Adelaide Brighton Cement Ltd.

Additional Information
Alternative Fuel Post Trial Report
Increased Refuse Derived Fuel Addition up to 25 t/h
Birkenhead Works EPA (Licence 1126)

Provided to the SA Environment Protection Authority – July 2020

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Glossary

Term	Definition
g/h	grams per hour
m^3	cubic metres
ng	nanogram. (10^{-9} gram)
Nm^3	gas volume in dry cubic metres at STP dry basis
ppm	parts per million
tph	tonnes per hour
Abbreviations	**Definition**
Air EPP	Environment Protection (Air Quality) Policy 2016
CKD	Cement Kiln Dust
GLC	Ground Level Concentration
ITEQ	International Toxic Equivalent for PCDD's & PCDF's, (NATO 1989 basis)
NATA	National Association of Testing Authorities, Australia
NEPM	National Environmental Protection Measure
PCDD's	Polychlorinated Dibenzo-p-Dioxins
PCDF's	Polychlorinated dibenzofurans
RDF	Refuse derived fuel – processed fuel produced from waste materials generated by construction, demolition, commercial and industrial sources
RPP	Recovered Products Plan
SA EPA	South Australian Environment Protection Authority
SCADA	Supervisory Control and Data Acquisition (a control system that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management)

Contents

1. Introduction

The Environment Protection Authority requested further information following the review of the "Alternative Fuel Post Trial Report- Increased Refuse Derived Fuel Addition up to 25 t/h Birkenhead Works EPA (Licence 1126), dated 23 January 2020", with minor correction submitted 5 March 2020.

This document provides additional information on the Increased Refuse Derived Fuel Addition up to 25 t/h trial in response to discussions between ABCL and the EPA.

2. Plastics Content of RDF

2.1 Current RDF approval - 15 tph with a maximum of 20% plastic

The nature of the material inputs into the production of Refuse Derived Fuel (RDF) has always resulted in variable plastic content. ABC requested an increase in RDF plastic level from 10% up to 20%, to manage the changes in material inputs, driven through improved separation and recovery of heavier recyclable components (typically, sand, brick, rock and concrete).

ABC submitted an Alternative Fuel - Post Trial Report Increasing Plastic Content to 20% in RCD Wood Waste, dated March 2015, to the EPA, with the application requesting an increase plastic levels up to 20% in RDF at 15 tph burn rate. This report noted that the plastics level during the trial averaged 14% by weight and laboratory records showed that the plastic content of RCD wood waste has historically been highly variable, with a standard deviation of 3% by weight. As a result, ABCL estimates that deliveries could contain up to 20% plastic content by weight and framed this submission around this percentage as a maximum plastic content the process is likely to receive. The report included test emission results at lower plastics levels and ABCL concluded that that, through extrapolating the data on emission of organic analytes from this trial and previous tests, the total destruction of the plastics is occurring in the calciner and emission levels will be no worse, and perhaps slightly better, at the maximum requested plastic content of 20% by weight.

The EPA approved the use of RDF with up to a maximum of 20% Plastic in June 2018, following a thorough review and analysis of the application submitted by ABCL. This review included the increased plastic content trial methodology, testing, results and trial report. Furthermore, the review also included a third-party peer review conducted by the Victorian EPA, which concluded that emissions from the cement kiln are not altered by the increase of plastics in the recycled construction and demolition supplementary fuel.

Along with the approval of RDF with up to a maximum of 20% plastic, additional controls were put in place to ensure quality assurance measures for the production and use of RDF. These controls require:

- The production and supply of RDF in compliance with an EPA approved Recovered Product Plan (RPP), for ABCL's Birkenhead Works, as required by the SA EPA "Standard for the production and use of refuse derived fuel", dated February 2010 (Standard).
- The supplier of the RDF to operate under an SA EPA approved Environmental Management Plan for the supply of RDF to ABCL's Works, as required by the Standard.
- The RDF Recovered Product Plan to detail the components and acceptance criteria for the RDF, quality control and quality assurance requirements and the management of the transport, storage and use of the RDF in the Birkenhead clinker kiln.

2.2 RDF Plastics Variation – 25 tph RDF Trial

2.2.1 RDF Sampling

The quality of the RDF delivered to the site is monitored by taking two representative samples of RDF per day, which are combined to form a daily composite sample. Twice a week, two composite samples are randomly selected for analysis. The plastic content is manually separated from the sample weighed and expressed as a percentage.

2.2.2 Statistical Analysis of RDF Plastic content

Statistical analysis of the laboratory tests results for plastic content in RDF delivered to the plant following EPA approval in June 2018, which allowed up to a maximum of 20% Plastic, is summarised in Table 1.

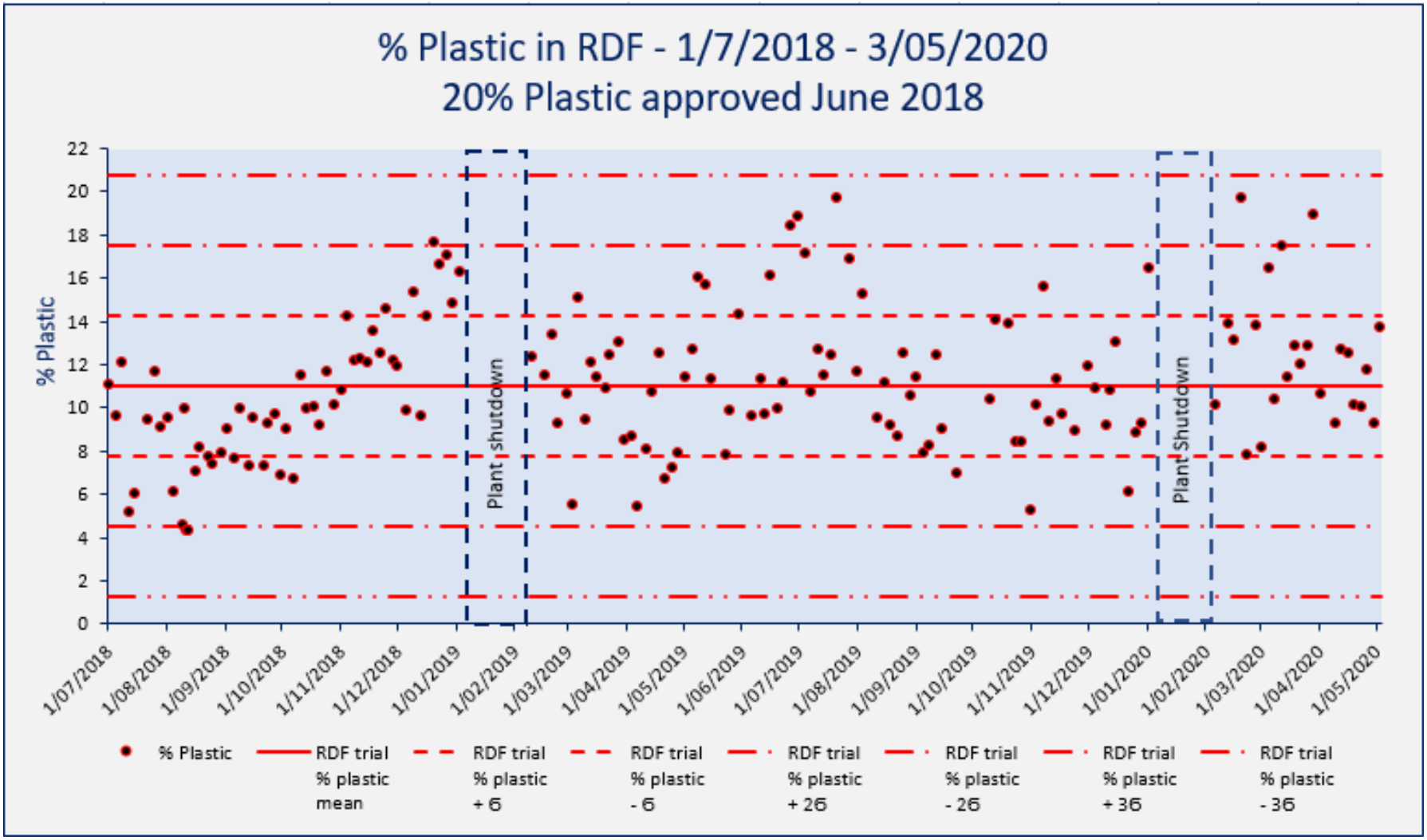
Table 1: Statistical analysis of % Plastics in RDF between 1/7/2018 to 3/5/2020

% Plastic	
Mean	11.05
Standard Error	0.26
Median	10.74
Mode	9.94
Standard Deviation	3.24
Sample Variance	10.53
Kurtosis	0.09
Skewness	0.45
Range	15.45
Minimum	4.28
Maximum	19.73
Sum	1757.18
Count	159

The statistical data, summarised in Table 1, indicates that the plastic content of the RDF is close to a normal distribution, with a mean of 11.05% and a standard deviation of 3.2%. As the data closely approximates a normal distribution, then 68.27%, 95.45% and 99.73% of the plastic values lie within one, two and three standard deviations of the mean respectively, and provides confidence that most (99.7%) of analysed values are likely to be below 20.8% plastic content.

The plastic content of the RDF has been presented graphically in Figure 1, which shows that plastic content is quite variable with a maximum content up to 20%.

Figure 1: RDF plastic content between 1/7/2018 - 3/05/2020 post EPA approval of 20% plastic content in June 2018



2.2.3 Statistical analysis of RDF plastic content during the 25 tph RDF trial period

Statistical analysis of plastic content of RDF delivered to the plant during the 25 tph RDF trial period between 13/05/2019 and 27/10/2019 is summarised in Table 2.

Table 2: Statistical analysis of RDF plastic content during the 25tph trial period 13/05/2019 and 27/10/2019

% Plastic	
Mean	11.92
Standard Error	0.53
Median	11.31
Mode	#N/A
Standard Deviation	3.31
Sample Variance	10.97
Kurtosis	-0.21
Skewness	0.77
Range	12.77
Minimum	6.94
Maximum	19.71
Sum	464.89
Count	39

The statistical data summarised in Table 2, indicates the plastic content of the RDF is close to a normal distribution, with a mean of 11.92% and a standard deviation of 3.31%, and aligns well with the much larger data set in Table 1. As the data closely approximates a normal distribution, then 68.27%, 95.45% and 99.73% of the plastic values lie within one, two and three standard deviations of the mean respectively, and provides confidence that most (99.7%) of analysed values fall within 21.85% plastic content.

The plastic content of the RDF during the trial has been presented graphically Figure 2, which shows that plastic content varied between 6.9% and 19.7%.

Figure 3 presents the plastic content of the RDF during the 25 tph trial period in the broader context of RDF plastics data for 2019.

The statistical analysis is consistent with the EPA approval of up to 20% plastic in RDF in June 2018 and demonstrates that the quality assurance measures that are in place are effective.

Figure 2: RDF % Plastics content during the 25 tph trial between 13/05/2019 - 27/10/2019

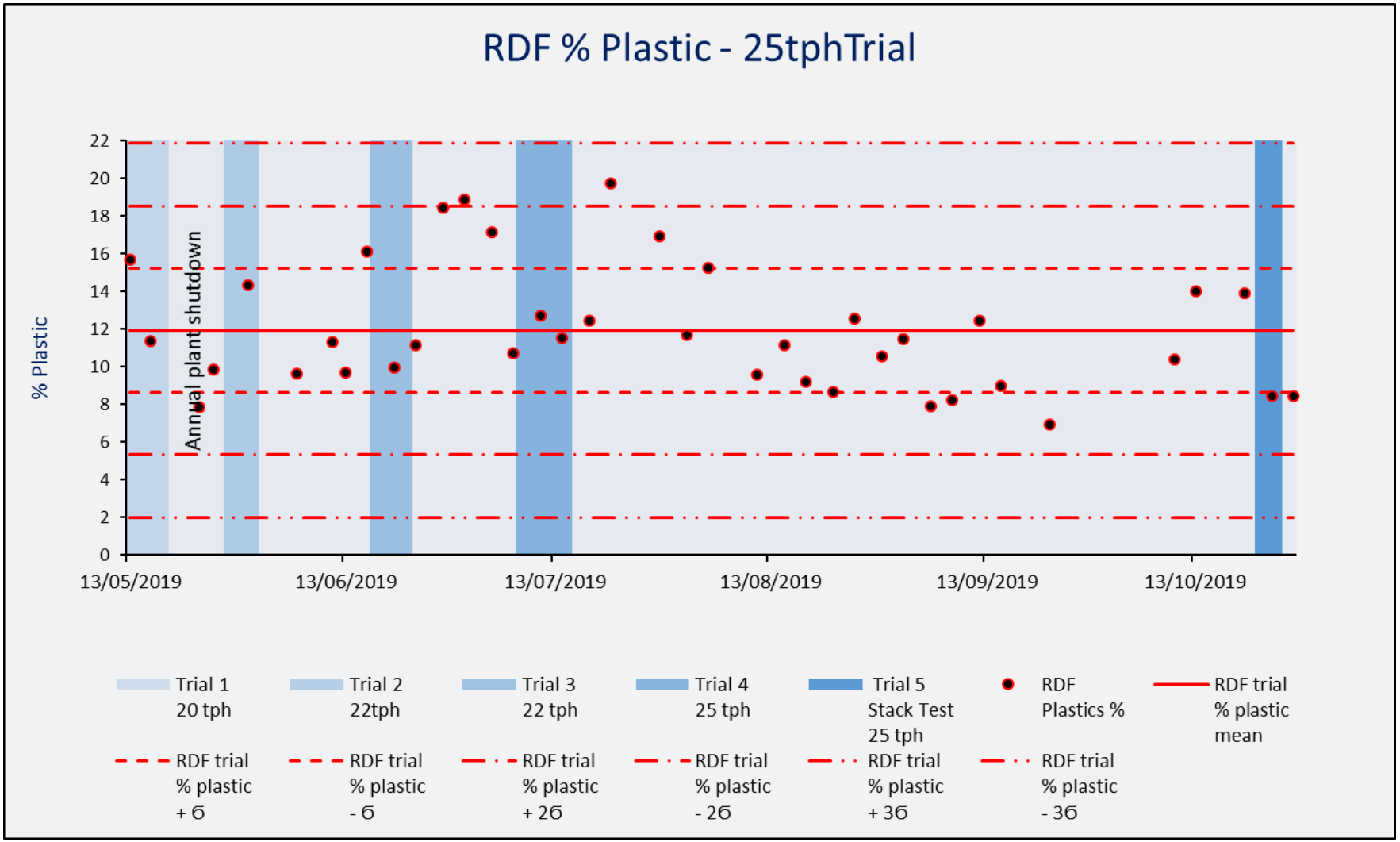
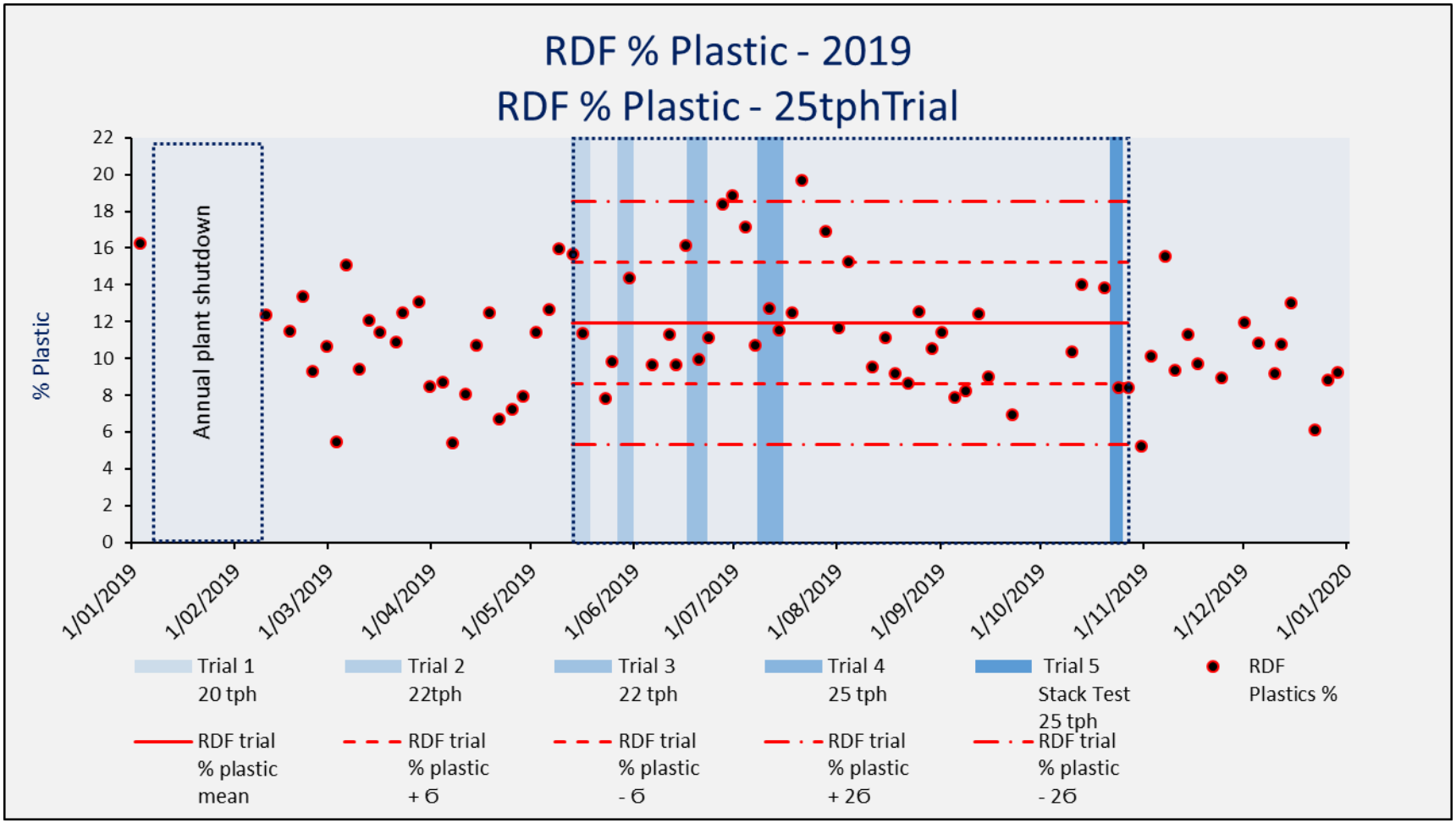


Figure 3: RDF % Plastics for 2019 including the 25 tph trial between 13/05/2019 - 27/10/2019



2.2.4 Plastic content during the 25 tph RDF trial

Whilst the plastic content in the RDF is highly variable, the statistical analysis confirms the RDF supplied is consistent with the 20% plastic content approved by the EPA in June 2018 and demonstrates that the quality assurance measures that are in place are effective.

ABCL is unable to adjust the plastic content of the RDF to achieve a consistent plastic level as close as possible to 20% for the purposes of the trial for the following reasons:

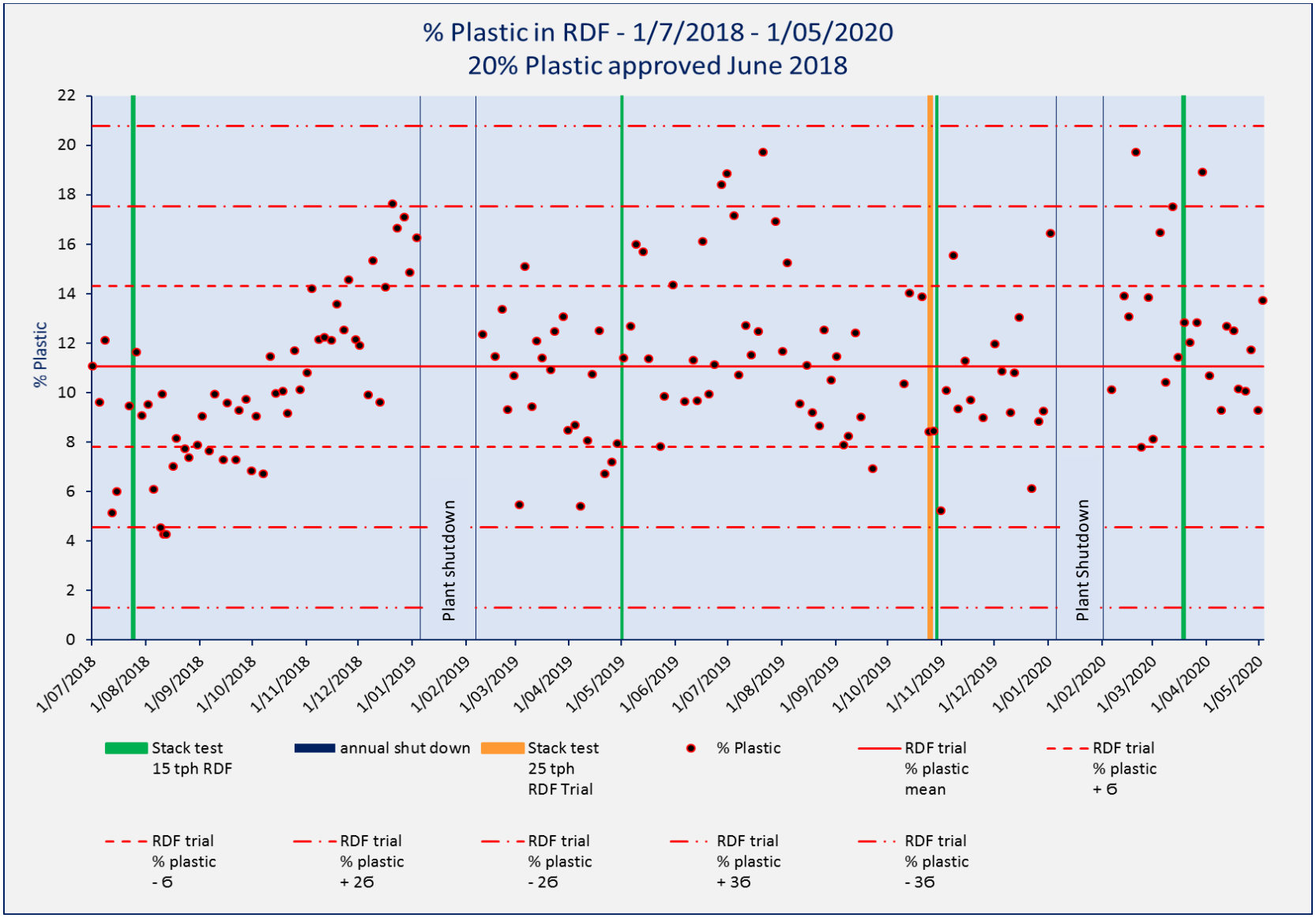
- The RDF, Recovered Products Plan - Birkenhead Works (EPA licence 1126), approved by the SA EPA on the 13/6/2018, prohibits the intentional addition of plastics.
- The use of RDF approved under the Recovered Products Plan cannot be undertaken without the RDF supplier having an EPA approved Environment Management Plan. Suez ResourceCo Refuse Derived Fuel Environmental Management Plan (Suez ResourceCo EPA licence 19583), dated September 2017 and approved by the SA EPA on the 24 November 2017, also prohibits the addition of neat plastic to the RDF.
- Even if it were permitted to add plastic to increase the plastic content of the RDF, the variable nature of the material inputs would make it very difficult and impractical to produce RDF with a consistent plastic content close to 20%, without the possibility of exceeding the allowable maximum of 20%.

ABCL's Standard RDF sampling and testing practices for plastic content were used during the RDF trial. The RDF was sampled and tested just before commencement of the 25 tph trial for stack emissions tests and analysed with a 14% plastic content. The next sample of RDF taken four days later towards the end of the stack emissions testing was analysed with an 8.4% plastic content.

Laboratory analysis of RDF plastic content during the trial period, presented in Figure 2, shows that the plastic content varied between 6.9% and 19.7%. It also shows that the plastic content of the two representative samples taken at the time of the RDF trial stack emission tests were 14% and 8.4% plastic. Given the statistical variation of the plastic content in the RDF, ABCL is highly confident that during the 25 tph RDF trial stack emissions tests, there would have been times when RDF with up to 20% plastics was burnt.

Figure 5 shows the plastic content of the RDF when stack emissions tests were performed, since the approval for 20% plastics content in June 2018. The graph shows that while the stack tests have generally coincided with plastic levels close to the mean, it is highly likely that some RDF deliveries with plastic content up to 20% was burnt during these stack emission test periods.

Figure 5: RDF Plastic content between 1/7/2018 - 3/05/2020 and stack emission tests post EPA approval of 20% plastic content in June 2018



3.0 Stack Emission Tests and Results for Specific Analytes

RDF is burnt in the Calciner and emissions from the the combustion of RDF are released to atmosphere via 4B stack.

Stack emission tests during the trial were conducted by AIrlabs Environmnental Pty Ltd.

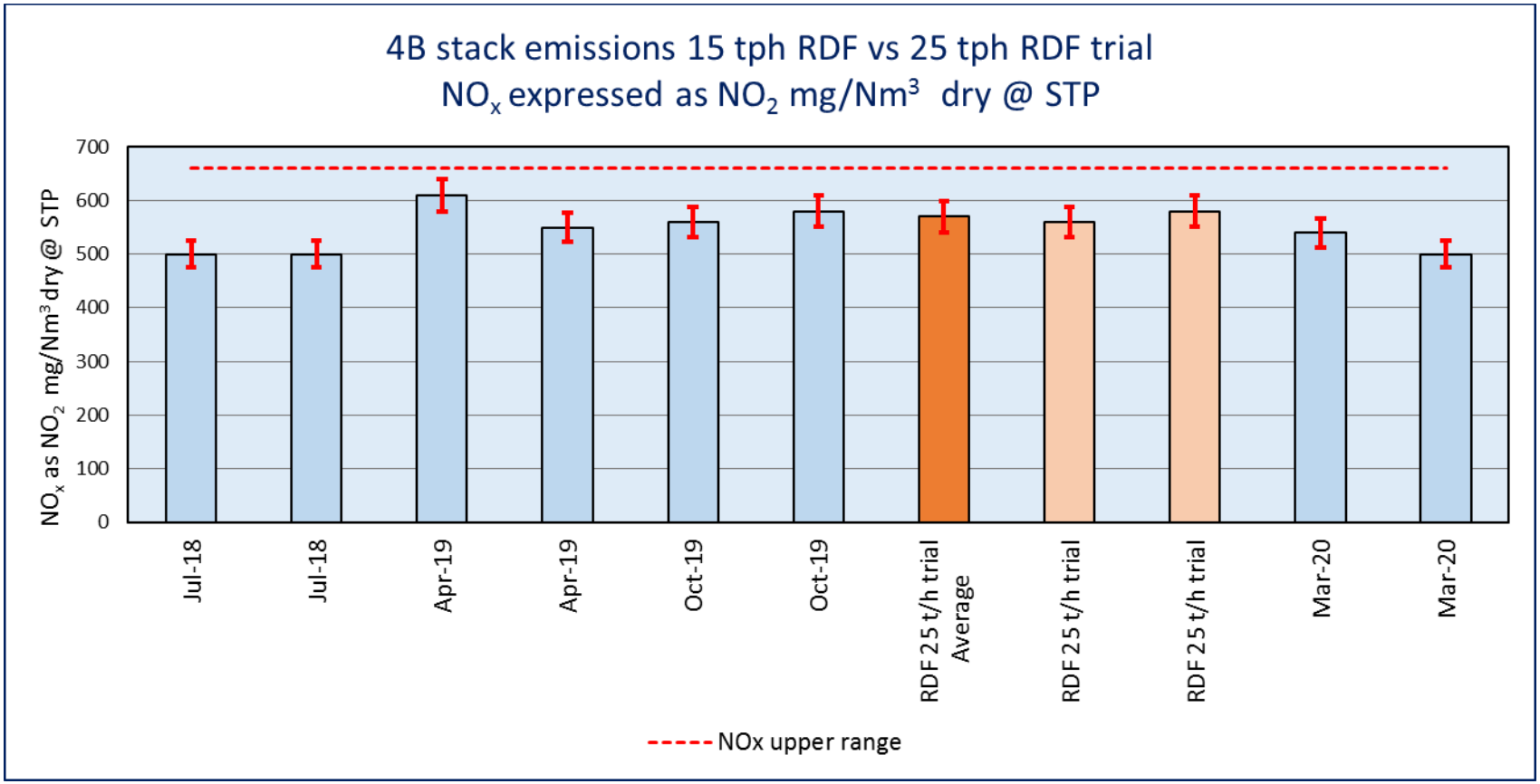
Analyte concentration levels during the trial have been compared to previous stack testing results to observe and comment on any changes that resulted from the increased burn rate of RDF at 25 tph.

The 25 tph RDF trial stack emisions have been compared against recent stack emission results for RDF with up to 20% plastic content, for selected analytes of interest. Comparison of emission concentrations for; oxides of nitrogen (NO_x), carbon monoxide (CO), benzene, dioxins and furans and volatile organic compounds (VOC), are shown in Figures 6,7,8,9 and 10 respectively. These graphs all show that the 25 tph RDF trial emissions fall within the normal process variation (indicated by dashed red line) and test variation (indicated by red error bars). This indicates that there is no significant change in these emissions, when RDF at 25 tph with up to 20 % plastic is burnt.

Modelling of the 25 tph RDF trial stack emissions, was undertaken by Airlabs Environmental Pty Ltd, so that they could be evaluated against Schedule Y-1 of the licence and the relevant ground level concentration criteria in the Environment Protection (Air Quality) Policy 2016. All the ground level concentrations were predicted to be well below the EPA guidelines.

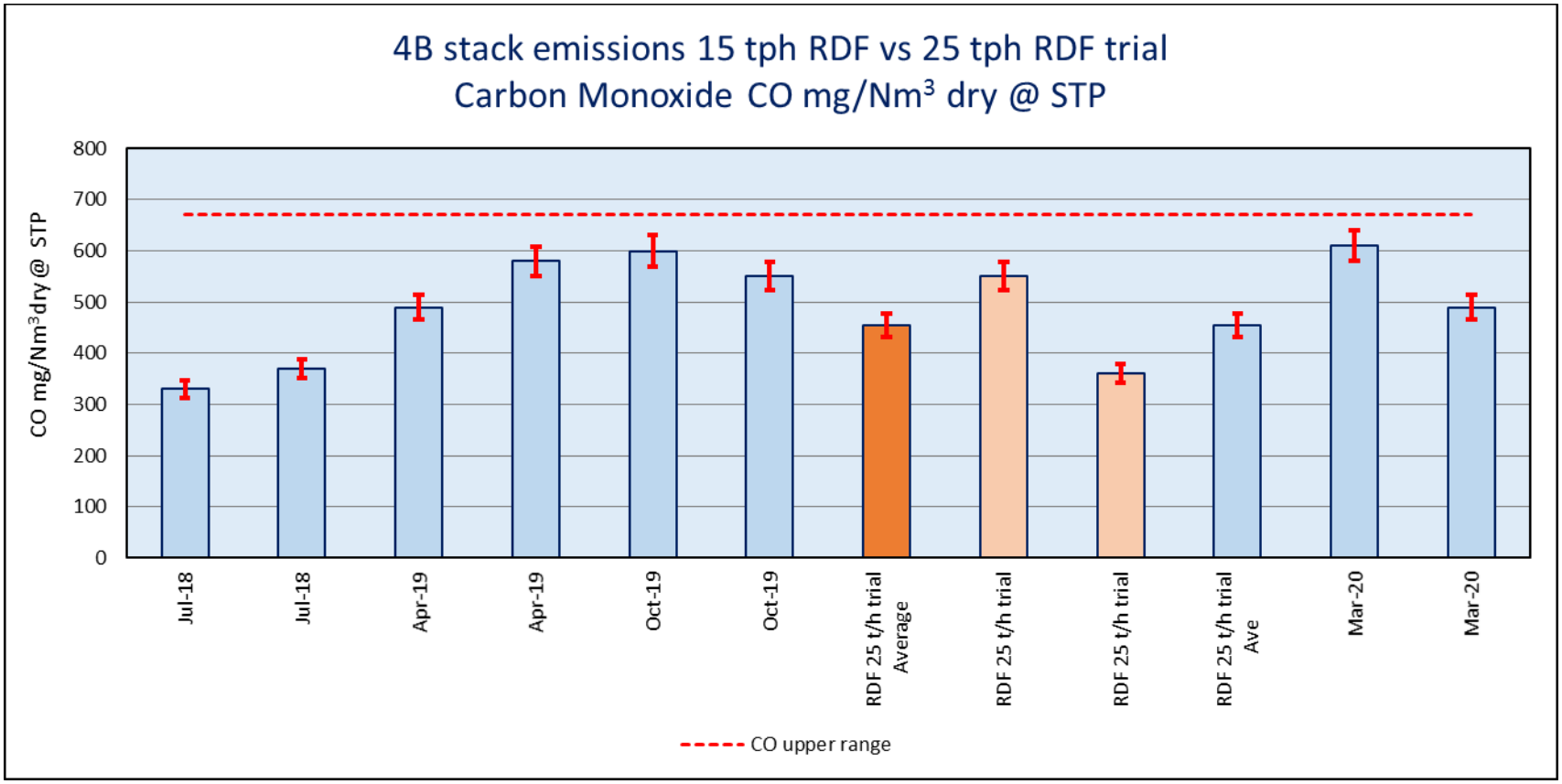
Comparison of ground level concentrations (GLC) for selected analytes, for recent stack tests using RDF with up to 20% plastic content for RDF burn rates at 15 tph and 25 tph are shown in figures 11 and 12. These figures show that there is no significant variation in modelled ground level concentrations for burn rates of RDF up to 25 tph and 20% plastics.

Figure 6: 4B Stack – Oxides of Nitrogen emissions NO_x expressed as NO_2



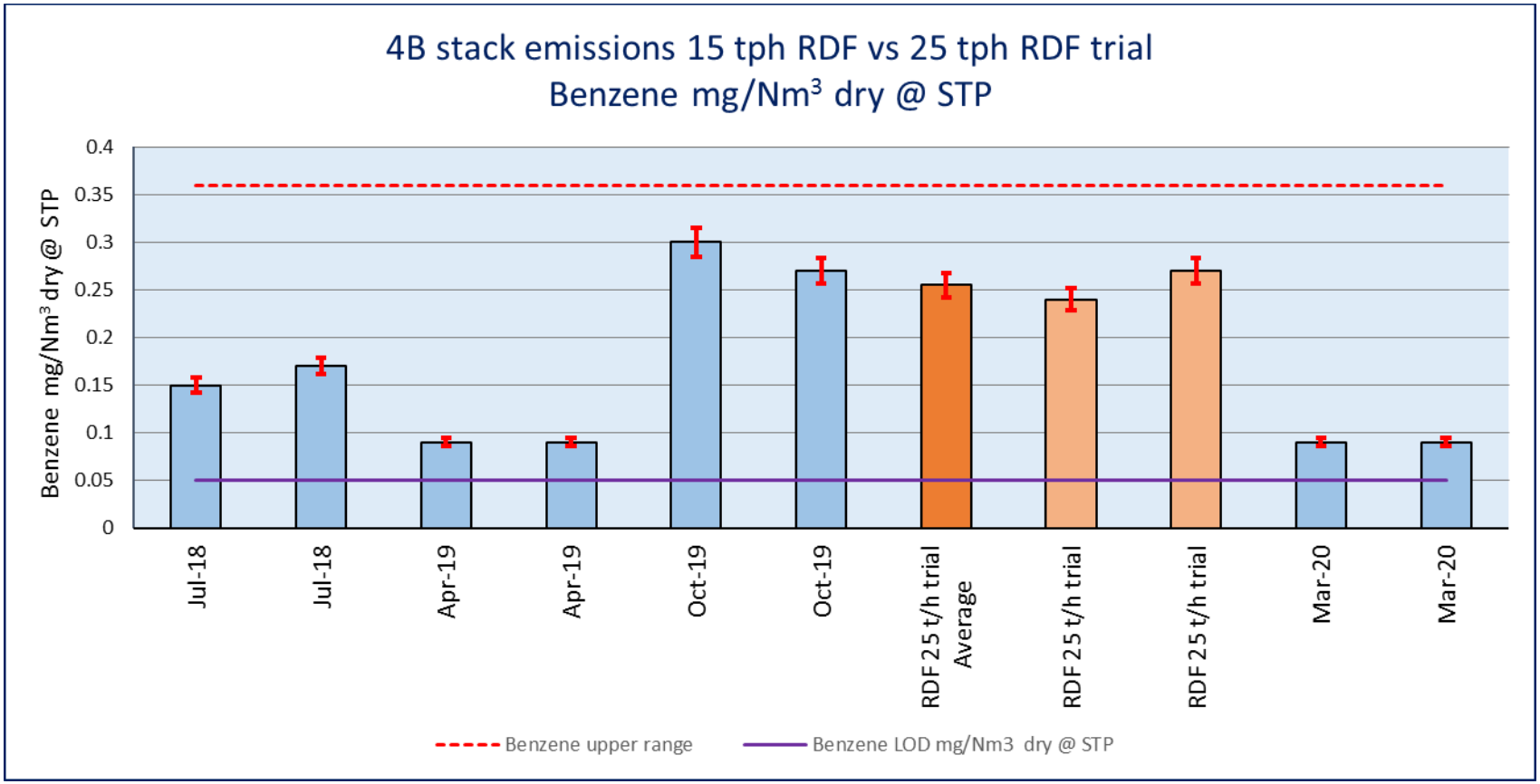
Note: EPA Licence was amended in June 2018 to allow up to 20% plastic by weight in RDF at a maximum burn rate of 15 tph
Note: Measurement uncertainty bars (expressed as a percentage) are shown for each test result

Figure 7: 4B Stack – Carbon monoxide (CO) emissions



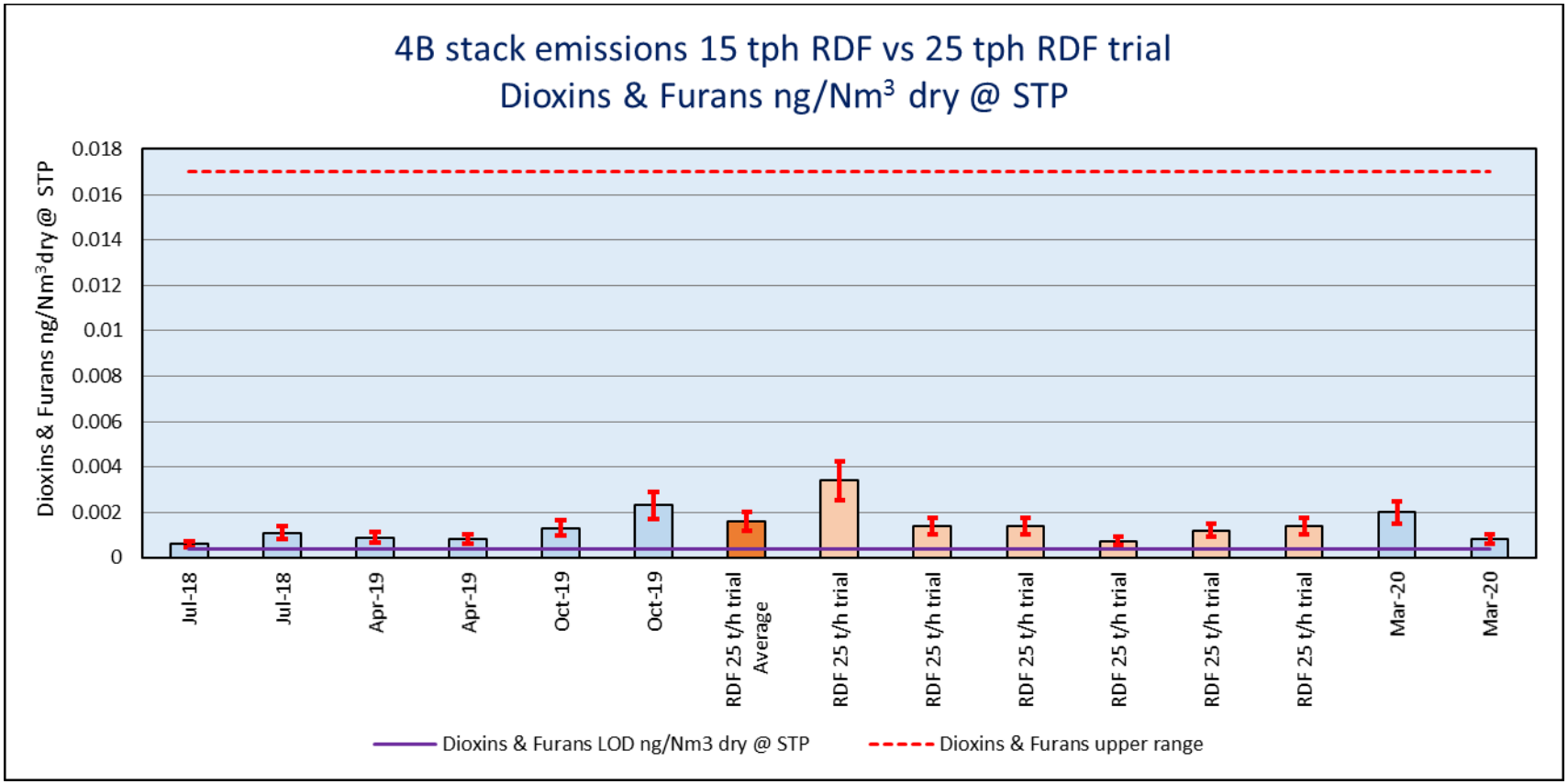
Note: EPA Licence was amended in June 2018 to allow up to 20% plastic by weight in RDF at a maximum burn rate of 15 tph
Note: Measurement uncertainty bars (expressed as a percentage) are shown for each test result

Figure 8: 4B Stack – Benzene emissions



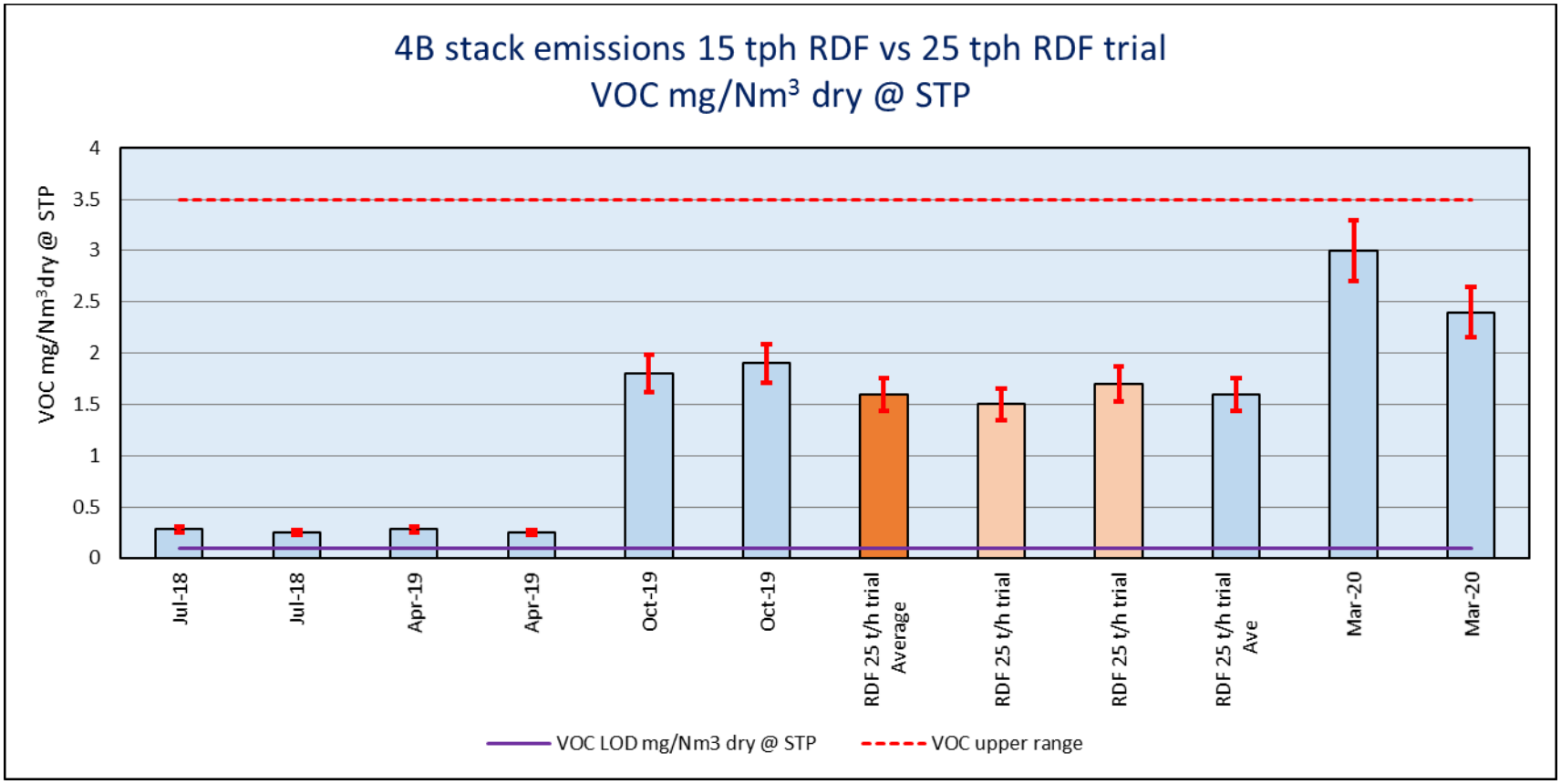
Note: EPA Licence was amended in June 2018 to allowup to 20% plastic by weight in RDF at a maximum burn rate of 15 tph
Note: Measurement uncertainty bars (expressed as a percentage) are shown for each test result

Figure 9: 4B Stack – Dioxins and Furans



Note: EPA Licence was amended in June 2018 to allowup to 20% plastic by weight in RDF at a maximum burn rate of 15 tph
Note: Measurement uncertainty bars (expressed as a percentage) are shown for each test result

Figure 10: 4B Stack – Volatile Organic Compounds (VOC)



Note: EPA Licence was amended in June 2018 to allowup to 20% plastic by weight in RDF at a maximum burn rate of 15 tph
Note: Measurement uncertainty bars (expressed as a percentage) are shown for each test result

Figure 11: Stack tests and modelled maximum ground level concentrations (including background) of selected analytes (RDF up to 20% plastic)

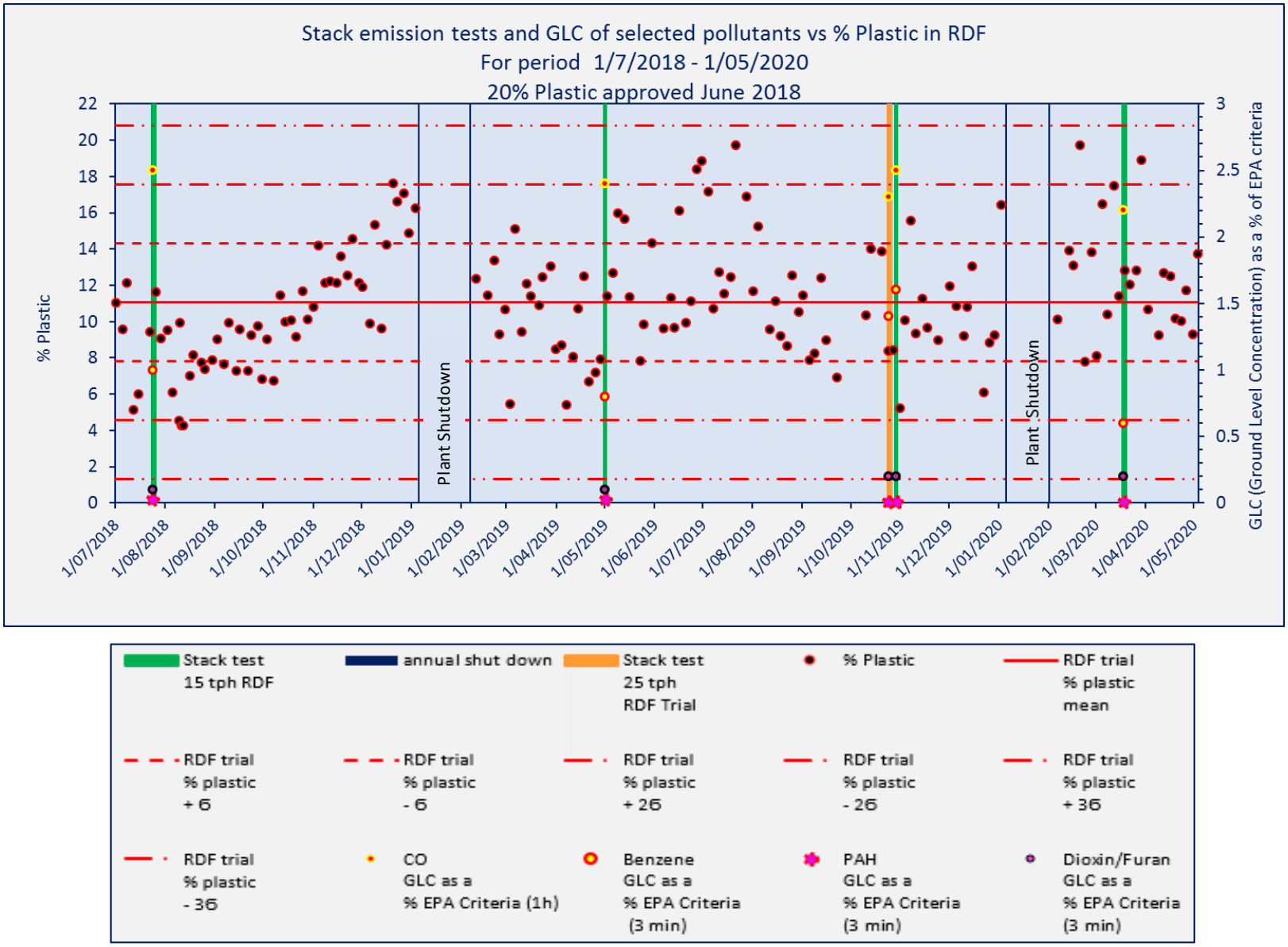
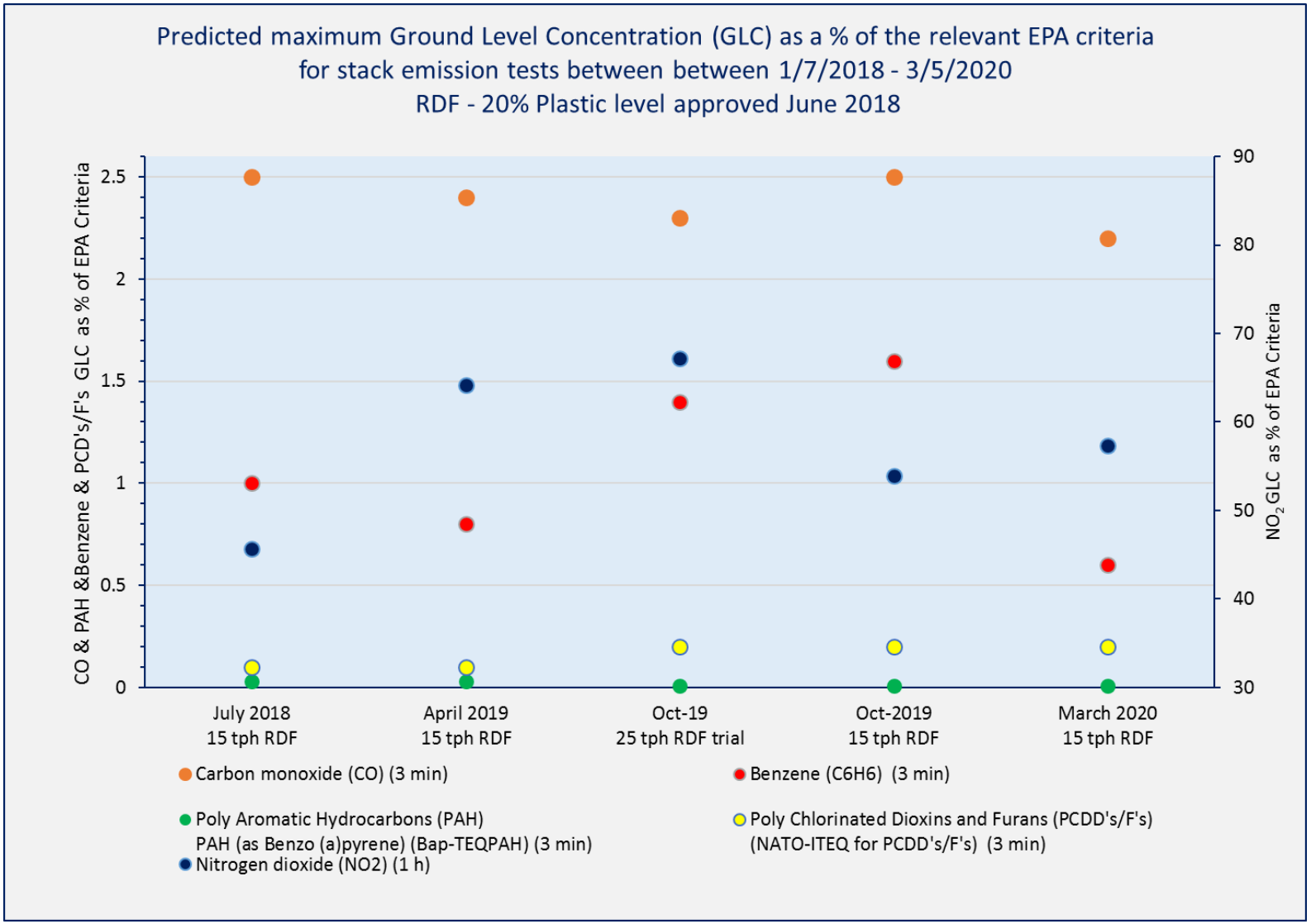


Figure 12: Stack emission tests and modelled maximum ground level concentrations (including background) of selected analytes



4. Complete Combustion of RDF

As discussed in the "Alternative Fuel Post Trial Report - Increased Refuse Derived Fuel Addition up to 25 tph", dated 5 March 2020, there was no significant change in carbon monoxide levels on 4B stack during the testing period compared to the previous stack testing results. Higher than normal levels of carbon monoxide on 4B stack could have indicated changes in burning conditions in the calciner, but it was pleasing to see this was not the case, providing confirmation that complete burnout of RDF is ocurring.

In addition, the measured levels of poly aromatic hydrocarbons, benzene and volatile organic compounds during the 25 tph RDF trial all remained within the normal range of variation previously observed. These results are further evidence that products of incomplete combustion are not being generated.

The Birkenhead site EPA licence requires ABCL to monitor and record operational conditions in accordance with licence condition U-725 Alternative Fuels – Operational Requirements as follows:

The Licensee must ensure that:

3.2.1 all alternative fuels listed in Schedule X-1 of this licence are:

a) completely combusted in a certified Type B gas appliance;

b) not admitted into the certified Type B gas appliance during start-up, shut down, or where the gas flame is not under stable operating conditions;

3.2.2 the following parameters are monitored and recorded whenever alternative fuels listed in Schedule X-1 of this licence are used:

a) the alternative fuel type and usage rate;

b) the temperature in degrees Celsius of the combustion gases exiting the Type B gas appliance;

c) the composition of the combustion gases exiting the Type B gas appliance, including but not limited to the percentage of oxygen, carbon monoxide and methane;

d) the temperature in degrees Celsius of the combustion gases entering the electrostatic precipitators;

3.2.3 records relating to this condition are kept for the term of the Licence, and are made available to an Authorised Officer upon request.

ABCL operates a Burner Management System (BMS), that has been independantly certified by the Office of the Technical Regulator for Type B combustion appliances. In addittion the kiln and calciner have process monitors to measure carbon monoxide, methane and oxygen at various points in the process, to assist in the optimisation of the combustion process and mitigate the risk of an uncontrolled combustion event in the electrostatic preciptators from unacceptable levels of carbon monoxide.

The process control system trips the RDF feed to the calciner as a first response to increases in carbon monoxide or methane levels, which indicates that a deterioration in combustion is ocurring. If carbon monoxide or methane levels levels continue to increase the whole combustion system is tripped for process safety reasons to mitigate the potential for an uncontrolled combustion event in the electrostatic precipitators. The response levels are shown in the Table 4.

Table 4: Combustion process trip levels

Trip Action	Carbon monoxide (CO)	Methane (CH_4)
RDF feed to Calciner is tripped	1.2%	0.9%
Combustion system is tripped	3% for 2 sec	1.25% for 2 sec

Figure 13 provides a schematic representation of the calciner and location of the process monitors.

Figure 14 is a screen capture of the Citect SCADA system providing an overview of the calciner operating conditions.

Temperature, carbon monoxide (CO), methane (CH_4), oxygen (O_2) levels from monitors measuring the process stream leaving the Calciner have been averaged for the 25 tph RDF trial and routine stack emission tests since 1 July 2018, and are shown in Figures 15, 16, 17 and 18 respectively. These figures show that the measured levels of carbon monoxide (CO) and methane (CH_4) are low and typical of efficient combustion in this type of process, indicating combustion has been optimised.

The calciner exit temperatures of 850 C, are well above the temperature needed for ignition and complete combustion of the RDF plastic content.

The burner management system and process control logic, ensures that the combustion of RDF is optimsed, minimising the risk of incomplete combustion and associated emissions.

During the trial the calciner feed rate and RDF addition rates were held as constant as possible, with small variations in natural gas. Normal operating set points for temperature, oxygen and pressures were maintained during the trial. The automatic burner managemnt system was able to control to all set points during the trial. Variations in feed rate were able to be automatically compensated for by adjusting the flow of natural gas to maintain temperature setpoints.

From an operational viewpoint, the trial was effective in providing an understanding of the effect of increased burning rate of RDF in the calciner. The impacts on process operation, the burner management systems, product quality and overall pyro processing circuit were assessed and no impediments to continuing at 25tph RDF feed rate were found.

Figure 13: Calciner schematic showing location of process monitors for carbon monoxide, methane, oxygen and temperature

Figure 14: Screen capture of the Citect SCADA system providing an overview of the calciner operating conditions

Figure 15: Calciner exit temperatures for stack emission tests and RDF trials since 1/7/2018

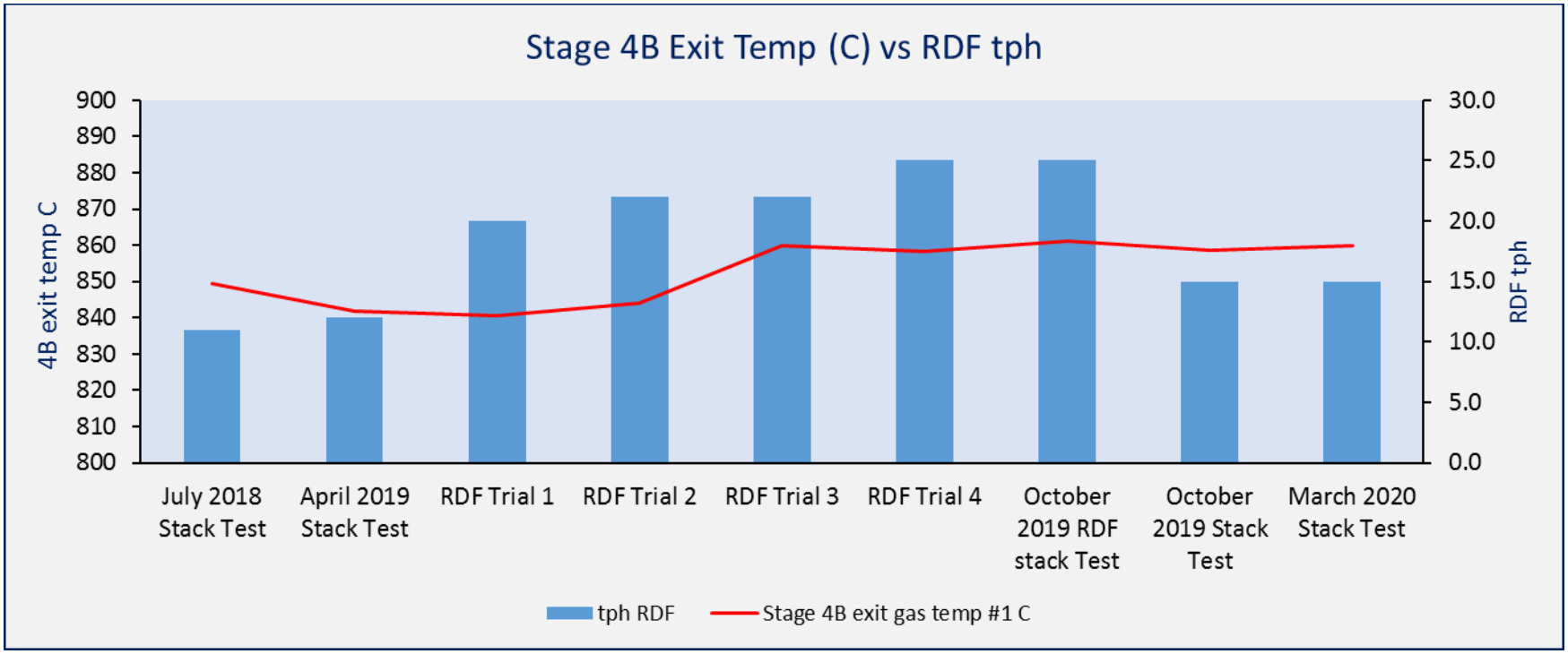


Figure 16: Carbon Monoxide (CO) levels on the Calciner process stream for stack emission tests and RDF trials since 1/7/2018

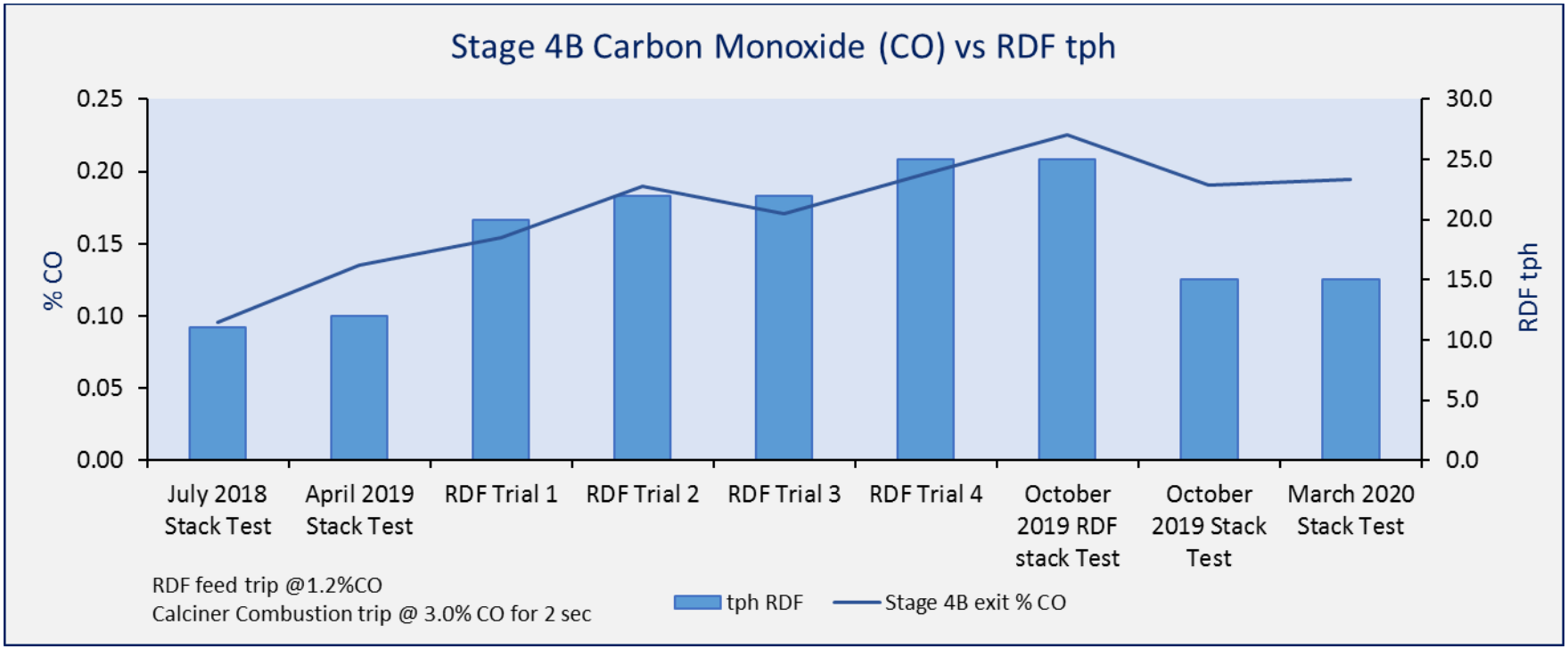


Figure 17: Methane (CH_4) levels on the Calciner process stream for stack emission tests and RDF trials since 1/7/2018

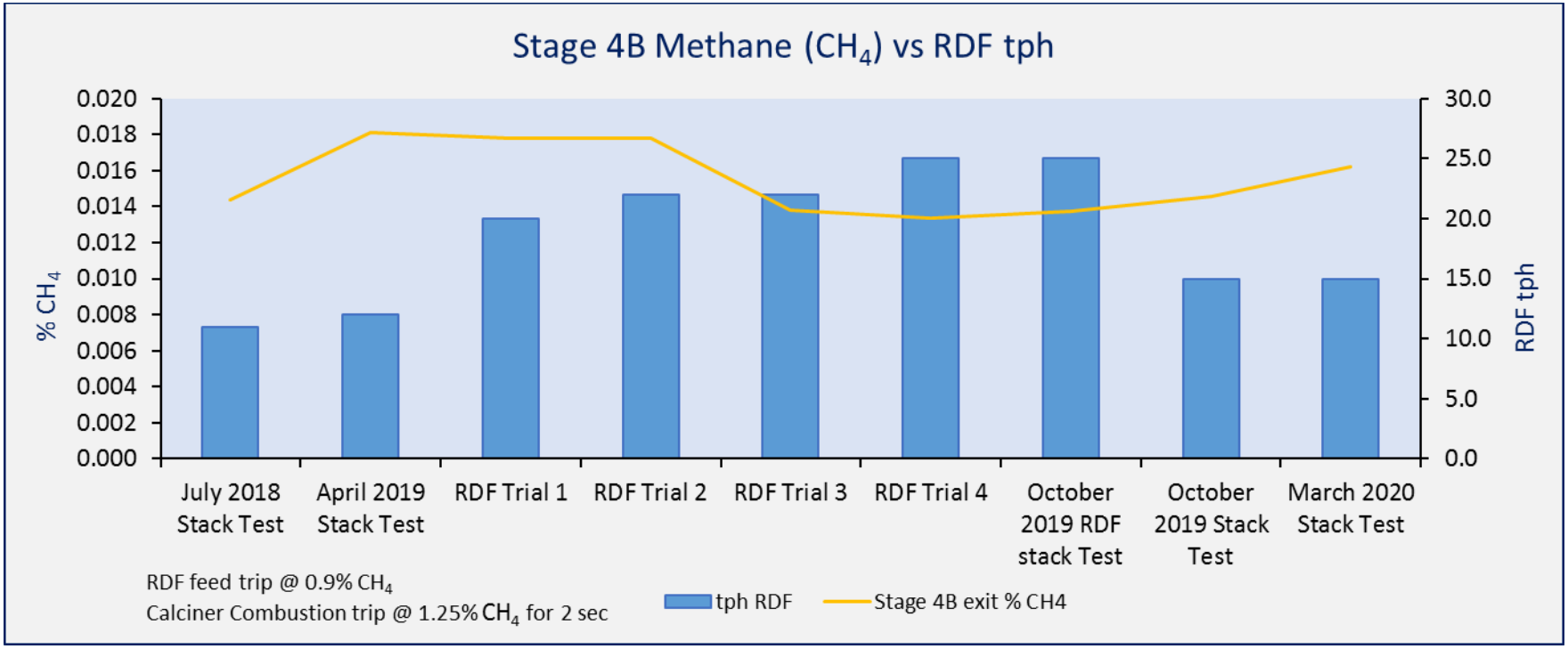


Figure 18: Oxygen (O_2) levels on the calciner process stream for stack emission tests and RDF trials since 1/7/2018

[redacted]

5.Summary

While the plastic content in the RDF is highly variable, the statistical analysis confirms the RDF supplied is consistent with the 20% plastic content approved by the EPA in June 2018 and demonstrates that the quality assurance measures that are in place are effective.

ABCL is of the opinion, that the stack emission tests undertaken during the trial are representative of a typical RDF composition with plastic levels up to 20% plastic, at a 25 tph burn rate.

Modelling of stack emissions measured during the 25tph trial has shown ground level concentrations of all schedule Y-1 pollutants to be well below the relevant criteria in the Environment Protection (Air Quality) Policy 2016.

There was no increase in carbon monoxide emissions on 4B stack that would indicate a change in burning conditions in the calciner and incomplete burnout of the RDF. Likewise the measured concentrations for hydrocarbons, remained within the normal range of variation previously observed, providing further evidence that products of incomplete combustion are not being generated.

The burner management system and process control logic ensures that the combustion of RDF is optimsed, minimising the risk of incomplete combustion and associated emissions.

From an operational viewpoint, the trial was effective in providing an understanding of the effect of increased burning rate of RDF in the calciner. The impacts on process operation, the burner management systems, product quality and overall pyro processing circuit were assessed and no impediments to continuing at 25 tph RDF feed rate were found.

ABCL therefore considers the use of RDF at 25 tph with up to 20% plastic is a viable option to reduce the total natural gas and raw material requirements for clinker production whilst also substantially reducing waste to landfill.