-0.70	0.70
4	10151.111	-0.70	100	-0.70	0.70
0	-1.389	-0.68	100	-0.68	0.68
Sum	33337.222			Max	2.02



Calculations Oxygen

6.1 Oxygen

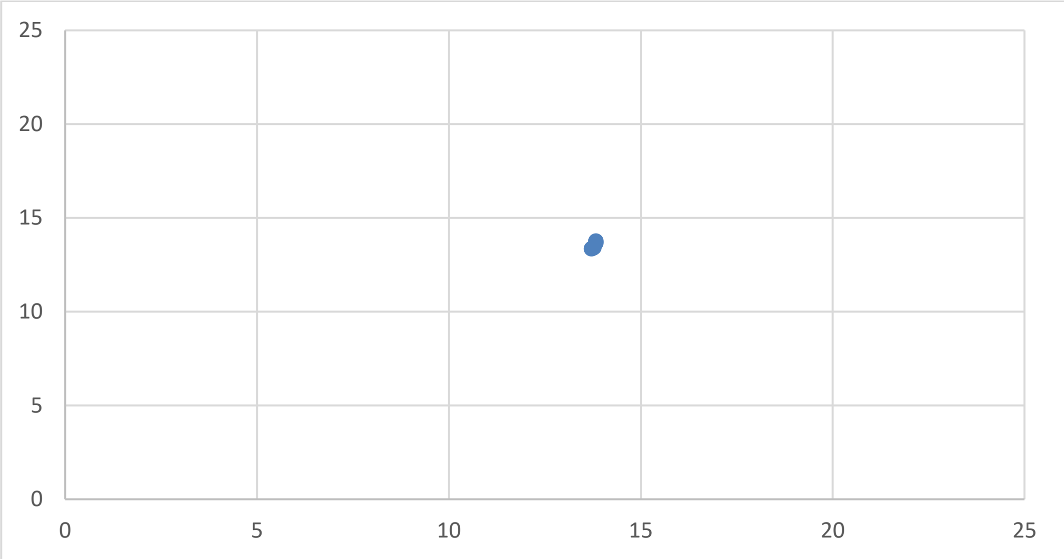
Parameter	Oxygen	
Reference O2	n/a	
ELV	21	
CI (%)	10	
Calibration Function	1.0014x - 0.0401	
Outliers	None	
	xAMS (% Dry)	y SRM (% Dry)
1	13.84	13.78
2	13.83	13.66
3	13.78	13.43
4	13.77	13.41
5	13.73	13.37
6	13.72	13.37
y = bx + a		
b	1.0014	
a	-0.0401	
Function	1.0014x - 0.0401	

Variability Test	xAMS (% Dry)	y SRM (% Dry)	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
			1.0014 -0.0401		
1	13.84	13.78	13.8164	13.7785	-0.04
2	13.83	13.66	13.8098	13.6641	-0.15
3	13.78	13.43	13.7604	13.4298	-0.33
4	13.77	13.41	13.7447	13.4074	-0.34
5	13.73	13.37	13.7107	13.3732	-0.34
6	13.72	13.37	13.6984	13.3651	-0.33
Calibration Test				SD	0.1300
Average D	0.25			σ	1.0714
$t_{0.95, n-1}$	2.015			Kv	0.9329
N	6			σ x Kv x 1.5	1.4993
I D I ≤	1.2			Test	Pass
Test	Pass				

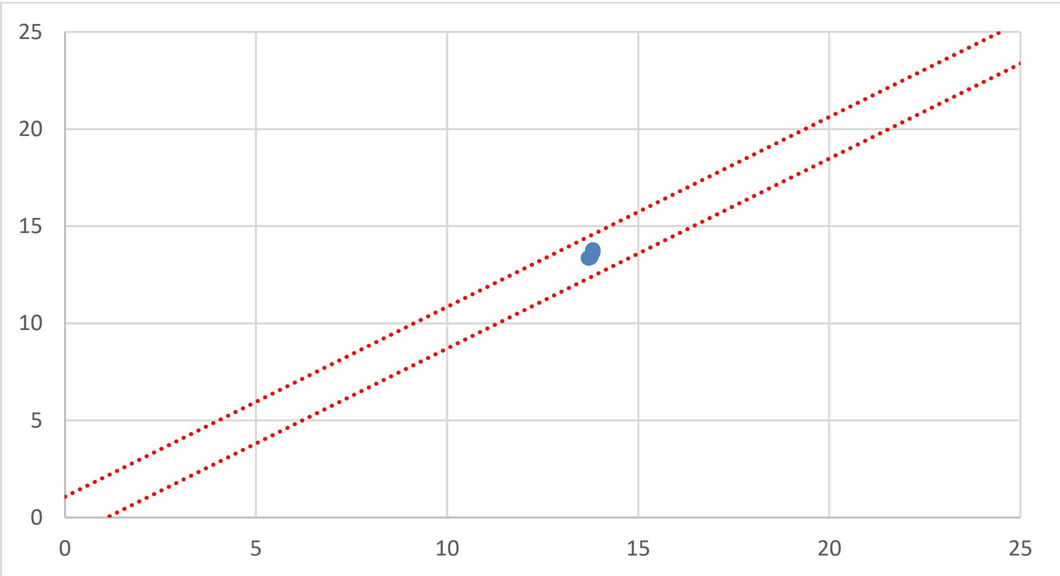
$$\left|\overline{D}\right| \leq t_{0,95,N-1} \frac{s_D}{\sqrt{N}} + \sigma_0$$

$$s_D \leq 1{,}5\ \sigma_0\ k_v$$

Plot 6-1: SRM vs CEMs



Plot 6-2: SRM vs Cal AMS @ Ref Conditions



6.2 Outliers

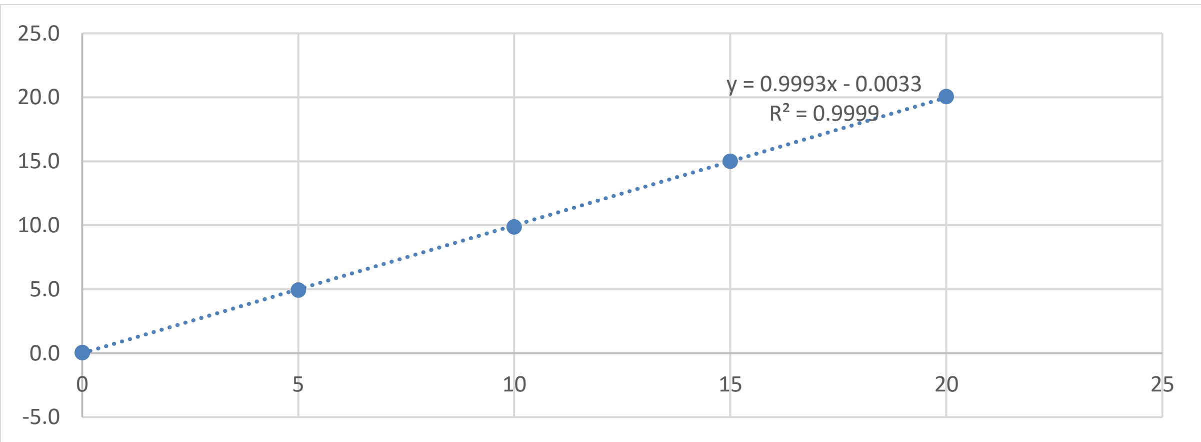
Run Number	AMS x % Dry	SRM y % Dry	Di	A abs(Di-Davg)	Outlier Yes / No
1	13.84	13.78	-0.06	0.22	No
2	13.83	13.66	-0.17	0.11	No
3	13.78	13.43	-0.35	0.08	No
4	13.77	13.41	-0.36	0.08	No
5	13.73	13.37	-0.36	0.08	No
6	13.72	13.37	-0.35	0.08	No
Average			**-0.2745**		
Std Dev x 2			**0.26**		

6.3. Linearity Checks

Oxygen

Linearity Checks

Effective Emission Limit Value			25	**%**	
Upper Range from CEMs to DCS			25	**%**	
Accuracy of the Cal Gas			<2	**%**	
Check Point	**Expected Result**	**Yc**	**Test 1**	**Test 2**	**Test 3**
20%	5	4.9	4.94	4.93	4.93
0%	0	0.0	0.05	0.05	0.04
40%	10	9.9	9.86	9.86	9.89
80%	20	20.1	20.05	20.06	20.05
60%	15	15.0	14.99	15.00	14.98
0%	0	0.1	0.05	0.05	0.05
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	5.00	4.9	4.993	-3.333	11.111
2	0.00	0.0	-0.003	-8.333	69.444
3	10.00	9.9	9.989	1.667	2.778
4	20.00	20.1	19.982	11.667	136.111
5	15.00	15.0	14.986	6.667	44.444
6	0.00	0.1	-0.003	-8.333	69.444
Average	8.33	8.32	Sums (?)	0.000	333.333
			Slope	**B=**	**0.999**
			Offset	**A=**	**-0.003**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-16.444	0.01	25	0.03	0.03
1	-0.389	0.00	25	0.01	0.01
2	16.450	0.01	25	0.04	0.04
3	233.956	0.02	25	0.07	0.07
4	99.933	0.01	25	0.06	0.06
0	-0.417	0.00	25	0.01	0.01
Sum	333.089			Max	0.07



6. Functional Tests

Parameter	Oxides of Nitrogen	Carbon monoxide	Oxygen
AMS Manufacturer and Model	Emerson	Rosemount / Emerson	Rosemount / Emerson
Serial Number	6002504321221	4002504321219	4002504321219
Measurement Principle	Chemiluminescence	Infra Red	Electrochemical cell
QAL 1 Compliant	Yes	Yes	Yes
MCERTS / TUV Approved	Yes	Yes	Yes

Species	Measured Units	Measured Range	Measurement Conditions	Current QAL2 calibration function (if applicable)
NOx as NO_2	mg/m^3	0 - 100	Dry	y = 1.0594x – 0.1236
Carbon Monoxide	mg/m^3	0 - 200	Dry	y = 1.0098x – 1.3759
Oxygen	%	0 - 25	Dry	y = 1.0014x - 0.0401

Measurement Site and Installation

In-Situ & Extractive AMS	Y/N	Notes
Is there a safe and clean working environment that has sufficient space and weather protection?	Y	The probes are located on an external sampling platform, ~20m above ground level. There is no shelter on the sampling platform.
Is there easy and safe access to the AMS?	Y	Located at ground level inside dedicated enclosure hut.
Are tools, spares parts and reference materials available?	Y	All available – spare unit
Are there facilities to introduce reference materials directly to the AMS as well as through the complete system (extractive only)?	Y	Reference materials can be introduced into the instrument and in to the sample system up to the probe assembly.

Reference Materials on site

Parameter	Concentration (mg/m^3 / %)	Cylinder Number	Cylinder Expiry	Certified Accuracy
Nitrogen Monoxide	80.0	276799SG	02-Aug-2024	2%
Carbon Monoxide	81.4	276799SG	02-Aug-2024	2%
Oxygen	20.9%	Scrubbed Air	N/a	0.35%
Zero Gas	0%	-	-	-

CEMS Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	80	-0.11	80.33	15.3
Carbon Monoxide	81.4	0.12	80.98	15.1
Oxygen	20.9	0.02	21.12	13.8

Sampling Line Leak Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	80	0.02	80.13	22.3
Carbon Monoxide	81.4	-0.04	80.91	25
Oxygen	20.9	0.03	21.05	23.4

Alignment and Cleanliness

In-Situ AMS	Y/N	Notes
Internal check of the AMS	N/a	N/a
Cleanliness of the optical components	N/a	N/a
Flushing of the air supply	N/a	N/a
Any obstructions in the optical path	N/a	N/a
Alignment of the measuring systems	N/a	N/a
Contamination control (internal check of the optical surfaces)	N/a	N/a
Flushing air supply	N/a	N/a

Extractive AMS

Extractive AMS	Y/N	Notes
Sampling probe	Y	In good condition from visual inspection
Gas conditioning systems	Y	In good condition from visual inspection
Pumps	Y	In good condition from visual inspection
All connections	Y	In good condition from visual inspection
Sample lines	Y	In good condition from visual inspection
Power supplies	Y	In good condition from visual inspection
Filters	Y	Filters not removed to check
NOx converter efficiency (if applicable)	-	-
Visual inspection of sampling train	Y	In good condition from visual inspection

Linearity

Extractive	Y/N	Notes
During the calibration / linearity tests the applied concentrations should be logged onto the DAHS to prove the complete system. i.e. Concentration applied to the instrument is represented by the instrument output and identical to the value logged on the DAHS. DAHS logged values should be included in the instrument service report.	Y	Complete
The linearity of the CEM response shall be checked using five different reference materials, including a zero concentration.	Y	Complete
The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.	Y	Complete
In case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration. The uncertainty must be ≤2%	Y	Blender used on ISO 17025 gases
The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of the range that is at least the short-term ELV. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference material shall be applied to the inlet of the CEM. (i.e. not down the line)	Y	Applied at analyser at said concentrations.

Interference

Extractive	Y/N	Notes
NO	N	A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL1 and there is a failure of the QAL2 or AST which could be due to interferences.
CO	N	
O_2	N	

QAL3 Checks Zero and Span Drift Audit

Extractive	Y/N	Notes
NO	Y	Successful zero and span check
CO	Y	Successful zero and span check
O_2	Y	Successful zero and span check
The test laboratory shall assess whether the operator has a QAL3 procedure in place, and whether the operator has applied this procedure. The evidence would comprise (i) a documented procedure, (ii) zero and span data, (iii) control charts. The company has all procedures and control charts in place.		

Documentation

Extractive	Y/N	Notes
A plan of the AMS	Y	We have been advised these are in place
AMS certification information	Y	We have been advised these are in place
Manuals	Y	We have been advised these are in place
Log Books (Detailing problems with the AMS and corrective action taken)	Y	We have been advised these are in place
Service Reports	Y	We have been advised these are in place
QAL3 Documentation	Y	We have been advised these are in place
Procedures for AMS maintenance, calibration and training	Y	We have been advised these are in place
Training records	Y	We have been advised these are in place
Maintenance Schedules	Y	We have been advised these are in place
Auditing plans and records	Y	We have been advised these are in place

Report

Extractive	Y/N	Notes
Are there any faults that require corrective action	N	None detected

Works Completion

Name	Company	Date	Role
Mark Burns	Aughinish Alumina	15-08-2023	Electrical Instrumentation
Tim Casey	AXIS	15-08-2023	Technician

Appendix

2024

EN14181

AST REPORT

PREPARED FOR:

Aughinish Alumina Limited
D Boiler

Report Title	EN 14181 Annual Surveillance Test Report
Company address	Axis Environmental Services Ltd., Unit 3 Westlink Business Park, Clondrinagh, Limerick, V94 K6XK
Contact Details	Phone: 061 324587, info@axisenv.ie
Report Commissioned by	Aughinish Alumina Limited
Facility Name	Aughinish Alumina Limited
EPA Licence Number	P0035-07
Licence Holder	Aughinish Alumina Limited
Stack Reference Number	D Boiler
Dates of the Monitoring Campaign	26-06-2024 & 27-06-2024
Job Reference Number	AUALTC250624
Report Written By	Mr. Tim Casey
Report Approved by	Mark McGarry
Stack Testing Team	Mr. Tim Casey & Mr. Aaron Carway
Report Date	08-10-2024
Report Type	Annual Surveillance Test
Version	2
Signature of Approver	

Contents

All sampling and reporting are completed in accordance with Environmental Protection Agency Air Guidance Note 2 requirements.

Document Sign Off			
Document Number:	AUALTC250624 – D Boiler		
Reason for Issue:	Annual Surveillance Test		
Issue Number:	2	**Date:**	08-10-2024
Originator:	**Signature:**	**Reviewer:**	**Customer:**
Tim Casey		Mark McGarry	Aughinish Alumina
Document History:			
Report Revision Number	**Revision Date**	**Section Revised**	**Reason for Revision**
2	08-10-2024	4	Updated QAL2 Function

1. Introduction

1.1 Summary Detail

AXIS environmental services Ltd were commissioned by Aughinish Alumina Limited to carry out an annual surveillance test and validation audit of the CEMS units installed on Emission Point D Boiler. The CEMS are installed to monitor:

- Oxides of Nitrogen (NOx as NO_2);
- Carbon Monoxide (CO);
- Oxygen (O_2).

1.1.1 Oxides of Nitrogen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

1.1.2 Oxygen:

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181. Under the Large combustion plant directive there is no requirement to complete QAL2 or AST for oxygen, therefore the application of a calibration function would need to be in agreement with the Agency. AG3 does request validation of oxygen.

1.1.3 Carbon Monoxide

The calibration function derived during the QAL 2 test has been deemed valid. The variability test and linearity tests have also passed the criteria for EN 14181.

The following table summarises the tests carried out and the equipment suitability:

Table 1.1: Calibration Function

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Variability Test Result	Pass	Pass	Pass
Calibration Function Validity	Pass	Pass	Pass
Calibration Function to be applied to Raw Data from AMS	y = 1.0249x + 0.0410	y = 1.0428x - 1.7159	y = 1.0534x - 0.1260
Confidence Interval to be applied to AMS Results	20	10*	10
Recommended Function to Use	As above	As above	As above
Calibrated / Extended Range at Reference Conditions	Valid Range 0 – 100 $mg.m^{-3}$	Valid Range 0 – 20 $mg.m^{-3}$	Valid Range 0 – 6.94 %

Note: The calibration function, once applied, only remains valid as long as the QAL3 data remains within control limits. There can be no manual adjustments made to the CEMs other than those allowed to bring the settings back within the QAL3 control limits.

*EPA Guidance note AG3: Please note that the confidence intervals for CO and Volumetric flow have been modified in this revision of AG3 to 20%. This is to prevent a possible failure of the variability test during the QAL2/AST. These revised confidence intervals are not relevant for the validation of normal monitoring results. For normal compliance monitoring, the original confidence intervals stipulated in the Industrial Emissions Directive and your IE licence apply.

Table 1.2: Linearity and Test of Residuals

Parameter	Oxides of Nitrogen NOx as NO_2	Carbon Monoxide CO	Oxygen O_2
Test of Residuals Max dc ,rel	1.28	0.57	0.27
Residuals Test Result Max dc ,rel <5%	Pass	Pass	Pass

1.2 Summary of Test Methods

Substance	Standard Reference Method	AG2 Compliant	INAB Accreditation
Oxides of Nitrogen	EN 14792	Yes	Yes – 408T
Carbon Monoxide	EN 15059	Yes	Yes – 408T
Oxygen	EN 14789	Yes	Yes – 408T

1.3 Deviations from Test Methods

Substance	Deviations from SRM or EN 14181	Impact on Results	Actions Required
Oxides of Nitrogen	None	N/a	N/a
Carbon Monoxide	None	N/a	N/a
Oxygen	None	N/a	N/a

2. Information Regarding Regulated Installation

2.1 Installation Information

Company Name	**Aughinish Alumina Limited**
Address	Aughinish West, Askeaton, Co. Limerick
Sector	Production of Inorganic Chemicals
Date of Last QAL2 / AST	August 2023

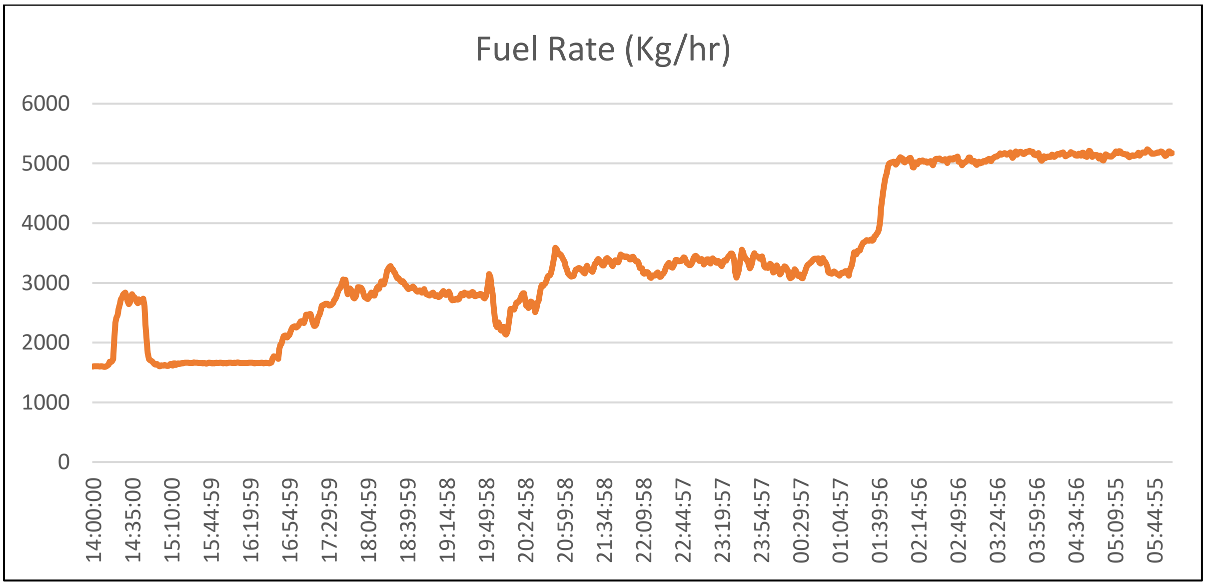
2.2 Emission Limit Values

Substance	**Short Term ELV**	**Daily Average ELV**	**Uncertainty Requirement**
Oxides of Nitrogen	-	100	20
Carbon Monoxide	-	100	20[3]
Oxygen	-	21[Note 1]	10[2]

Note 1: Effective ELV AG3:2017 (Page 28);
Note 2: Uncertainty applied in AG3:2017 (Page 22);
Note 3: EPA AG3 does allow for an uncertainty of 20% to be applied to EN 14181 calculations;

2.3 Operational Information

Process	Description
Continuous or batch process	Continuous
Operating phases	No variation
Load	Fuel consumption rate kg/hour
Expected variation of emissions	None
Influence of variation on sampling times	None
Other factors affecting monitoring results	None
Historical data checked beforehand	Yes
Parameters near zero	CO but reading normally
CEMs at or near zero	CO but reading normally



2.4 Type of Fuel

Fuel Type	Proportion Used during QAL2	Normal Fuels Used	Multiple Calibration Functions Required
Natural gas	100%	Natural gas	No

2.5 Abatement

Abatement Types	Impact on Emissions
None	N/a

2.6 Stack Arrangement

Parameter	Descriptions
Arrangement	Vertical Stack
Dimensions	Circular – 2.17m
Location of the ports	c. 30 meters above ground
Number of sampling ports	Numerous
Picture of the Emission Point	
Picture of the Platform	

2.7 Monitoring Platform and Provisions

Platform	Description
Safe Working Area	Yes
Clean Working Area	Yes
Sufficient Space to Work	Yes
Weather Protection	Yes – At CEMS hut at base of stack
CEMs	
Safe Access	Yes
Easy Access	Yes
Calibration Gases Used	Yes – 6141 Compliant
Tools Available	Yes
Spare Parts Available	Yes
Gases Introduced to Analyser	Yes
Gases Introduced to Line	Yes
Compliance with EN 15259	The platform meets all criteria for platform installation.

2.8 Representative Sample

Sample Location	Description
Homogeneity Test Complete	There was no requirement for homogeneity as part of this assessment
Date of Homogeneity Test	-
Ratio High to Low Flow	<3:1 determined from previous report

2.9 CEMs Overview

Parameter	Brand	Model	Principle	QAL 1 Compliant	Location
Oxides of Nitrogen	Emerson	NGA 2000	Chemiluminescence	Yes	CEMS Hut
Carbon Monoxide	Rosemount / Emerson	NGA2000	Infra-Red	Yes	CEMS Hut
Oxygen	Rosemount / Emerson	NGA2000	Electrochemical cell	Yes	CEMS Hut

Parameter	CEMS Ranges	Wet or Dry Measurement	Horiba PG350 AMS Certified Range
Oxides of Nitrogen	0 – 100	Dry	0 - 102.5[1] mg/m^3
Carbon Monoxide	0 – 200	Dry	0 - 75 mg/m^3
Oxygen	0 - 25	Dry	0 - 25 mg/m^3

Note 1: as NO_2, this corresponds to approx. 0-67 mg/m^3 NO

2.10 Peripheral Determinands

Parameter	Recorded at CEMs
Temperature	Yes
Pressure	No
Water Vapour	No

2.11 Reference Conditions

Temperature	Pressure	Oxygen	Moisture
0 Deg C	101.3kPa	3%	0%

2.12 Sample Times

Run No	Date	Oxides of Nitrogen	Carbon Monoxide	Oxygen
1	26-06-2024	15:00 – 15:30	15:00 – 15:30	15:00 – 15:30
2	26-06-2024	16:00 – 16:30	16:00 – 16:30	16:00 – 16:30
3	27-06-2024	02:00 – 02:30	02:00 – 02:30	02:00 – 02:30
4	27-06-2024	03:00 – 03:30	03:00 – 03:30	03:00 – 03:30
5	27-06-2024	04:00 – 04:30	04:00 – 04:30	04:00 – 04:30
6	27-06-2024	05:00 – 05:30	05:00 – 05:30	05:00 – 05:30

3. Monitoring Campaign

3.1 Test Laboratory Technicians

Function	Name
Team Leader	Tim Casey
Technician	Aaron Carway

3.2 Standard Reference Methods

Substance	Standard Reference Method	Principle	Certified Range	Method Uncertainty	INAB Accreditation
Oxides of Nitrogen	EN 14792	Chemiluminescence	1.8 - 2050	<10%	Yes
Carbon Monoxide	EN 15059	NDIR	1.7 - 1250	<6%	Yes
Oxygen	EN 14789	Paramagnetic	0.1 – 26	<6%	Yes

3.3 Equipment Inventory

Type	Equipment Reference	Parameter
Horiba PG350	23EQ522	NOx, SO2, CO & O_2
Chiller Unit	24EQ512	Moisture Removal
Heated Line	22EQ510	-
Gas Blender	21EQ527	-
NO	24MG516	Calibration Gas Certified <2%
O_2	23MG502	Calibration Gas Certified <2%
CO	23MG512	Calibration Gas Certified <2%
Nitrogen	BOC	Certified Grade 99.9999%

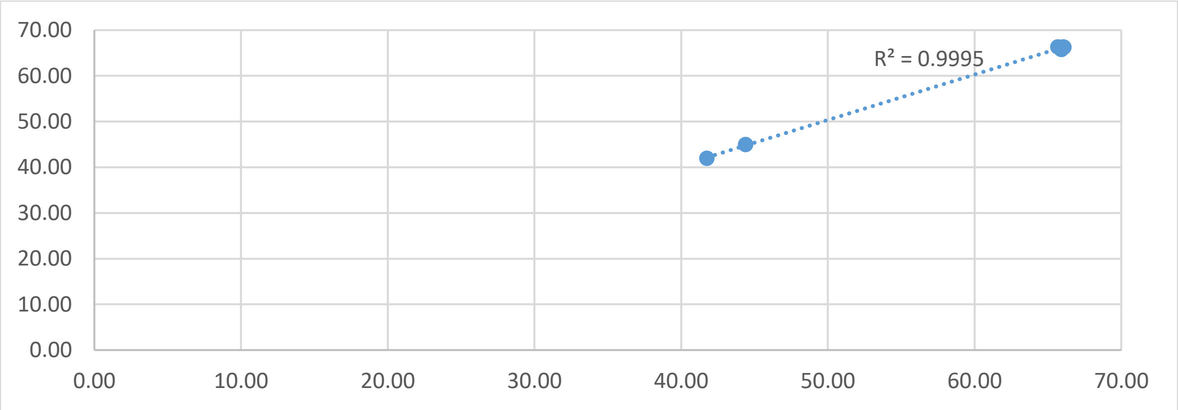
4. Calculation: Oxides of Nitrogen

4.1 Raw Data

Parameter	Oxides of Nitrogen	
Reference O_2	3	
ELV	50	
CI (%)	10	
Calibration Function	y=1.0249x + 0.0410	
Outliers	None	
Factor	2.053	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
26/06/24 15:00 - 15:30	41.76	41.99
26/06/24 16:00 - 16:30	44.40	44.94
27/06/24 02:00 - 02:30	65.68	66.30
27/06/24 03:00 - 03:30	66.04	66.34
27/06/24 04:00 - 04:30	66.09	66.28
27/06/24 05:00 - 05:30	65.92	65.78

y = bx + a	
b	1.0249
a	0.0410
Function	y=1.0249x+0.0410

Plot 4-1: Reference SRM vs Reference CEMs



4.2 Outlier Assessment

Nitrogen Oxides					
	AMS	SRM	Di	A	Outlier
Time and Date	x	y		abs(Di-Davg)	
	ppm STP Dry	ppm STP Dry			Yes / No
26/06/24 15:00 - 15:30	20.34	20.5	0.11	0.0293	No
26/06/24 16:00 - 16:30	21.63	21.9	0.27	0.1224	No
27/06/24 02:00 - 02:30	31.99	32.3	0.30	0.1616	No
27/06/24 03:00 - 03:30	32.17	32.3	0.14	0.0016	No
27/06/24 04:00 - 04:30	32.19	32.3	0.10	0.0462	No
27/06/24 05:00 - 05:30	32.11	32.0	-0.07	0.2101	No
Average			**0.1430**		
Std Dev x 2			**0.2657**		

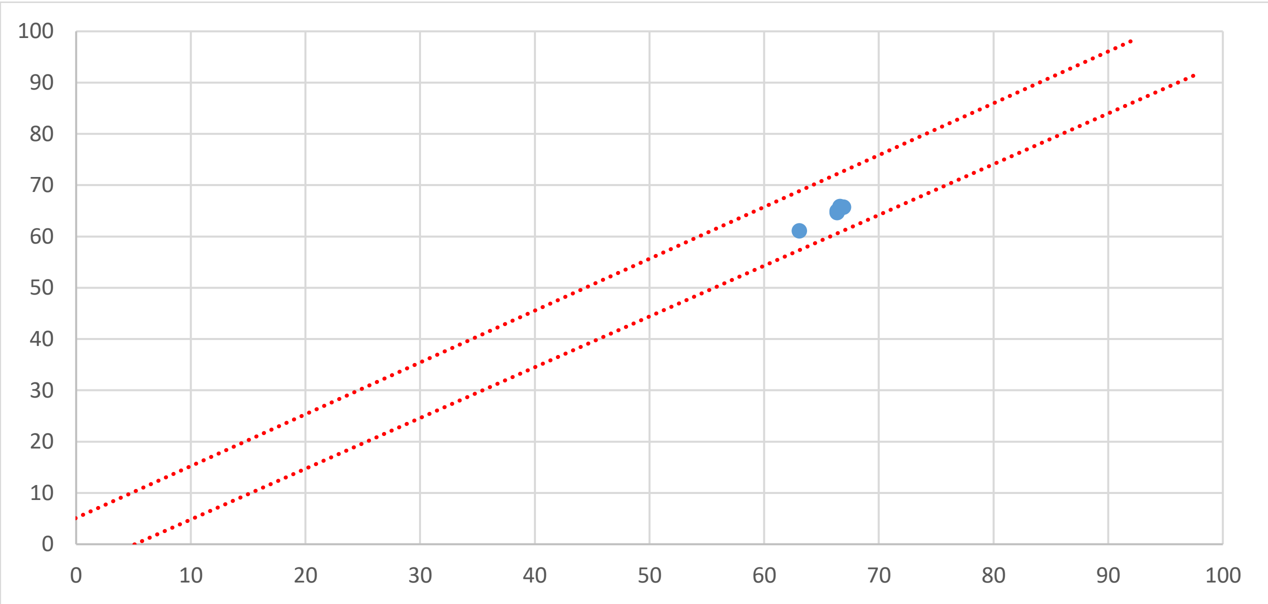
4.3 Calibration Assessment

Variability Test	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				1.0534		1.0249		
				-0.126		0.0410		
26/06/24 15:00 - 15:30	41.76	41.99	8.42	8.74	8.60	63.0804	61.1012	-1.98
26/06/24 16:00 - 16:30	44.40	44.94	8.30	8.61	8.46	66.3616	64.6540	-1.71
27/06/24 02:00 - 02:30	65.68	66.30	2.78	2.80	2.87	66.6016	65.8294	-0.77
27/06/24 03:00 - 03:30	66.04	66.34	2.76	2.78	2.83	66.9212	65.7077	-1.21
27/06/24 04:00 - 04:30	66.09	66.28	2.70	2.72	2.81	66.7107	65.5989	-1.11
27/06/24 05:00 - 05:30	65.92	65.78	2.65	2.66	2.78	66.3578	65.0006	-1.36

Calibration Test	
Average D	1.36
t 0.95, n-1	2.015
SD	0.432
σ	2.551
N	6
I D I ≤	2.91
Test	Pass

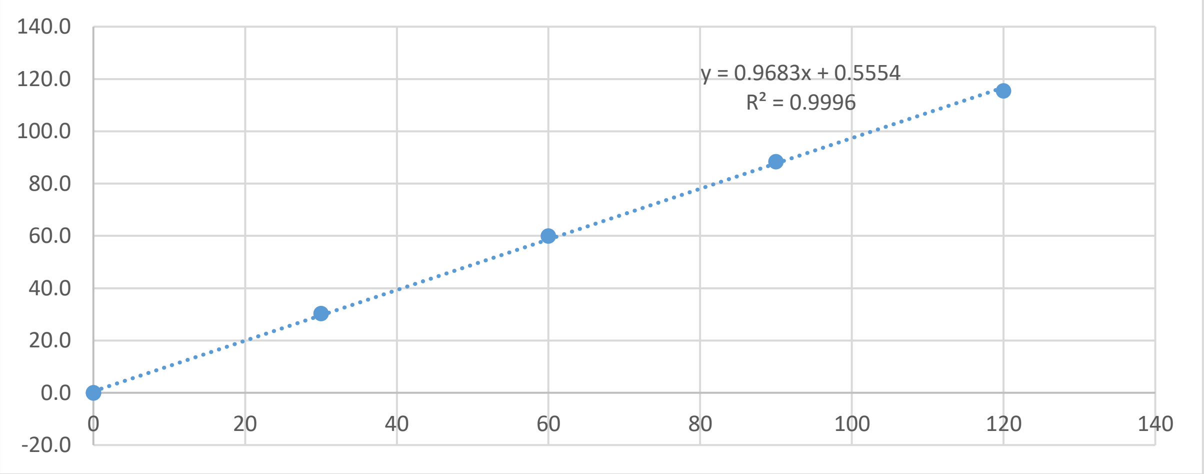
SD	0.4319
σ	2.5510
Kv	0.9329
1.5 x σ x Kv	3.5698
Test	Pass

Plot 4-2: x-y plot SRM vs CEMs



4.4 Linearity Assessment

			Nitrogen Monoxide Linearity Checks		
Effective Emission Limit Value			100	mg/m³	
Upper Range from CEMs to DCS			150	ppm	
Accuracy of the Cal Gas			<2	%	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	30.2	30.2	30.3	30.2
0%	0	-0.10	-0.1	-0.1	-0.1
40%	60	59.9	59.9	59.9	60.0
80%	120	115.5	115.5	115.5	115.4
60%	90	88.4	88.5	88.4	88.3
0%	0	0.0	0.0	-0.1	0.0
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	30.2	29.606	-20.000	400.000
2	0.00	-0.1	0.555	-50.000	2500.000
3	60.00	59.9	58.656	10.000	100.000
4	120.00	115.5	116.757	70.000	4900.000
5	90.00	88.4	87.707	40.000	1600.000
6	0.00	0.0	0.555	-50.000	2500.000
Average	50.00	48.97	Sums (?)	0.000	12000.000
			Slope	**B=**	**0.968**
			Offset	**A=**	**0.555**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-604.200	0.60	100	0.60	0.60
1	4.833	-0.65	100	-0.65	0.65
2	598.967	1.24	100	1.24	1.24
3	8083.133	-1.28	100	-1.28	1.28
4	3535.600	0.68	100	0.68	0.68
0	1.833	-0.59	100	-0.59	0.59
Sum	11620.167			Max	1.28

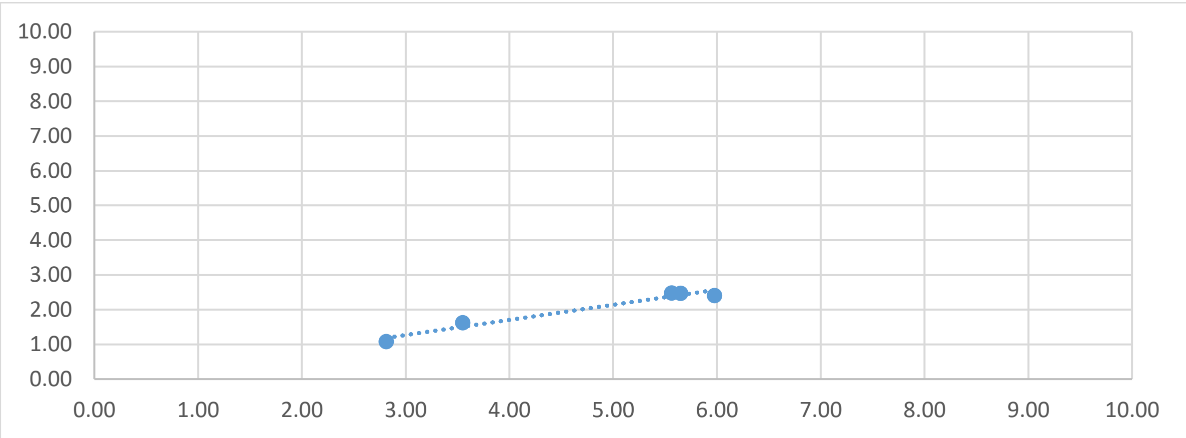


5. Calculation: Carbon Monoxide

5.1 Raw Data

Parameter	Carbon Monoxide	
Reference O_2	3	
ELV	100	
CI (%)	20	
Calibration Function	y=1.0428x - 1.7159	
Outliers	None	
Factor	1.26	
	xAMS (mg/Nm^3 Dry)	y SRM (mg/Nm^3 Dry)
26/06/24 15:00 - 15:30	3.55	1.62
26/06/24 16:00 - 16:30	2.81	1.08
27/06/24 02:00 - 02:30	5.65	2.48
27/06/24 03:00 - 03:30	5.56	2.48
27/06/24 04:00 - 04:30	5.98	2.40
27/06/24 05:00 - 05:30	5.97	2.13
y = bx + a		
b	1.0428	
a	-1.7159	
Function	y=1.0428x – 1.7159	

Plot 5-1: Reference SRM vs Reference CEMs



5.2 Outlier Assessment

Carbon Monoxide					
Run Time and Date	AMS x ppm STP Dry	SRM y ppm STP Dry	Di	A abs(Di-Davg)	Outlier Yes / No
26/06/24 15:00 - 15:30	3.55	1.6	-1.93	0.9593	No
26/06/24 16:00 - 16:30	2.81	1.1	-1.73	1.1587	No
27/06/24 02:00 - 02:30	5.65	2.5	-3.17	0.2853	No
27/06/24 03:00 - 03:30	5.56	2.5	-3.08	0.1941	No
27/06/24 04:00 - 04:30	5.98	2.4	-3.57	0.6853	No
27/06/24 05:00 - 05:30	5.97	2.1	-3.84	0.9533	No
Average			**-2.8877**		
Std Dev x 2			**1.7345**		

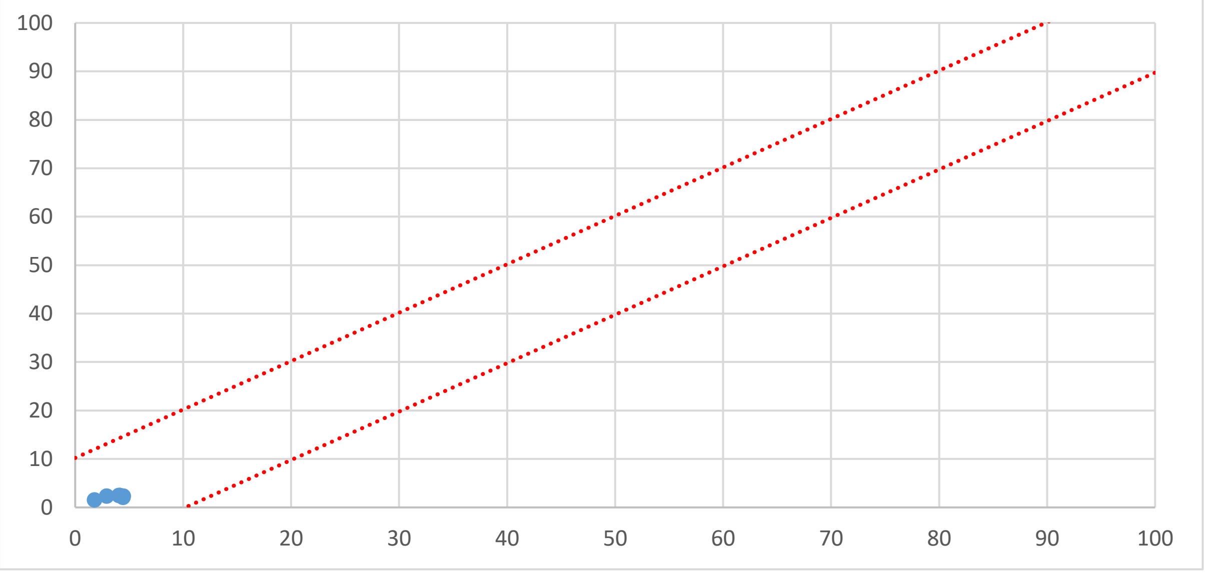
5.3 Calibration Assessment

Variability Test	xAMS (mg/Nm³ Dry)	y SRM (mg/Nm³ Dry)	O_2 AMS (%) Dry	Cal O_2 AMS (%) Dry	O_2 SRM (%) Dry	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
				1.0534		1.0428		
				-0.126		-1.7159		
26/06/24 15:00 - 15:30	3.55	1.62	8.42	8.74	8.60	2.9224	2.3576	-0.56
26/06/24 16:00 - 16:30	2.81	1.08	8.30	8.61	8.46	1.7724	1.5579	-0.21
27/06/24 02:00 - 02:30	5.65	2.48	2.78	2.80	2.87	4.1277	2.4578	-1.67
27/06/24 03:00 - 03:30	5.56	2.48	2.76	2.78	2.83	4.0373	2.4583	-1.58
27/06/24 04:00 - 04:30	5.98	2.40	2.70	2.72	2.81	4.4460	2.3789	-2.07
27/06/24 05:00 - 05:30	5.97	2.13	2.65	2.66	2.78	4.4279	2.1050	-2.32

Calibration Test	
Average D	1.40
$t_{0.95, n-1}$	2.015
SD	0.837
σ	10.204
N	6
I D I ≤	10.96
Test	Pass

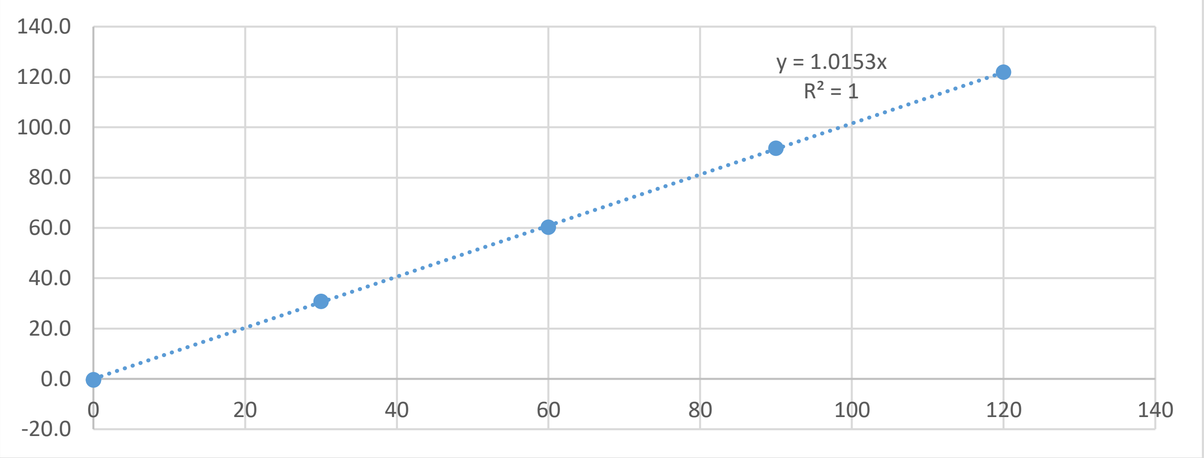
SD	0.8372
σ	10.2041
Kv	0.9329
1.5 x σ x Kv	14.2791
Test	Pass

Plot 5-2: x-y plot SRM vs CEMs



5.4 Linearity Assessment

		Carbon Monoxide Linearity Checks			
Effective Emission Limit Value			100	mg/m³	
Upper Range from CEMs to DCS			150	ppm	
Accuracy of the Cal Gas			<2	%	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	30	30.8	30.8	30.7	30.9
0%	0	-0.4	-0.3	-0.3	-0.5
40%	60	60.3	60.1	60.4	60.4
80%	120	121.9	121.9	122.0	121.8
60%	90	91.6	91.5	91.7	91.6
0%	0	-0.5	-0.5	-0.6	-0.5
Gas Divider Point	**Actual y**	**Measured x**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	30.00	30.8	30.235	-20.000	400.000
2	0.00	-0.4	-0.338	-50.000	2500.000
3	60.00	60.3	60.808	10.000	100.000
4	120.00	121.9	121.953	70.000	4900.000
5	90.00	91.6	91.380	40.000	1600.000
6	0.00	-0.5	-0.338	-50.000	2500.000
Average	50.00	50.62	Sums (?)	0.000	12000.000
			Slope	**B=**	**1.019**
			Offset	**A=**	**-0.338**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-616.000	0.57	100	0.57	0.57
1	18.333	-0.03	100	-0.03	0.03
2	603.000	-0.51	100	-0.51	0.51
3	8533.000	-0.05	100	-0.05	0.05
4	3664.000	0.22	100	0.22	0.22
0	26.667	-0.20	100	-0.20	0.20
Sum	12229.000			Max	0.57

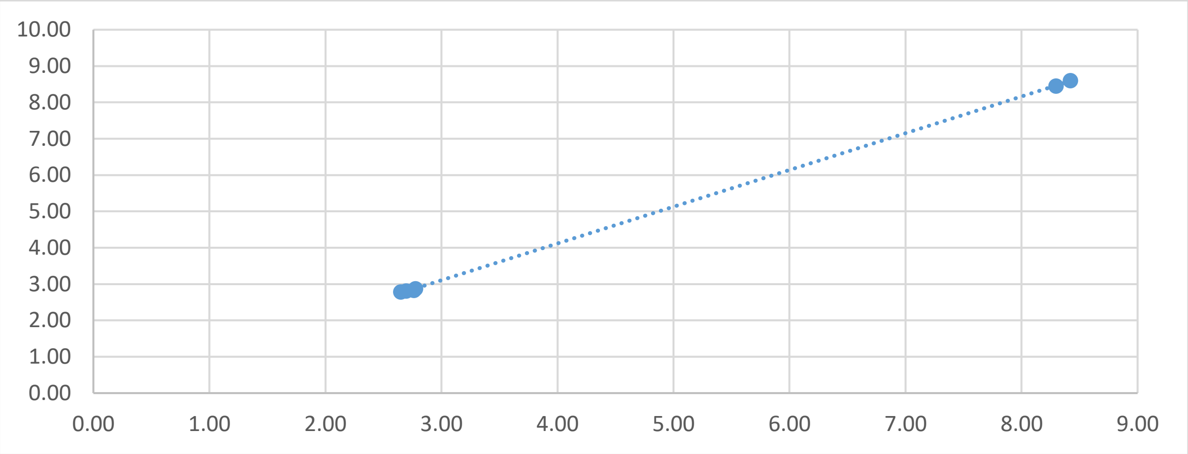


6. Calculation: Oxygen

6.1 Raw Data

Parameter	Oxygen	
Reference O2	N/a	
ELV	21	
CI (%)	10	
Calibration Function	y=1.0534x -0.1260	
Outliers	None	
	xAMS (% Dry)	y SRM (% Dry)
26/06/24 15:00 - 15:30	8.42	8.60
26/06/24 16:00 - 16:30	8.30	8.46
27/06/24 02:00 - 02:30	2.78	2.87
27/06/24 03:00 - 03:30	2.76	2.83
27/06/24 04:00 - 04:30	2.70	2.81
27/06/24 05:00 - 05:30	2.65	2.78
y = bx + a		
b	1.0534	
a	-0.1260	
Function	y=1.0534x-0.1260	

Plot 6-1: Reference SRM vs Reference CEMs



6.2 Outlier Assessment

Oxygen Run Time and Date	AMS x % Dry	SRM y % Dry	Di	A abs(Di-Davg)	Outlier Yes / No
26/06/24 15:00 - 15:30	8.42	8.60	0.18	0.05	No
26/06/24 16:00 - 16:30	8.30	8.46	0.16	0.03	No
27/06/24 02:00 - 02:30	2.78	2.87	0.10	0.03	No
27/06/24 03:00 - 03:30	2.76	2.83	0.07	0.06	No
27/06/24 04:00 - 04:30	2.70	2.81	0.12	0.01	No
27/06/24 05:00 - 05:30	2.65	2.78	0.14	0.01	No
Average			**0.1250**		
Std Dev x 2			**0.08**		

6.3 Calibration Assessment

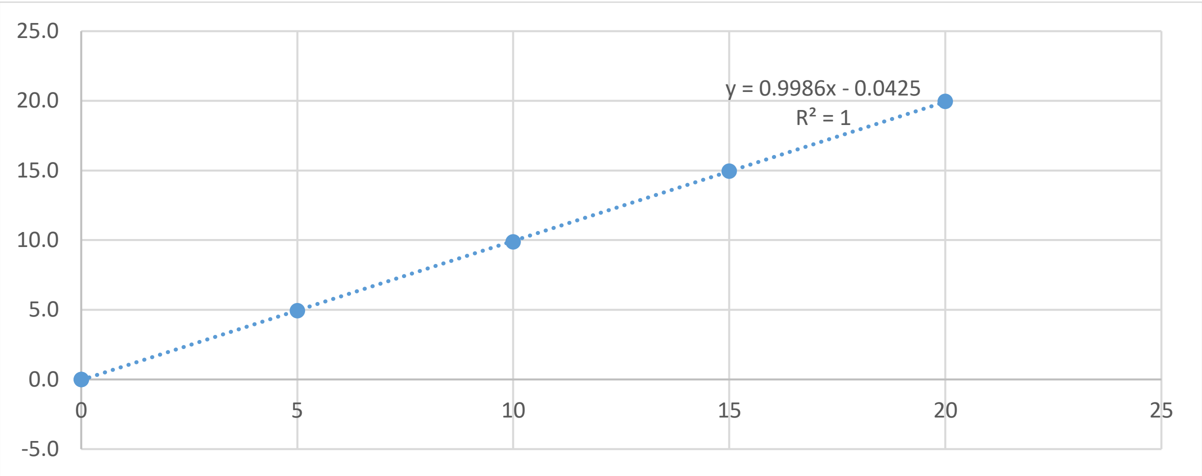
Variability Test	xAMS (% Dry)	y SRM (% Dry)	Cal AMS @ Ref Cond (% dry)	SRM @ Ref Cond (%, dry)	SRM Ref - AMS Ref
			1.0534		
			-0.1260		
26/06/24 15:00 - 15:30	8.42	8.60	8.7438	8.5983	-0.15
26/06/24 16:00 - 16:30	8.30	8.46	8.6147	8.4568	-0.16
27/06/24 02:00 - 02:30	2.78	2.87	2.7982	2.8716	0.07
27/06/24 03:00 - 03:30	2.76	2.83	2.7841	2.8278	0.04
27/06/24 04:00 - 04:30	2.70	2.81	2.7153	2.8131	0.10
27/06/24 05:00 - 05:30	2.65	2.78	2.6645	2.7850	0.12

Calibration Test	
Average D	0.01
$t_{0.95, n-1}$	2.015
N	6
I D I ≤	1.2
Test	Pass

SD	0.1243
σ	1.0714
Kv	0.9329
σ x Kv x 1.5	1.4993
Test	Pass

6.4 Linearity Assessment

			Oxygen		
			Linearity Checks		
Effective Emission Limit Value			21	**%**	
Upper Range from CEMs to DCS			25	**%**	
Accuracy of the Cal Gas			<2	**%**	
Check Point	**Expected Result**	**Yc**	**Test 1 3 x Response**	**Test 2 +1 x Response**	**Test 3 +1 x Response**
20%	5	4.9	4.9	4.9	4.9
0%	0	0.0	0.0	0.0	0.0
40%	10	9.9	9.9	9.9	9.9
80%	20	20.0	20.0	20.0	20.0
60%	15	15.0	14.9	15.0	15.0
0%	0	0.0	0.0	0.0	0.0
Gas Divider Point	**Actual %**	**Measured %**	**Regression Fit y**	**(c_i-c)**	**(c_i-c)^2**
1	5.00	4.9	4.950	-3.333	11.111
2	0.00	0.0	-0.043	-8.333	69.444
3	10.00	9.9	9.943	1.667	2.778
4	20.00	20.0	19.929	11.667	136.111
5	15.00	15.0	14.936	6.667	44.444
6	0.00	0.0	-0.043	-8.333	69.444
Average	8.33	8.28	Sums (?)	0.000	333.333
			Slope	**B=**	**0.999**
			Offset	**A=**	**-0.043**
	x_i*(c_i-c)	**dc**	**Upper Limit**	**% dc rel**	**ABS % dcrel**
0	-16.400	-0.03	25	-0.12	0.12
1	0.167	0.02	25	0.09	0.09
2	16.461	-0.07	25	-0.27	0.27
3	232.828	0.03	25	0.11	0.11
4	99.689	0.02	25	0.07	0.07
0	0.111	0.03	25	0.12	0.12
Sum	332.856			Max	0.27



7. Functional Tests

Parameter	Oxides of Nitrogen	Carbon monoxide	Oxygen
AMS Manufacturer and Model	Emerson	Rosemount / Emerson	Rosemount / Emerson
Serial Number	6003403939746	4002403939747	4002403939747
Measurement Principle	Chemiluminescence	Infra-Red	Electrochemical cell
QAL 1 Compliant	Yes	Yes	Yes
MCERTS / TUV Approved	Yes	Yes	Yes

Species	Measured Units	Measured Range	Measurement Conditions	Current QAL2 calibration function (if applicable)
NOx as NO_2	mg/m^3	0 - 100	Dry	y = 1.0249x + 0.0410
Carbon Monoxide	mg/m^3	0 - 200	Dry	y = 1.0428x - 1.7159
Oxygen	%	0 - 25	Dry	y = 1.0534x - 0.1260

Measurement Site and Installation

In-Situ & Extractive AMS	Y/N	Notes
Is there a safe and clean working environment that has sufficient space and weather protection?	Y	The probes are located on an external sampling platform, ~20m above ground level. There is no shelter on the sampling platform.
Is there easy and safe access to the AMS?	Y	Located at ground level inside dedicated enclosure hut.
Are tools, spares parts and reference materials available?	Y	All available – spare unit
Are there facilities to introduce reference materials directly to the AMS as well as through the complete system (extractive only)?	Y	Reference materials can be introduced into the instrument and in to the sample system up to the probe assembly.

Reference Materials on site

Parameter	Concentration (mg/m^3 / %)	Cylinder Number	Cylinder Expiry	Certified Accuracy
Nitrogen Monoxide	81.5	194931SG	02-06-2025	2%
Carbon Monoxide	79.7	194931SG	02-06-2025	2%
Oxygen	20.9%	Scrubbed Air	N/a	0.35%
Zero Gas	0%	-	-	-

CEMS Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	81.5	0.09	79.16	11
Carbon Monoxide	79.7	-0.1	81.9	11
Oxygen	20.9	-0.04	20.88	13

Sampling Line Leak Check

Parameter	Concentration (mg/m³ / %)	Zero (mg/m³ / %)	Span (mg/m³ / %)	Response (T_{90} – secs)
Nitrogen Monoxide	81.5	-0.03	79.15	18
Carbon Monoxide	79.7	-0.2	81.5	22
Oxygen	20.9	0.06	20.89	21

Alignment and Cleanliness

In-Situ AMS	Y/N	Notes
Internal check of the AMS	N/a	N/a
Cleanliness of the optical components	N/a	N/a
Flushing of the air supply	N/a	N/a
Any obstructions in the optical path	N/a	N/a
Alignment of the measuring systems	N/a	N/a
Contamination control (internal check of the optical surfaces)	N/a	N/a
Flushing air supply	N/a	N/a

Extractive AMS

Extractive AMS	Y/N	Notes
Sampling probe	Y	In good condition from visual inspection
Gas conditioning systems	Y	In good condition from visual inspection
Pumps	Y	In good condition from visual inspection
All connections	Y	In good condition from visual inspection
Sample lines	Y	In good condition from visual inspection
Power supplies	Y	In good condition from visual inspection
Filters	Y	Filters not removed to check
NOx converter efficiency (if applicable)	-	-
Visual inspection of sampling train	Y	In good condition from visual inspection

Linearity

Extractive	Y/N	Notes
During the calibration / linearity tests the applied concentrations should be logged onto the DAHS to prove the complete system. i.e. Concentration applied to the instrument is represented by the instrument output and identical to the value logged on the DAHS. DAHS logged values should be included in the instrument service report.	Y	Complete
The linearity of the CEM response shall be checked using five different reference materials, including a zero concentration.	Y	Complete
The reference material with zero concentration, as well as the reference materials with four different concentrations, shall have a verifiable quantity and quality.	Y	Complete
In case of gaseous reference materials, these four reference materials can be obtained from different gas cylinders or can be prepared by means of a calibrated dilution system from one single gas concentration. The uncertainty must be ≤2%	Y	Blender used on ISO 17025 gases
The reference material concentrations shall be selected such that the measured values are at approximately 20%, 40%, 60% and 80% of the range that is at least the short-term ELV. It is necessary to know the values of the ratios of their concentrations precisely enough so that an incorrect failure of the linearity test does not occur. The dry test reference material shall be applied to the inlet of the CEM. (i.e. not down the line)	Y	Applied at analyser at said concentrations.

Interference

Extractive	Y/N	Notes
NO	N	A test shall be undertaken if the process gases to be monitored contain components that are known interferences, as identified during QAL1 and there is a failure of the QAL2 or AST which could be due to interferences.
CO	N	
O_2	N	

QAL3 Checks Zero and Span Drift Audit

Extractive	Y/N	Notes
NO	Y	Successful zero and span check
CO	Y	Successful zero and span check
O_2	Y	Successful zero and span check
The test laboratory shall assess whether the operator has a QAL3 procedure in place, and whether the operator has applied this procedure. The evidence would comprise (i) a documented procedure, (ii) zero and span data, (iii) control charts. The company has all procedures and control charts in place.		

Documentation

Extractive	Y/N	Notes
A plan of the AMS	Y	We have been advised these are in place
AMS certification information	Y	We have been advised these are in place
Manuals	Y	We have been advised these are in place
Log Books (Detailing problems with the AMS and corrective action taken)	Y	We have been advised these are in place
Service Reports	Y	We have been advised these are in place
QAL3 Documentation	Y	We have been advised these are in place
Procedures for AMS maintenance, calibration and training	Y	We have been advised these are in place
Training records	Y	We have been advised these are in place
Maintenance Schedules	Y	We have been advised these are in place
Auditing plans and records	Y	We have been advised these are in place

Report

Extractive	Y/N	Notes
Are there any faults that require corrective action	N	None detected

Works Completion

Name	Company	Date	Role
Mark Byrnes	Aughinish Alumina	26-06-2024	Electrical Instrumentation
Tim Casey	AXIS Environmental services Ltd	26-06-2024	Technician

Attachment 2
Process Effluent VOC & Toxicity Reports

Toxicity Testing Report on behalf of Aughinish Alumina Limited

Sample Details

Aughinish Alumina Limited requested toxicity testing on their final effluent in quarter 1 of 2024 as part of their EPA Licence requirements.
Aughinish Alumina Limited provided a sample named ‘’W1-1 Industrial Effluent 18/01/2024’’ which was sent to Enva laboratory in Ringaskiddy for analysis. The sample was to be tested on the following species.

- 30 Minutes EC50 to *Vibrio fischeri*
- 48 Hours LC50 to *Brachionus Plicatilis*

Methods

Method 1: ENVCM.136**:** Based on ISO 11348-3:2007 Determination of the inhibitory effect of water sample on the light emission of *Vibrio fischeri*.

ISO 11348 describes three methods for determining the inhibition of the luminescence emitted by the marine bacterium *Vibrio fischeri* (NRRL B-11177). ISO 11348-3:2007 specifies a method using freeze-dried bacteria.

This method is applicable to wastewater, fresh water (surface and ground water), sea and brackish water.

Method 2 ENVCM.137: Rotifer *Brachionus plicatilis*: Based on ASTM E1440-91.

This guide describes procedures for obtaining laboratory data concerning the acute toxicity of chemicals and aqueous effluents released into estuarine or marine waters. Acute toxicity is measured by exposing *Brachionus* newly hatched from cysts to a series of toxicant concentrations under controlled conditions.

The *Brachionus plicatilis* rotifer is specific to sea and brackish water.

Client Information

Contact Name	Peter Murphy	**Address**	Aughinish Alumina Limited Aughinish, Co. Limerick

Certification Details

Certificate Number	080220242403289	**Enva Lab ID**	2403289
Date Received	19th January 2024	**Certificate Date**	08th February 2024
Order Number		**Test Date**	01st February 2024

Sample Information

Sampled By	Customer
Sampling Procedure	Grab
Storage Conditions	Refrigerated
Temperature (°C)	24.4
pH (at 25°C)	7.78
Dissolved Oxygen (mg/L)	5.75
Dissolved Oxygen (% Saturation)	65.8
Conductivity (µs/cm at 25°C)	6764

Aquatic Toxicity Test Results

Test Parameters	Concentration (% Vol./Vol.)	Toxic Units	95% Confidence Limits (% Vol./Vol.)	Method of Calculation
30 min EC50 to *Vibrio fischeri*	>100	**<1**	N/A	Microtox
48 LC50 to *Brachionus plicatilis*	>100	**<1**	N/A	Rotifer LC50 Calculation Programme

Conclusions

All tests performed were deemed to be valid as they met all the criteria specified in the guidelines.

Reported By

Bruno Caputo

Project Scientist

Enva Ireland, Cork

Toxicity Testing Report on behalf of Aughinish Alumina Limited

Sample Details

Aughinish Alumina Limited requested toxicity testing on their final effluent in quarter 3 of 2024 as part of their EPA Licence requirements.
Aughinish Alumina Limited provided a sample named ''W1-1 Industrial Effluent 16/07/2024'' which was sent to Enva laboratory in Ringaskiddy for analysis. The sample was to be tested on the following species.

- 30 Minutes EC50 to *Vibrio fischeri*
- 48 Hours LC50 to *Brachionus Plicatilis*

Methods

Method 1: ENVCM.136**:** Based on ISO 11348-3:2007 Determination of the inhibitory effect of water sample on the light emission of *Vibrio fischeri*.

ISO 11348 describes three methods for determining the inhibition of the luminescence emitted by the marine bacterium *Vibrio fischeri* (NRRL B-11177). ISO 11348-3:2007 specifies a method using freeze-dried bacteria.

This method is applicable to wastewater, fresh water (surface and ground water), sea and brackish water.

Method 2 ENVCM.137: Rotifer *Brachionus plicatilis*: Based on ASTM E1440-91.

This guide describes procedures for obtaining laboratory data concerning the acute toxicity of chemicals and aqueous effluents released into estuarine or marine waters. Acute toxicity is measured by exposing *Brachionus* newly hatched from cysts to a series of toxicant concentrations under controlled conditions.

The *Brachionus plicatilis* rotifer is specific to sea and brackish water.

Client Information

Contact Name	Peter Murphy	**Address**	Aughinish Alumina Limited Aughinish, Co. Limerick

Certification Details

Certificate Number	1508202424291347	**Enva Lab ID**	2429137
Date Received	17th July	**Certificate Date**	15th August
Order Number		**Test Date**	01st February 2024

Sample Information

Sampled By	Customer
Sampling Procedure	Grab
Storage Conditions	Refrigerated
Temperature (°C)	25
pH (at 25°C)	7.89
Dissolved Oxygen (mg/L)	4.98
Dissolved Oxygen (% Saturation)	52
Conductivity (µs/cm at 25°C)	7089

Aquatic Toxicity Test Results

Test Parameters	Concentration (% Vol./Vol.)	Toxic Units	95% Confidence Limits (% Vol./Vol.)	Method of Calculation
30 min EC50 to *Vibrio fischeri*	>100	**<1**	N/A	Microtox
48 LC50 to *Brachionus plicatilis*	>100	**<1**	N/A	Rotifer LC50 Calculation Programme

Conclusions

All tests performed were deemed to be valid as they met all the criteria specified in the guidelines.

Reported By

Bruno Caputo

Project Scientist

Enva Ireland, Cork

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Customer	*Peter Murphy*	Lab Report Ref. No.	3120/970/01
	Aughinish Alumina Ltd	Date of Receipt	04/01/2024
	Auginish Island	*Sampled On*	*04/01/2024*
	Askeaton	Date Testing Commenced	04/01/2024
	Co Limerick	Received or Collected	Courier
	Ireland	Condition on Receipt	Acceptable
Customer PO	*P4816716*	Date of Report	22/01/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
1,1,1,2-Tetrachloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1,1-Trichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1,2,2-Tetrachloroethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
1,1,2-Trichloroethane (Industrial Eff.)	154	GCMS	<2	ug/L	INAB
1,1-Dichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1-Dichloropropene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,3-Trichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,3-Trichloropropane (Industrial Eff.)	154	GCMS	<2	ug/L	INAB
1,2,4-Trichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,4-Trimethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dibromo-3-chloropropane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
1,2-Dibromoethane (Industrial Eff.)	154	GCMS	<2	ug/L	INAB
1,2-Dichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dichloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,3,5-Trimethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,3-Dichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,3-Dichloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,4-Dichlorobenzene (Industrial Eff.)	154	GCMS	<2	ug/L	INAB

Signed: A Harmon **Date: 22/01/2024**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

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All organic results are analysed as received and all results are corrected for dry weight at 104 C
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Results contained in this report relate only to the samples tested (P) : Presumptive Results

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		Date of Receipt	04/01/2024
		Sampled On	*04/01/2024*
		Date Testing Commenced	04/01/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4816716*	Date of Report	22/01/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
2,2-Dichloropropane (Industrial Eff)	154	GCMS	<5.0	ug/L	
2-Chlorotoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
4-Chlorotoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Acetone	328	GCMS	0.63	mg/L	
Acetonitrile	328	GCMS	<0.33	mg/L	
Benzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromochloromethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromodichloromethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromoform (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromomethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Carbon tetrachloride (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chloroethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Chloroform (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chloromethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
cis-1,2-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
cis-1,3-Dichloropropene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Dibromochloromethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Dibromomethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB

Signed: A Harmon **Date: 22/01/2024**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

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		Sampled On	*04/01/2024*
		Date Testing Commenced	04/01/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4816716*	Date of Report	22/01/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Dichlorodifluoromethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Dichloromethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Ethanol	328	GCMS	<0.35	mg/L	
Ethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Hexachlorobutadiene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Isopropyl Alcohol	328	GCMS	<0.34	mg/L	
Isopropylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
m- & p-Xylene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
MEK	328	GCMS	<0.22	mg/L	
Methanol	328	GCMS	<0.45	mg/L	
Naphthalene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
n-Butylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
n-Propylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
o-Xylene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
p-Isopropyltoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
sec-Butylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Styrene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
tert-Butylbenzene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
Tetrachloroethene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
Toluene (Industrial Eff)	154	GCMS	<1	ug/L	INAB

Signed: A Harmon **Date: 22/01/2024**

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		Date Testing Commenced	04/01/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4816716*	Date of Report	22/01/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
trans-1,2-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
trans-1,3-Dichloropropene (Industrial Eff.)	154	GCMS	<2	ug/L	INAB
Trichloroethene (Industrial Eff)	154	GCMS	<5.0	ug/L	
Trichlorofluoromethane (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Vinyl chloride (Industrial Eff.)	154	GCMS	<5.0	ug/L	
Volatile Organic Compounds	154	GCMS	<1.0	ug/L	
Xylene Total (Industrial Eff)	154	GCMS	<1	ug/L	

Signed: A Harmon

Date: 22/01/2024

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Customer	*Peter Murphy* *Aughinish Alumina Ltd* *Auginish Island* *Askeaton* *Co Limerick* *Ireland*	Lab Report Ref. No.	3120/2408010/01
		Date of Receipt	15/08/2024
		Sampled On	*14/08/2024*
		Date Testing Commenced	15/08/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4820627*	Date of Report	29/08/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
1,1,1,2-Tetrachloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1,1-Trichloroethane (Industrial Eff.)	154	GCMS	<0.3	ug/L	INAB
1,1,2,2-Tetrachloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1,2-Trichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1-Dichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,1-Dichloropropene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,3-Trichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,3-Trichloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,4-Trichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2,4-Trimethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dibromo-3-chloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dibromoethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dichlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dichloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,2-Dichloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,3,5-Trimethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,3-Dichlorobenzene (Industrial Eff.)	154	GCMS	<0.2	ug/L	INAB
1,3-Dichloropropane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
1,4-Dichlorobenzene (Industrial Eff.)	154	GCMS	<3	ug/L	INAB

Signed: A Harmon **Date: 29/08/2024**

Aoife Harmon - Laboratory Supervisor

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		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4820627*	Date of Report	29/08/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
2,2-Dichloropropane (Industrial Eff)	154	GCMS	<5	ug/L	
2-Chlorotoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
4-Chlorotoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Acetone	328	GCMS	<0.22	mg/L	
Acetonitrile	328	GCMS	<0.33	mg/L	
Benzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromochloromethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Bromodichloromethane (Industrial Eff.)	154	GCMS	0.5	ug/L	INAB
Bromoform (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Carbon tetrachloride (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chlorobenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chloroethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Chloroform (Industrial Eff.)	154	GCMS	<4	ug/L	INAB
Chloromethane (Industrial Eff.)	154	GCMS	<1	ug/L	
cis-1,2-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
cis-1,3-Dichloropropene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Dibromochloromethane (Industrial Eff.)	154	GCMS	<0.6	ug/L	INAB
Dibromomethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Dichlorodifluoromethane (Industrial Eff.)	154	GCMS	<1	ug/L	INAB

Signed: A Harmon **Date: 29/08/2024**

Aoife Harmon - Laboratory Supervisor

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		Date Testing Commenced	15/08/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4820627*	Date of Report	29/08/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Dichloromethane (Industrial Eff.)	154	GCMS	<3	ug/L	INAB
Ethanol	328	GCMS	<0.35	mg/L	
Ethylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Hexachlorobutadiene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Isopropyl Alcohol	328	GCMS	<0.34	mg/L	
Isopropylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
m- & p-Xylene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
MEK	328	GCMS	<0.22	mg/L	
Methanol	328	GC-FID	<0.45	mg/L	
Naphthalene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
n-Butylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
n-Propylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
o-Xylene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
p-Isopropyltoluene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
sec-Butylbenzene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Styrene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
tert-Butylbenzene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
Tetrachloroethene (Industrial Eff)	154	GCMS	<1	ug/L	INAB
Toluene (Industrial Eff)	154	GCMS	<1.1	ug/L	INAB
trans-1,2-Dichloroethene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB

Signed: A Harmon **Date: 29/08/2024**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

ilac-MRA | INAB ISO 17025 ACCREDITED TESTING DETAILED IN SCOPE REG NO.389T

For bacterial analysis a result of 0 means none detected in volume examined
All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of Fitz Scientific
Results contained in this report relate only to the samples tested (P) : Presumptive Results

** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2024)

Final results will be issued without any estimated uncertainty of measurement being applied. This can be supplied on request.
Fitz Scientific maintain all customer information in the strictest confidence which is legally enforceable.

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Customer	*Peter Murphy* *Aughinish Alumina Ltd* *Auginish Island* *Askeaton* *Co Limerick* *Ireland*	Lab Report Ref. No.	3120/2408010/01
		Date of Receipt	15/08/2024
		Sampled On	*14/08/2024*
		Date Testing Commenced	15/08/2024
		Received or Collected	Courier
		Condition on Receipt	Acceptable
Customer PO	*P4820627*	Date of Report	29/08/2024
Customer Ref	*W1-1*	*Sample Type*	*Effluent*
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
trans-1,3-Dichloropropene (Industrial Eff.)	154	GCMS	<1	ug/L	INAB
Trichloroethene (Industrial Eff)	154	GCMS	<1	ug/L	
Trichlorofluoromethane (Industrial Eff.)	154	GCMS	<1	ug/L	
Vinyl chloride (Industrial Eff.)	154	GCMS	<0.1	ug/L	INAB
Volatile Organic Compounds	154	GCMS	0.5	ug/L	
Xylene Total (Industrial Eff)	154	GCMS	<1	ug/L	

Signed: A Harmon **Date: 29/08/2024**

Aoife Harmon - Laboratory Supervisor

Acc. : Accredited Parameters by ISO/IEC 17025:2017

ilac-MRA | INAB ISO 17025 ACCREDITED TESTING DETAILED IN SCOPE REG NO.389T

For bacterial analysis a result of 0 means none detected in volume examined
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** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2024)

Final results will be issued without any estimated uncertainty of measurement being applied. This can be supplied on request.
Fitz Scientific maintain all customer information in the strictest confidence which is legally enforceable.

Attachment 3
Energy Efficiency Report

ENERGY EFFICIENCY REPORT 2024

AUGHINISH ALUMINA LIMITED

1. Table of Contents

1. Background

This report summarises the 2024 energy performance for inclusion in the Annual Environmental Report for Aughinish Alumina Limited (AAL). Reports for earlier years were included in previous Environmental Reports.

2. Energy Management System

The plant is certified to ISO 50001:2018 and successfully completed a vigilance audit by SGS in December 2024.

The plant operates a high efficiency CHP, certified as such through the Commission for Energy Regulation's scheme.

3. Steam Efficiency

Steam efficiency is reported as the energy in the total steam produced by the plant divided by the hydrate production; GJ/t. The chart below shows steam efficiency data for each year since 2020.

Steam efficiency improved in 2024 by 0.72GJ/t over 2023, the improvement being attributable to increased production over the previous year. The facility has continued to implement efficiency saving projects which will yield efficiencies in 2025. These projects are;

- Continuation of the heater retube program: 5 heaters retubed to improve overall average heat transfer coefficient
- Insulation program; phase 3, which has reduced the heat loss in the digestion area
- Desuperheating projects which will improve the long-term performance of digestion heaters.
- The boiler feedwater preheating project, to capture waste heat and use it to preheat boiler feedwater.

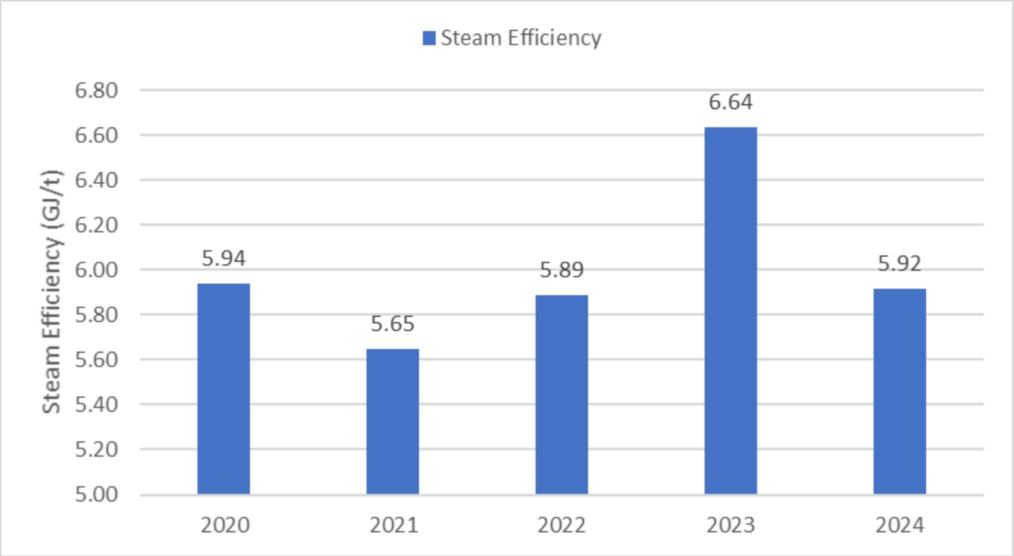

Figure 1 Steam efficiency (GJ/t) from 2020 to 2024

4. Power Efficiency

Power efficiency is reported as the electrical energy used divided by the hydrate production; GJ/t. The chart below shows the power efficiency performance for each year since 2020. The 2024 result was 0.78GJ/t.

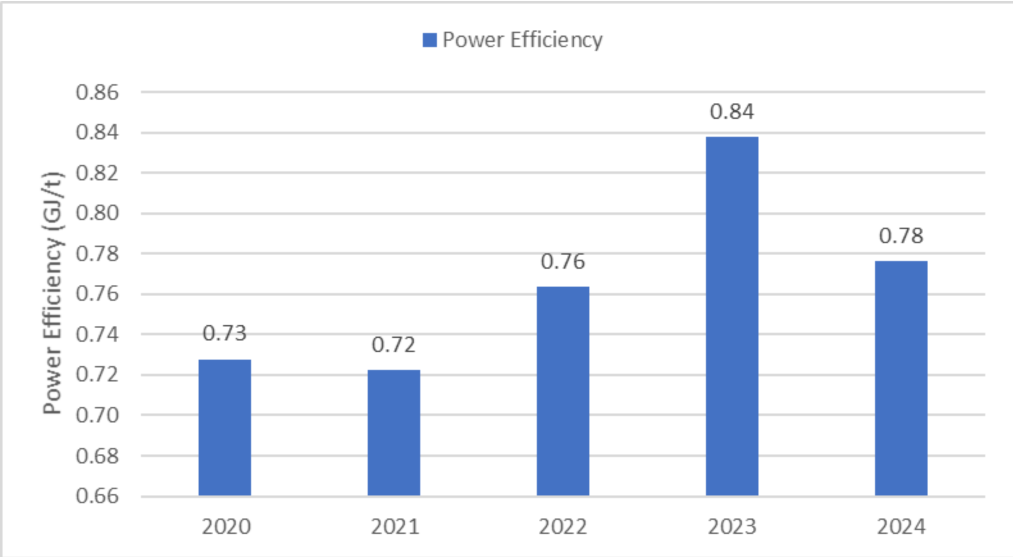

Figure 2 Power Efficiency (GJ/t) from 2020 to 2024

The high voltage Renewable Electric Boiler for the production of up to 40tons per hour steam from electricity has been operational since mid-2024 and can be called upon during periods of high renewable electricity generation .

5. Calcination

The overall calcination efficiency performance for 2024 was in line with the 2023 performance. The plant continues to monitor and optimise the air to fuel ratio, which is one of the main drivers for calcination efficiency outside of the production rate.

6. Energy Programme for 2025

Aughinish continued to maintain the energy efficiency improvements in 2024 and these will continue to be the focus of 2025.

1. Continue to heater retubing to maintain performance
2. Continue to maintain/improve the water balance project with the objective of reducing digester temperature and overall energy input to the process.
3. Insulation phase 4 program
4. Fitting of desuperheating systems to 1 no. Flash tank
5. Replacement of boiler feedwater heater and modification of existing 5^{th} stage heaters.

Attachment 4
Ambient Air Monitoring Locations

Continuous and External Ambient Air Monitoring Locations:

Parameter	1 Ballysteen (Kennricks)	3 Morgans Nth (Keanes)	4 WTP (LCC)	5 Foynes (LCC Reservoir)	7 Fawnamore (Fitzsimons)	8 A23 North	9 BRDA	11 Cronin	12 Sullivan	13 Ford
PM10 (continuous)	Osiris		Osiris	Osiris		Osiris	Osiris		Osiris	
PM2.5 (continuous)	Osiris		Osiris	Osiris		Osiris	Osiris		Osiris	
Deposited dust (monthly)		Dust Gauge (DG29)			Dust Gauge (DG30)			Dust Gauge (DG31)	Dust Gauge (DG32)	Dust Gauge (DG33)
SOx (monthly)	Diffusion tube			Diffusion tube						

Attachment 5
BRDA Restoration Works Report by Enrich

Report for

Aughinish Alumina

On

Monitoring of the BRDA 2024

From:

Enrich Environmental Limited

Date:

2025

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Introduction

Enrich took part in sampling, analysis, and observation of the soil and vegetation in areas 1-6 that were previously amended. Sampling, analysis, and observation of the soil and vegetation in the Compost-like output (CLO), Area 7a and compost trial cell, Area 7b continued. This trial cell was originally established as part of the EPA funded research project "Valorisation Alternatives to Landfill for Organic Residues". This research project was concluded in 2023. The trial areas are now managed in line with the management practices applied to previously revegetated areas

Herbage and soil samples were collected by Enrich staff in June 2024. The grass was cut on three occasions. (July, late August/early September, and October), with aeration completed in July and October. Topdressing was applied in October after cutting and collection, and thatch was removed in November.

2. Site Information

2.1 Location

Aughinish

Figure 1: Arial view of Aughinish BRDA Areas 1-7

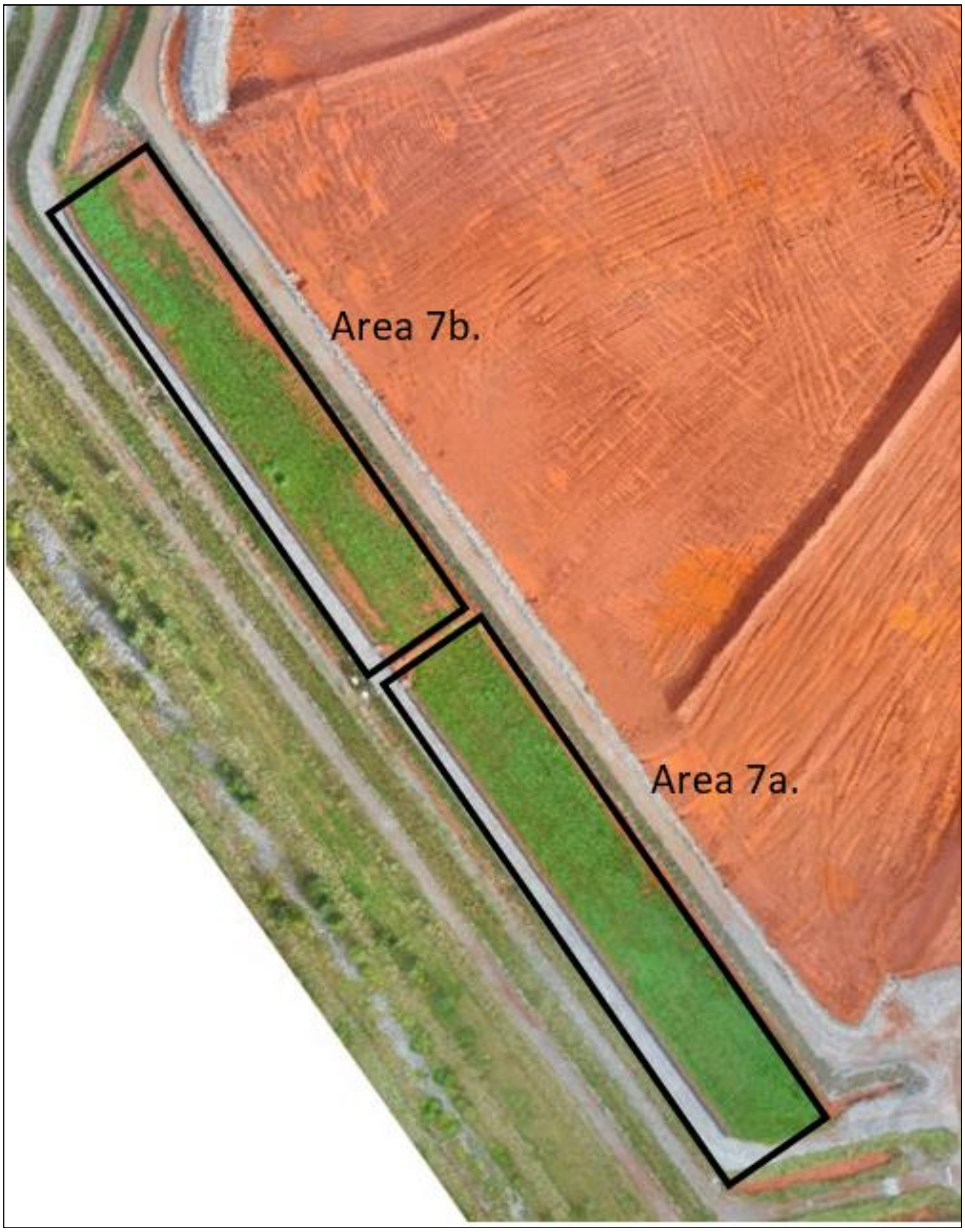

Figure 2: Arial View of Trial Cells. Area 7a was amended with Compost-like output and, Area 7b was amended with compost

3. Methods

To ensure a representative sample was taken for the herbage and soil analyses, a minimum sample size of 20 grab samples was taken for each. The grab samples were then homogenously mixed, and the final sample was taken from this homogenous mixture. Each sample was taken from each area by walking in a "W" pattern.

Soil samples were analysed for pH, % organic matter, total nitrogen, available phosphorous, potassium magnesium, sodium, and calcium, electrical conductivity, cation exchange capacity and exchangeable potassium, magnesium, sodium, and calcium.

Herbage samples were analysed for total nitrogen, phosphorous, potassium, calcium, magnesium, sodium, sulphur, manganese, copper, zinc, iron, boron, lead, molybdenum, nickel, cadmium, aluminium, mercury, arsenic, chromium, and titanium.

Sample ID	Area
OH24001	1
OH24002	2
OH24003	3
OH24004	4
OH24005	5
OH24006	6
OH24007	7a
OH24008	7b

Table 1: List of soil samples taken in June 2024 in Aughinish Alumina

Sample ID	Area
OH24017	Grass Control
OH24009	1
OH24010	2
OH24011	3
OH24012	4
OH24013	5
OH24014	6
OH24015	7a
OH24016	7b

Table 2: List of grass samples taken in June 2024 in Aughinish Alumina

4. Results and Analysis

4.1 Soil Analysis and Interpretation

4.1.1 Soil Analysis

Sample ID	Area	Soil pH	Organic Matter (%)	Electrical Conductivity (uS/cm)	Total Nitrogen (%w/w)
OH24001	1	8.5	14	265	0.339
OH24002	2	8.3	16.9	210	0.549
OH24003	3	8.4	15.4	218	0.512
OH24004	4	8.3	15.8	242	0.454
OH24005	5	8.8	11.7	273	0.269
OH24006	6	8.7	10.3	530	0.173
OH24007	7a	8.8	11.1	361	0.220
OH24008	7b	8.4	10.4	343	0.234

Table 3: Soil pH, Organic Matter, Electrical Conductivity and Total Nitrogen

Sample ID	Area	P (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	Ca (mg/l)
OH24001	1	20.4	229	187	267	1946
OH24002	2	25.2	223	207	209	1847
OH24003	3	25	225	203	209	1838
OH24004	4	28.6	243	195	291	1830
OH24005	5	27.2	259	197	622	1344
OH24006	6	22.4	247	148	839	1313
OH24007	7a	25.8	219	202	535	1506
OH24008	7b	19.8	134	67.4	478	1612

Table 4: Soil available Phosphorus (P), Potassium (K), Magnesium (Mg), Sodium (Na) and Calcium (Ca)

Sample ID	Area	Ca (meq/100g)	K (meq/100g)	Mg (meq/100g)	Na (meq/100g)	CEC (meq/100g)
OH24001	1	8.5	0.91	3.26	2.22	14.9
OH24002	2	10.2	0.93	4.09	1.93	17.5
OH24003	3	10.2	0.90	3.70	1.81	16.7
OH24004	4	12.2	0.96	3.71	2.19	19.4
OH24005	5	3.8	1.23	4.33	4.94	14.3
OH24006	6	1.9	1.03	2.65	6.59	12.2
OH24007	7a	4.2	0.85	2.93	4.87	12.9
OH24008	7b	5.6	0.44	1.32	3.04	10.5

Table 5: Soil exchangeable Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na) and Cation Exchange Capacity (CEC).

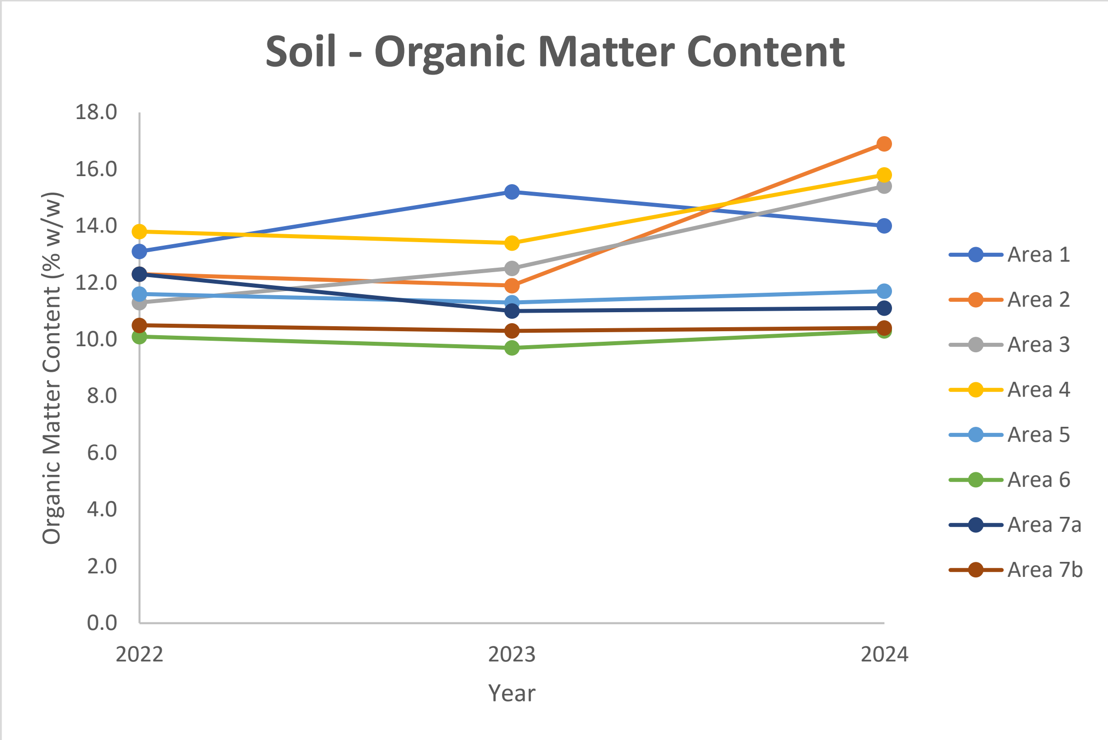

Figure 3: Areas 1-6 Organic Matter LOI

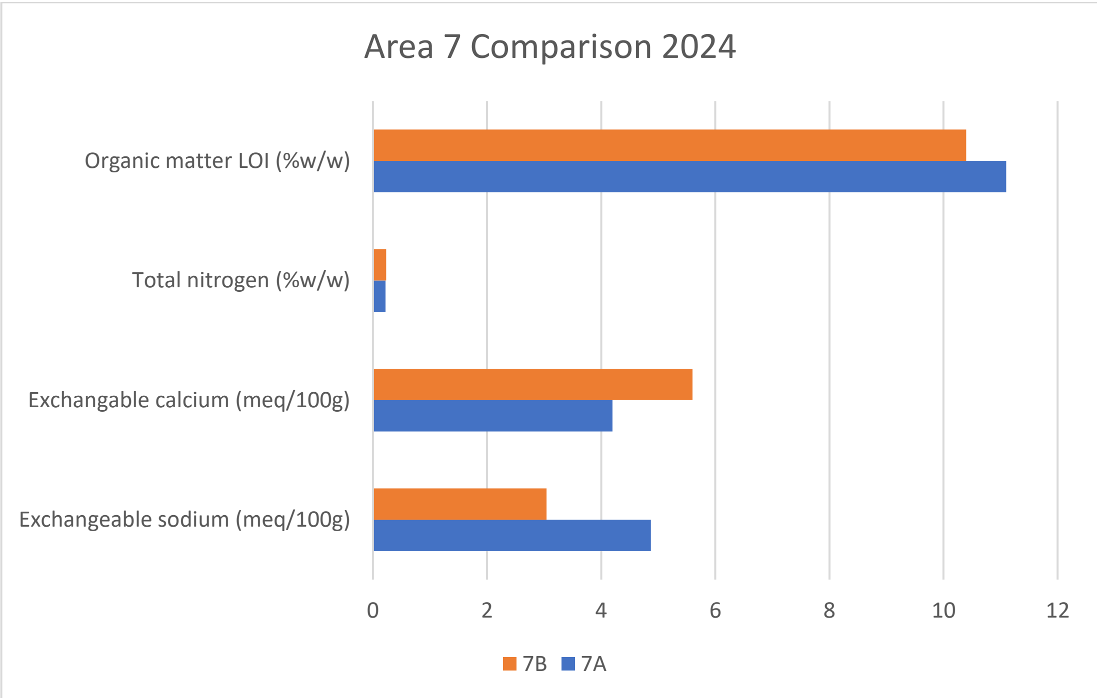

Figure 4: Area 7 (Trial Cell) Comparison

Figure 5: Area 1 Visual Analysis

Figure 6: Area 1 Soil Profile

4.1.2 Interpretation

The principle parameters in the soil analyses for the remediation of the Bauxite Residue Disposal Area (BRDA) are sodium, calcium and organic matter. The chemical process used to extract alumna from unprocessed bauxite is called the Bayer process. As a result of this chemical process, sodium concentrations become overly abundant in the bauxite residue that is subsequently stored in the BRDA. The sodium ions bind to the bauxite particles, and prevent particle aggregation form occurring, thus creating a dispersed structure within the residue.

To address the problem of sodium concentrations, gypsum is incorporated into the BRDA remediation mix. Gypsum provides a supply of calcium ions, which preferentially displace sodium ions from cation exchange sites, thereby reducing sodium concentrations.

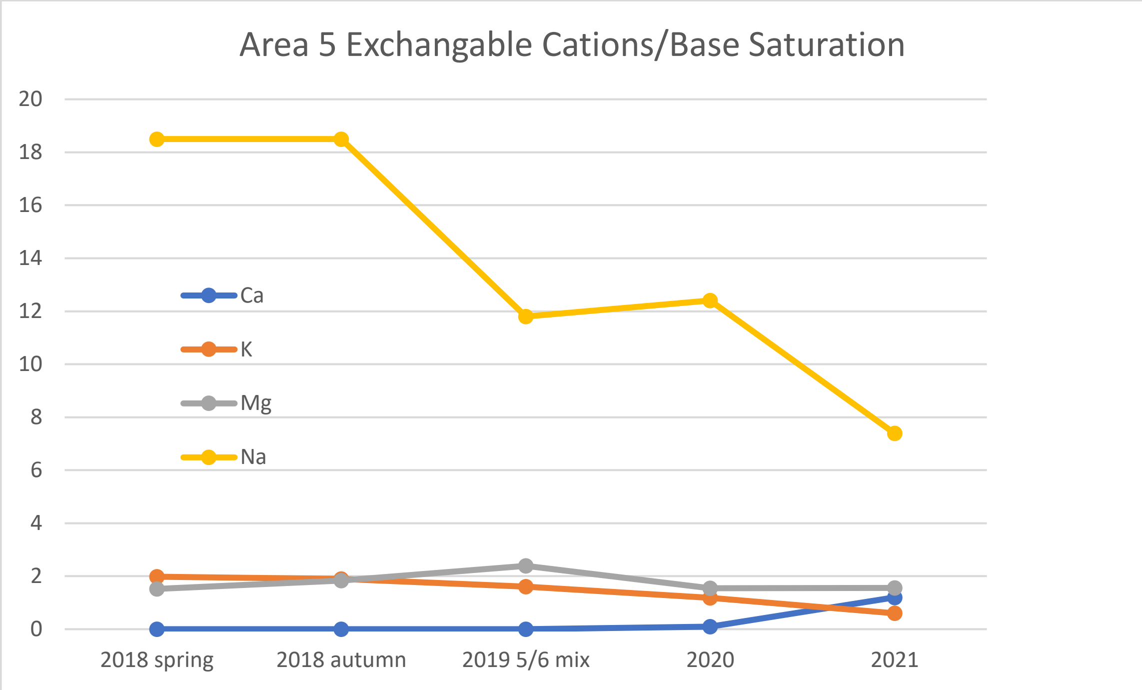

Figure 7: Graph showing Exchangeable Cation Trends

Figure 8: Visual of Area 5

As can be seen from the exchangeable sodium trend shown in Figure 7, sodium concentrations have been decreasing across time in the BRDA remediated areas. The exchangeable calcium, potassium and magnesium are also on a slight increase. This would be beneficial for reducing the binding capacity of the soil and sodium. This trend is also replicated in Areas 1-4 and Area 6, 7a, 7b.

Another expected outcome of this remediation strategy is the increase in calcium concentrations over time. This is the case for areas 1 through 5. Area 6 has had consistently low concentrations of calcium across time (under 0.1meq/100g). However, as can be seen from the herbage analysis results below, calcium concentrations found in the plant tissue of area 6 are no different to calcium concentrations found in the plant tissue of areas 1 to 5.

As indicated in Figure 3 the percentage of organic matter also shows an upward trend with each passing year. This would be expected, as organic amendments have been incorporated into the BRDA remediation areas annually. In combination with the addition of organic amendments, the natural life cycle of vegetation will contribute to the increase in organic matter concentrations. As green plants grow, they synthesise a host of carbon compounds for a range of purposes, such as structural integrity and food storage. These carbon compounds are made through the conversion of carbon dioxide from the atmosphere fuelled by energy from the sun. When these green plants die, the organic matter they synthesised through their lifetime is incorporated into the soil ecosystem.

The importance of maintaining adequate concentrations of organic matter in the BRDA remediation areas cannot be overstated, as organic matter is crucial to fostering soil microbiological life. Soil microbiological life is important as it creates the soil conditions for sustainable vegetation growth on the bauxite residue disposal areas. This will help Aughinish Alumina successfully meet their post-closure criteria.

2022 was the first year both soil and herbage samples were taken from the trial cell where CLO was incorporated into the remediation mix instead of compost. The "Area 7 Comparison" chart (Figure 4) shows that the CLO section outperformed the compost section in a few key parameters. This is an encouraging result as using CLO as the soil improver ensures a predictable supply of organic amendments into the future as compost and other sources are increasingly moved towards higher value uses in food and agriculture production.

4.2 Herbage Analysis and Interpretation

4.2.1 Herbage Analysis

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7a)	Arae 7b)
Total Nitrogen DUMAS (% w/w)	1.15	1.28	11.3	1.19	1.53	1.38	1.39	1
Total Phosphorous (mg/kg)	2905	2269	2572	2300	2588	2020	1540	1395
Total Potassium (mg/kg)	18867	17315	18017	15930	17519	17600	17728	16656
Total Calcium (mg/kg)	2733	4116	2943	3065	2827	2140	3253	1114
Total Magnesium (mg/kg)	1078	1296	1274	1264	1681	1230	925	1017
Total Sodium (mg/kg)	2140	1812	4393	3061	2641	5390	1726	2006
Total Sulphur (mg/kg)	1722	1435	2231	2005	2023	2500	1166	942
Total Manganese (mg/kg)	18.1	16	36.9	31.8	52.6	43.3	36.5	36.3
Total Copper (mg/kg)	4.2	4.5	4.2	3.9	4.5	4	4.3	2.6
Total Zinc (mg/kg)	17.8	22.1	19.5	16.6	21.4	18.8	30.8	14.6
Total Iron (mg/kg)	65.8	52.7	91.7	104	141	117	140	65
Total Boron (mg/kg)	4.8	7.8	7	5.6	8.2	6	7.3	4.9
Total Lead (mg/kg)	0.06	≤0.06	0.08	0.07	0.1	0.09	0.11	0.06
Total Molybdenum (mg/kg)	3.77	2.98	3.37	3.68	2.26	3.29	1.11	0.91
Total Nickel (mg/kg)	0.7	0.7	0.5	0.5	0.4	0.4	0.3	0.3
Total Cadmium (mg/kg)	0.01	0.01	≤0.01	≤0.01	≤0.01	≤0.01	0.02	≤0.01
Total Aluminium (mg/kg)	21	18	36	31	32	44	38	25
Total Mercury (mg/kg)	≤0.01	≤0.01	≤0.01	0.01	0.01	0.01	0.01	0.01
Total Arsenic (mg/kg)	0.03	0.03	0.09	0.06	0.07	0.11	0.07	0.05
Total Chromium (mg/kg)	1	0.8	≤1	1.1	1.2	1.1	0.7	0.7
Total Titanium (mg/kg)	3.6	4.3	4.6	5	5.7	5	5.4	2.8

Table 6: Herbage Analysis Results 2022

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7a)	Area 7b)
Total Nitrogen DUMAS (% w/w)	1.89	1.65	1.6	1.78	1.74	1.56	1.94	2.07
Total Phosphorous (mg/kg)	3169	3131	2687	2823	3061	3083	3364	2999
Total Potassium (mg/kg)	24634	23823	21038	20781	24445	20962	30406	24532
Total Calcium (mg/kg)	4602	3992	3568	3543	2569	3171	3401	4232
Total Magnesium (mg/kg)	1894	1671	1551	1663	1759	1853	1234	1480
Total Sodium (mg/kg)	1121	955	1074	1146	2270	3871	2051	2888
Total Sulphur (mg/kg)	1972	1700	1492	1542	1587	1769	2068	1637
Total Manganese (mg/kg)	14.8	16.9	18.1	18	28.5	52.7	25.3	17.7
Total Copper (mg/kg)	4.9	4.3	4.9	4.5	4.8	4.8	7.3	5.4
Total Zinc (mg/kg)	21.4	19.2	18.5	17.1	19.3	17.4	31.9	20.9
Total Iron (mg/kg)	203	166	63.5	84.1	88.1	195	83.9	152
Total Boron (mg/kg)	7.3	5.8	4.4	5.8	9.7	9.6	8.9	8.1
Total Lead (mg/kg)	0.2	0.12	<0.06	0.08	<0.06	0.08	0.10	<0.06
Total Molybdenum (mg/kg)	3.14	2.44	2.56	2.7	1.08	1.78	0.97	1.27
Total Nickel (mg/kg)	0.6	0.5	0.5	0.6	0.4	0.4	0.6	0.4
Total Cadmium (mg/kg)	0.02	0.01	0.01	0.01	≤0.01	0.01	0.02	≤0.01
Total Aluminium (mg/kg)	60	47	21	25	26	42	25	21
Total Mercury (mg/kg)	≤0.01	≤0.01	≤0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Arsenic (mg/kg)	0.05	0.04	<0.02	0.03	0.04	0.06	0.04	0.03
Total Chromium (mg/kg)	1.3	1.2	7.7	11.6	0.7	1.1	0.7	0.6
Total Titanium (mg/kg)	10.9	10.7	5.1	5.5	4.0	6.4	4.6	5.5

Table 7: Herbage Analysis Results 2023

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7a)	Area 7b)
Total Nitrogen DUMAS (% w/w)	1.71	1.59	1.52	1.87	2.23	1.71	1.67	1.74
Total Phosphorous (mg/kg)	3170	2838	2671	3466	3300	2648	3114	2801
Total Potassium (mg/kg)	23957	24566	22087	25329	23956	21698	26087	24186
Total Calcium (mg/kg)	4305	3459	3844	3521	2599	3144	4039	3509
Total Magnesium (mg/kg)	1352	1516	1478	1401	1869	1311	1559	1316
Total Sodium (mg/kg)	758	789	817	900	3352	1187	2268	7302
Total Sulphur (mg/kg)	2115	1705	1638	2111	2046	1391	2025	1808
Total Manganese (mg/kg)	25.1	12.9	13.5	18.1	133	43.7	24.3	22.6
Total Copper (mg/kg)	3.7	4.3	4	5.3	6.7	5	4.5	5.1
Total Zinc (mg/kg)	18	17.6	16.5	42.8	24.8	22.4	23.9	27.9
Total Iron (mg/kg)	82.1	101	65.3	102	71	74	84.4	81.7
Total Boron (mg/kg)	6.9	6.6	8.8	7.6	8.4	8.1	12.1	8
Total Lead (mg/kg)	0.17	0.15	0.09	0.18	0.09	0.07	0.1	0.19
Total Molybdenum (mg/kg)	2.47	1.60	1.95	3.60	1.98	1.91	1.30	1.3
Total Nickel (mg/kg)	0.6	0.5	0.4	0.5	0.3	0.3	0.6	0.5
Total Cadmium (mg/kg)	00.02	0.01	0.01	0.01	0.01	<0.01	0.02	<0.01
Total Aluminium (mg/kg)	68	50	31	44	28	42	44	54
Total Mercury (mg/kg)	0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01
Total Arsenic (mg/kg)	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.04
Total Chromium (mg/kg)	0.9	0.7	0.6	0.7	0.5	0.7	1.1	0.5
Total Titanium (mg/kg)	4.4	3.3	3.8	4.1	2.5	3.2	4.5	3.6

Table 8: Herbage Analysis Results 2024

4.2.2 Interpretation

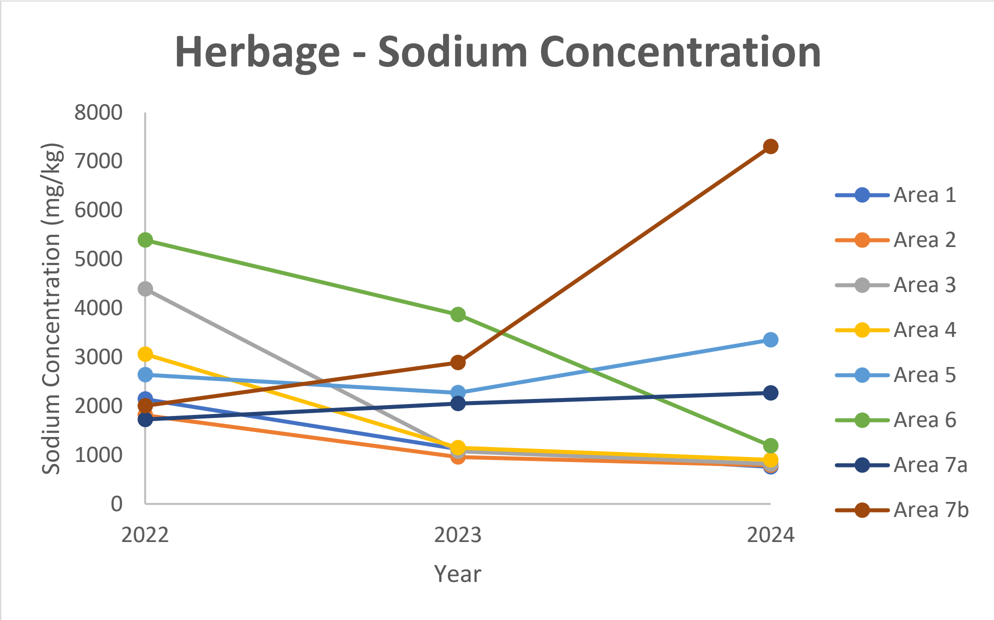

Figure 9: Graph showing Na concentration in herbage, 2022-2024

The remediation strategy at Aughinish Alumina's Bauxite Residue Disposal Area (BRDA) is showing promising progress, with both Compost-Like Output (CLO) and compost contributing positively to soil restoration and vegetation growth.

The incorporation of compost has enhanced soil structure and organic matter content, supporting microbial activity and fostering long-term soil stability. It provides a gradual release of nutrients, which helps sustain plant growth over time. Additionally, compost contributes to improving soil aggregation, which enhances water retention and aeration—key factors for healthy vegetation.

On the other hand, CLO has also demonstrated strong results, particularly in reducing sodium toxicity. The high levels of potassium (K) and ammonium nitrogen (NH_4-N) in CLO influence nutrient uptake, effectively limiting sodium absorption in plants. While this creates some nutrient competition (cation antagonism), it plays a crucial role in mitigating the negative effects of excess sodium.

Both amendments contribute to the increasing organic matter levels, which is essential for sustaining soil health and biodiversity. The continued use of compost and CLO in different areas ensures a balanced approach to soil rehabilitation, fostering a self-sustaining ecosystem that supports long-term biodiversity at Aughinish. The bauxite storage area has the potential to create useful habitat for a diversity of plant and animal life. The development of such an ecosystem is dependent on a self-sustaining soil system. The soil and herbage analysis have indications that this process is now well under way on the side slopes which have been remediated and revegetated.

Moving forward Enrich intends to work closely with the multidisciplinary team at Aughinish to advance the biodiversity and long-term sustainability of the soil management in Aughinish.

Attachment 6
Constructed Wetland Overview

Constructed Wetland – Performance for 2024

Overview

Bauxite residue from the Bayer process contains residual caustic soda with alkaline leachate of pH > 10.5. Bauxite Residue Disposal Area (BRDA) closure and aftercare plans must address the timeframes required for leachate to reduce to ≤ pH 9.0 so it can be discharged to the receiving environment. A novel approach to ensure that BRDA leachate can be passively treated and made suitable for discharge within a short period (months) of BRDA closure is to incorporate constructed wetland(s) into the Closure Plan. Constructed wetlands are gaining global acceptance by regulators in mine closure.

Constructed Wetland - Field Demonstration

In 2012 Aughinish Alumina received funding from its owner UC Rusal and the International Aluminium Association for a research programme investigating the use of a constructed wetland to treat alkaline residue leachate. A field scale wetland demonstration unit was implemented in August 2013 and successfully treated leachate to pH <9 over a 1 year period.

A second phase of the field demonstration commenced in Spring 2015. To determine the effectiveness of wetland technology for treating leachate with low Ca, the mixing system was modified to use de-ionised water for dilution. Results to date (Figure 1) demonstrate that the constructed wetland can effectively buffer alkalinity of low Ca content residue leachate over a 116 month period. The trial wetland is successfully treating alkaline residue leachate to pH<9 with no indications of the system reaching capacity. The 10 years of continuous wetland operation, plus the previous 1-year operation from Phase I, illustrates the capacity for wetland systems to treat alkaline bauxite residue leachate for 10+ years.

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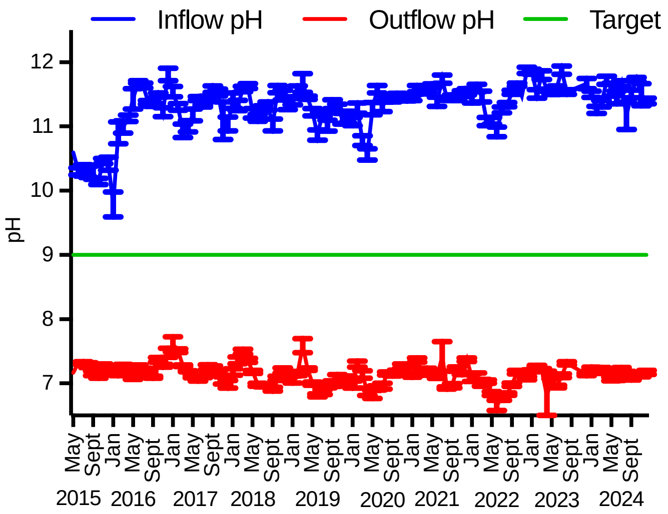

Figure 1. **Monthly average pH values of inflow and outflow in constructed wetland treating bauxite residue leachate**

For 2024, CW feed (inflow) pH monthly mean varied between 11.17 and 11.73 (mean 11.49) with treated leachate (outflow) ranging from 7.07 to 7.24 (mean of 7.15) (Fig. 1) with consistent reduction to below the target value (pH 9).

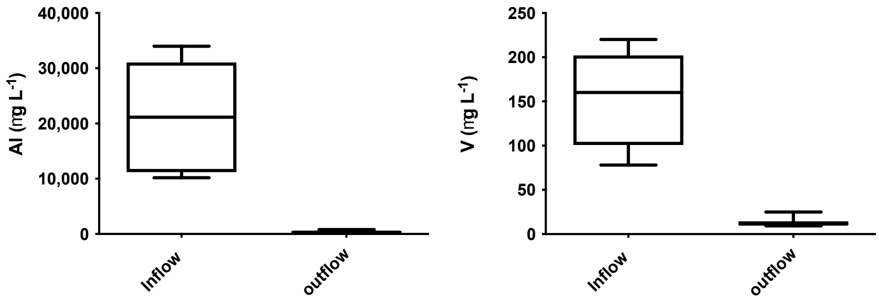

Figure 2. **Trace element (Al and V) content in constructed wetland inflow and outflow water for year 2024**

Content of both Al and V was significantly decreased in wetland outflow. Reductions in trace element (mean values) were Al 98 % and V 92 %.

Findings & Continuing Work

Decrease in leachate pH is achievable within a constructed wetland with results achieved below the target pH 9 permissible for discharge. Successful reduction of leachate pH has now been achieved for ca. 10 years over Phase I and Phase II operation. The bauxite residue leachate trial wetland system will continue to be operated and monitored.

New Constructed Wetland Trials

Operation and monitoring of the current constructed wetland (CW) has demonstrated the suitability of this technology to treat alkaline leachate in the medium/long term (ca. 10 years) (Figure 1). Further, laboratory trials have demonstrated the increased efficiency in organic amended soils for pH reduction and element removal and retention rates. Within the CW, soil analysis has indicated 'front-loading' of wetland soils with increases in pH and Na content (Figure 3).

To assess longevity and management implications of CW operation, two new upscaled and multi-celled (3-cells) CW were installed on the BRDA. Previous laboratory trials have demonstrated that addition of organic matter to soil increased both rate of pH reduction, with greater decreases also recorded. To further explore the addition of organic matter to CW substrate material, the new CW treatments consist of unamended soil (no organic amended) and soil with organic added (unamended). Each CW treatment is composed of 3 cells and received leachate from a PLC controlled leachate/ water mixing tank (Figure 3).

Following an acclimatisation period, discharge of alkaline leachate (ca. pH 11) to the CW commenced in May 2024. A monitoring and assessment programme will assess the long-term potential of CW treatment for alkaline leachates and highlight any potential post-closure management requirements

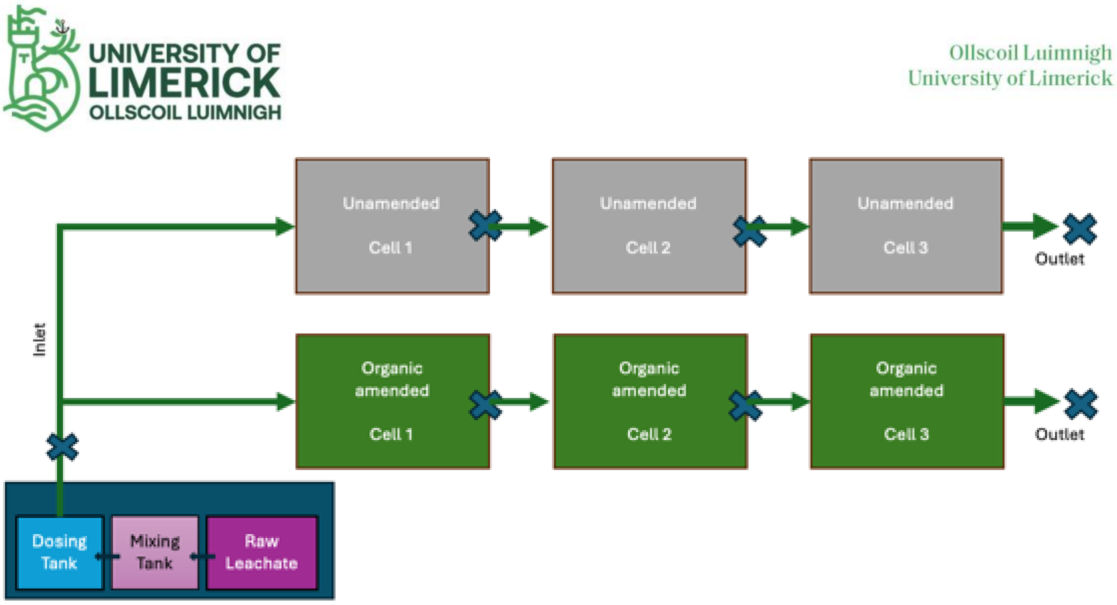

Figure 3. Schematic of upscaled constructed wetland (CW) trials, showing multi-celled design and organic/ unamended treatments

Wetland feed (inflow) pH monthly mean varied between 11.08-11.41 (mean 11.24) with treated leachate (outflow) in the organic amended CW ranging from; Cell 1 7.6 to 7.9 (mean of 7.76), Cell 2 7.4 to 7.6 (mean 7.51), Cell 3 7.1 – 7.5 (mean 7.3), and in the CW without organic amendment the outflow pH in Cell 1 ranged 7.9 – 8.5 (mean 8.1), Cell 2 7.5 - 7.8 (mean 7.7), and Cell 3 7.4 – 7.7 (mean 7.6). (Fig. 4). Outflow for all Cells across the two treatments showed consistent reduction to below the target value (pH 9).

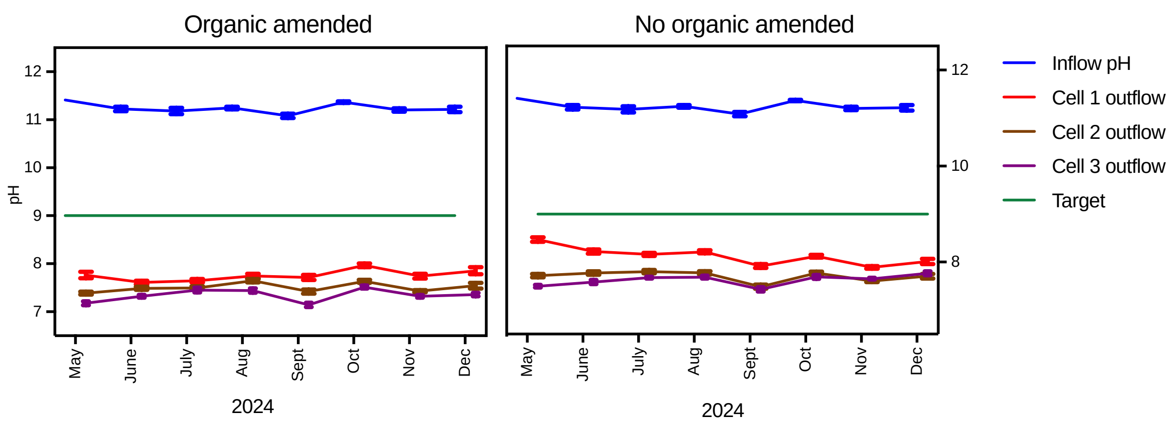

Figure 4. Monthly average pH values of inflow and outflow in constructed wetland (CW) treatments (organic/ no organic) and CW cells treating bauxite residue leachate

Residue Rehabilitation – Demonstration Cell

A demonstration cell was implemented in 2023, to trial rehabilitation strategies assessing depth of amended cover (0.3 m and 1m), gypsum application rate (45 t/ha and 90 t/ha) and the installation of a capillary layer (capillary layer and no capillary layer). Following standard residue rehabilitation procedures, amended residue was seeded with grassland mix in September 2023. Established vegetation growth in the following February and May (2024) are shown in Figure 5.

Figure 5. Photograph of residue rehabilitation demonstration cell in February 2024 (left) and May 2024 (right).

Samples of residue and vegetation were taken in Summer 2024. Results of vegetation analysis are shown for N, P and Mn (Figure 6) and for nutrient cations (Na, Ca, Mg and K) (Figure 7). Results for non-nutrients elements As, Cr and V were all below limit of detection.

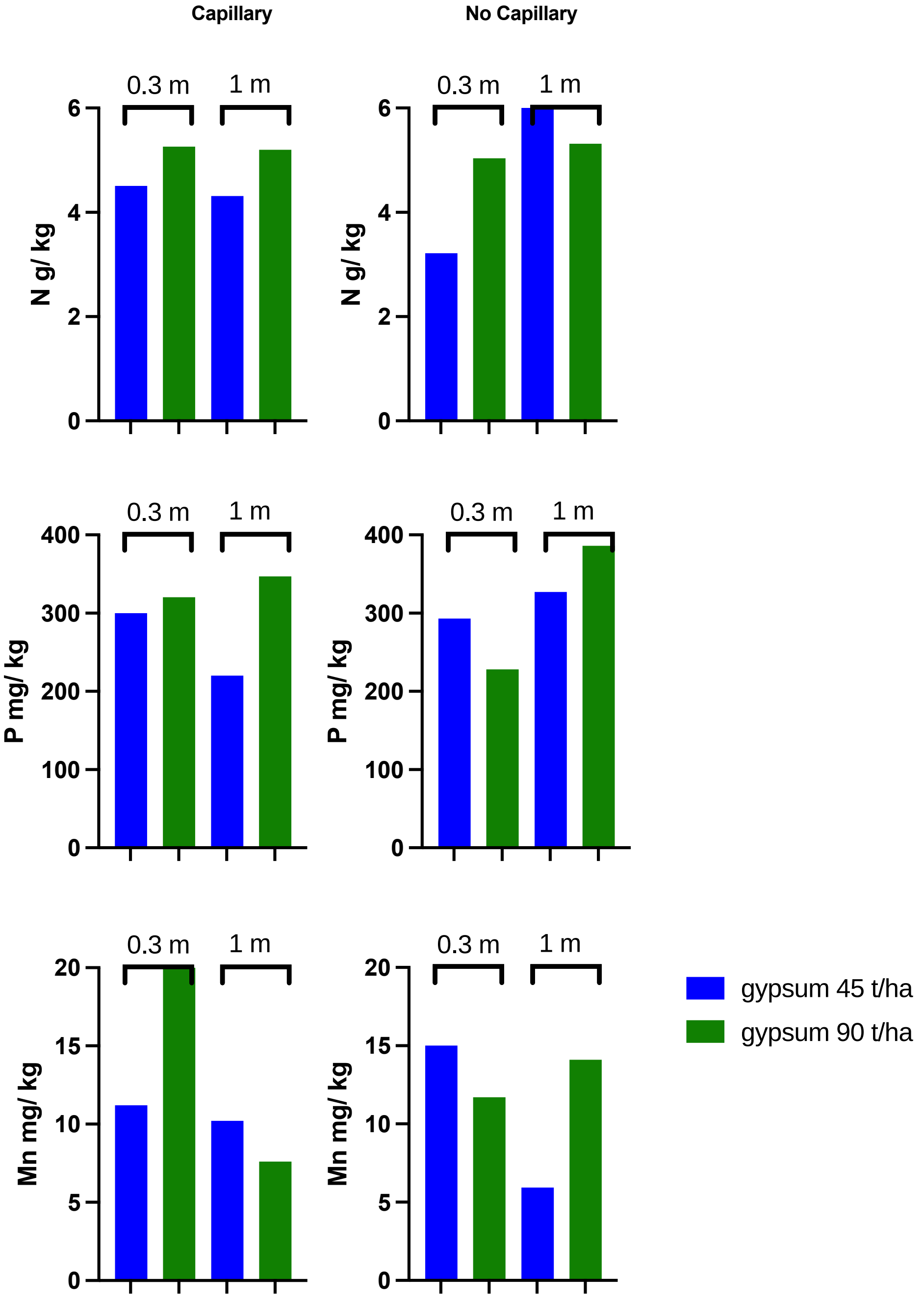

Figure 6. Nutrient (N, P and Mn) content in vegetation sampled from different rehabilitation treatments

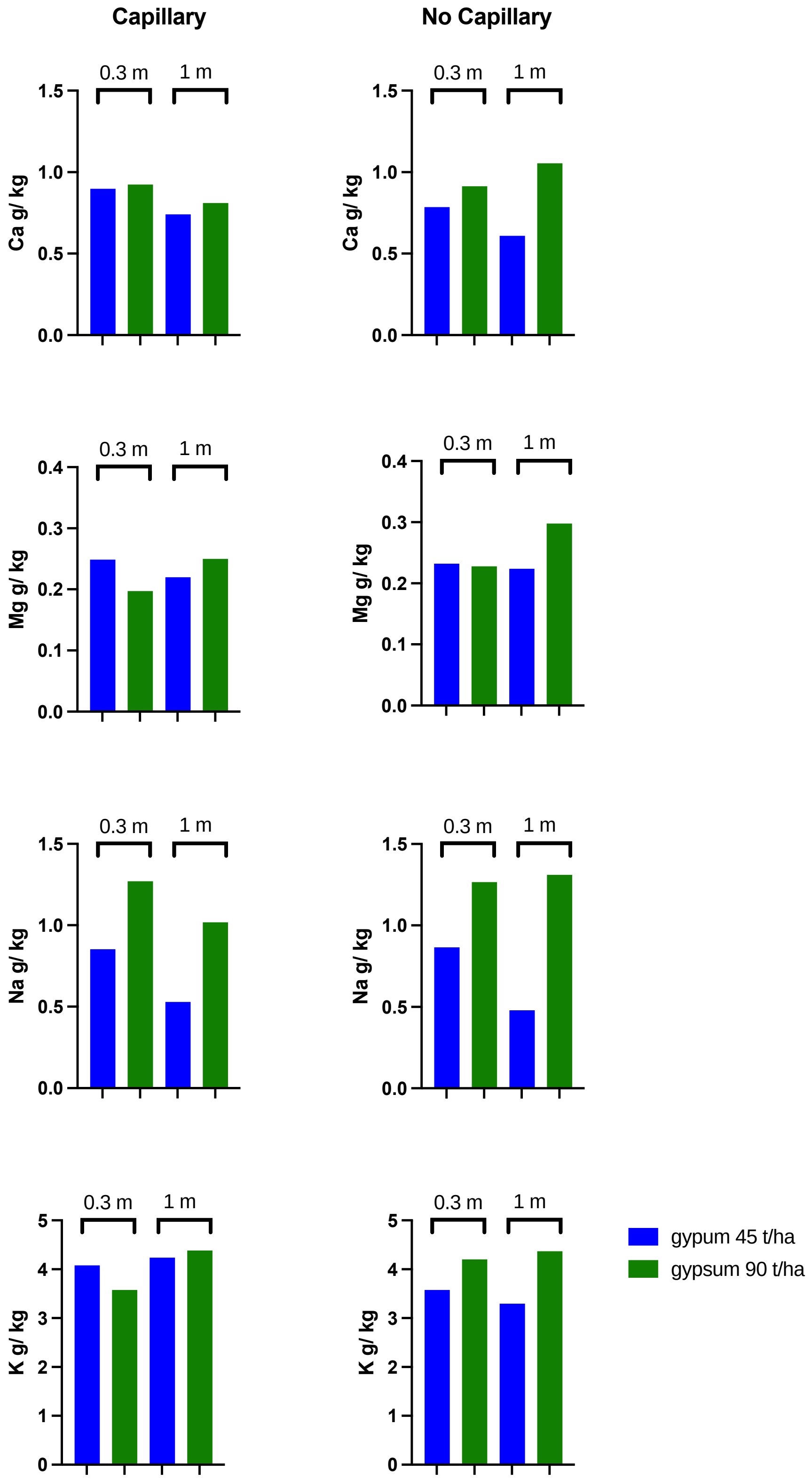

Figure 7. Nutrient cations in vegetation sampled from different rehabilitation treatments

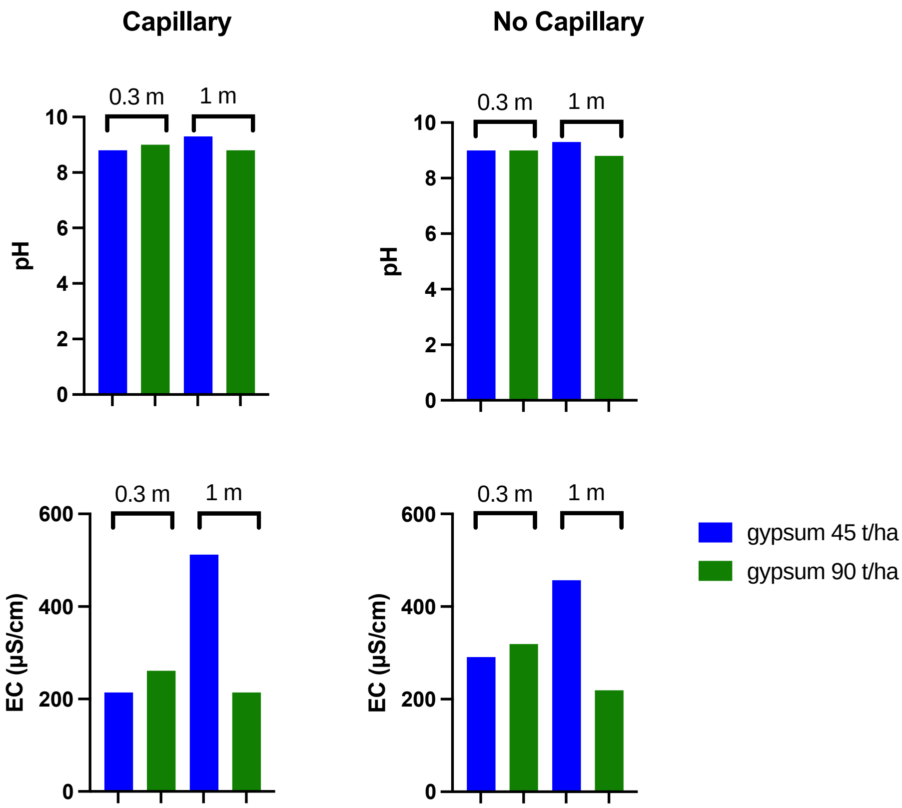

Figure 8. Rehabilitated residue (0-10 cm) pH and EC in different rehabilitation treatments

Rehabilitated residue pH and EC for 0-10cm in different rehabilitation treatments are shown in Figure 8. Further soil physico-chemical analysis is ongoing.

Findings & Continuing Work

There was no evidence of elevated content for non-essential elements in vegetation from the different rehabilitation treatments. Soil analysis is ongoing and both vegetation and soil will be monitored in 2025.

Attachment 7
Annual Blast Report

Aughinish Alumina Limited

BORROW PIT DEVELOPMENT

ANNUAL BLAST REPORT 2024

FEBRUARY 2025

CONFIDENTIAL

TECHNICAL REPORT (VERSION 0) CONFIDENTIAL

PROJECT NO. 4000128

DATE: FEBRUARY 2025

WSP

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Dublin Road
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Issue/revision	First issue	Revision 1	Revision 2	Revision 3
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EXECUTIVE SUMMARY

WSP Ireland Consulting Limited (WSP), formerly Golder, prepared a Blast Vibration Assessment Report (Golder 2017) to assess the potential blasting impacts on the BRDA, the Gas Networks Ireland (GNI) transmission pipeline and the designated off-site monitoring locations during the operation of the permitted Borrow Pit, located to the north-east of the Phase 1 BRDA.

WSP reviewed the Blast Plans prepared for each blast by Exol Ltd. and provided guidance for the maximum instantaneous charge (MIC) for all blasts carried out in 2024.

During the blasts, WSP conducted pore pressure, settlement, lateral movement and observation monitoring services and review the vibration and air over pressure data recorded by Exol Ltd.

All the monitoring data recorded (vibration, air overpressure, pore pressure, settlement, lateral movement and observation) to date are fully compliant with the IEL limits values and completed in accordance with the response framework for blasting at AAL Borrow Pit between June and August 2024.

- The vibration and air overpressure limit values listed in Schedule B.5 of the IEL for the designated monitoring locations (NSL2, NSL5 and NV1) were compliant for all blasts.
- The recorded values for the GNI gas transmission pipeline designated monitoring locations (GP1, GP2 and GP3) were lower than the established vibration threshold for all blasts.
- Two locations (BRDA1 and BRDA2) on the BRDA were designated for additional vibration monitoring based on advice from WSP (Golder 2017). PPV readings recorded at these locations were used to improve the accuracy of the PPV prediction model. This is an iterative process that has resulted in a more accurate model after assessment of the prediction methodology for the 2024 blasts. Based on the reassessment of the prediction methodology, it was concluded to use two sets of site law parameters to design future blasts.

WSP is satisfied that all blasts carried out in 2024 had no impact offsite at the licensed monitoring locations and had no impact on the structural integrity of the BRDA or the GNI gas transmission pipeline.

This iterative process is proposed to continue for the subsequent blasts during 2025 in order to refine the predicted vibration values further and set a limit for the MIC in the Blast Plans.

1 INTRODUCTION

1.1 BACKGROUND

Aughinish Alumina Limited (AAL) has applied for a 10-year development plan to establish a Borrow Pit covering approximately 4.5 hectares, with plans to extract about 374,000 m^3 of rock to a maximum depth of 8.5 meters OD. Extraction is set to occur annually from April to September.

WSP Ireland Consulting Limited (formerly Golder) prepared a Blast Vibration Assessment Report in 2017, which evaluated potential blasting impacts on the Phase 1 BRDA and the Gas Networks Ireland (GNI) gas transmission pipeline. The report, part of the planning and licensing applications with Limerick City and County Council (LCCC), An Bord Pleanála, and the EPA, established vibration thresholds, provided initial blast vibration model parameters, and outlined a response framework for managing blasting activities.

1.2 PLANNING CONDITIONS

The relevant planning conditions (ABP-301011-18) for blasting at the Borrow Pit include:

- **Condition 2**: Full implementation of all environmental mitigation measures as outlined in the Environmental Impact Assessment Report, with annual reporting to the planning authority for public access.
- **Condition 3:** Blasting operations are restricted to April through September.

1.3 LICENCE CONDITIONS

The conditions from Industrial Emissions Licence P0035-07 specify controls for blasting, including noise and vibration restrictions:

- **Condition 4.6:** Off-site vibration and air overpressure levels at noise-sensitive locations must not exceed specified thresholds.

Table 1-1 – Vibration and Air Overpressure thresholds

Parameter	Limit Values at Designated Locations (NSL2, NSL5, NV1)
Vibration	12 mm/second
Air Overpressure	125 dB(lin) max peak

- **Condition 5.12:** Limits blasting to one event per week within the hours of 08:00 and 18:00 from April through September, with strict controls over equipment use to minimize noise impacts.

The method statement for blasting must include:

- Standard Operating Procedures
- Communication plans for residents
- Noise, vibration, and air overpressure controls

- Monitoring and safety protocols

1.4 MONITORING LOCATIONS

Designated vibration and air overpressure monitoring locations include:

Table 1-2 - Monitoring Location

Monitoring Location	Coordinates
NSL2	129056E, 151690N
NSL5	128802E, 151106N
NV1	128958E, 151596N

Additional monitoring is set at:

- BRDA Vibration Monitoring: Locations BRDA 1 and BRDA 2.
- GNI Pipeline Monitoring: GP1, GP2, and GP3.
- Pore Pressure Monitoring: Strain gauge piezometers (VWP1, VWP3) and standpipe piezometers (8APL, BGT15A, BGT15D, BGT15E).
- Settlement and Lateral Movement Monitoring: Inclinometers (8AIL, 8BIU), extensometers (8AIL), and visual site inspections before and after each blast.

1.5 CHANGE IN PORE WATER PRESSURE IMMEDIATELY AFTER BLAST

To assess immediate pore water pressure changes within the embankment due to blasting, an RST Vibrating Wire Piezometer was installed at the nearest point to the blasting area. This piezometer was linked to a SATURN Transient Recorder to capture transient pore pressure variations during each blast event, providing real-time monitoring of blast impacts on embankment stability.

1.6 SUBMITTALS TO THE EPA

AAL submitted a blasting method statement to the EPA on January 19, 2022 (under licensee return LR060880), which received approval on January 26, 2022. An Annual Blast Report, as required under Schedule E of the IEL, summarizes blast data and compliance with specified limits.

1.7 SCOPE OF WORK

In 2024, WSP reviewed Blast Plans by Exsol Ltd., advising on Maximum Instantaneous Charges (MICs) to meet threshold requirements for vibration and air overpressure at designated monitoring locations. WSP also provided monitoring for pore pressure, settlement, lateral movement, and vibration, analyzing data collected by Exsol Ltd. during each blast.

2 BLAST PLAN

For 2024, Exsol Ltd. prepared and executed tailored blast plans for the Borrow Pit, prioritizing safety and compliance with vibration limits at sensitive receptor locations. Each blast was planned based on the Maximum Instantaneous Charge (MIC) permitted by the current vibration model, which was adjusted according to the plan distance to BRDA2, the most sensitive receptor for this site. This receptor's threshold helped shape the specific charge configurations and delay timings applied in each blast.

The blast planning incorporated insights from past monitoring data, including calibration with historical peak particle velocity (PPV) values collected at various monitoring points. This historical data allowed for fine-tuning the site-specific factors, denoted as k (site confinement) and b (rock type), which predict PPV in relation to distance and charge weight. For 2024, two PPV prediction models were employed:

- Model 1, with k = 5,000 and b = 2.10, provided predictions for general site conditions.
- Model 2, with k = 2,700 and b = 1.90, offered predictions based on adjustments reflecting conditions from blasts in previous years (2022 and 2023).

Each blast was structured to minimize environmental and structural impacts, while maximizing the efficiency of rock extraction. The blast parameters, including the type and quantity of explosive (Sureblend 100), were selected for optimal energy output and fragmentation, maintaining a controlled impact radius. Following each blast, actual PPV readings were analyzed against predicted values, refining the vibration models for future operations.

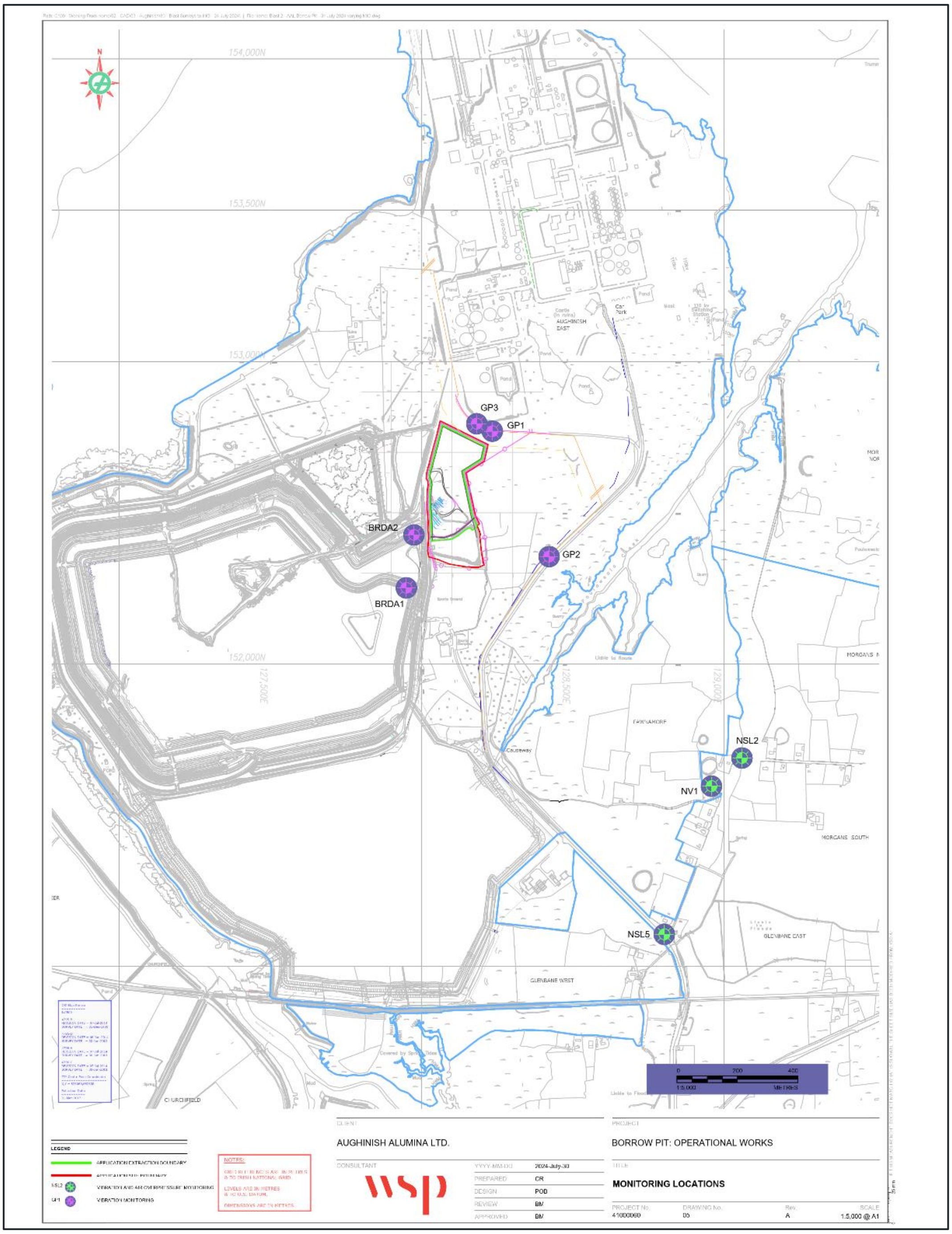
Table 2-1 - Borrow Pit Blast Details 2024

Blast ID	Date & Time	MIC (Range)	Total Blast Charge	Explosive Type	Estimated Rock Volume
Blast #1	13:45, 18 June 2024	96 kg	9,900 kg	Sureblend 100	16,065 m³
Blast #2	13:30, 31 July 2024	Area 1: 30-48 kg Area 2: 66-96 kg	10,056 kg	Sureblend 100	17,950 m³
Blast #3	13:45, 14 August 2024	Area 1: 78 kg Area 2: 84 kg	11,500 kg	Sureblend 100	17,750 m³
Total			**31,456 kg**		**51,765 m³**

Each of the three blasts were executed with specific MIC adjustments across different pit sections to stay within PPV thresholds. The second blast, conducted on 31 July 2024, required a more complex design due to the proximity of Area 1 and Area 2 to sensitive receptors. The MIC was adjusted accordingly within these areas to keep PPV values compliant with the threshold for BRDA2, utilizing variable charges between 30 kg and 96 kg in two distinct charge zones.

For the third blast on 14 August 2024, MIC variations in similar range (78 and 84 kg) were applied to accommodate specific geological and receptor conditions, ensuring PPV did not exceed limits at monitoring locations. Each blast was followed by PPV monitoring to validate the efficacy of the predictive models and to provide feedback for ongoing model refinement.

Figure 2-1 - Monitoring Locations



3 BLASTING LOCATIONS AND VIBRATION MANAGEMENT

The three blast locations for the Borrow Pit in 2024 are illustrated in Figure 3-1 and on Drawing 01 (Appendix A). The borehole layouts for each blast represent the surveyed drill sites, with blasting operations progressing northward from the exposed quarry face. Each blast was carefully located and designed to control vibration levels, particularly at sensitive receptor sites such as the BRDA embankments.

3.1 BLAST LOCATION SUMMARY

- **Blast #1:** Conducted on the eastern side of the quarry face, this blast was situated furthest from the BRDA, allowing a larger MIC to be used without exceeding vibration thresholds.
- **Blast #2:** Positioned along the east-west quarry face, this blast was closer to the BRDA, necessitating a reduced MIC to ensure compliance with vibration limits.
- **Blast #3:** Conducted on the northern side of the quarry, this blast maintained the maximum feasible distance from the BRDA to further minimize vibration impacts.

Vibration Thresholds and Regulatory Standards: To manage vibration impacts, thresholds were set based on Irish Environmental Licensing (IEL) guidelines and other standards for sensitive structures:

- **BRDA Embankments:** The recommended PPV threshold for the BRDA embankments is 50 mm/s (Charlie et al., 2001). For earth fill dams on medium-density sands or silts, a more conservative buffer reduced the operational threshold to 25 mm/s to protect the BRDA.
- **GNI Gas Transmission Pipeline:** Based on 2017 consultations with GNI, the pipeline threshold was set at 75 mm/s. With a similar buffer applied, the final operational threshold was adjusted to 50 mm/s.

These established thresholds of 25 mm/s for the BRDA and 50 mm/s for the GNI pipeline became the operational targets for each blast, guiding MIC settings and PPV predictions at critical monitoring locations.

In addition, Golder (2017) recommended a “Response Framework for Blasting at the Aughinish Borrow Pit,” permitting a 25% exceedance over predictions for the BRDA and pipeline while remaining within an "Acceptable Situation" criterion.

3.2 VIBRATION PREDICTION MODEL AND METHODOLOGY

The standard PPV prediction model, based on the United States Bureau of Mines (1959) equation, calculates PPV for surface blasts as follows:

$PPV = \pi \left(\frac{D}{\sqrt{W}}\right)^{-b}$ where:

- **PPV** = Peak Particle Velocity (mm/s),
- **D** = Distance from blast to receptor (m),
- **W** = Explosive Charge Weight per Delay (MIC) (kg),
- **k** and **b** = site-specific constants, where **k** is a site exponent (ranging from 500 to 5,000) and **b** is a rock exponent (ranging from 1.9 to 3.0).

Table 3-1 – Typical K and b ranges

Site Exponent (k)	Description	Rock Exponent (b)	Material
500	Free Face – Hard Rock	2.1 – 2.4	Granite
1,140	Free Face – Average to Soft Rock	2.1	Limestone
5,000	Heavily Confined Site	1.9 – 3.0	Basalt

Using these refined models resulted in no PPV exceedances for the blasts in 2024.

Figure 3-1 - Blast Areas

4 BLAST MONITORING RESULTS

The monitoring program included the calculated and measured Peak Particle Velocity (PPV) comparison and , assessment of changes in water level and excess pore pressure readings to confirm compliance with safety and environmental standards.

4.1 BLAST #1

PEAK PARTICLE VELOCITY (PPV) MEASUREMENTS

Table 4-1 summarizes the actual PPV readings at various monitoring locations, comparing these values against predicted PPVs from two models. Model 1 used parameters k=5,000 and b=2.10, while Model 2 used k=2,700 and b=1.90.

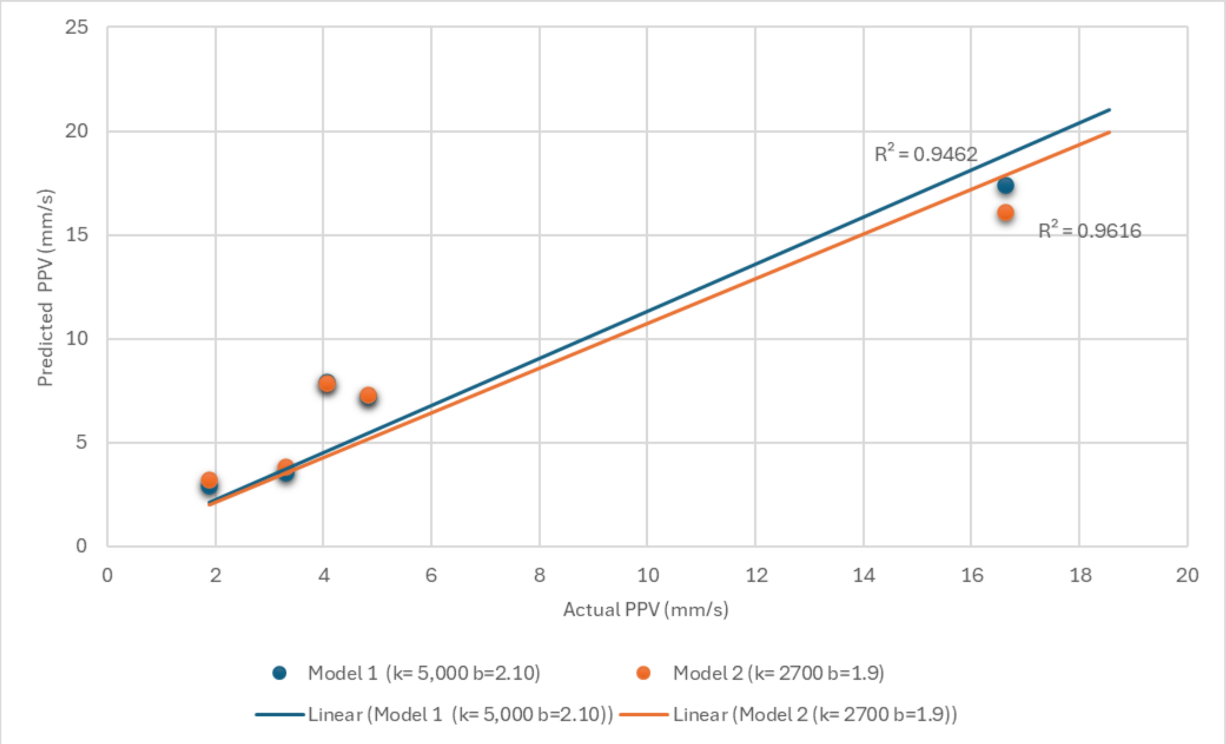
Table 4-1 - Measured and Predicted PPV Values for Blast #1, 2024

Monitoring Location	Actual Reading (mm/s)	Threshold (mm/s)	Distance (m)	Predicted PPV (Model 1) (mm/s)	Predicted PPV (Model 2) (mm/s)
BRDA 1	3.29	25	308	3.58	3.86
BRDA 2	16.62	25	145	17.44	16.14
GP 1	4.06	50	211	7.93	7.91
GP 2	1.88	50	337	2.97	3.25
GP 3	4.83	50	220	7.27	7.31
NSL5	No Trigger	12	1591	0.11	0.17
NSL2	No Trigger	12	1254	0.19	0.27
NV1	No Trigger	12	1255	0.19	0.27

PREDICTED VS. MEASURED PPV ANALYSIS

To evaluate model accuracy, R-squared (R^2) values were calculated for the measured versus predicted PPV readings, as shown in Figure 4-1. Model 1, with an R^2 of 0.96, provided a slightly better fit than Model 2 ($R^2 = 0.95$). The close alignment between measured and predicted PPVs confirmed the reliability of both models for Blast #1's design parameters.

Figure 4-1 – Comparison between actual and predicted PPV for Blast #1



WATER TABLE CHANGES

Standpipe piezometers located near the blasting area were monitored to assess water table fluctuations before and after the blast. Table 4-2 summarizes the minor changes observed in water levels, showing a temporary rise in levels shortly after the blast, with stabilization occurring by the following day.

Table 4-2 - Water Table Changes in Standpipe Piezometers

Piezometer	Before Blast (m)	0.5 hrs After Blast (m)	Difference (m)	Day After Blast (m)
8APL	5.61	5.67	-0.06	5.62
BGT15D	1.31	1.32	-0.01	1.30
BGT15A	1.28	1.31	-0.03	1.27
BGT15C	2.19	2.22	-0.03	2.20
BGT15E	5.39	5.45	-0.06	5.43

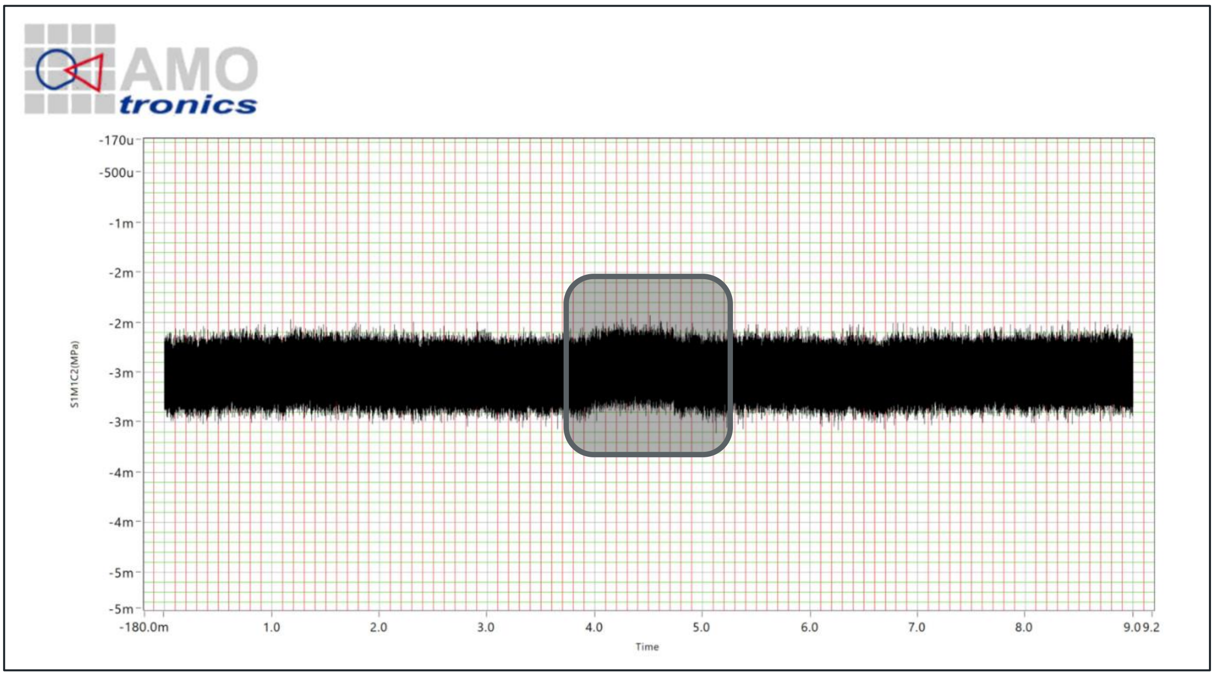
These minor fluctuations indicate:

- **Short-Term Impact:** The immediate rise in water levels following the blast reflects a temporary response to pressure changes induced by blast vibrations.
- **Long-Term Stability:** The stabilization of water levels by the next day indicates that the blast had no significant lasting effect on the water table.

PORE WATER PRESSURE CHANGES

The RST Vibrating Wire Piezometer, connected to a SATURN Transient Recorder, recorded pore water pressure changes. As shown in Figure 4-2, a slight increase in pore pressure (approximately 1.5 to 3 Pa) was detected. Such minimal changes are negligible for most soil and rock types and unlikely to affect the ground's mechanical behaviour significantly.

Figure 4-2 - Blast #1: Fluctuations in pore water pressure during the blast



4.2 BLAST #2

PEAK PARTICLE VELOCITY (PPV) MEASUREMENTS

Table 4-3 below summarizes the measured PPV values for various monitoring locations compared to the predicted PPVs from Model 1 for both areas. Model 1 (parameters k=5,000, b=2.10) was applied to both areas for comparative analysis.

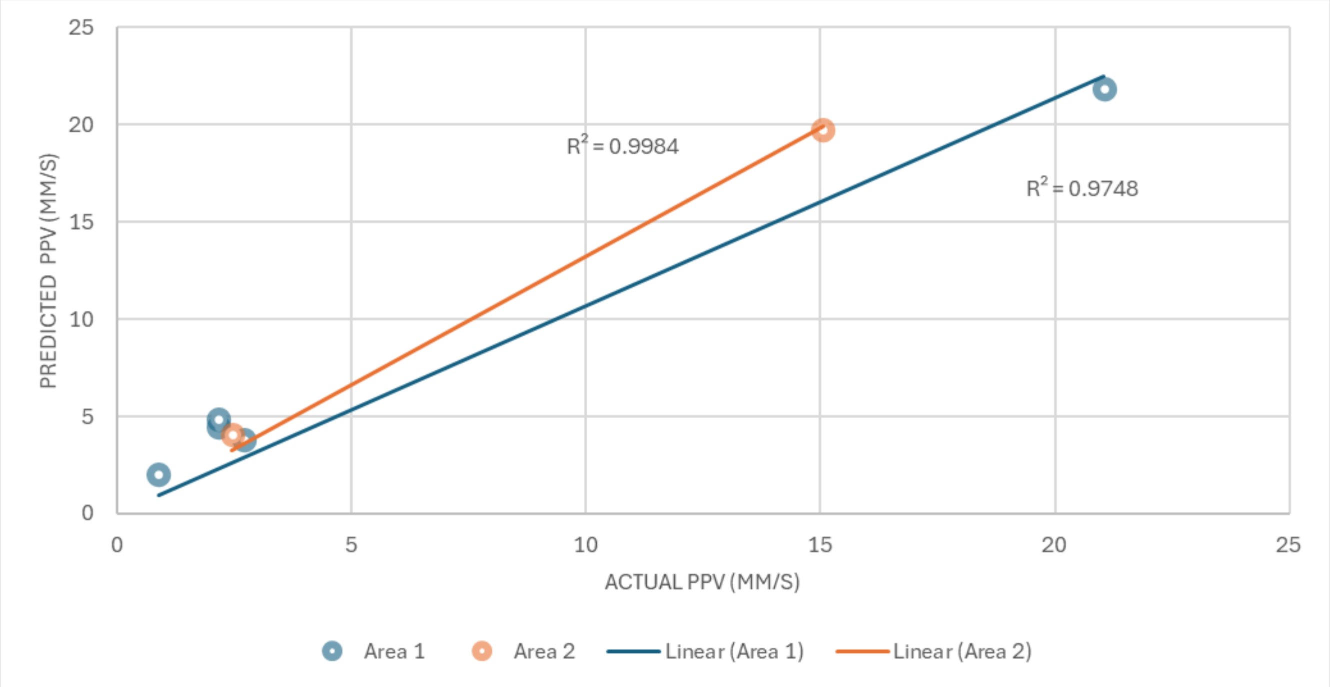
Table 4-3 - Measured and Predicted PPV Values for Blast #2, 2024

Monitoring Location	Actual Reading (mm/s)	Threshold (mm/s)	Distance (m)	Predicted PPV (Model 1 Area 1) (mm/s)	Predicted PPV (Model 1 Area 2) (mm/s)
BRDA 1	2.703 (Area 1)	25	277	3.79	4.06
	2.459 (Area 2)				
BRDA 2	21.04 (Area 1)	25	108	21.84	19.79
	15.05 (Area 2)				
GP 1	2.16 (Area 1)	50	277	4.48	4.72
GP 2	0.89 (Area 1)	50	401	2.06	2.34
GP 3	2.16 (Area 1)	50	267	4.84	5.06
NSL5	No Trigger	12	1557	0.06	0.09
NSL2	No Trigger	12	1304	0.17	0.25
NV1	No Trigger	12	1262	0.18	0.25

PREDICTED VS. MEASURED PPV ANALYSIS

Figure 4-3 displays the predicted versus actual PPV readings for both areas. To evaluate model accuracy, R-squared (R^2) values were calculated, with Model 1 for Area 1 achieving $R^2 = 0.97$ and for Area 2, $R^2 = 0.99$. The high R^2 values suggest a strong correlation between predicted and actual PPVs, demonstrating that the blast design parameters were effective and accurately estimated the expected impact.

Figure 4-3 - Predicted vs Measured PPV values from Model 1 Area 1 and 2



WATER TABLE CHANGES

Water level changes in standpipe piezometers near the blast sites were measured before and after the blast, with results summarized in Table 4-4. The minor fluctuations observed in water levels ranged from 0.02 to 0.09 meters, consistent with temporary adjustments due to blast vibrations, followed by a quick return to initial levels.

Table 4-4 - Water Table Changes in Standpipe Piezometers

Piezometer	Before Blast (m)	0.5 hrs After Blast (m)	Difference (m)
8APL	5.75	5.77	-0.02
BGT15D	1.52	1.50	0.02
BGT15A	1.43	1.39	0.04
BGT15C	2.05	2.14	-0.09
BGT15E	5.55	5.51	0.04

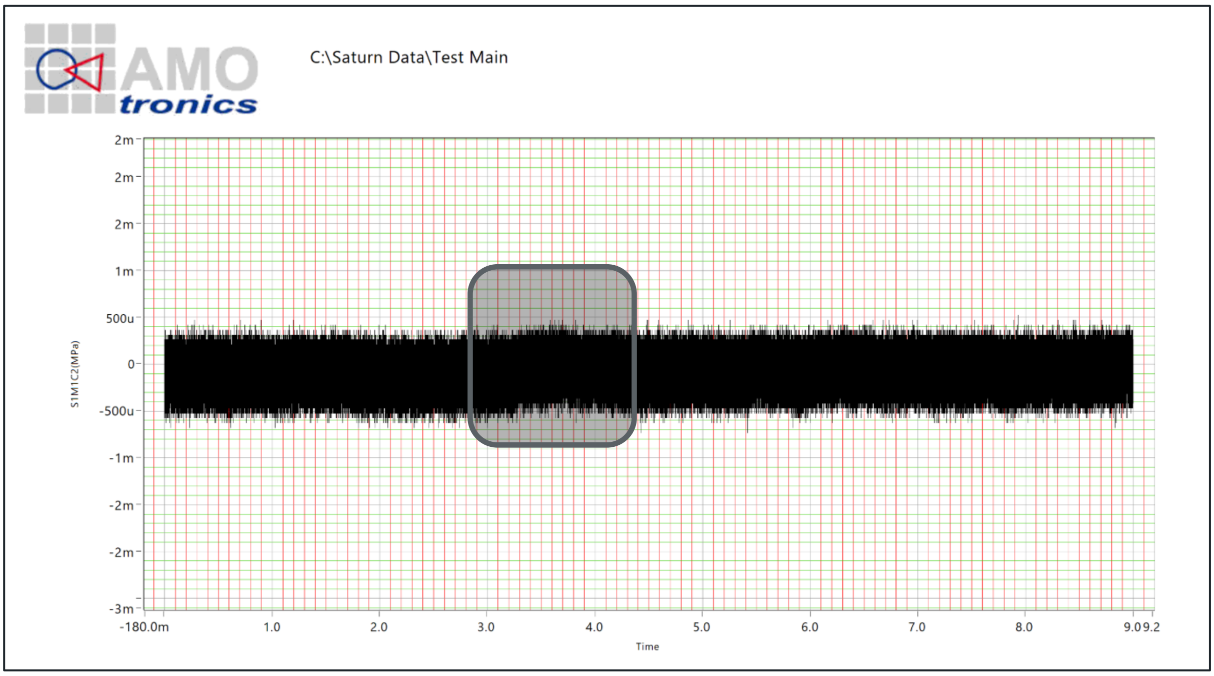
These results indicate:

- **Short-Term Impact:** The immediate, small changes in water levels suggest a temporary response to the blast's pressure fluctuations.

PORE WATER PRESSURE CHANGES

A nearby RST Vibrating Wire Piezometer, equipped with a SATURN Transient Recorder, captured changes in pore water pressure during the blast. Minor variations of approximately 1 to 2 Pa were observed, indicating a negligible effect on soil and rock behaviour.

Figure 4-4 - Pore Water Pressure Fluctuations During Blast



4.3 BLAST 3#

PEAK PARTICLE VELOCITY (PPV) MEASUREMENTS

Table 4-5 below provides a comparison of measured PPV values against predicted values from two models: Model 1 (parameters k=5,000, b=2.10) and Model 2 (parameters k=2,700, b=1.90).

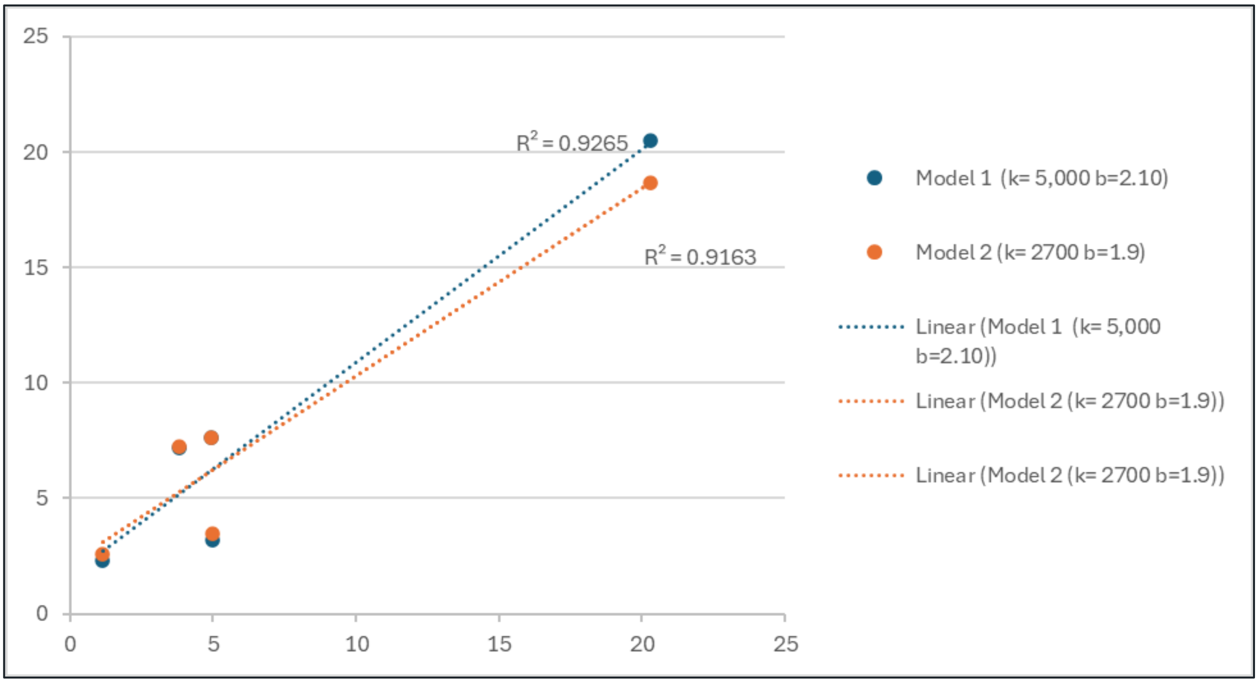
Table 4-5 - Measured and Predicted PPV Values for Blast #3, 2024

Monitoring Location	Actual Reading (mm/s)	Threshold (mm/s)	Distance (m)	Predicted PPV (Model 1) (mm/s)	Predicted PPV (Model 2) (mm/s)
BRDA 1	4.98	25	294	3.18	3.46
BRDA 2	20.30	25	121	20.5	18.69
GP 1	4.95	50	201	7.63	7.64
GP 2	1.14	50	355	2.31	2.59
GP 3	3.81	50	207	7.18	7.23
NSL5	No Trigger	12	1621	0.09	0.14
NSL2	No Trigger	12	1272	0.16	0.23
NV1	No Trigger	12	1275	0.16	0.23

PREDICTED VS. MEASURED PPV ANALYSIS

Figure 4-5 compares predicted versus actual PPV values for Blast #3. The R-squared (R^2) values for both models demonstrate a high correlation, with Model 1 achieving $R^2 = 0.93$ and Model 2 $R^2 = 0.92$. The close fit between predicted and actual readings confirms the accuracy of the blast design parameters and the reliability of both models.

Figure 4-5 - Predicted vs Measured PPV values from Model 1 and Model 2



WATER TABLE CHANGES

Table 4-6 summarizes water level changes in standpipe piezometers before and after the blast. Minimal fluctuations, ranging from -0.01 to -0.05 meters, were observed, indicating a temporary effect due to blast-induced pressure changes.

Table 4-6 - Water Table Changes in Standpipe Piezometers

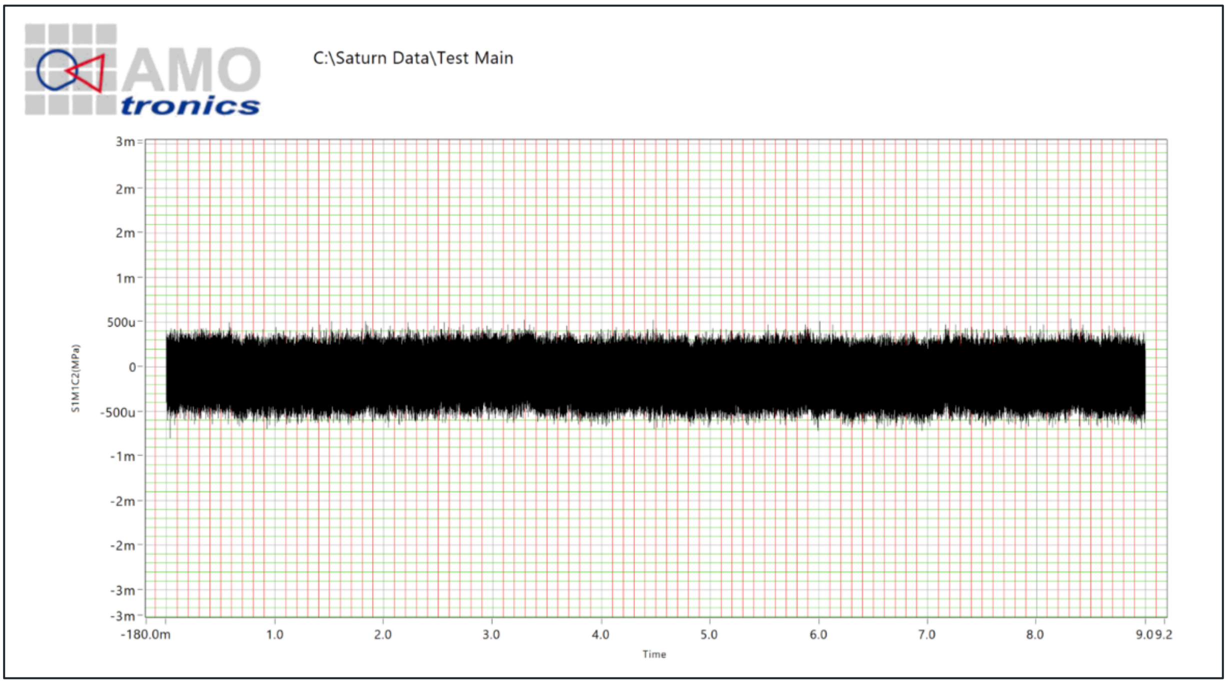
Piezometer	Before Blast (m)	0.5 hrs After Blast (m)	Difference (m)
8APL	5.68	5.73	-0.05
BGT15D	1.49	1.51	-0.02
BGT15A	1.43	1.45	-0.02
BGT15C	2.13	2.14	-0.01
BGT15E	5.53	5.55	-0.02

These changes suggest a temporary, slight increase in water levels immediately after the blast.

PORE WATER PRESSURE CHANGES

The RST Vibrating Wire Piezometer, located nearest to the blast area and connected to a SATURN Transient Recorder, recorded no significant change in pore water pressure during Blast #3, as shown in Figure 4-6.

Figure 4-6 – Pore Water Pressure Fluctuations During Blast



5 CONCLUSION

Between June and August 2024, three blasts were conducted at the AAL Borrow Pit. Blasting performance was closely monitored for vibration (PPV), air overpressure, pore pressure, settlement, lateral movement, and visual observations. All monitoring data were fully compliant with the IEL limit values, as outlined in the response framework for blasting.

- **Blast Performance and PPV Analysis:**
  For the three blasts, the measured PPV at the monitoring locations were compared to the established threshold of 25 mm/s (Golder 2017). Observations:
  - Blast #1 at BRDA 2 had a recorded maximum PPV of 16.62 mm/s, which is below the 25 mm/s threshold and consistent with the predicted values from both models.
  - Blast #2 at BRDA 2 recorded a maximum PPV of 21.04 mm/s, also below the threshold and in good alignment with predicted PPV values of both models.
  - Blast #3 at BRDA 2 had a recorded maximum PPV of 20.30 mm/s, again within the acceptable range for BRDA 2.

For all three blasts, the distance from the monitoring station at BRDA 2 decreased for Blast #2 and Blast #3, but the measured PPVs were still below the threshold of 25 mm/s.

Predicted PPV values are consistent across both models, demonstrating strong predictive accuracy for each blast location and distance.

- **Changes in Water Level and Pore Pressure:** During the blasting events, changes in water levels and pore pressure were carefully monitored. Following each blast, there were slight transient increases in pore pressure near the blast zone, but these levels returned to baseline values within a short period, indicating no significant or lasting effects on the groundwater system. The water level showed minimal fluctuations, consistent with the expected hydraulic response to localized blasting. These changes were well within the acceptable range and did not pose any risk to the surrounding environment or the structural stability of the site.
- **Impact on Structural Integrity and Offsite Locations:**
  WSP confirms that Blasts #1 to #3 did not have any offsite impact at the licensed monitoring locations. Additionally, the structural integrity of the BRDA and the GNI gas transmission pipeline were unaffected. No damage was reported at any of the monitored locations during or after the blasts.
- **Model Refinement and Prediction Methodology:**
  The iteration of site law parameters based on measured data has led to the adoption of two sets of site law parameters for future blast designs. This ensures a more accurate model for predicting PPV and air overpressure, with the goal of remaining below established thresholds during future blasts.
- **Future Blasting and Monitoring Strategy:**
  This iterative process of refining site law parameters will continue for subsequent blasts in 2025. With improved PPV prediction capabilities, future blast plans will include a set limit for the maximum allowable vibration to ensure compliance with IEL thresholds. This ongoing effort will minimize vibration levels and enhance the safety of the site and surrounding areas.
- **Summary:**
  WSP is confident that Blasts #1 to #3 at the AAL Borrow Pit did not cause any adverse effects to

the surrounding area or infrastructure. The data collected has been instrumental in improving the accuracy of future blast predictions and will ensure continued compliance with IEL limits in upcoming blasts.

6 REFERENCES

AAL 2022, Method Statement for AAL Borrow Pit Blasting Operations, January 2022

Charlie et al. 2001, Charlie WA, Lewis WA, Doehring DO., 2001. "Explosive Induced Pore Pressure in a Sandfill Dam". Geotechnical Testing Journal, GTJODJ, Vol. 24, No. 4, December 2001, pp. 391–400.

Golder 2017, Golder Associates Ireland Limited, Borrow Pit: Phase 1 BRDA Blast Vibration Assessment, 1667376.R01.A1, July 2017

United States Bureau of Mines, 1959. Spherical propagation of explosion generated strain pulses in rock, Duvall, W.I. and Petkof, B., U.S. Department of the Interior, Bureau of Mines

Appendix A

DRAWING

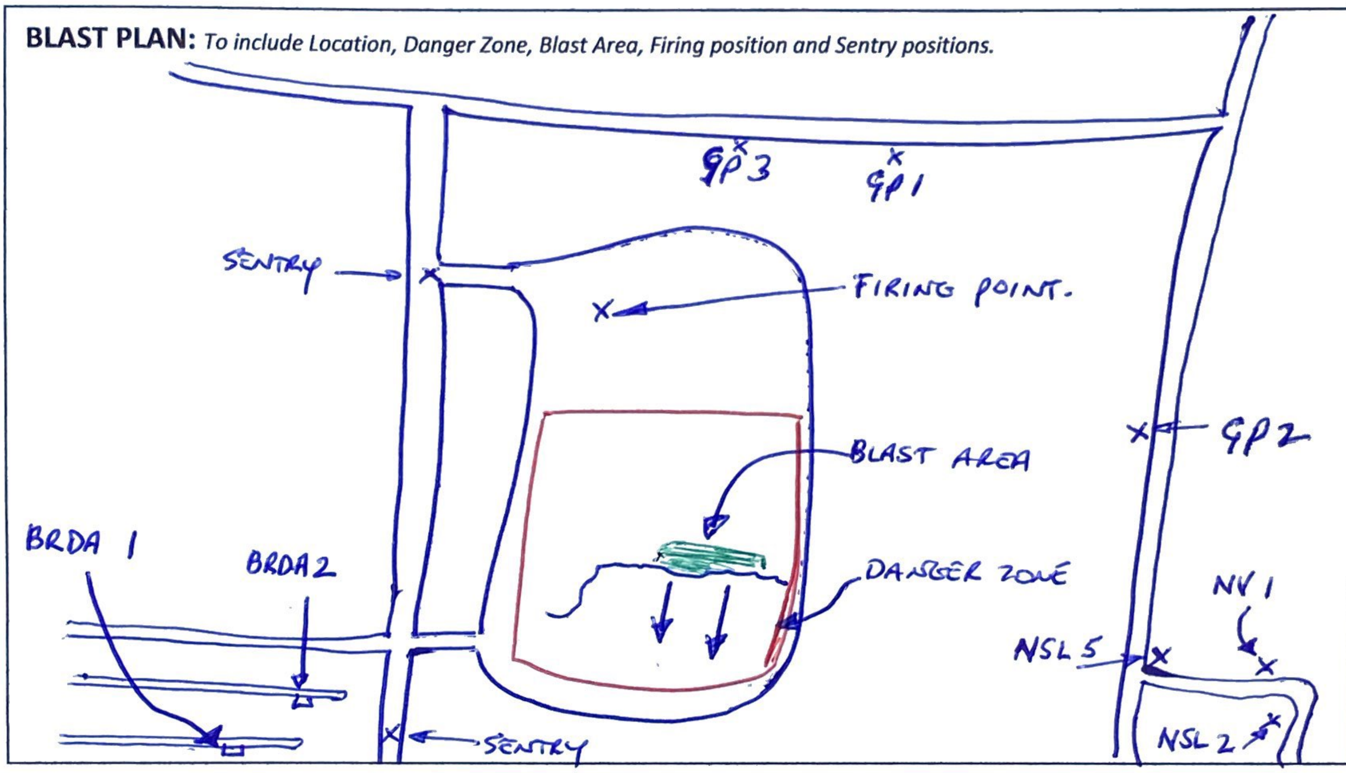
Appendix B

BLAST PLANS #1 TO #3

Exsol Ltd. **Blast Specification**

Location: APH. AUGHINISH - AUGHINISH, FOYNES, Co. LIMERICK Blast No: ____________ Date: 18/6/24

BLAST PLAN: *To include Location, Danger Zone, Blast Area, Firing position and Sentry positions.*



Explosive Order					
Quantity		Type			
300	of	12	metre	475	m/s
10	of	9	metre	475	m/s
	of		metre		m/s
2	of	6	metre	25	m/s
25	of	6	metre	42	m/s
125	of	6	metre	100	m/s
	of		metre		m/s
2	of	100	metre	0	m/s
	of		metre		m/s
	of		metre		m/s
160	of	450g	boosters		
	of	250g	boosters		
9,900	Kg's	Sureblend 100			

Blast Calculations	
Hole Diameter	110 mm
Hole Depth	7.5 — 11.0m
Bench Height	7.5 — 11.0m
Sub Grade	—
Burden	3.6 m
Spacing	3.5 m
Stemming	3.0 m
Decking	—
Estimated Volume	16,065 m³
Estimated Tonnage	40,165 t
M.I.C.	96 Kgs
Charge per metre	12 Kg
Charge per hole	54 — 96 Kgs
Total blast charge	9,900 Kg
Blast Ratio	4.05

Blast Pattern	
No. of Holes	150
No. of Rows	6
Hole Depth	7.5-11.0m
Total Drilled	1,275.0m

Blasting Accessories	
Gas Bags	—
Mo Caps	—
Lay Flap	—
Rock Locks	—

Environmental Considerations	
P.P.V.	<
Air Overpressure	<
Plan Distance	145.0m BRDA 2

Comments: Blast Calculations :- 150 holes - 7.5 — 11.0m.
1,275.0 metres / 150 = 8.5m Average

150 x 3.6 x 3.5 x 8.5 → 16,065 m³ → 40,165 tonnes.

8.5 - 3.0m = 5.5m = 66 Kg x 150 = 9,900 Kgs = 4.05 t/Kgs

Shotfirer [signature] Explosive Supervisor [signature]

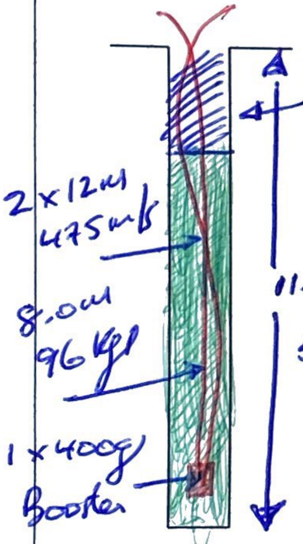
Exsol Ltd.

Charging Plan

APH . AUGHINISH

Location: AUGHINISH, FOYNES, Co. LIMERICK   Blast No: ______________   Date: 18/6/24

Hole Numbers 1 to 150
Delay Numbers 0 to 1,012 m/s (475–1487 m/s).



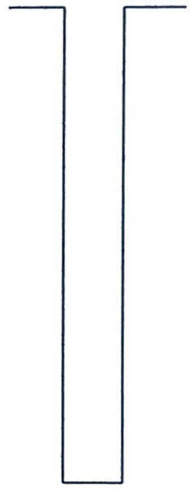
Stemming = 3.0 m.

PLANNED Column Charge
__________ kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed ______ kg's

PLANNED base charge
54 — 96 kg's Sureblend 100
ACTUAL base charge not to exceed 96 kg's in weight or 8.0 metres in height.

Holes to be loaded as indicated in the charging plan

Hole Numbers ______ to ______
Delay Numbers ______ to ______



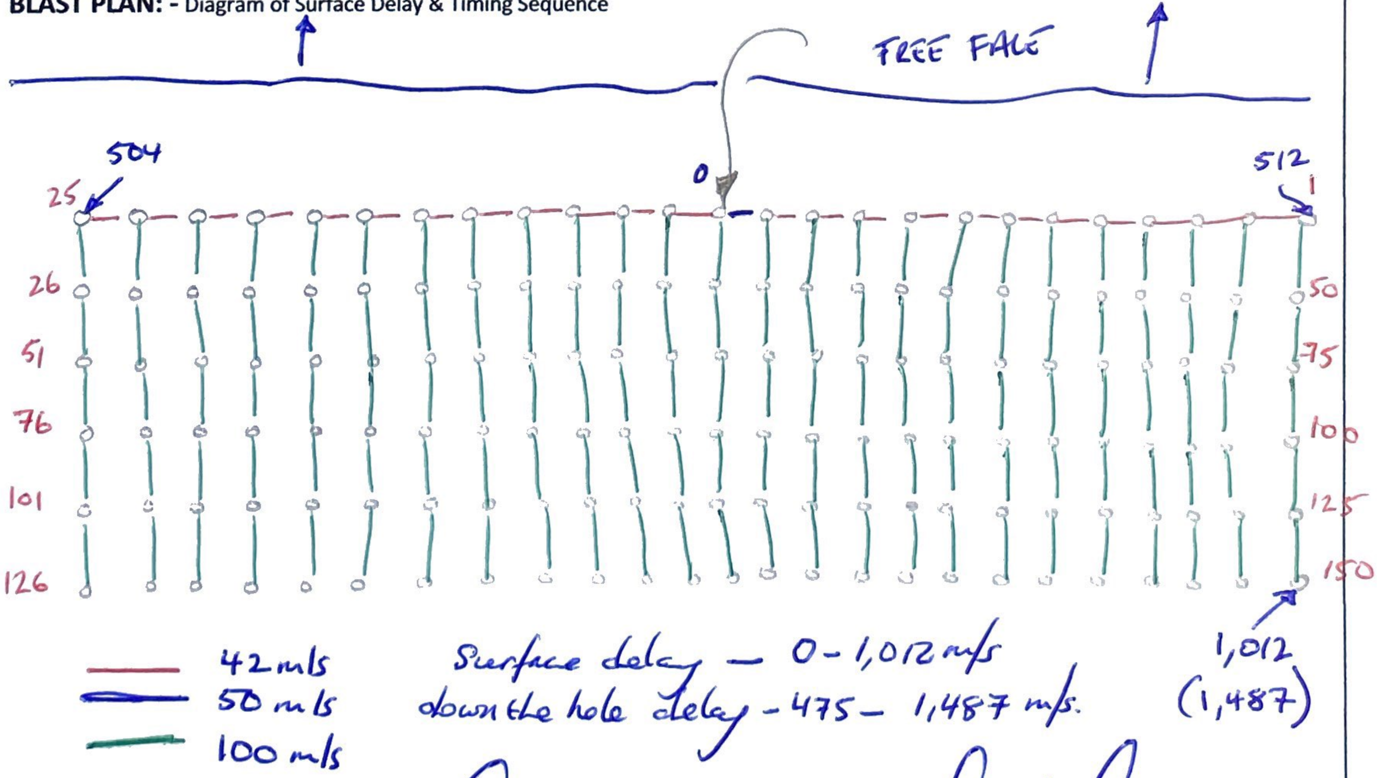
Stemming =

PLANNED Column Charge
__________ kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed ______ kg's

PLANNED base charge
__________ kg's Sureblend 100
ACTUAL base charge not to exceed ______ kg's in weight or ______ metres in height.

Holes to be loaded as indicated in the charging plan

BLAST PLAN: - Diagram of Surface Delay & Timing Sequence



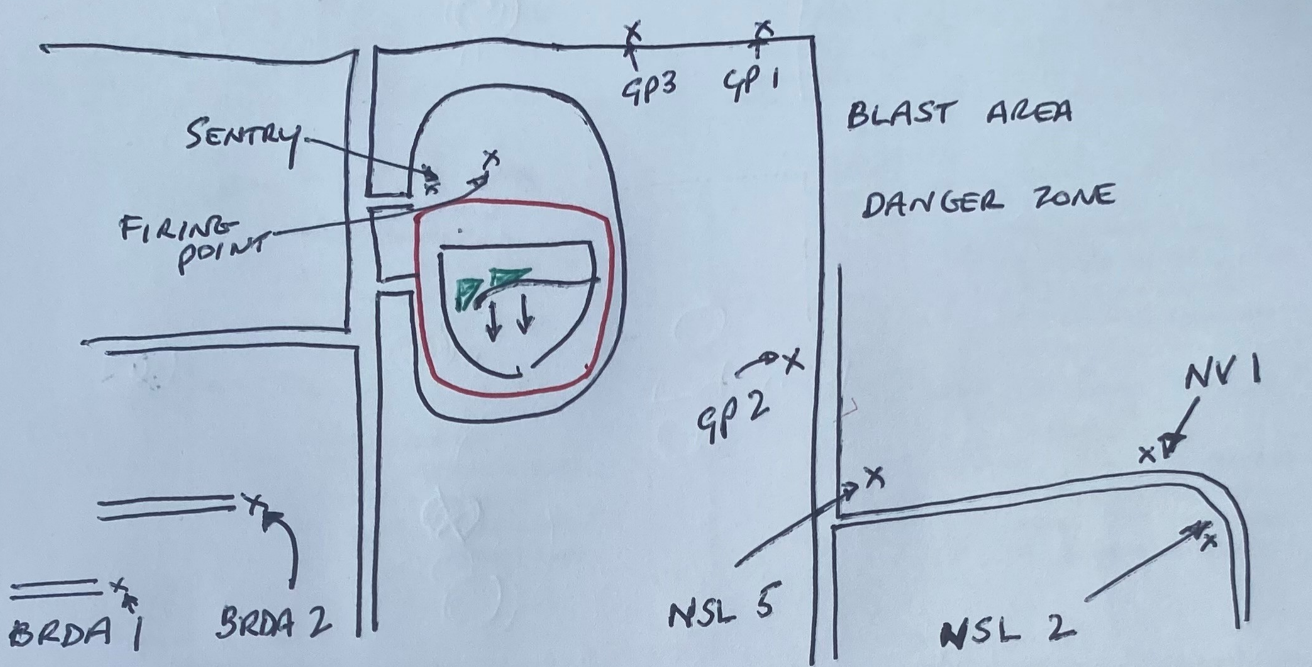
Shotfirer: ______________________   Explosive Supervisor ______________________

Exsol Ltd. **Blast Specification**

ATLANTIC PLANT HIRE

Location: AUGHINISH, Co. LIMERICK Blast No: ____________ Date: 31/7/24

BLAST PLAN: *To include Location, Danger Zone, Blast Area, Firing position and Sentry positions.*



Explosive Order					
Quantity		Type			
280	of	12	metre	475	m/s
110	of	9	metre	500	m/s
	of		metre		m/s
2	of	6	metre	17	m/s
140	of	6	metre	33	m/s
	of		metre		m/s
3	of	100	metre	0	m/s
	of		metre		m/s
	of		metre		m/s
	of		metre		m/s
238	of	450g	boosters		
	of	250g	boosters		
10,056	Kg's	Sureblend 100			

Blast Calculations	
Hole Diameter	110mm
Hole Depth	10.7m AV.
Bench Height	10.7m.
Sub Grade	0.0m
Burden	3.5
Spacing	3.5
Stemming	3.0
Decking	1.5
Estimated Volume	17,950
Estimated Tonnage	46,695 t
M.I.C.	30 — 96
Charge per metre	12kg.
Charge per hole	30 — 96
Total blast charge	10,056
Blast Ratio	4.6

Blast Pattern	
No. of Holes	137
No. of Rows	7
Hole Depth	10 — 11.0m
Total Drilled	

Blasting Accessories	
Gas Bags	—
Mo Caps	—
Lay Flap	—
Rock Locks	—

Environmental Considerations	
P.P.V.	<1
Air Overpressure	<
Plan Distance	73m to BRDA #2

Comments: Blast Calculations.

137 × 3.5 × 3.5 × 10.7 — 17,950 m³ — 46,695 tonnes.

10,056kg = 4.64t

6.2 metre = 76kg × 96 = 7,296

7.7 metre = 92kg × 30 = 2760

10,056kg

Every hole will NOT exceed M.I.C. Set out per instruction.

Shotfirer: [signature]

Explosive Supervisor: [signature]

Exsol Ltd.

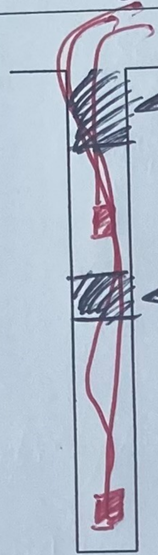
Charging Plan

APH - ATLANTIC PLANT HIRE

Location: AUGHINISH, Co. LIMERICK Blast No: ____________ Date: 31/7/24

AREA #1 64 Holes

Hole Numbers	1	to	64
Delay Numbers	0	to	1089 m/s



Stemming = 3.0m.

PLANNED Column Charge
30 – 42 kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed 42 kg's

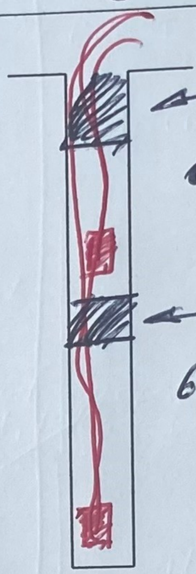
Decking = 1.5m

PLANNED base charge
30 – 48 kg's Sureblend 100
ACTUAL base charge not to exceed 48 kg's in weight or 4.0 metres in height.

Holes to be loaded as indicated in the charging plan

AREA #2 – 73 Holes.

Hole Numbers	65	to	137.
Delay Numbers	0	to	1188.



Stemming = 3.0m.

PLANNED Column Charge
0 – 30 kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed kg's

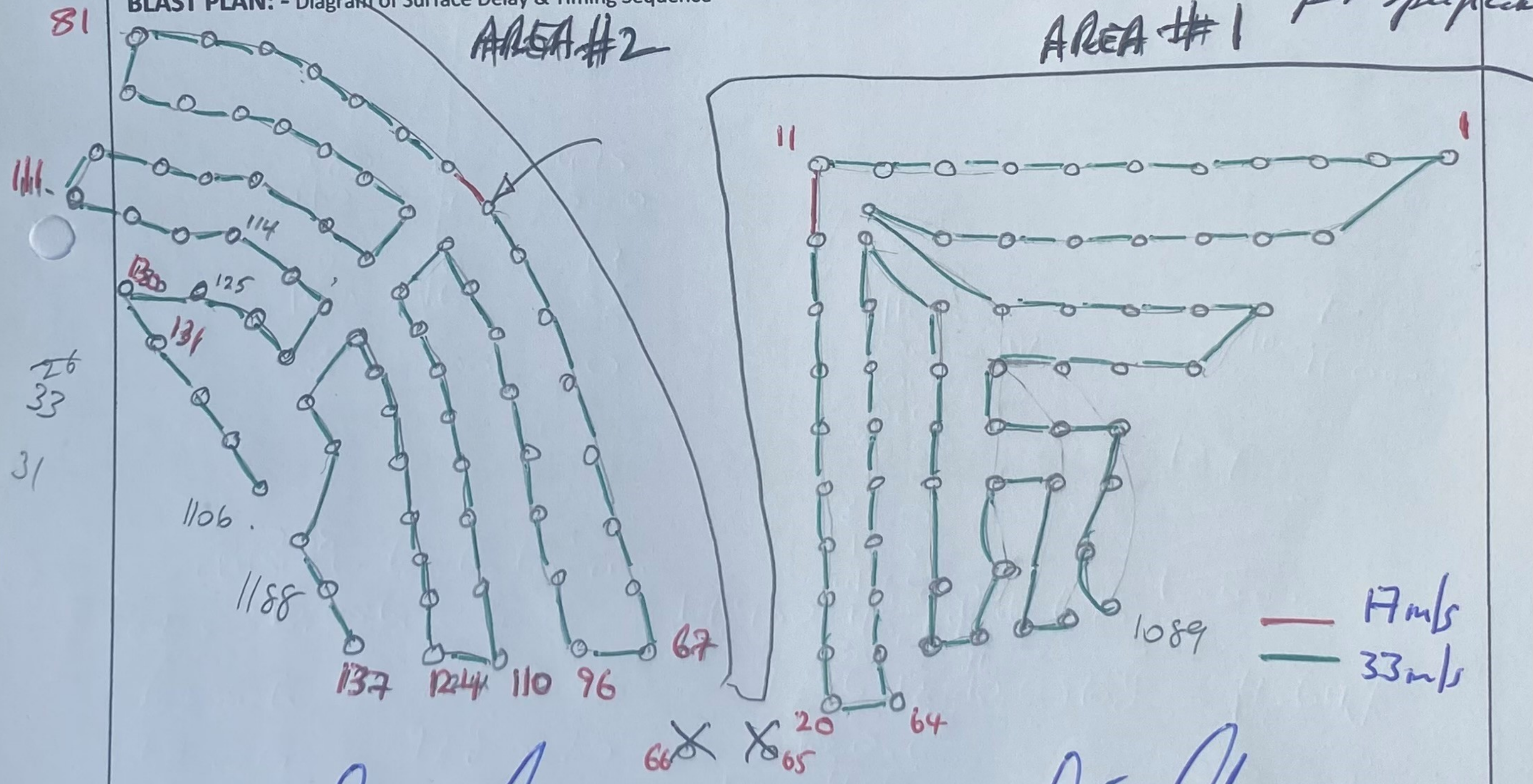
Decking 1.5m

PLANNED base charge
66 – 96 kg's Sureblend 100
ACTUAL base charge not to exceed 96 kg's in weight or 8.0 metres in height.

Holes to be loaded as indicated in the charging plan

M.I.C. not to be exceeded per Specification

BLAST PLAN: - Diagram of Surface Delay & Timing Sequence

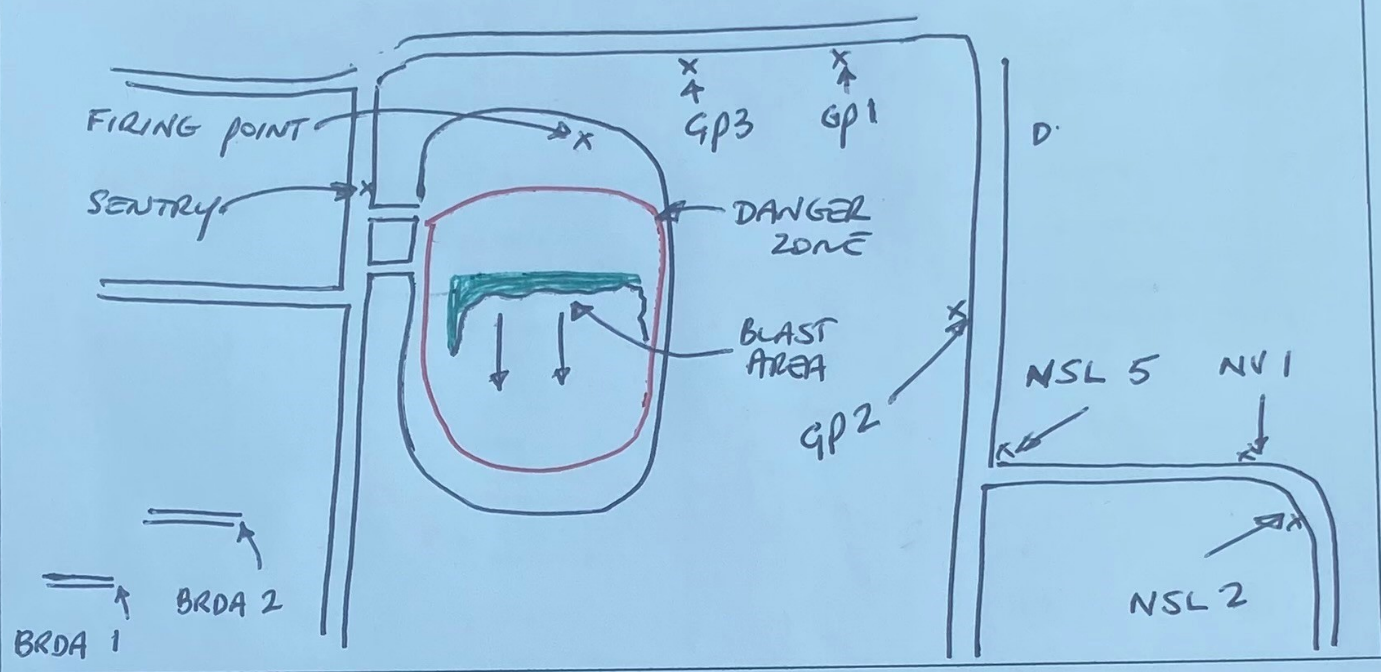


Shotfirer: ____________ Explosive Supervisor ____________

Exsol Ltd. **Blast Specification**

ATLANTIC PLANT HIRE
Location: AUGHINISH, Co. LIMERICK Blast No: 11764-24 Date: 14/8/24

BLAST PLAN: *To include Location, Danger Zone, Blast Area, Firing position and Sentry positions.*



Explosive Order				
Quantity		Type		
330	of 12	metre	475	m/s
	of	metre		m/s
40	of 6	metre	25	m/s
130	of 6	metre	67	m/s
	of	metre		m/s
3	of 100	metre	0	m/s
	of	metre		m/s
	of	metre		m/s
	of	metre		m/s
	of	metre		m/s
168	of	450g	boosters	
	of	250g	boosters	
11,500		Kg's	Sureblend 100	

Blast Calculations	
Hole Diameter	110mm
Hole Depth	8.5 — 9.7m.
Bench Height	8.0 — 9.0
Sub Grade	0.5 — 0.7
Burden	3.5m
Spacing	3.5m.
Stemming	3.0 — 3.5
Decking	—
Estimated Volume	17,750m³
Estimated Tonnage	46,150t
M.I.C.	78kgs / 84kgs.
Charge per metre	12kg.
Charge per hole	72kgs AV.
Total blast charge	11,500kg
Blast Ratio	4.01 t/kg

Blast Pattern	
No. of Holes	161
No. of Rows	7
Hole Depth	9.0m Average
Total Drilled	

Blasting Accessories	
Gas Bags	—
Mo Caps	—
Lay Flap	—
Rock Locks	—

Environmental Considerations	
P.P.V.	<
Air Overpressure	<
Plan Distance	121.0m.

Comments: Blast Calculations —

161 × 3.5 × 3.5 × 9.0m — 17,750m³ — 46,150 tonnes

9.0m Average depth − 3.0m = 6.0m charge × 12 = 72kgs 11,500kgs.

M.I.C = 72 − 78 kgs Considering Zone #1 4.01 t/kg
= 72 − 84 kgs Considering Zone #2

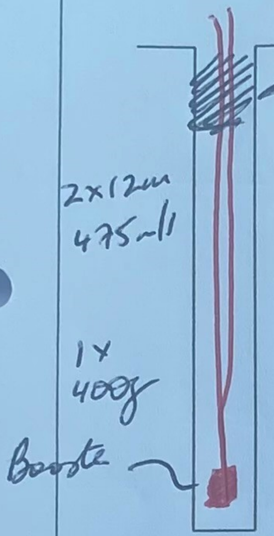
Shotfirer [signature]   Explosive Supervisor [signature]

Exsol Ltd. *Charging Plan*

Location: ATLANTIC PLANT HIRE AUGHINISH, Co. LIMERICK   Blast No: 11764-24   Date: 14/8/24

Considering – Area #1

Hole Numbers 1 to 161
Delay Numbers 475 to 2,129 m/s   AREA #1



Stemming = 3.0 – 3.5m.

PLANNED Column Charge
__________ kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed kg's

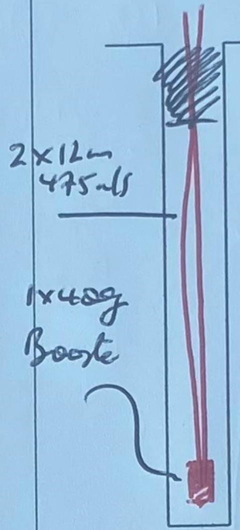
PLANNED base charge
72 – 78 kg's Sureblend 100
ACTUAL base charge not to exceed 78 kg's in weight or 6.5 metres in height.

78 Kgs = MIC.

Holes to be loaded as indicated in the charging plan

Considering – Area #2

Hole Numbers 1 to 161
Delay Numbers 475 to 2,129 m/s   AREA #2



Stemming = 3.0 – 3.5m

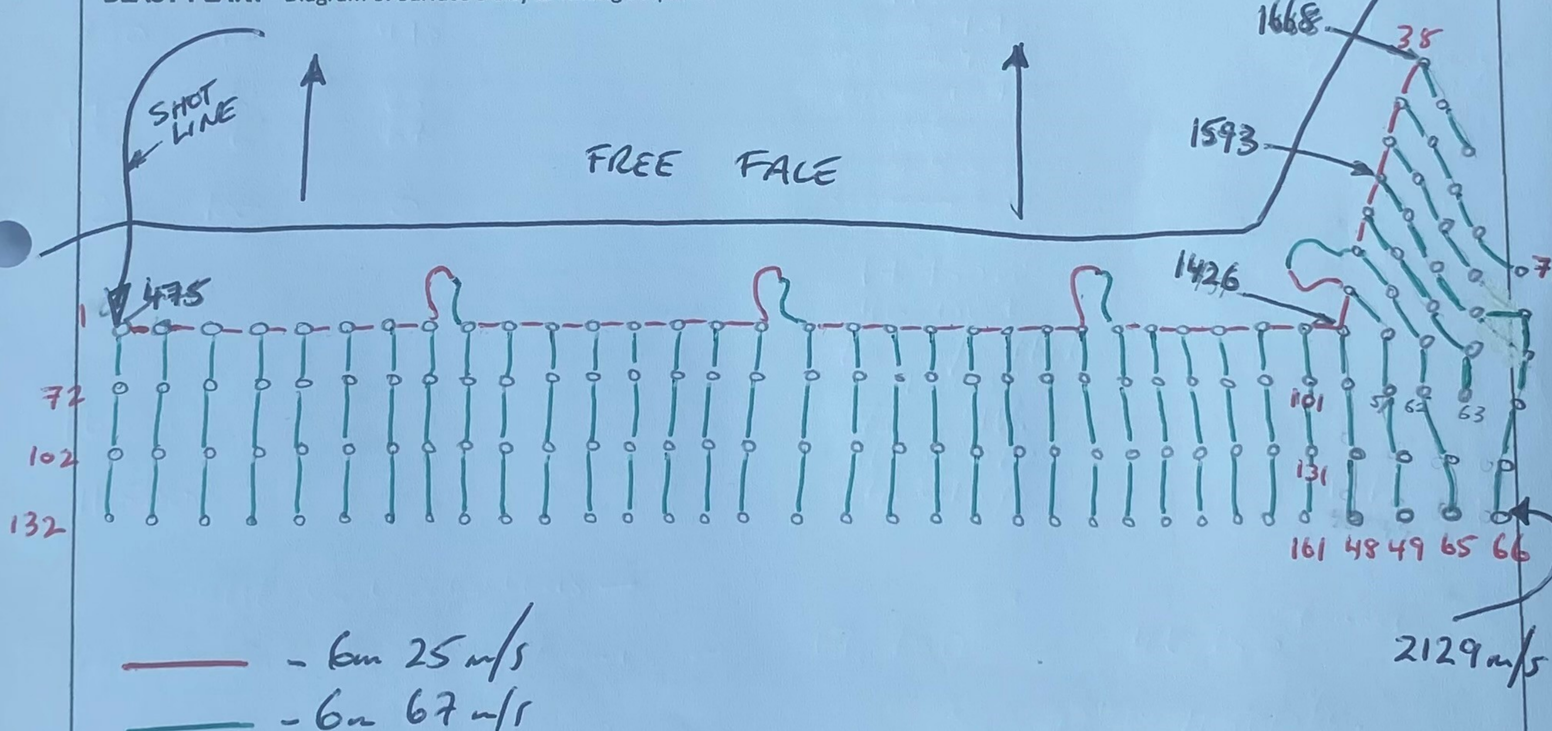
PLANNED Column Charge
__________ kg's Sureblend 100
To be loaded as indicated.
ACTUAL Column Charge not to exceed kg's

PLANNED base charge
72 – 84 kg's Sureblend 100
ACTUAL base charge not to exceed 84 kg's in weight or 7.0 metres in height.

84 Kgs = MIC.

Holes to be loaded as indicated in the charging plan

BLAST PLAN: - Diagram of Surface Delay & Timing Sequence



Shotfirer: [signature]   Explosive Supervisor [signature]

Town Centre House
Dublin Road
Naas
Co Kildare

wsp.com

Attachment 8
Waste Analysis

Quarter 1 2024

Emission Point Reference	Description	Date	IEL Limits	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	**Red Mud****		N/A	11.46	67.95	311.00	68.40	1997.00	3181.00	39008.84	5.19	<0.01	656.92	41.31	100168.26	18.33	462.73	<0.0025	17.54	6614.91	23.84
	Sand		N/A	9.50	83.75	397.40	2.90	514.00	3076.00	20371.1	5.48	<0.01	555.55	45.12	233018.16	42.38	149	<0.0025	9.42	3764.50	57.12
	Salt Cake		N/A	13.26	56.27	5143.10	3271.30	219036.00	249141.00	32081.64	30.17	<0.01	1.15	5.83	2127.42	<0.01	142	<0.0025	5.63	12.83	10.14
				pH	**--**	**Chloride**	**Fluoride**	**Soda**	**Total Alkalinity**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
						mg/l	**mg/l**	**mg/l**	**mg/l $CaCO_3$**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Red Mud stack Leachate		N/A	12.28	N/A	67.50	15.40	1.4	1977.20	148.2	179.0	<1	27.00	14	79	<1	0.1	1.04	1	117	<2
				pH	**Dry matter**	**Organic matter**	**N**	**P**	**--**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
					%	**%**	**mg/l**	**mg/l**		**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Sanitary Sludge		N/A	7.2	<1.52	99.9	113.0	64.9	N/A	27300	12	4	40	4265	22367	55	13.8	<0.06	86	<5	2947

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**
**** Farmed red mud**

Quarter 2 2024

Emission Point Reference	Description	Date	IEL Limits	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	**Red Mud****		N/A	11.00	72.46	55.1	55.38	1785.06	2865.02	23482	<.01	<.01	449.11	24.01	60226.19	9.54	263.05	<.0025	6.43	5906.39	24.51
	Sand		N/A	9.62	80.43	30.0	8.68	627.87	925.99	18586.4	14.32	<.01	1877.58	25.41	2138.37	19.55	69.31	<.0025	37.42	3422.69	41.05
	Salt Cake		N/A	13.20	55.21	6089.0	2891.06	270470.19	345394.70	22182.00	110.80	<.01	<.01	2.19	31.02	<.01	26.88	<.0025	2.08	14.74	1.10
				pH	--	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
						mg/l	mg/l	mg/l	mg/l $CaCO_3$	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Red Mud stack Leachate		N/A	12.10	N/A	101.37	22.48	1920.0	4798.00	155.5	425.0	<1	25.00	24	54	<1	0.1	1.91	4	9	2
				pH	Dry matter	Organic matter	N	P	--	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	%	mg/l	mg/l		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Sanitary Sludge		N/A	7.4	<1.52	84.9	55.8	54.0	N/A	84	1	<1	<1	35	728	<1	9.9	<.006	2	<5	56

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**

**** Farmed red mud**.

Quarter 3 2024

Emission Point Reference	Description	Date	IEL	pH	Dry matter	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
			Limits		%	mg/Kg	mg/Kg	mg/Kg	mg/Kg $CaCO_3$	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
C.4 Waste Monitoring	**Red Mud****		N/A	10.47	72.01	114.1	76.50	3676.03	4669.81	44472	5.79	1.73	711.25	54.37	98054.00	19.74	249.38	<.0025	9.83	4035.91	31.55
	Sand		N/A	8.67	85.60	58.7	6.85	797.24	578.84	22252.7	12	3.76	901.00	53.13	234392.00	28.42	105.39	<.0025	10.27	3557.82	73.43
	Salt Cake		N/A	12.72	56.97	5262.4	666.19	319782.59	309786.19	39165.00	29.13	<.01	<.01	9.84	20.25	<.01	55.37	<.0025	1.89	7.25	1.94
				pH	**--**	**Chloride**	**Fluoride**	**Soda**	**Total Alkalinity**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
						mg/l	**mg/l**	**mg/l**	**mg/l $CaCO_3$**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Red Mud stack Leachate		N/A	10.52	N/A	261.61	23.90	4800.0	4693.60	113.0	0.4	<.001	0.02	0.039	0.384	<.001	1	0.0002	0.008	0.037	<.002
				pH	**Dry matter**	**Organic matter**	**N**	**P**	**--**	**Al***	**As***	**Cd***	**Cr***	**Cu***	**Fe***	**Pb***	**Mg***	**Hg***	**Ni***	**Ti***	**Zn***
					%	**%**	**mg/l**	**mg/l**		**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**mg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
	Sanitary Sludge		N/A	7.1	0.43	75.7	86.1	25.3	N/A	8513	8	4	19	4186	17178	42	23.3	<.08	54	<5	2998

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**

**** Farmed red mud**.

Quarter 4 2024

Emission Point Reference	Description	Date	IEL Limits	pH	Dry matter %	Chloride mg/Kg	Fluoride mg/Kg	Soda mg/Kg	Total Alkalinity mg/Kg $CaCO_3$	Al* mg/Kg	As* mg/Kg	Cd* mg/Kg	Cr* mg/Kg	Cu* mg/Kg	Fe* mg/Kg	Pb* mg/Kg	Mg* mg/Kg	Hg* mg/Kg	Ni* mg/Kg	Ti* mg/Kg	Zn* mg/Kg
C.4 Waste Monitoring	Red Mud**		N/A	11.33	72.45	215.1	134.30	6967.91	9591.07	43972	4.43	1.42	606.69	32.25	156888.00	18.36	383.32	<.0025	8.68	6545.85	27.86
	Sand		N/A	9.97	84.83	17.7	3.87	1480.82	1626.82	29220	7.56	3.93	9002.14	53.71	312643.61	29.18	121.30	<.0025	6.90	4371.04	68.66
	Salt Cake		N/A	13.05	57.66	5316.3	820.76	236754.26	336494.50	35600	24.73	<.01	0.21	4.70	84.60	<.01	76.20	<.0026	2.45	16.79	1.45
				pH	--	Chloride	Fluoride	Soda	Total Alkalinity	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
						mg/l	mg/l	mg/l	mg/l $CaCO_3$	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Red Mud stack Leachate		N/A	11.23	N/A	659.49	25.73	2160.0	12716.00	281.90	733.0	<1	60.00	71	373	<1	0.1	0.76	9	65	<2
				pH	Dry matter	Organic matter	N	P	--	Al*	As*	Cd*	Cr*	Cu*	Fe*	Pb*	Mg*	Hg*	Ni*	Ti*	Zn*
					%	%	mg/l	mg/l		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l
	Sanitary Sludge		N/A	7.6	0.53	77.0	44.1	24.1	N/A	2560	12	5	63	6226	345	55	24.9	8.85	87	85	4272

***Metal analysis & Sanitary Sludge analysis : Fitz Scientific**

**** Farmed red mud**.