Experts in Continuous Monitoring

# Ambient Air Quality Monitoring Update, Kirby Misperton A Wellsite, KM8 Production Well.

## 14th February 2018 to 6th March 2018

**Prepared for:**

**Third Energy UK Gas Ltd.**

For: Third Energy UK Gas Ltd.

Ref No.: GGS1197AQMU190418

Date: 19/04/2018

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# Document Control Page

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**GGS is the trading name of Ground-Gas Solutions Limited**

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# 1 Outline of Monitoring

Third Energy has appointed GGS to conduct ambient air quality monitoring at the KMA wellsite before, during and after the hydraulic fracturing stimulation operations.

Ambient air quality monitoring undertaken before hydraulic fracturing stimulation operations commenced has established a baseline condition at the KMA wellsite (See Report Ref: GGS1197AQBR). This will allow Third Energy to benchmark results collected during the hydraulic fracturing stimulation operations, to determine whether Third Energy's operations have any significant effect on air quality.

GGS has been undertaking air quality monitoring at the KMA wellsite, following the baseline monitoring which ended on 4th October 2017, as part of the ongoing monitoring phase whilst operational activities take place at the KMA wellsite, namely the management of extractive waste as presented within Table S1.1 as activity A1 of the Environmental Permit. For clarity, the management of extractive waste did not commence until the extraction process of the mining waste began. i.e. the bringing of waste streams to surface, which occurred on 16th October 2017.

The monitoring undertaken is designed to address both the Environment Agency's permit (reference: Decision Document EPR/DB3002HE) and North Yorkshire County Council planning permission conditions (reference: Decision Notice C3/15/00971/CPO). The ongoing monitoring undertaken by GGS includes the parameters listed in Table 1.

With site operations temporarily ceasing, and with approval from the Environment Agency, Third Energy requested GGS to conclude all ambient air quality monitoring on site on 6th March 2018.

The complete continuous and periodic monitoring results have already been published in previous reports. This report provides all outstanding sets of data for the laboratory results from the sampling undertaken on site between 14th February 2018 and 6th March 2018.

**Table 1.** Required Ambient Air Quality Parameters.

| Parameters | Monitoring frequency | Required By |
|---|---|---|
| Methane ($CH_4$) | Continuous monitoring and periodic monitoring every two weeks | Environment Agency / NYCC |
| Carbon Dioxide ($CO_2$) | Continuous monitoring and periodic monitoring every two weeks | Environment Agency |
| TSP, $PM_{10}$, $PM_{2.5}$, $PM_{1.0}$ | Continuous monitoring | Environment Agency |
| Dust | 2 week duration passive sampling | Environment Agency |
| BTEX | 2 week duration passive sampling | Environment Agency |
| Top 10 VOC | 2 week duration passive sampling | Environment Agency |
| Nitrogen dioxide ($NO_2$) | Continuous monitoring and passive sampling | Environment Agency |
| Nitric Oxide (NO) | Continuous monitoring and passive sampling | Environment Agency |
| Hydrogen Sulphide ($H_2S$) | 2 week duration passive sampling | NYCC – Planning Condition 25 |
| Carbon Monoxide (CO) | Continuous monitoring and periodic monitoring every two weeks | NYCC – Planning Condition 25 |
| Oxygen ($O_2$) | Continuous monitoring and periodic monitoring every two weeks | NYCC – Planning Condition 25 |
| Ozone ($O_3$) | Continuous monitoring and passive sampling | GGS recommendation |

## 2 Site Monitoring Locations

Four monitoring locations have been established around the site in order to capture a wide coverage of the ambient air quality at the site. Figure 1 below illustrates the monitoring locations.

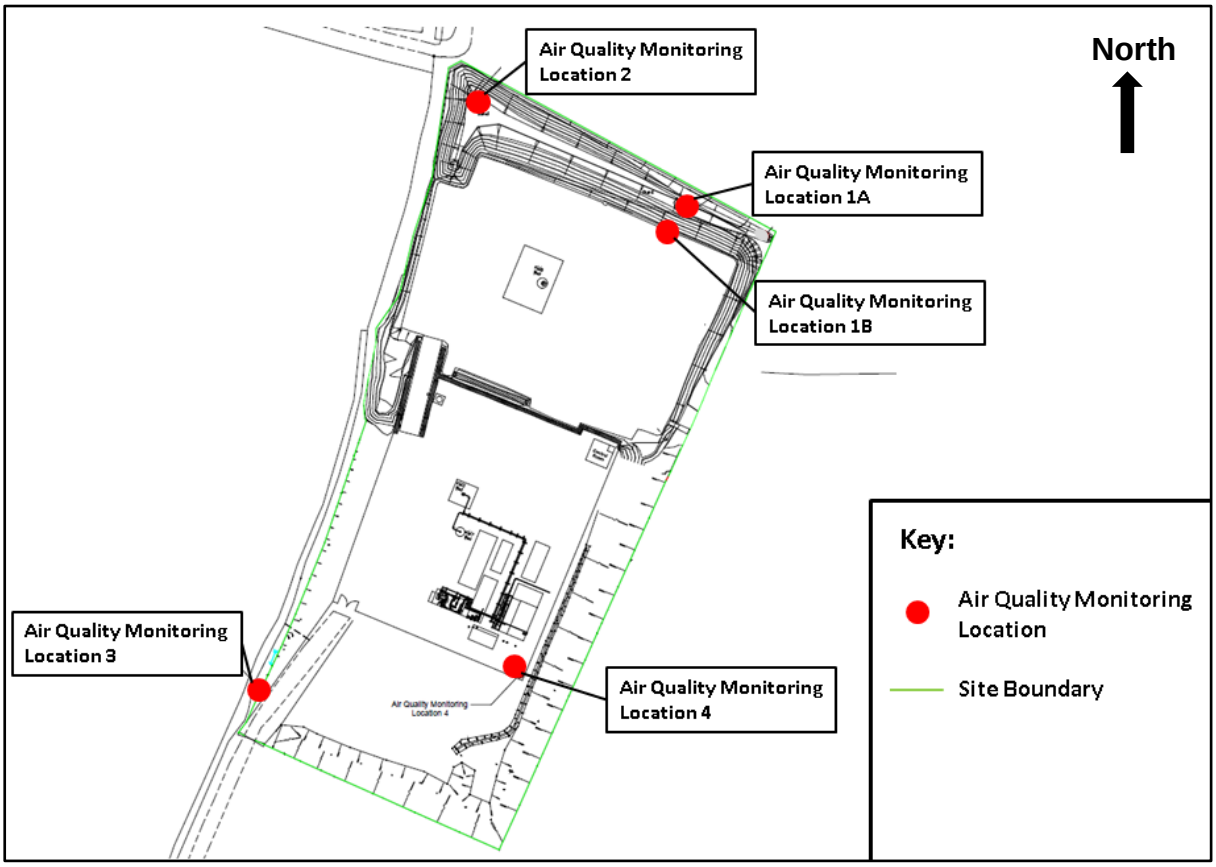


**Figure 1.** Ambient Air Quality Monitoring Locations.

Upon completion of the installation of the noise barriers on 12th October 2017, Monitoring Location 1A (on top of the existing soil mound) was relocated to 1B (raised platform at the top of the noise barriers) and Monitoring Location 2 was raised by approximately 6 metres above ground level using a telescopic mast.

# 3 Ongoing Monitoring

## 3.1 Dust

Dust can be defined as all airborne particulate matter. It is present naturally in the atmosphere wherever there are particles present that may become suspended in the atmosphere due to air movement (i.e. wind). It is likely that dust will be generated on the site during operations and therefore monitoring of dust at the site is required by the EA.

### 3.1.1 Methodology

The latest rounds of passive dust monitoring were undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

The dust samplers used were the DustScan DS100-D, which is a combined directional and deposited dust sampler. The directional and deposited dust sampler collects dust in horizontal flux from 360° around the sampling head as well as dust depositing out of the air. The collected dust is measured to determine dust coverage (AAC) and dust soiling (EAC); these measurements are expressed as percentages and are noted in the Institute of Air Quality Management (IAQM) guidance.

- AAC% is a measure of the dust coverage on a surface, irrespective of colour;
- EAC% is a measure of dust soiling, or obscuration, on a surface.

AAC and EAC can be combined to indicate possible annoyance caused by dust deposition.

### 3.1.2 Results

The laboratory results, including a dust impact risk assessment, can be provided to the EA upon request. A summary of the results is presented in the tables and figures below.

**Table 3.1.1** Depositional Dust sampling and analysis results

| Location | Exposure Interval | AAC% / interval | EAC% / interval | AAC% / day | EAC% / day | Dust Impact Risk |
|---|---|---|---|---|---|---|
| 1B | 20 days | 50.0 | 1.7 | 2.5 | <0.1 | Very Low |
| 2 | 20 days | 49.4 | 1.1 | 2.5 | <0.1 | Very Low |
| 3 | 20 days | 68.2 | 2.7 | 3.4 | 0.1 | Very Low |
| 4 | 20 days | 64.9 | 2.0 | 3.2 | <0.1 | Very Low |

**Table 3.1.2** Directional Dust Flux sampling and analysis results

| Location | Exposure Interval | AAC% / interval | EAC% / interval | AAC% / day | EAC% / day | Maximum Dust Impact Risk |
|---|---|---|---|---|---|---|
| 1B | 20 days | 48.1 | 1.1 | 2.4 | 0.1 | Low |
| 2 | 20 days | 55.6 | 1.8 | 2.8 | 0.1 | Low |
| 3 | 20 days | 19.5 | 0.4 | 1.0 | 0.0 | Very Low |
| 4 | 20 days | 30.4 | 1.0 | 1.5 | 0.0 | Very Low |

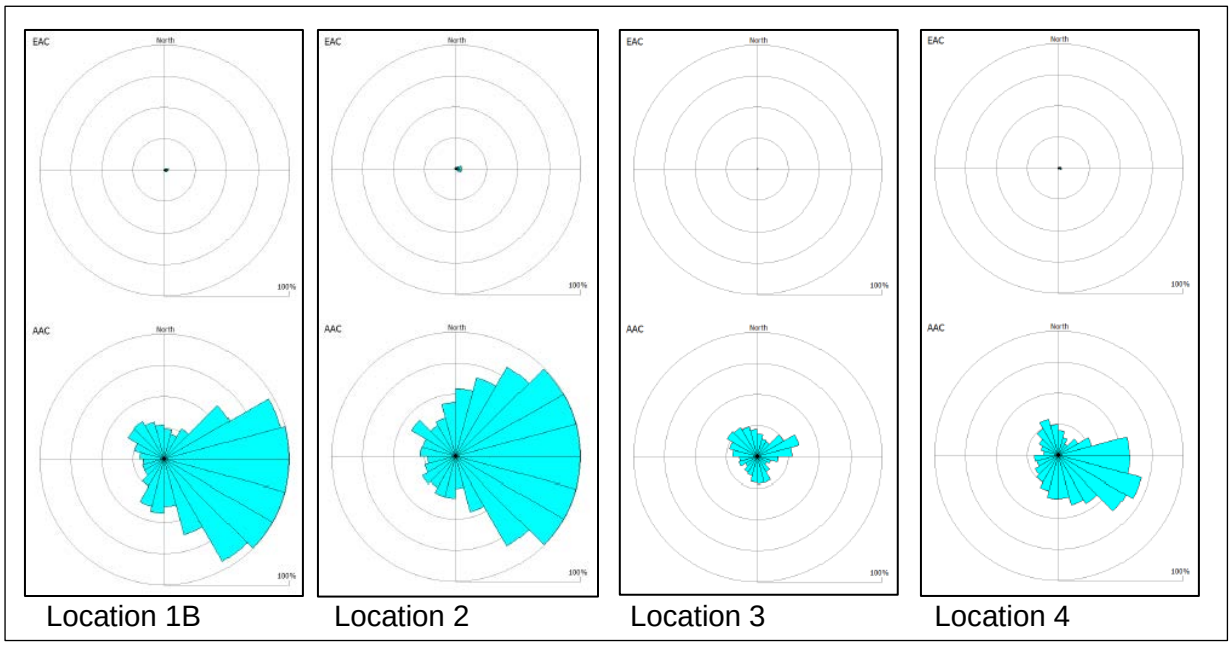


**Figure 2** Directional Dust rose diagrams

The “Low” directional dust impact risk observed during this monitoring period are in relation to dust coming from an easterly direction at monitoring locations 1B and 2 (as illustrated in the Figure 2 rose diagrams). Given the position of these monitoring stations, it is likely that this dust originated from the neighbouring agricultural land, rather than from the site itself. The neighbouring land to the north and east of the site comprised of fields with no or very little vegetation during this monitoring period.

## 3.2 BTEX

BTEX refers to the chemicals benzene, toluene, ethylbenzene and xylene. These compounds occur naturally in petroleum deposits and are also present in vehicle exhaust fumes and cigarette smoke. BTEX monitoring at the site is required by the EA.

### 3.2.1 Methodology

The latest round of passive BTEX monitoring was undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled for BTEX using Tenax sorbent tubes located at the four monitoring locations. The tubes were exposed for an approximate two-week period and dispatched to an appropriately accredited laboratory for BTEX analysis. A field blank was also deployed as a quality check in line with best practice guidelines to ensure that the samples were not contaminated in transit. This was left sealed in its container at Location 4 for the exposure period.

### 3.2.2 Results

The laboratory results can be provided to the EA upon request. Summaries of the results are presented in the tables below.

**Table 3.2.1** BTEX laboratory results – Location 1B

| BTEX | Accreditation Status | ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzene | U | 14.7 | 0.7 | 2.3 |
| Toluene | U | 19.6 | 0.7 | 2.4 |
| Ethylbenzene | U | <5.0 | <0.1 | <0.5 |
| m/p-Xylene | U | 6.9 | 0.2 | 0.7 |
| o-Xylene | U | <5.0 | <0.1 | <0.5 |

**Table 3.2.2** BTEX laboratory results – Location 2

| BTEX | Accreditation Status | ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzene | U | 9.2 | 0.5 | 1.4 |
| Toluene | U | 34.9 | 1.2 | 4.3 |
| Ethylbenzene | U | 6.1 | 0.1 | 0.6 |
| m/p-Xylene | U | 10.4 | 0.2 | 1.0 |
| o-Xylene | U | <5.0 | <0.1 | <0.5 |

**Table 3.2.3** BTEX laboratory results – Location 3

| BTEX | Accreditation Status | ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzene | U | 10.3 | 0.5 | 1.6 |
| Toluene | U | 14.7 | 0.5 | 1.8 |
| Ethylbenzene | U | 5.4 | 0.1 | 0.5 |
| m/p-Xylene | U | 7.8 | 0.2 | 0.8 |
| o-Xylene | U | <5.0 | <0.1 | <0.5 |

**Table 3.2.4** BTEX laboratory results – Location 4

| BTEX | Accreditation Status | ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzene | U | 10.1 | 0.5 | 1.5 |
| Toluene | U | 15.4 | 0.5 | 1.9 |
| Ethylbenzene | U | <5.0 | <0.1 | <0.5 |
| m/p-Xylene | U | 6.3 | 0.1 | 0.6 |
| o-Xylene | U | <5.0 | <0.1 | <0.5 |

**Table 3.2.5** BTEX laboratory results – Field Blank

| BTEX | Accreditation Status | ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzene | U | <5.0 | <0.2 | <0.8 |
| Toluene | U | <5.0 | <0.2 | <0.6 |
| Ethylbenzene | U | <5.0 | <0.1 | <0.5 |
| m/p-Xylene | U | <5.0 | <0.1 | <0.5 |
| o-Xylene | U | <5.0 | <0.1 | <0.5 |

*Results with < (less than) indicate that concentrations are below the reporting limit.
U – Analysis is UKAS accredited
N – Analysis is not UKAS accredited

The latest rounds of passive BTEX monitoring results are in line with expected results for the activity undertaken at the site.

## 3.3 Top 10 VOCs

Volatile organic compounds (VOCs) are substances with low boiling points that evaporate from solids or liquids. They occur both naturally and as products used in industrial processes. There are many different VOCs but one of the most common is formaldehyde which is found in building products and furniture. VOCs are also produced by diesel combustion. Monitoring of the top 10 VOC compounds is required by the EA.

### 3.3.1 Methodology

The latest round of passive VOC monitoring was undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled VOCs using Tenax sorbent tubes located at the four monitoring locations in line with the Emissions Monitoring Plan. The tubes were exposed for an approximate two-week period and dispatched to an appropriately accredited laboratory for Top 10 VOC analysis. A field blank was also deployed as a quality check in line with best practice guidelines to ensure that the samples were not contaminated in transit. This was left sealed in its container at Location 4 for the exposure period.

The Top 10 VOCs were identified and their estimated concentrations were carried out in accordance with ISO16000-6.

### 3.3.2 Results

The laboratory results can be provided to the EA upon request. Summaries of the results are presented in the tables below.

**Table 3.3.1** Top 10 VOC laboratory results – Location 1B

| Top 10 VOC | | Estimated ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzoic acid | N | 205 | 3.5 | 17.3 |
| Benzaldehyde** | U | 63 | 1.1 | 4.6 |
| Acetic acid | U | 57 | 1.0 | 2.3 |
| Acetophenone** | U | 47 | 0.8 | 3.9 |
| Phenylmaleic anhydride | U | 43 | 0.7 | 5.2 |
| Isopropyl myristate | N | 37 | 0.6 | 6.9 |
| Decanal** | N | 26 | 0.5 | 2.8 |
| Phenol | U | 25 | 0.4 | 1.6 |
| Nonanal** | N | 22 | 0.4 | 2.2 |
| Pentane, 3-methyl- | U | 22 | 0.4 | 1.3 |

**Table 3.3.2** Top 10 VOC laboratory results – Location 2

| Top 10 VOC | | Estimated ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Benzoic acid | N | 89 | 1.5 | 7.5 |
| Isopropyl myristate | N | 78 | 1.3 | 14.4 |
| Pentane, 2-methyl- | U | 73 | 1.3 | 4.3 |
| Benzaldehyde** | U | 58 | 1.0 | 4.3 |
| Decanal** | N | 56 | 1.0 | 6.1 |
| Nonanal** | N | 51 | 0.9 | 5.0 |
| Pentane, 3-methyl- | U | 43 | 0.7 | 2.6 |
| Phenol | U | 31 | 0.5 | 2.0 |
| Acetophenone** | U | 28 | 0.5 | 2.3 |
| Dibutyl phthalate | U | 26 | 0.4 | 4.9 |

**Table 3.3.3** Top 10 VOC laboratory results – Location 3

| Top 10 VOC | | Estimated ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Isopropyl myristate | N | 79 | 1.4 | 14.7 |
| Benzoic acid | N | 63 | 1.1 | 5.3 |
| Pentane, 2-methyl- | U | 49 | 0.8 | 2.9 |
| Benzaldehyde** | U | 35 | 0.6 | 2.5 |
| Nonanal** | N | 27 | 0.5 | 2.7 |
| Pentane, 3-methyl- | U | 25 | 0.4 | 1.5 |
| Decanal** | N | 18 | 0.3 | 1.9 |
| Acetophenone** | U | 17 | 0.3 | 1.4 |
| Phenol | U | 17 | 0.3 | 1.1 |
| Phenylmaleic anhydride | U | 14 | 0.2 | 1.7 |

**Table 3.3.4** Top 10 VOC laboratory results – Location 4

| Top 10 VOC | | Estimated ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Pentane, 2-methyl- | U | 54 | 0.9 | 3.2 |
| Benzaldehyde** | U | 45 | 0.8 | 3.3 |
| Benzoic acid | N | 36 | 0.6 | 3.0 |
| Dibutyl phthalate | U | 32 | 0.6 | 6.2 |
| Pentane, 3-methyl- | U | 30 | 0.5 | 1.8 |
| Acetophenone** | U | 22 | 0.4 | 1.8 |
| Diethyl phthalate | U | 17 | 0.3 | 2.6 |
| Decanal** | N | 16 | 0.3 | 1.7 |
| Hexane | U | 15 | 0.3 | 0.9 |
| Phenol | U | 14 | 0.2 | 0.9 |

**Table 3.3.5** Top 10 VOC laboratory results – Field Blank

| Top 10 VOC | Accreditation Status | Estimated ng on tube | ppb in air* | µgm$^{-3}$* |
|---|---|---|---|---|
| Isopropyl myristate | N | 72 | 1.3 | 13.5 |
| Acetic Acid | U | 61 | 1.1 | 2.5 |
| Decanal** | N | 47 | 0.8 | 5.1 |
| Nonanal** | N | 39 | 0.7 | 3.8 |
| 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester | N | 28 | 0.5 | 5.3 |
| 1-Hexadecanol | N | 24 | 0.4 | 4.1 |
| Benzaldehyde** | U | 21 | 0.4 | 1.5 |
| Diethyl phthalate | U | 20 | 0.3 | 3.1 |
| Cyclotetradecane | N | 19 | 0.3 | 2.6 |
| Dibutyl phthalate | U | 17 | 0.3 | 3.3 |

* Laboratory results obtained using exposure data.
** Compounds may be an artefact due to reaction of ozone with the Tenax sorbent.
U – Analysis is UKAS accredited
N – Analysis is not UKAS accredited

The latest rounds of passive VOC monitoring results are in line with expected results for the activity undertaken at the site.

## 3.4 Nitrogen Dioxide ($NO_2$)

Trace concentrations of nitrogen dioxide occur naturally in the atmosphere from volcanic sources and lightening strikes. It is also a product of combustion and is present in vehicle exhaust fumes and cigarette smoke. Nitrogen dioxide monitoring is required by the EA.

### 3.4.1 Methodology

The latest round of passive nitrogen dioxide monitoring was undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled nitrogen dioxide using diffusion tubes at all four locations. The tubes were exposed for an approximate two-week period and dispatched to an appropriately accredited laboratory for nitrogen dioxide analyses. Field blanks were also deployed in line with best practice guidelines.

### 3.4.2 Results

A summary of the latest monitoring results is presented in the table below. The laboratory certificates can be provided to the EA upon request.

**Table 3.4.1** Nitrogen Dioxide passive sampling results for period between 14th February 2018 and 6th March 2018.

| Location | Unit | Nitrogen Dioxide |
|---|---|---|
| 1B | µg/m$^3$ | 14.54 |
| | ppb | 7.59 |
| 2 | µg/m$^3$ | 14.28 |
| | ppb | 7.45 |
| 3 | µg/m$^3$ | 9.65 |
| | ppb | 5.04 |
| 4 | µg/m$^3$ | 10.37 |
| | ppb | 5.41 |

The latest nitrogen dioxide results are in line with expected results for the activity undertaken at the site.

## 3.5 Nitric Oxide (NO)

Trace concentrations of nitric oxide occur naturally from lightening strikes. It is also a product of combustion and is present in vehicle exhaust fumes. Nitric oxide monitoring is required by the EA.

### 3.5.1 Methodology

The latest round of passive Nitric Oxide was undertaken between 14th February 2018 and 6th March 2018. The sampling media was dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled nitrogen dioxide using diffusion tubes at all four locations. The tubes were exposed for an approximate two-week period and dispatched to an appropriately accredited laboratory for nitrogen dioxide analyses. Field blanks were also deployed in line with best practice guidelines.

### 3.5.2 Results

The laboratory results can be provided to the EA upon request. Summaries of the latest results, including results from previous rounds not yet reported, are presented in the table below.

**Table 3.5.2** Nitric Oxide Active Sampling results for period between 14th February 2018 and 6th March 2018.

| Location | Unit | Nitric Oxide |
|---|---|---|
| 1B | µg/m$^3$ | 5.5 |
| 2 | µg/m$^3$ | 2.6 |
| 3 | µg/m$^3$ | 4.5 |
| 4 | µg/m$^3$ | 4.5 |

**Results with < (less than) indicate that concentrations are below the reporting limit.*

The latest Nitric Oxide results are in line with expected results for the activity undertaken at the site.

## 3.6 Hydrogen Sulphide ($H_2S$)

Hydrogen sulphide is a naturally occurring compound found in peaty deposits, volcanic areas and petroleum deposits. As such, North Yorkshire County Council requires it to be monitored under Planning Condition 25.

### 3.6.1 Methodology

The latest round of passive hydrogen sulphide monitoring was undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled hydrogen sulphide using diffusion tubes at all four locations. The tubes were exposed for an approximate two-week period and dispatched to an accredited laboratory for hydrogen sulphide analysis. Field blanks were also deployed in line with best practice guidelines.

### 3.6.2 Results

The laboratory results can be provided to NYCC upon request. Summaries of the latest results are presented in the table below.

**Table 3.6.1** Hydrogen Sulphide Passive Sampling results for period between 14th February 2018 and 6th March 2018.

| Location | Unit | Hydrogen Sulphide |
|---|---|---|
| 1B | µg/m$^3$ | 0.09 |
| | ppb | 0.06 |
| 2 | µg/m$^3$ | 0.10 |
| | ppb | 0.07 |
| 3 | µg/m$^3$ | 0.09 |
| | ppb | 0.06 |
| 4 | µg/m$^3$ | 0.14 |
| | ppb | 0.10 |

**Results with < (less than) indicate that concentrations are below the reporting limit.*

## 3.7 Ozone ($O_3$)

Ozone occurs naturally in the upper atmosphere and is formed by the action of ultraviolet light and lightening discharges on oxygen. Near ground level it is formed by chemical reactions between the oxides of nitrogen and VOCs in the presence of sunlight. Ozone is a powerful oxidising agent and is an indicator of poor air quality. Monitoring of Ozone is not a requirement by either the EA or NYCC, but GGS has advised that this parameter be included in the monitoring regime at the site.

### 3.7.1 Methodology

The latest round of passive Ozone monitoring was undertaken between 14th February 2018 and 6th March 2018. The sampling media were dispatched to the laboratories by GGS on 7th March 2018.

GGS passively sampled Ozone using diffusion tubes at all four locations. The tubes were exposed for an approximate two-week period and dispatched to an appropriately accredited laboratory for Ozone analysis. Field blanks were also deployed in line with best practice guidelines.

### 3.7.2 Results

The laboratory results can be provided upon request. Summaries of the results are presented in the table below.

**Table 3.7.1** Ozone Passive Sampling results for period between 14th February 2018 and 6th March 2018.

| Location | Unit | Ozone |
|---|---|---|
| 1B | µg/m$^3$ | 68.49 |
| | ppb | 34.25 |
| 2 | µg/m$^3$ | 71.34 |
| | ppb | 35.67 |
| 3 | µg/m$^3$ | 30.49 |
| | ppb | 15.25 |
| 4 | µg/m$^3$ | 62.12 |
| | ppb | 31.06 |

The latest Ozone results are in line with expected results for the activity undertaken at the site.

# 4 Quality Control & Assurance

All monitoring equipment operated by GGS is maintained in accordance with the manufacturer's guidelines. Annual services and calibrations are undertaken when required and routine visual inspections of the equipment are undertaken prior to and during site visits by GGS staff.

GGS operates an Integrated Management System (IMS) that is accredited by QMS International plc as complying with the following international standards:

- BS EN ISO 9001:2008 (Quality Management System);
- ISO 14001:2004 (Environmental Management System), and;
- OHSAS 18001:2007 (Occupational Health and Safety Management System).

All of GGS' monitoring and sampling are carried out to procedures that are subject to independent annual audit.

# 5 Ongoing Monitoring Regime

With site operations ceasing temporarily and with approval from the Environment Agency, Third Energy requested GGS to conclude all ambient air quality monitoring on site on 6th March 2018. This report concludes all monitoring and reporting requirements for the period up until 6th March 2018. No further monitoring will take place until explicitly requested by Third Energy, in conjunction with the requirements of the EA/NYCC respectively.