Appendix I

Rules 9 and 10 of the Regional Air Quality Plan for Taranaki 2011

Rule 9: Hydrocarbon exploration well sites

Activity classification: Controlled

This rule applies to discharges of contaminants to air from hydrocarbon exploration well sites, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and the testing or enhancement of well head production flows.

The Council has noted through experience in dealing with petroleum exploration that there are a number of adverse effects on the environment (especially on people) from the discharge of contaminants to air from the activity, specifically from flaring, that justify the Council in retaining control over the activities.

The Council has therefore designed Rule 9 which facilitates exploration activities in areas away from dwelling houses and limits the time per zone of flaring to be carried out.

A time limit of 15 days, per zone to be appraised, for the discharge from the flare, has been adopted to cover the range of reservoir conditions in Taranaki and ensure that adequate production performance information is able to be gained from well testing, while at the same time protecting the environment.

If the activity cannot comply with the conditions of Rule 9 or Rule 10, Rule 55 applies.

Rule 10: Hydrocarbon exploration well sites

Activity classification: Restricted Discretionary

This Rule applies to discharges of contaminants to air from hydrocarbon exploration well sites, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and the testing or enhancement of well head production flows, where one or more of the conditions (a) to (b) of Rule 9 cannot be met.

In certain situations the flare or incinerator point may not be able to be at least 300 metres from any dwelling/house and/or the discharge from the flare may need to last longer than 15 days per zone. This Rule is designed to enable discharges from hydrocarbon exploration well sites to continue whilst retaining sufficient control.

The Council will be guided by the relevant policies in the Plan. However, the Council's power to decline a resource consent and to impose conditions are restricted to the matters to which the Council has restricted the exercise of its discretion, noted in the 'control/discretion' column of the Rule in the Plan.

The notification requirements, when the Council is satisfied that the adverse effects of the activity will not be more than minor, are restricted to those that were located within the buffer, at the time this Plan became operative or the time the activity was first established[25], whichever was the earlier. The notification requirements also provide for those situations where previous sign-off for the activity has been obtained and the nature of the activity is

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[25] *'Activity first established' means the date an air discharge consent was first issued by the Taranaki Regional Council for the activity.*

otherwise unchanged and the sign-off specifies that it applies or is given irrespective of the duration of the activity.

This approach has been designed to acknowledge the issues that are currently being faced by hydrocarbon exploration operations, that is, new developments are establishing near lawfully established hydrocarbon exploration operations, that have addressed off site effects as far as is practicable and reasonable, and are now becoming constrained by the emergence of new and often incompatible land uses in the neighbourhood, especially at the time of consent renewal or consent replacement.

If the activity cannot comply with the conditions of Rule 10, Rule 55 applies.

Activity	Rule	Standards/Terms/Conditions	Classification	Notification	Control/Discretion
Discharges of contaminants to air from hydrocarbon exploration well sites, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well head production flows	9 Hydrocarbon exploration well sites	a) Flare or incinerator point is at least 300 metres from any dwelling house b) The discharge to air from the flare must not last longer than 15 days cumulatively, inclusive of testing, clean-up, and completion stages of well development or work-over, per zone to be appraised c) No material to be flared or incinerated, other than those derived from or entrained in the well steam	Controlled		a) Duration of consent b) Duration of flaring or other emissions c) The material to be flared d) Imposition of limits on or relating to discharge or ambient concentrations of contaminants, or on or relating to mass discharge rates e) Best practicable option to prevent or minimise any adverse effects on the environment f) Location of any facilities or equipment for hydrocarbon flaring in relation to surrounding land uses g) Separation of natural gas from liquid hydrocarbons and water h) Notification of flaring to neighbours, affected parties, and the Council i) Recording of flare usages and smoke emissions j) Oil recovery requirements k) Visual effects, loss of amenity value of air, chronic or acute human health effects, soiling or damage to property, odour, annoyance and offensiveness, effects on ecosystems, plants and animals and effects on areas identified in Policy 2.3 l) Monitoring and information m) Contingency measures and investigations, remediation and response procedures for non-routine discharge events and complaints n) Review of the conditions of consent and the timing and purpose of the review o) Payment of administrative charges p) Payment of financial contributions

Activity	Rule	Standards/Terms/Conditions	Classification	Notification	Control/Discretion
Discharges of contaminants to air from hydrocarbon exploration well sites, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well head production flows, that do not meet one or more of the conditions (a) to (b) of Rule 9	10 Hydrocarbon exploration well sites that do not comply with Rule 9	a) No material to be flared or incinerated, other than those derived from or entrained in the well steam	Restricted Discretionary	Applications will be publicly notified unless the Taranaki Regional Council is satisfied that the adverse effects of the activity on the environment will not be more than minor If the Taranaki Regional Council is satisfied that the adverse effects of the activity will not be more than minor, the Council will serve notice of applications on the owners and the occupiers of any dwelling/house located within 300 metres of the flare or incinerator point at the time this Plan became operative or the time the activity was first established[26], whichever was the earlier, who have not otherwise given written approval for the activity.	a) Duration of consent b) Duration of flaring or other emissions c) The material to be flared d) Imposition of limits on or relating to discharge or ambient concentrations of contaminants, or on or relating to mass discharge rates e) Best practicable option to prevent or minimise any adverse effects on the environment f) Location of any facilities or equipment for hydrocarbon flaring in relation to surrounding land uses g) Separation of natural gas from liquid hydrocarbons and water h) Notification of flaring to neighbours, affected parties, and the Council i) Recording of flare usages and smoke emissions j) Oil recovery requirements k) Visual effects, loss of amenity value of air, chronic or acute human health effects, soiling or damage to property, odour, annoyance and offensiveness, effects on ecosystems, plants and animals and effects on areas identified in Policy 2.3 l) Monitoring and information m) Contingency measures and investigations, remediation and response procedures for non-routine discharge events and complaints

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[26] *'Activity first established' means the date an air discharge consent was first issued by the Taranaki Regional Council for the activity.*

Activity	Rule	Standards/Terms/Conditions	Classification	Notification	Control/Discretion
				For the avoidance of doubt, a written approval given by an owner or occupier when an activity was first established shall remain applicable to, and be deemed to also be written approval for, the re-consenting of that activity, if the following conditions are met: (a) a new consent is being applied for to replace or renew an existing consent; and (b) the nature, scale and extent of the activity and its effects (other than duration of flaring) are the same as or less than that authorised by the existing consent being replaced or renewed; and (c) the approval states that it is given irrespective of the duration of the flaring activity.	n) Review of the conditions of consent and the timing and purpose of the review o) Payment of administrative charges p) Payment of financial contributions

Appendix II

Typical consent for discharge to air by flaring

Special conditions

Duration

1. This consent shall not be exercised for more than an accumulated duration of 45 days per zone, allowing four zones to be tested per well, from up to eight wells. The time interval specified in this condition refers to that period during which this consent is exercised and is not regarded as continuous elapsed time from the first exercise of this consent.

2. In the eventuality of the need to exercise this consent due to safety concerns in respect of returned fluids arising from hydraulic fracturing operations, the consent holder shall terminate such flaring as soon as practicable after the possibility of a combustible or explosive atmosphere due to the returned fluids has been eliminated, and shall in any case advise the Chief Executive, Taranaki Regional Council, if flaring is to continue beyond 48 hours after commencement of such flaring.

Information and notification

3. Prior to the commencement of testing, the consent holder shall supply to the Chief Executive, Taranaki Regional Council, a final site layout plan, demonstrating configuration of the facilities and equipment so as to avoid or mitigate the potential effects of air emissions.

4. Prior to the commencement of any hydraulic fracturing operation, the consent holder shall supply to the Chief Executive, Taranaki Regional Council, a Mitigation Plan for the flaring of fracture fluids. The plan shall identify measures to avoid or mitigate possible adverse effects of the flaring (including discharge by evaporation or volatilisation) of fracture fluids.

5. The Taranaki Regional Council shall be notified within 24 hours prior to the initial flaring of each zone being commenced.

6. At least 24 hours prior to any flaring and/or the initiation of any hydraulic fracturing operation, the consent holder shall undertake all practicable measures to notify residents within 1000 metres of the wellsite of the commencement of flaring and/or the initiation of any hydraulic fracturing operation. The consent holder shall include in the notification a 24-hour contact telephone number for a representative of the consent holder, and shall keep and make available to the Chief Executive, Taranaki Regional Council, a record of all queries and/or complaints received.

7. The Chief Executive, Taranaki Regional Council, shall be notified within 24 hours of any flaring of fracture fluids derived from the well stream.

8. No alteration shall be made to plant equipment or processes which may substantially alter the nature or quantity of flare emissions or other wellsite emissions, including but not limited to the recovery of produced gas, other than as notified in this consent application, without prior consultation with the Chief Executive, Taranaki Regional Council.

Flaring

9. Other than for the maintenance of a pilot flare flame, the consent holder shall have regard to the prevailing and predicted wind speed and direction at the time of initiation of any episode of flaring or other combustion of hydrocarbons.

10. All gas being flared, at any time during well clean-up, drill stem testing, initial testing, or production testing, or at any other time, (with the exception of the flow of returned fracture fluids to flare when undertaken for safety reasons) must first be treated by effective liquid and solid separation and recovery, as far as

11. If separation cannot be implemented and/or maintained at any time while there is a flow from the well, whether natural or induced, then the consent holder shall notify the Chief Executive, Taranaki Regional Council, and (with the exception of the flow of returned fracture fluids to flare when undertaken for safety reasons) shall in any case re-establish liquid separation and recovery within three hours.

12. No liquid or solid hydrocarbons shall be combusted through the gas flare system (with the exception of the flow of returned fracture fluids to flare when undertaken for safety reasons).

13. As soon as is practicable after flow commences, the separated gas shall be combusted so that emissions of smoke are minimised.

14. The consent holder shall adopt the best practicable option, as defined in section 2 of the Resource Management RMA 1991, to prevent or minimise any actual or potential effect on the environment arising from the flare emission, emissions from the flare pit, or any other emissions from the wellsite (including use of a separator during well clean-up). This requirement applies in addition to any of the specific requirements set out in conditions 1, 9, 10, 11, 12 and 13.

15. Only substances originating from the well stream and treated as outlined by conditions 9, 10, 11, 12, 13 and 14 shall be combusted within the flare pit.

16. The consent holder shall not discharge any contaminant to air authorised by this consent at a rate or a quantity such that the contaminant, whether alone or in combination with other contaminants, is or is liable to be hazardous or toxic or noxious at or beyond the boundary of the wellsite, or beyond 100 metres of the flare, whichever distance is greater.

17. There shall not be any offensive odour or smoke, as determined by an enforcement officer of the Taranaki Regional Council, beyond the boundary of the wellsite or beyond 100 metres of the flare, whichever distance is greater, arising from the exercise of this consent.

18. The opacity of any smoke emissions shall not exceed a level of 1 as measured on the Ringelmann Scale for more than four minutes cumulative duration in any 60-minute period.

19. The consent holder shall control all emissions of carbon monoxide to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the wellsite, in order that the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 mg/m3 (eight-hour average exposure), or 30 mg/m3 one-hour average exposure) at or beyond the boundary of the wellsite or beyond 100 metres from the flare, whichever distance is greater.

20. The consent holder shall control all emissions of nitrogen oxides to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the wellsite, in order that the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 100 mg/m3 (24-hour average exposure), or 200 mg/m3 (1-hour average exposure) at or beyond the boundary of the wellsite, or beyond 100 metres from the flare, whichever distance is greater.

21. The consent holder shall control emissions to the atmosphere from the wellsite and flare of contaminants other than carbon dioxide, carbon monoxide, and nitrogen oxides, whether alone or in conjunction with any emissions from the flare, in order that the maximum ground level concentration for any particular contaminant arising from the exercise of this consent measured at or beyond the boundary of the wellsite or beyond 100 metres from the flare, whichever distance is greater, is not increased above background levels:

    a) by more than 1/30th of the relevant Occupational Threshold Value-Time Weighted Average, or by more than the Short Term Exposure Limit at any time (all terms as defined in Workplace Exposure Standards, 2002, Department of Labour); or

    b) if no Short Term Exposure Limit is set, by more than three times the Time Weighted Average at any time (all terms as defined in Workplace Exposure Standards, 2002, Department of Labour).

Recording and reporting information

22. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and crude oil stream from the field, covering sulphur compound content and the content of carbon compounds of structure C6 or higher number of compounds.
23. The consent holder shall keep and make available to the Chief Executive, Taranaki Regional Council, upon request, a record of all smoke-emitting incidents noting time, duration and cause.

24. The consent holder shall keep and make available to the Chief Executive, Taranaki Regional Council, logs of all flaring, including time, duration and (as far as is practicable) volumes of substances flared.

25. Further to Condition 24 above, the consent holder shall, for every contingency event of flaring of returned fracture fluids when undertaken for safety reasons , provide to the Chief Executive, Taranaki Regional Council, within 30 days a record of time, duration, reason for the contingency flaring being required, prevailing weather

conditions at the time, the quantity of fluids discharged to air (whether by combustion within the flare or by evaporation or volatilisation), and any complaint or enquiry received from the public including any neighbour.

Lapse and Review

26. This consent shall lapse on the expiry of five years after the date of issue of this consent, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management RMA 1991.

27. The Taranaki Regional Council may review, amend, delete or add to the conditions of this consent up to three times during the period March 2012 and March 2013, for the purpose of ensuring that any additional information of the possible effects of the exercise of this consent in relation to the flaring (including evaporation or volatilisation) of hydraulic fracturing fluids and having considered the conditions appropriately take account of any additional information.

28. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2009 and/or June 2015, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Appendix III

Hydraulic fracturing liquid air discharge monitoring report
February 2012

STNZ for Taranaki Regional Council

Taranaki Regional Council

HYDRAULIC FRACTURING LIQUID AIR DISCHARGE MONITORING REPORT, FEBRUARY 2012

Issue

May 2012

new zealand accredited laboratory

Taranaki Regional Council

HYDRAULIC FRACTURING LIQUID AIR DISCHARGE MONITORING REPORT, FEBRUARY 2012

Issue

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Source Testing New Zealand Ltd
PO Box 32 017
Maungaraki
Lower Hutt 5010
Tel: 0275 533 210
Fax: 04 569 4446

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SOURCE TESTING NZ Ltd

Contents

Executive Summary

Source Testing NZ Ltd (STNZ) was commissioned by the Taranaki Regional Council (TRC) to conduct the Hydraulic Fracturing Liquid Air Discharge Monitoring Programme. The project involved the assessment of emissions to air from the operation of a flare pit containing hydraulic fracturing liquid.

In order to assess total emissions from the flare pit containing the hydraulic fracturing liquid, air discharge samples were collected from both the active combustion zone (Combustion Zone Samples) and the zone of evaporation only (Evaporation Zone Samples). Tables 1 and 2 summarise the results of the emission testing carried out from the combustion zone on 7 February 2012 and the evaporation zone on 8 February 2012.

- **Table 1 Combustion Zone Air Discharge Monitoring Results, 7 February 2012**

Contaminant, Emission Units and Sample Duration	Range	Average
Particulate (mg/m^3)^1	<0.3 – 1.6	0.9
Sulphuric Acid Mist (including SO_3) (mg/m^3)^1	<0.03	<0.03
Sulphur Dioxide (mg/m^3)^1	<0.07	<0.07
Total Aldehydes as Formaldehyde (mg/m^3)^1	0.05 – 0.25	0.16
Formaldehyde (mg/m^3)^1	0.04 – 0.23	0.14
VOCs (expressed as carbon) (ppmv)^2	<LOD – 0.171	0.096
Benzene (ppmv)^2	<LOD – 0.109	0.057
Toluene (ppmv)^2	<LOD – 0.057	0.035
Ethyl Benzene (ppmv)^2	<LOD – 0.004	0.004
m,p - xylene (ppmv)^2	<LOD – 0.010	0.007
o - xylene (ppmv)^2	<LOD – 0.006	0.004
Dioxins/Furans - (ng/m^3)^1 WHO-TEQ (upper bound)	0.0035	0.0035
Poly Aromatic Hydrocarbons - (ng/m^3)^1 Toxic USEPA (upper bound)	208	208
Methanol (mg/m^3)^1	<1.22 – 2.66	1.79
Carbon Dioxide (%)	<0.1 to 1.0	0.2
Carbon Monoxide (ppmv)	<1 - 99	7
Oxides of Nitrogen (ppmv)	<1 - 6	2
Sulphur Dioxide (ppmv)	<1 - 5	1

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis
2. ppm = parts per million by volume
3. LOD = limit of detection

- **Table 2 Evaporation Zone Air Discharge Monitoring Results, 8 February 2012**

Contaminant, Emission Units and Sample Duration	Range	Average
Total Aldehydes as Formaldehyde (mg/m^3)^1	0.04 – 0.05	0.05
Formaldehyde (mg/m^3)^1	0.03 – 0.04	0.04
VOCs (expressed as carbon) (ppmv)^1	<LOD – 0.047	0.025
Benzene (ppmv)^2	<LOD – 0.013	0.013
Toluene (ppmv)^2	<LOD – 0.030	0.017
Ethyl Benzene (ppmv)^2	<LOD	<LOD
m,p - xylene (ppmv)^2	<LOD – 0.005	0.005
o - xylene (ppmv)^2	<LOD – 0.003	0.003
Poly Aromatic Hydrocarbons - (ng/m^3)^1 Toxic USEPA (upper bound)	5.98	5.98
Methanol (mg/m^3)^1	<2.01 – 5.25	3.19

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis
2. ppm = parts per million by volume
3. LOD = limit of detection

A full list of the VOC's under investigation is presented in Appendix A. For information regarding WHO-TEQ and Toxic USEPA benzo[a]pyrene equivalent values and the relevance of upper bound results, refer to Sections 4.6 and 4.7.

1. Introduction

Source Testing NZ Ltd (STNZ) was commissioned by the Taranaki Regional Council (TRC) **t**o conduct the Hydraulic Fracturing Liquid Air Discharge Monitoring Programme. The project involved the assessment of emissions to air from a flare pit containing hydraulic fracturing liquid.

Under normal operating conditions all hydraulic fracturing liquid recovered from the well head would be stored in tanks for offsite disposal. However, in emergency situations it may become necessary for the hydraulic fracturing liquid to be diverted to the flare pit via a separate pipe line to ensure the main flare continues to operate normally. At this stage the hydraulic fracturing liquid would be evaporated by the heat of the flare. It is possible that some of the evaporating liquid could be combusted within the flare itself while the remainder of the liquid surface would be evaporated naturally due to the heat of the flare.

As the diversion of hydraulic fracturing liquid to the flare pit would only occur in emergency conditions, a simulated event was conducted in an attempt to replicate conditions where samples could be collected. The simulation involved holding recovered hydraulic fracturing liquid in a tank and allowing the liquid to flow under gravity to the flare pit where samples were collected. The time frame allowed for the project was limited to 36 hours due to time constraints caused by the operation of the well site.

In order to assess total emissions from the flare flame and evaporating hydraulic fracturing liquid, air discharge samples were collected from both the active combustion zone (Combustion Zone Samples) and the zone of evaporation only (Evaporation Zone Samples). The following compounds were assessed from the combustion zone within the flare pit:

- Particulate Matter (PM);
- Oxides of Sulphur (SO_x);
- Aldehydes (formaldehyde, acetaldehyde, propionaldehyde);
- Volatile Organic Compounds (VOC);
- Dioxins and Furans (PCDD/PCDF);
- Poly-Aromatic Hydrocarbons (PAH);
- Methanol;
- Combustion gases – oxygen (O_2), carbon dioxide (CO_2), carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2).

The following compounds were assessed from the evaporation zone within the flare pit:

- Aldehydes (formaldehyde, acetaldehyde, propionaldehyde);
- Volatile Organic Compounds (VOC);
- Poly-Aromatic Hydrocarbons (PAH); and
- Methanol.

Matthew Newby, Air Quality Scientist with STNZ, performed the emission testing on 7 and 8 February 2012. Matthew has over 15 year's air quality monitoring experience and is designated as a Key Technical Person under STNZ's IANZ accreditation.

This report presents the sampling methodology and equipment used to collect the flare pit samples. A brief review of how the flare pit was operated for the duration of the project is presented followed by the presentation of the results of the air discharge monitoring.

2. Sampling Methodologies

2.1 Introduction

The following sections outline the sampling approach taken to collect the air discharge samples followed by a brief summary of the individual test methods used to assess each of the contaminants of interest. A description of the sampling equipment including the sampling probe/manifold and the individual sampling trains completes this section.

2.2 Sampling Approach

The selected flare pit was surrounded by an earth wall bund approximately 10 m long by 8 m wide elevated approximately 2 m above ground level. Within the pit the gas flare produced a ball of flame approximately 3 to 5 m in diameter. See Figure 1.

- Figure 1: Gas Flare

The lack of any form of flue or stack from the gas flare made applying standard source testing methods difficult. Isokinetic sampling conditions normally required by stationary source test methods could not be replicated under such conditions. Furthermore, in order to safely access the flare, sampling equipment and personnel need to stay approximately 10 m away from the flare, behind the earth bund. In addition, the wide range of contaminants under investigation and the limited amount of time allowed, required the use of multiple individual sampling systems or sampling trains. This made for a very unique situation for the collection of air emissions samples.

The approach taken for the TRC Hydraulic Fracturing Liquid Air Discharge Monitoring Programme was to employ a 9 m stainless steel sampling probe connected to a 2 m stainless steel sampling manifold which fed each of the sampling trains. More details on the sampling system are presented in Section 2.3.1

2.3 Sampling Methods

Table 3 summarises the testing methodologies employed by STNZ for the TRC Hydraulic Fracturing Liquid Air Discharge Monitoring Programme along with STNZ accreditation status. As mentioned above, while isokinetic sampling conditions could not be obtained, all other aspects of the below sampling methods were adhered to.

- **Table 3: Sampling Methods**

Contaminant	STNZ Standard Test Methods	IANZ Accredited Test Method
Gas Molecular Mass Determination (Products of Combustion)	Method 3 "Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight"	Yes
Determination of Moisture Content	Method 4 "Determination of Moisture Content in Stack Gases"	Yes
Determination of Total Particulate Matter	Method 5 "Determination of Particulate Emissions From Stationary Sources'	Yes
Determination of Sulphuric acid mist (including SO_3) and sulphur dioxide (SO_2)	Method 8 "Determination of sulphuric acid mist (including SO_3) and sulphur dioxide (SO_2) from stationary sources"	Yes
Determination of Aldehyde Compounds	Method 0011 "Sampling for Selective Aldehyde and Ketone Emissions From Stationary Sources"	Yes
Determination of Volatile Organic Compounds	Method 18 'Measurement of Gaseous Organic Compound Emissions by Gas Chromatography"	Yes
Determination of PCDD/PCDF Compounds	Method 23 "Determination of PCDD/PCDF from Municipal Waste Combustors"	Yes
Determination of PAH Compounds	Method 23 "Determination of PCDD/PCDF from Municipal Waste Combustors"	Yes
Determination of Methanol	USEPA Method 308 "Procedure for the Determination of Methanol Emissions from Stationary Sources"	No
Determination of Nitrogen Oxides and Sulphur Dioxide	Testo 350XL Combustion Gas Analyser	No
Determination of Combustion Gases (oxygen, carbon dioxide, carbon monoxide)	Testo 350XL Combustion Gas Analyser	No

2.3.1 Gaseous Products of Combustion

Gaseous products of combustion were measured using a Testo 350 XL combustion gas analyser. In its current configuration, the Testo 350 XL monitors oxygen (O_2 %), carbon monoxide (CO ppmv), nitric oxide (NO ppmv), nitrogen dioxide (NO_2 ppmv) and sulphur dioxide (SO2) using electro-chemical cells. The carbon dioxide (CO_2 %) concentration is measured using an infrared cell. Refer to Section 2.4.3 for further details.

2.3.2 Particulate Matter

Particulate matter was withdrawn directly from the sampling manifold at a rate of approximately 20 L/min and collected on a glass fibre filter maintained at a temperature of 120 °C ± 14 °C. The particulate mass was determined gravimetrically, after the removal of un-combined water. This approach conforms to USEPA Method 5 "Determination of Particulate Matter from Stationary Sources". Particulate analysis was performed by STNZ.

2.3.3 Oxides of Sulphur Discharges

Oxides of sulphur discharges were collected in accordance with USEPA Method 8 "*Determination of Sulphuric Acid Mist and Sulphur Dioxide Emissions From Stationary Sources*". A sample of gas was withdrawn from the sampling manifold via an 8 mm Teflon sampling line at a rate of approximately 20 L/min. Sulphur trioxide and sulphuric acid were collected in a solution of 80 % isopropanol and on a glass fibre filter, with sulphur dioxide being collected in a solution of 3 % hydrogen peroxide. On completion of the sampling, the isopropanol was purged with ambient air to ensure any SO2 captured in the isoproponal was transferred to the hydrogen peroxide. Each solution was analysed using a barium-thorin titration method by STNZ staff in their Wellington laboratory.

2.3.4 Aldehyde Discharges

Aldehyde discharges were collected in accordance with USEPA Method 0011 *"Sampling for Selected Aldehyde and Ketone Emissions from Stationary Sources"*. Gaseous and particulate pollutants were withdrawn from the sampling manifold via a heated Teflon sampling line at a rate of approximately 20 L/min and collected in aqueous solution acidified 2,4-dinitrophylhydrazine (DNPH). Aldehydes react with DNPH to form stable compounds. These compounds were then extracted, solvent-exchanged, concentrated and then analysed by high performance liquid chromatography (HPLC). Analysis was performed by AsureQuality Ltd, Auckland who is an IANZ accredited laboratory for this analysis. AsureQuality Ltd, Auckland also provided the DNPH solution.

2.3.5 Volatile Organic Compounds

Volatile organic compounds were measured in accordance with USEPA Method 18 – "*Measurement of Gaseous Organic Compounds Emissions by Gas Chromatography*". Gases were extracted from the sampling manifold and subsequently passed through a charcoal sorbent tube to collect VOC's at a rate of approximately 1.0 L/min. This sampling was conducted in duplicate using spiked and un-spiked sorbent tubes. The samples were then forwarded to Hill Laboratories Ltd, Hamilton where carbon disulphide was used to desorb the collected VOC's. The extract was subsequently analysed by gas chromatography- mass spectrometry (GC-MS). Hill Laboratories Ltd is IANZ accredited for this analysis. The total organic carbon content was then determined by summation of the individual compounds detected and expressed as carbon.

2.3.6 Dioxin/Furans (PCDD/PCDF) & Poly Aromatic Hydrocarbons (PAHs)

Dioxins/Furans and PAHs were collected in accordance with USEPA Method 23 – "*Determination of PCDD/PCDF from Municipal Waste Combustors*". This sampling method also allows for the determination of PAH compounds. A gas sample was extracted from the sampling manifold via a heated Teflon sampling line at a rate of approximately 20 L/min. The gas stream was then passed through a glass fibre filter maintained at 120 °C ± 14 °C connected to a combined condenser and XAD-2 resin trap. The condenser was continuously cooled (to below 20 ^{o}C) by circulating chilled water via a submersible pump.

Upon completion of the sampling, the system was leak checked, the trap and filter were recovered and sealed. The condensate was collected and the whole sampling system rinsed with acetone and dichloromethane. All three components (filter, resin trap, and condensate/rinse were combined at the laboratory to form a single sample for analysis.

The PCDD/PCDF and PAHs were extracted from the sample, separated by high resolution gas chromatography (HRGC), and measured by high resolution mass spectrometry (HRMS). Sampling reagents and analysis was provided by AsureQuality Ltd, Gracefield who are IANZ accredited for this work.

2.3.7 Methanol

Methanol emissions were measured in accordance with USEPA Method 308 –"*Procedure for the Determination of Methanol Emissions from Stationary Sources*". A gas sample was extracted from the sampling manifold via a ¼ inch Teflon sampling line at a rate of approximately 1 L/min. Methanol was collected in distilled water contained in a midget impinger and adsorbed onto a silica gel sorbent tube. The liquid portion of the sample was recovered using distilled water. The liquid sample and sorbent tube were forwarded to Hill Laboratories Ltd, Hamilton for analysis. The methanol in the water fraction was separated from other organic compounds using gas chromatography (GC) with subsequent measurement by a flame ionization detector (FID). The fraction adsorbed on the silica gel tube was extracted with an aqueous solution of n-propanol with analysis by GC/FID.

2.4 Sampling Equipment

2.4.1 Sampling Probe

The configuration of the flare pit did not allow for standard air discharge sampling probes to be used. The wide range of contaminants which needed to be sampled simultaneously would normally have required multiple sampling probes. However, due to the length of the sampling probe required to access the sampling locations, it was decided that a single probe would be used with a sampling manifold employed to attach each of the various sampling trains to the primary probe.

The primary sampling probe consisted of a 9.5 m x 18 mm (OD) stainless steel tube encased within a 9 m x 3 inch diameter steel pipe for structural support and to act as a heat shield. The sampling manifold consisted of a 2 m x 2 inch stainless steel pipe with seven “T” joints of varying diameters to allow for the connection of the individual sampling trains. Figures 2 and 3 depict the sampling probe and sampling manifold respectively. The inlet of the manifold was attached to the sampling probe with the outlet of the manifold connected to a sampling pump set to approximately 20 L/min to flush the system. The aim was to keep the velocity within the sampling probe as high as possible to minimise the level of deposition. The probe was rinsed with distilled water and isopropanol between the collection of the combustion zone and evaporation zone samples.

- **Figure 2: Sampling Probe**

■ **Figure 3: Sampling Manifold**

2.4.2 Sampling Trains

The following sampling systems were used for the air discharge monitoring. Figure 3 depicts the sampling trains connected to the sampling manifold.

- Combustion gases were monitored using a Testo 350XL combustion gas analyser. For more details on the Testo 350XL refer to Section 2.2.3.
- The particulate samples were collected using a Clean Air Engineering (CAE) manual USEPA Method 5 sampling train. This unit was also used during the collection of the evaporation samples to maintain suitable flow rates within the primary probe.
- The oxides of sulphur samples were collected from the combustion zone using USEPA Method 8 sampling train.
- The aldehyde samples were collected using a Tecora Isostack Basic automated sampling train configured to meet the requirements of USEPA Method 0011.
- The VOC samples were collected using a dual low flow adaptor connected to an SKC PCXR8 sampling pump. The sampling rates were determined using a Bios Defender 510 dry cal flow meter.

- The PCDD/PCDF & PAH samples were collected using a Tecora Isostack G4 automated stack sampling train configured to meet the requirement of USEPA Method 23.
- The methanol samples were collected using an Environmental Supply Co. Inc. Universal Volatile Organic Sampler (Uni-VOS) configured to meet the requirements of USEPA Method 308.

- **Figure 4: Sampling Manifold with Sampling Trains Attached**

2.4.3 Testo 350XL Combustion Gas Analyser

Gaseous products of combustion were measured using a Testo 350 XL combustion gas analyser. The Testo 350 XL utilises electrochemical cells to monitor oxygen (O_2 %), carbon monoxide (CO ppmv), nitric oxide (NO ppmv), nitrogen dioxide (NO_2 ppmv) and sulphur dioxide (SO_2 ppmv). The concentration of carbon dioxide (CO_2 %) was measured using an Infra Red (IR) cell. Table 4 presents the measurement specifications for the Testo 350XL combustion gas analyser.

- **Table 4 Testo 350XL Cell Specifications**

Cell	Range	Accuracy	Resolution	Response Time
O_2	0 to 25% vol.	< 0.2% of m.v.	0.1 vol. %	20 s (t95)
CO_2i	0 to 50% vol.	± 0.3% vol. +1% of m.v. (0 to 25% vol.) ± 0.5% vol. +1.5% of m.v (> 25 to 50% vol.)	0.01% vol. (0 to 25% vol.) 0.01% vol. (> 25% vol.)	10 s (t90)
CO	0 to 10,000 ppm H2 comp.	< 5 ppm (0 to 99 ppm) < 5% of m.v. (100 to 2,000 ppm) < 10% of m.v. (2,001 to 10,000 ppm)	1 ppm	40 s (t90)
NO	0 to 3,000 ppm	< 5 ppm (0 to 99 ppm) < 5% of m.v. (100 to 2,000 ppm) < 10% of m.v. (2,001 to 3,000 ppm)	1 ppm	30 s (t90)
NO_2	0 to 500 ppm	< 5 ppm (0 to 99 ppm) < 5% of m.v. (500 ppm)	0.1 ppm	40 s (t90)
SO_2	0 to 5,000 ppm	< 5 ppm (0 to 99 ppm) < 5% of m.v. (100 to 2,000 ppm) < 10% of m.v. (2,001 to 5,000 ppm)	1 ppm	30 s (t90)

3. Sampling Review

The TRC Hydraulic Fracturing Liquid Air Discharge Monitoring Programme was undertaken over the period 6 to 9 February with the combustion zone samples collected on 7 February and the evaporation zone samples collected on 8 February 2012. The hydraulic fracturing liquid recovered from the well from a recent hydraulic fracturing exercise was stored in steel tanks for the purposes of the trial.

Preparation for the air discharge monitoring commenced on 6 February 2012 which involved the preparation of the sampling probe including placement on the flare pit. The inlet to the probe was located as far as practical at the edge of the flare flame. A solid base of scaffolding planks was constructed for the sampling equipment and the sampling manifold was set up and tested. The Testo 350XL combustion gas analyser was connected to the sampling manifold and indicated an O_2 concentration of around 20.2 % with a corresponding CO_2 concentration of 0.6 %, indicating that combustion gases were being collected by the sampling train.

To investigate evaporation rate and to ensure sufficient liquid was available for the project, hydraulic fracturing liquid was piped into the flare pit at about 17:00. The solution was gravity fed from the storage tank via a four inch pipe and after approximately 2-hours the pit was full up to the level of the flare head. This was left overnight to get an indication of evaporation rate. On returning to the site at 7:00 on 7 February 2012, the bulk of the liquid had evaporated with only a small puddle left.

Hydraulic fracturing liquid was allowed to flow from the storage tank to the flare pit under gravity until the liquid level reached the flare head, at which point it was stopped. This took approximately 2 hours from empty. The solution was then allowed to evaporate for a couple of hours before being topped up again.

The sampling equipment was prepared where the sampling probe had been erected the day before. However, the wind direction was forcing the flare flame to the opposite side of the flare pit. The wind direction was forecast to change in the morning to direct the flare flame back towards the sampling equipment. However, by 12:00, it was apparent that the wind was not going to change so the sampling equipment was re-deployed to the opposite side of the flare pit. Figure 5 depicts the inlet of the sampling probe positioned for the combustion zone monitoring. Active sampling of the combustion zone was performed over the period 13:00 to 17:00 on 7 February 2012.

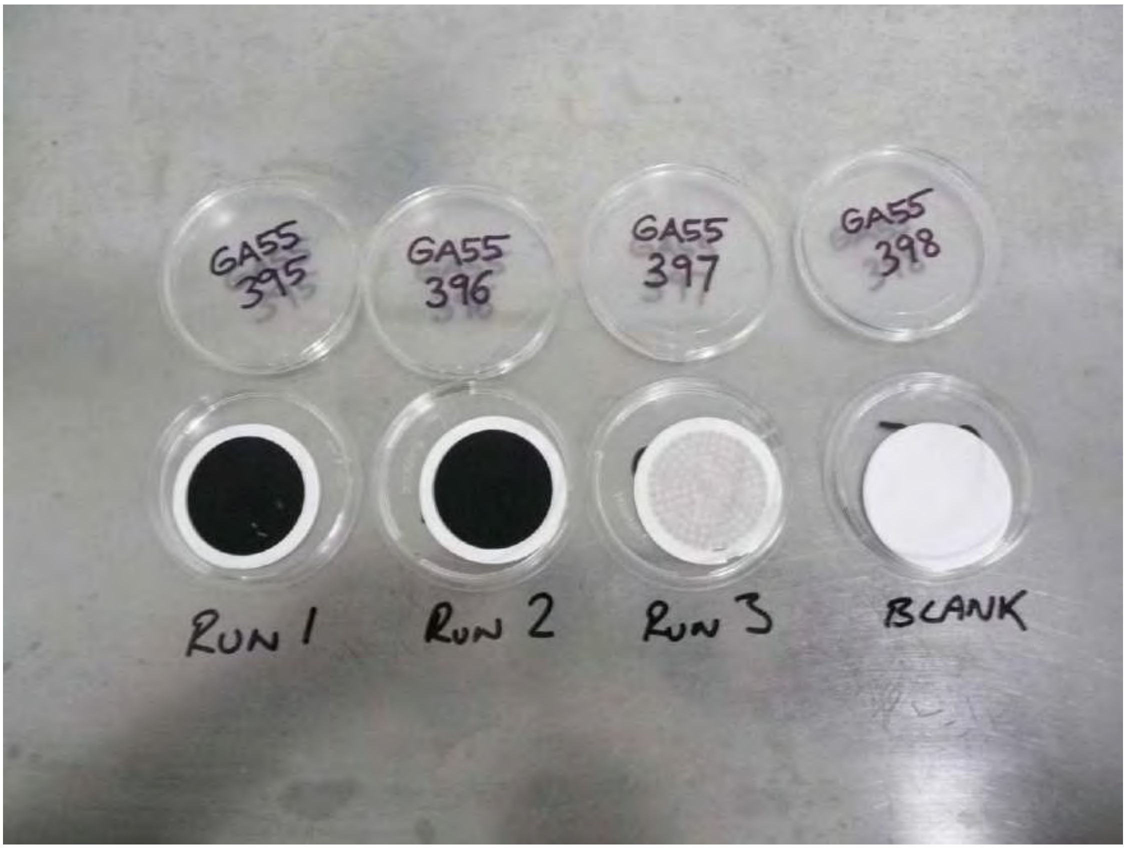
On 8 February 2012, the air discharge monitoring of the evaporation zone was performed. The sampling probe was rinsed and brushed clean with isopropanol and distilled water to remove any residue from the combustion zone sampling performed the day before. A small stainless steel hood with a foot print of 0.1 m^2 was added to the inlet of the probe to help capture evaporative emissions. The probe was located downwind of the flare to ensure no combustion gases were captured, and lowered as far as practical into the flare pit and as close as possible to the evaporating solution. Figure 6 depicts the inlet of the sampling probe positioned for the evaporation zone sampling. Active sampling of the evaporation zone was performed over the period 10:00 to 14:00 on 8 February 2012.

Hydraulic fracturing liquid was initially fed to the flare pit using a small pump but it was found that the gravity fed approach was equally effective. Hydraulic fracturing liquid was allowed to fill the pit to the level of the flare head at which point it was stopped. The solution was then allowed to evaporate for a couple of hours before being topped up again. Over the duration of the project the majority of the storage tank was used which had an estimated volume of 20 m^3.

- **Figure 5: Combustion Zone Sampling Probe Position**

- **Figure 6: Evaporation Zone Sampling Probe Position**

For the combustion zone sampling performed on 7 February 2012, the nature of the flare pit and the wind flow conditions on the day resulted in variable levels of emissions being collected. For the combustion zone sampling, the sampling probe was well positioned for the first and second sampling runs. However, over the duration of the day the wind direction changed forcing the gas flare to vary in its location. As a result, less of the combustion gases were able to be collected by the sampling system. Examination of the particulate filters (depicted in Figure 7) clearly shows the differences caused by the varying flare locations.



- **Figure 7: Combustion Zone Particulate Filters**

4. Air Discharge Monitoring Results

4.1 Introduction

The following sections present the results of the TRC Hydraulic Fracturing Liquid Air Discharge Monitoring Programme performed on 7 and 8 February 2012.

4.2 Particulate Matter Results

The results of the particulate matter samples collected from the hydraulic fracturing liquid combustion zone on 7 February 2012 are presented in Table 8. The raw sampling data is presented in Appendix A with particulate mass calculations contained in Appendix B.

- **Table 8 : Combustion Zone Particulate Matter Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled $(m^3)^1$	Mass (mg)	Conc. $(mg/m^3)^1$
PM Run 1	7/02/2012	13:00 - 14:00	1.474	2.4	1.6
PM Run 2	7/02/2012	14:30 - 15:30	1.727	1.3	0.8
PM Run 3	7/02/2012	16:00 - 17:00	1.946	<0.5	<0.3

1. Corrected to 0 ^{o}C, one atmospheric pressure, dry gas basis

The particulate discharge concentrations from the hydraulic fracturing liquid combustion zone collected on 7 February 2012 ranged from <0.3 to 1.6 mg/m^3 adjusted to 0 ^{o}C, one atmosphere pressure, and dry gas basis (mg/Sm^3), with an average of 0.9 mg/Sm^3.

4.3 Oxides of Sulphur Results

The results of the oxides of sulphur samples collected from the hydraulic fracturing liquid combustion zone on 7 February 2012 are presented in Table 9. The raw sampling data is presented in Appendix A with sulphate mass calculations contained in Appendix B.

- **Table 9: Combustion Zone Oxides of Sulphur Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled (m^3)[1]	Mass (mg)	Conc. (mg/m^3)[1]
Acid Mist Run 1	7/02/2012	13:00 - 1400	1.143	<0.04	<0.03
SO2 Run 1				<0.08	<0.07
Acid Mist Run 2	7/02/2012	14:30 - 15:30	1.203	<0.04	<0.03
SO_2 Run 2				<0.08	<0.07
Acid Mist Run 3	7/02/2012	16:00 - 17:00	1.035	<0.04	<0.04
SO_2 Run 3				<0.08	<0.08

1. Corrected to 0 °C, 101.3 kPa, dry gas basis

The sulphuric acid mist (including SO_3) discharge concentrations from the hydraulic fracturing liquid gas flare combustion zone measured on 7 February 2012 were less than the method detection limit of 0.03 mg/Sm^3 for all three sampling runs.

The SO_2 discharge concentration from the hydraulic fracturing liquid gas flare combustion zone measured on 7 February 2012 was less than the method detection limit of 0.07 mg/Sm^3 for all three sample runs.

4.4 Aldehyde Results

The results of the aldehyde samples collected from the hydraulic fracturing liquid combustion zone on 7 February are presented in Tables 10 and 11. Table 10 presents the total aldehydes as formaldehyde with Table 11 presenting the concentrations for the individual aldehyde compounds.

The results of the aldehyde samples collected from the hydraulic fracturing liquid evaporation zone on 8 February 2012 are presented in Tables 12 and 13. Table 12 presents the total aldehydes as formaldehyde with Table 13 presenting the concentrations for the individual aldehyde compounds.

The raw sampling data is presented in Appendix A with Appendix C containing the laboratory analytical reports.

- **Table 10: Combustion Zone Aldehydes as Formaldehyde Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled (m^3)^1	Total Aldehydes as Formaldehyde	
				Mass (µg)^2	Conc. (mg/m^3)^1
Run 1	7/02/2012	13:00 - 14:00	1.112	277	0.25
Run 2	7/02/2012	14:30 - 15:30	1.119	197	0.18
Run 3	7/02/2012	16:00 - 17:00	1.113	57	0.05

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis
2. Includes the detection limit mass from each aldehyde compound tested

- **Table 11: Combustion Zone Aldehydes Results, 7 February 2012**

Sampling Run	Formaldehyde		Acetaldehyde		Propionaldehyde		Acrolein	
	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1
Run 1	260	0.23	<10	<0.01	<10	<0.01	<10	<0.01
Run 2	180	0.16	<10	<0.01	<10	<0.01	<10	<0.01
Run 3	40	0.04	<10	<0.01	<10	<0.01	<10	<0.01

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

- **Table 12: Evaporation Zone Aldehydes as Formaldehyde Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled (m^3)^1	Total Aldehydes as Formaldehyde	
				Mass (µg)^2	Conc. (mg/m^3)^1
Run 1	8/02/2012	10:05 - 11:05	1.116	57	0.05
Run 2	8/02/2012	11:30 - 12:30	1.116	47	0.04
Run 3	8/02/2012	12:55 13:55	1.115	57	0.05

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis
2. Includes the detection limit mass from each aldehyde compound tested

- **Table 13: Evaporation Zone Aldehydes Results, 8 February 2012**

Sampling Run	Formaldehyde		Acetaldehyde		Propionaldehyde		Acrolein	
	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1	Mass (µg)	Conc. (mg/m^3)^1
Run 1	40	0.04	<10	<0.01	<10	<0.01	<10	<0.01
Run 2	30	0.03	<10	<0.01	<10	<0.01	<10	<0.01
Run 3	40	0.04	<10	<0.01	<10	<0.01	<10	<0.01

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

The total aldehydes as formaldehyde discharge concentration from the hydraulic fracturing liquid combustion zone measured on 7 February 2012 ranged from 0.05 to 0.25 mg/Sm^{3}with an average of 0.16 mg/Sm^3. Of the aldehydes investigated only formaldehyde was detected.

The total aldehydes as formaldehyde discharge concentration from the hydraulic fracturing liquid evaporation zone measured on 8 February 2012 ranged from 0.04 to 0.05 mg/Sm^{3}with an average of 0.05 mg/Sm^3. As with the combustion zone samples, only formaldehyde was detected.

These results would suggest that low level formaldehyde emissions are being produced from the flare pit containing hydraulic fracturing liquid and that the emissions are slightly higher from the combustion zone. This was possibly due to the formation of aldehyde compounds associated with the combustion process rather than just the presence of aldehyde compounds in the hydraulic fracturing liquid.

4.5 Volatile Organic Compound Results

The results of the VOC samples collected from the hydraulic fracturing liquid combustion zone on 7 February and the evaporation zone on 8 February 2012 are presented in Tables 14 and 15. Tables 14 and 15 contain only the VOC detected and present the VOC concentrations in terms of ppm expressed as carbon, ppm expressed as compound and mg/m^3 of compound (corrected to 0 ºC, 101.3 kPa, dry gas basis). Appendix A presents the raw sampling data with Appendix B presenting the mass and concentration determinations of individual VOC investigated as ppm expressed as carbon and ppm expressed as the compound. Appendix C contains the laboratory analytical reports.

- **Table 14: Combustion Zone VOC Results, 7 February 2012**

Sample Description	Sampling Date	Sampling Period	Conc. ppm (expressed as carbon)	Conc. ppm (expressed as compound)	Conc. (mg/m^3)^1
Run 1 Total	7/02/2012	13:00 - 14:00	0.171		
Benzene			0.100	0.109	0.379
Toulene			0.052	0.057	0.233
ethyl benzene			0.003	0.004	0.017
m,p- xylene			0.009	0.010	0.046
o - xylene			0.005	0.006	0.027
Run 2 Total	7/02/2012	14:18 - 16:40	0.020		
Benzene			0.005	0.005	0.018
Toulene			0.012	0.013	0.052
ethyl benzene			<LOD	<LOD	<LOD
m,p- xylene			0.003	0.003	0.014
o - xylene			0.001	0.002	0.007
Run 3 Total	7/02/2012	16:45 - 17:45	<LOD		
Benzene			<LOD	<LOD	<LOD
Toulene			<LOD	<LOD	<LOD
ethyl benzene			<LOD	<LOD	<LOD
m,p- xylene			<LOD	<LOD	<LOD
o - xylene			<LOD	<LOD	<LOD

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

The results of the combustion zone VOC monitoring performed on 7 February 2012 show the concentrations ranged from less than the method detection limit to 0.171 (expressed as carbon) with an average of 0.096 ppmv (expressed as carbon). The concentration of benzene ranged from less than the method detection limit to 0.109 ppm with an average of 0.057 ppm. The concentration of toluene ranged from less than the method detection limit to 0.057 ppm with an average of 0.035 ppm. The concentration of ethyl benzene ranged from less than the method detection limit to 0.004 ppm with an average of 0.004 ppm. The concentration of m,p - xylene ranged from less than the method detection limit to 0.010 ppm with an average of 0.007 ppm. The concentration of o - xylene ranged from less than the method detection limit to 0.006 ppm with an average of 0.004 ppm.

- **Table 15: Evaporation Zone VOC Results, 8 February 2012**

Sample Description	Sampling Date	Sampling Period	Conc. ppm (expressed as carbon)	Conc. ppm (expressed as compound)	Conc. (mg/m^3)^1
Run 1 Total	8/02/2012	10:05 - 11:05	0.003		
Benzene			<LOD	<LOD	<LOD
Toulene			0.003	0.004	0.014
ethyl benzene			<LOD	<LOD	<LOD
m,p- xylene			<LOD	<LOD	<LOD
o - xylene			<LOD	<LOD	<LOD
Run 2 Total	8/02/2012	11:30 - 12:30	<LOD		
Benzene			<LOD	<LOD	<LOD
Toulene			<LOD	<LOD	<LOD
ethyl benzene			<LOD	<LOD	<LOD
m,p- xylene			<LOD	0.004	<LOD
o - xylene			<LOD	0.003	<LOD
Run 3 Total	8/02/2012	12:55 - 13:55	0.047		
Benzene			0.012	0.013	<LOD
Toulene			0.027	0.030	0.123
ethyl benzene			<LOD	<LOD	<LOD
m,p- xylene			0.004	0.005	0.022
o - xylene			0.003	0.003	0.016

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

The results of the evaporation zone VOC monitoring performed on 8 February 2012 show the concentrations ranged from less than the method detection limit to 0.047 (expressed as carbon) with an average of 0.025 ppmv (expressed as carbon). The concentration of benzene ranged from less than the method detection limit to 0.013 ppm with an average of 0.013 ppm. The concentration of toluene ranged from less than the method detection limit to 0.030 ppm with an average of 0.017 ppm. The concentration of ethyl benzene was less than the method detection limit for all three sampling runs. The concentration of m,p - xylene ranged from less than the method detection limit to 0.005 ppm with an average of 0.005 ppm. The concentration of o - xylene ranged from less than the method detection limit to 0.003 ppm with an average of 0.003 ppm

These results would suggest that the flare pit containing hydraulic fracturing liquid could be producing low level VOC emissions. However, given the scope of compounds detected and the low levels observed, it could also be possible that the observed VOC's were from the well site itself rather than from the hydraulic fracturing liquid.

4.6 Dioxin/Furan Results

The results of the PCDD/PCDF samples collected from the hydraulic fracturing liquid combustion zone on 7 February are presented in Table 16 with Table 17 presenting the PCDD/PCDF laboratory blank. The raw sampling data is presented in Appendix A with Appendix C containing the laboratory analytical reports.

The results of the PCDD/PCDF analysis are reported in terms of World Health Organisation toxic equivalence factors (WHO-TEQ Van den Berg et al., 2005) as lower, medium and upper bound. Toxic equivalent factors are a means of summation of the individual PCDD/PCDF compounds based on their relative toxicity to the most toxic PCDD/PCDF compound, namely 2,3,7,8 TCDD.

In order to account for compounds which may be slightly below the method detection limit, a range of concentration data is presented, namely lower bound, medium bound and upper bound. Lower bound concentrations are based on adding a zero contribution to the total TEQ for each non-detect conger. The medium bound requires the addition of half the detection limit of non-detect congers with the upper bound requiring the addition of the full method detection limit TEQ.

- **Table 16: Combustion Zone PCDD/PCDF Results**

	Sampling Date	**Sampling Period**	**Sample Volume (m^3)[2]**	**Mass (ng)[1]**	**Conc. (ng/m^3)[2]**
Total WHO –TEQ[3] Lower Bound	7/02/2012	12:45 - 17:00	3.183	0.0000	0.0000
Total WHO –TEQ[3] Medium Bound				0.0056	0.0017
Total WHO –TEQ[3] Upper Bound				0.0111	0.0035

1. Mass not corrected for laboratory blank.
2. Corrected to 0 °C, 101.3 kPa, dry gas basis
3. World Health Organisation Toxic Equivalency (WHO-TEQ)

- **Table 17: PCDD/PCDF Laboratory Blank Results**

	Sampling Date	**Sampling Period**	**Sample Volume (m^3)[2]**	**Mass (ng)[1]**	**Conc. (ng/m^3)[2]**
Total WHO –TEQ[3] Lower Bound	February 2012		3.183	0.00000	0.00000
Total WHO –TEQ[3] Medium Bound				0.00527	0.00166
Total WHO –TEQ[3] Upper Bound				0.0105	0.0033

1. Mass not corrected for laboratory blank.
2. Corrected to 0 °C, 101.3 kPa, dry gas basis
3. World Health Organisation Toxic Equivalency (WHO-TEQ)

The PCDD/PCDF discharge concentration from the hydraulic fracturing liquid combustion zone measured on 7 February 2012 was 0.0035 ng/Sm^3 I-TEQ (Upper Bound). For WHO-TEQ values the PCDD/PCDF discharge concentration was 0.0033 ng/Sm^3 WHO-TEQ (Upper Bound). The results of the PCDD/PCDF monitoring indicate that the discharge concentrations were low and amounts collected were at a similar level to the laboratory blank.

4.7 Poly Aromatic Hydrocarbon Results

The results of the PAH samples collected from the Hydraulic fracturing liquid combustion zone measured on 7 February 2012 are presented in Table 18 with the results from the hydraulic fracturing liquid evaporation zone measured on 8 February 2012 presented in Table 19. Table 20 presents the results of the laboratory blank. The raw sampling data is presented in Appendix A with Appendix C containing the laboratory analytical reports.

Please note that an incident occurred in the final minutes of the collection of the evaporation zone PAH sample which resulted in cooling water being sucked into the filter and resin trap. However, due to the limited time allowed for the sampling programme (36 hours), the sample was recovered as best as possible and was analysed. Despite the loss of sample integrity, analytical quality control parameters were all within the acceptable range with the exception of indeno[123-c,d]pyrene, dibenz[g,h,i]anthracene and benzo[g,h,i]perylene which all exhibited elevated standard recoveries.

As with the PCDD/PCDF results, the PAH results have been reported in terms of the United States Environmental Protection Agency benzo[a]pyrene equivalence factors (Toxic USEPA; USEPA 1993) as lower, mediun and upper bound. The toxic equivalent factors are a means of summation of the individual PAH compounds based on their relative toxicity to the most toxic PAH, namely benzo[a]pyrene.

In order to account for compounds which may be slightly below the method detection limit, a range of concentration data is presented, namely lower bound, medium bound and upper bound. Lower bound concentrations are based on adding a zero contribution to the total TEQ for each non-detect conger. The medium bound requires the addition of half the detection limit of non-detect congers with the upper bound requiring the addition of the full method detection limit TEQ.

Table 18: Combustion Zone PAH Results

	Sampling Date	Sampling Period	Sample Volume (m^3)[2]	Mass (ng)[1]	Conc. (ng/m^3)[2]
Toxic USEPA[3] Lower Bound	7/02/2012	12:45 - 17:00	3.183	661	208
Toxic USEPA[3] Medium Bound				661	208
Toxic USEPA[3] Upper Bound				661	208

1. Mass not corrected for laboratory blank.
2. Corrected to 0 °C, 101.3 kPa, dry gas basis
3. Toxic United States Environmental Protection Agency (USEPA) Benzo[a]pyrene Equivalents

Table 19: Evaporation Zone PAH Results

	Sampling Date	Sampling Period	Sample Volume (m^3)[2]	Mass (ng)[1]	Conc. (ng/m^3)[2]
Toxic USEPA[3] Lower Bound	8/02/2012	10:05 - 14:58	4.298	17.1	3.98
Toxic USEPA[3] Medium Bound				21.4	4.98
Toxic USEPA[3] Upper Bound				25.7	5.98

1. Mass not corrected for laboratory blank.
2. Corrected to 0 °C, 101.3 kPa, dry gas basis
3. Toxic United States Environmental Protection Agency (USEPA) Benzo[a]pyrene Equivalents

Table 20: PAH Laboratory Blank Results

	Sampling Date	Sampling Period	Sample Volume (m^3)[1]	Mass (ng)[1]	Conc. (ng/m^3)[2]
Toxic USEPA[3] Lower Bound	February 2012		4.298	0.00	0.000
Toxic USEPA[3] Medium Bound				6.71	2.11
Toxic USEPA[3] Upper Bound				13.4	4.21

1. Mass not corrected for laboratory blank.
2. Corrected to 0 °C, 101.3 kPa, dry gas basis
3. Toxic United States Environmental Protection Agency (USEPA) Benzo[a]pyrene Equivalents

The PAH discharge concentration from the hydraulic fracturing liquid combustion zone measured on 7 February 2012 was 224 ng/Sm^3 Toxic CARB. For Toxic USEPA values the PAH discharge concentration was 208 ng/Sm^3 Toxic USEPA.

The PAH discharge concentration from the hydraulic fracturing liquid evaporation zone measured on 8 February 2012 was 6.68 ng/Sm^3 Toxic CARB (Upper Bound). For Toxic USEPA values the PAH discharge concentration was 5.98 ng/Sm^3 Toxic USEPA (Upper Bound). These results were similar to the levels observed in the laboratory blank.

These results indicate low level PAH emissions were occurring from the hydraulic fracturing liquid combustion zone. However, emissions from the evaporation zone were negligible.

4.8 Methanol Results

The results of the methanol samples collected from the hydraulic fracturing liquid combustion zone on 7 February and the evaporation zone on 8 February 2012 are presented in Tables 21 and 22 respectively. The raw sampling data is presented in Appendix A, the methanol mass calculations are in Appendix B with Appendix C containing the laboratory analytical reports.

- **Table 21 : Combustion Zone Methanol Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled (m^3)^1	Mass (mg)	Conc. (mg/m^3)^1
Run 1	7/02/2012	13:00 - 1400	0.057	<0.070	<1.2
Run 2	7/02/2012	14:30 - 15:30	0.048	0.128	2.66
Run 3	7/02/2012	16:00 - 17:00	0.057	<0.084	<1.5

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

- **Table 22 : Evaporation Zone Methanol Results**

Sampling Run	Sampling Date	Sampling Period	Volume Sampled (m^3)^1	Mass (mg)	Conc. (mg/m^3)^1
Run 1	8/02/2012	10:05 - 11:05	0.055	<0.128	<2.3
Run 2	8/02/2012	11:30 - 12:30	0.054	0.284	5.25
Run 3	8/02/2012	12:55 - 13:55	0.053	<0.106	<2.0

1. Corrected to 0 °C, one atmospheric pressure, dry gas basis

The methanol discharge concentrations from the hydraulic fracturing liquid combustion zone collected on 7 February 2012 ranged from less than 1.2 to 2.66 mg/Sm^3 with an average of 1.79 mg/Sm^3. The method discharge concentration from the hydraulic fracturing liquid evaporation zone measured on 8 February 2012 ranged from less than 2.0 to 5.25 mg/Sm^3 with an average of 3.19 mg/Sm^3.

These results suggest low level methanol emissions were being produced from the flare pit containing hydraulic fracturing liquid and the emissions are slightly higher from the evaporation zone. This was possibly due to the destruction of methanol in the flare flame.

4.9 Gaseous Products of Combustion Monitoring Results

The results from the Testo 350XL combustion gas analyser collected from the hydraulic fracturing liquid combustion zone on 7 February 2012 are presented in Table 23. The raw sampling data is presented in graphical form in Appendix E.

- **Table 23: Products of Combustion Results, 7 February 2012**

Date		O_2 (%)[1]	CO_2 (%)[1]	CO (ppmv)[2]	NO (ppmv)[2]	NO_2 (ppmv)[2]	NO_x (ppmv)[2]	SO_2 (ppmv)[2]
Run 1	Ave.	20.8	0.3	11	2	0.5	2	1
	Max.	20.9	1.0	99	6	1.1	6	5
	Min.	19.7	0.2	<1	<1	<0.1	<1	<1
Run 2	Ave.	20.8	0.2	8	1	0.2	1	1
	Max.	20.8	0.5	89	5	0.5	6	5
	Min.	20.4	0.2	<1	<1	<0.1	<1	<1
Run 3	Ave.	21.0	<0.1	1	<1	0.1	<1	1
	Max.	21.0	<0.1	1	<1	0.2	<1	1
	Min.	21.0	<0.1	<1	<1	0.0	<1	<1

1. Dry gas basis
2. parts per million per volume, dry gas basis

The results from the Testo 350XL combustion gas analyser collected from the hydraulic fracturing liquid combustion zone on 7 February 2012 indicate that the CO_2 concentrations ranged from 0.2 to 1.0 % for Run 1, 0.2 to 0.5 % for Run 2 but were less than 0.1 for the final run. This highlights the movement of the flare flame described in Section 3.

For Runs 1 and 2, the CO concentrations ranged from less than 1 to 99 ppmv with an average of 11 ppmv for Run 1 and 8 ppmv for Run 2. The NOx concentration for Runs 1 and 2 ranged from less than 1 to 6 ppmv with an average of 2 ppmv for Run 1 and 1 ppmv for Run 2. The SO_2 concentration for Runs 1 and 2 ranged from less than 1 to 5 ppmv with an average of 1 ppmv. These results mimic the low SO_2 emissions observed using the Method 8 sampling train.

Appendix A Raw Sampling Data

This Appendix contains 16 pages including cover.

Both the Tecora G4 used for the PCDD/PCDF and PAH monitoring and the Tecora IsoStack Basic used for the aldehyde monitoring provide electronic data files recording a wide range of sampling parameters. These reports are presented at the end of this Appendix.

The data presented in the Tecora data sheets are based on assumed moisture contents. The tabulated data presented is based on actual measured moisture content. As a result the corrected volumetric flow rates may differ between the two data sheets.

Combustion Zone Particulate Raw Sampling Data

Sample Description:	PM Run 1	PM Run 2	PM Run 3	Averages
Sampling Date:	7/02/2012	7/02/2012	7/02/2012	
Filter ID:	ST0395	ST0396	ST0397	
Sampling Period:	13:00 - 14:00	14:30 - 15:30	16:00 - 17:00	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	0.975	0.975	0.975	
Intial DGM Reading (ft^3)	277.0000	336.2000	406.0050	
Final DGM Reading (ft^3)	336.1000	405.8800	484.5100	
DGM Sample Volume (m^3):	1.6735	1.9731	2.2230	
DGM Std. Sample Volume (m^3):	1.4744	1.7268	1.9455	
Initial Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Final Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Moisture Collected (g):	NA	NA	NA	
Moisture Content (%):	1.6	1.6	1.6	1.6
TCR DGM Sample Volume (m^3):				
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	NA
TCR Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	NA
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^{o}C):	NA	NA	NA	NA
At DGM (^{o}C):	28.0	30.0	30.0	
Ambient Pressure (kPa):	100.94	100.94	100.94	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

Combustion Zone Oxides of Sulphur Raw Sampling Data

Sample Description:	SOx Run 1	SOx Run 2	SOx Run 3	Averages
Sampling Date:	7/02/2012	7/02/2012	7/02/2012	
Filter ID:	NA	NA	NA	
Sampling Period:	13:00 - 1400	14:30 - 15:30	16:00 - 17:00	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	0.977	0.977	0.977	
Intial DGM Reading	635.0540	636.4720	638.1640	
Final DGM Reading	636.3385	637.8432	639.3402	
DGM Sample Volume (m^3):	1.2845	1.3712	1.1762	
DGM Std. Sample Volume (m^3):	1.1434	1.2025	1.0349	
Initial Leak Test Vacuum (Bar):	-0.70	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Final Leak Test Vacuum (Bar):	-0.70	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Moisture Collected (g):	NA	NA	NA	
Moisture Content (%):	1.6	1.6	1.6	1.6
TCR DGM Sample Volume (m^3):				
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	NA
TCR Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	NA
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^oC):	NA	NA	NA	NA
At DGM (^oC):	25.5	30.0	29.0	
Ambient Pressure (kPa):	100.94	100.94	100.94	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

Combustion Zone Aldehydes Raw Sampling Data

Sample Description:	Ald Run 1	Ald Run 2	Ald Run 3	Averages
Sampling Date:	7/02/2012	7/02/2012	7/02/2012	
Filter ID:	NA	NA	NA	
Sampling Period:	13:00 - 14:00	14:30 - 15:30	16:00 - 17:00	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	1.0249	1.0249	1.0249	
Intial DGM Reading	400.5765	401.8230	403.0912	
Final DGM Reading	401.8135	403.0802	404.3420	
DGM Sample Volume (m^3):	1.2370	1.2572	1.2508	
DGM Std. Sample Volume (m^3):	1.1124	1.1186	1.1130	
Initial Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	50	350	350	
Final Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	150	450	350	
Moisture Collected (g):	18.2	14.2	11.9	
Moisture Content (%):	2.0	1.6	1.3	1.6
TCR DGM Sample Volume (m^3):	1.2616	1.2819	1.2757	
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	NA
TCR Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	NA
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^oC):	NA	NA	NA	NA
At DGM (^oC):	37.0	40.3	40.3	
Ambient Pressure (kPa):	100.94	100.94	100.94	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

Evaporation Zone Aldehydes Raw Sampling Data

Sample Description:	Ald Run 4	Ald Run 5	Ald Run 6	Averages
Sampling Date:	8/02/2012	8/02/2012	8/02/2012	
Filter ID:	NA	NA	NA	
Sampling Period:	10:05 - 11:05	11:30 - 12:30	12:55 13:55	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	1.0249	1.0249	1.0249	
Intial DGM Reading	404.3485	405.5905	406.8482	
Final DGM Reading	405.5758	406.8362	408.1052	
DGM Sample Volume (m^3):	1.2273	1.2457	1.2570	
DGM Std. Sample Volume (m^3):	1.1155	1.1155	1.1151	
Initial Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	50	250	200	
Final Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	250	180	150	
Moisture Collected (g):	12.3	13.1	11	
Moisture Content (%):	1.4	1.4	1.2	1.3
TCR DGM Sample Volume (m^3):	1.2516	1.2705	1.2819	
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	NA
Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	NA
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^{o}C):	NA	NA	NA	NA
At DGM (^{o}C):	34.0	38.6	41.6	
Ambient Pressure (kPa):	101.04	101.04	101.04	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

Combustion Zone VOC Raw Sampling Data

Sample Description	Sample ID	Sampling Date	Sampling Period	Sample Duration (min)	Initial Flow (mL/min)	Final Flow (mL/min)	Ave Flow (mL/min)	Sample Vol (m^3)	Ambient Temp (^{o}C)	Ambient Press. (kPa)	Sample Vol (m^3)[1]
VOC Run 1 - Spike	ST0201/02	7/02/2012	13:00 - 14:00	60	590.6	490.7	540.7	0.0324	25.0	100.9	0.0296
VOC Run 2 - Spike	ST0201/04	7/02/2012	14:18 - 16:40	60	511.0	507.1	509.1	0.0305	25.0	100.9	0.0279
VOC Run 3 - Spike	ST0201/06	7/02/2012	16:45 - 17:45	60	510.5	463.6	487.1	0.0292	25.0	100.9	0.0267
VOC Run 1 - Sample	ST0201/01	07/02/2012	13:00 - 14:00	60	660.6	672.0	666.3	0.0400	25.0	100.9	0.0365
VOC Run 2 - Sample	ST0201/03	07/02/2012	14:18 - 16:40	60	677.9	686.0	682.0	0.0409	25.0	100.9	0.0373
VOC Run 3 - Sample	ST0201/05	07/02/2012	16:45 - 17:45	60	707.5	605.2	656.4	0.0394	25.0	100.9	0.0359

1. Corrected to 0 ^{o}C, 101.3 kPa

Evaporation Zone VOC Raw Sampling Data

Sample Description	Sample ID	Sampling Date	Sampling Period	Sample Duration (min)	Initial Flow (mL/min)	Final Flow (mL/min)	Ave Flow (mL/min)	Sample Vol (m^3)	Ambient Temp (^{o}C)	Ambient Press. (kPa)	Sample Vol (m^3)[1]
VOC Run 1 - Spike	ST0201/08	8/02/2012	10:05 - 11:05	60	537.3	480.1	508.7	0.0305	25.0	100.1	0.0276
VOC Run 2 - Spike	ST0201/10	8/02/2012	11:30 - 12:30	60	471.3	461.9	466.6	0.0280	25.0	100.1	0.0253
VOC Run 3 - Spike	ST0201/12	8/02/2012	12:55 - 13:55	60	507.1	474.1	490.6	0.0294	25.0	100.1	0.0266
VOC Run 1 - Sample	ST0201/07	08/02/2012	10:05 - 11:05	60	457.8	452.5	455.2	0.0273	25.0	100.1	0.0247
VOC Run 2 - Sample	ST0201/09	08/02/2012	11:30 - 12:30	60	657.5	594.3	625.9	0.0376	25.0	100.1	0.0340
VOC Run 3 - Sample	ST0201/11	08/02/2012	12:55 - 13:55	60	667.1	656.9	662.0	0.0397	25.0	100.1	0.0360

1. Corrected to 0 ^{o}C, 101.3 kPa

■ PCDD/PCDF & PAH Raw Sampling Data

Sample Description:	PCDD/PCDF/PAH	PAH
Sampling Date:	7/02/2012	8/02/2012
Filter ID:	170112-A	170112-F
Sampling Period:	12:45 - 17:00	10:05 - 14:58
Total Sample Time (minutes)	180	234
Nozzle Diameter (mm)	NA	NA
Nozzle Area (m2)	NA	NA
DGM Calibration Factor	1.0125	1.0125
Intial DGM Reading	13.2400	19.1600
Final DGM Reading	19.1535	30.0670
DGM Sample Volume (m^3):	5.9135	10.9070
DGM Std. Sample Volume (m^3):	3.1826	4.2976
Initial Leak Test Vacuum (kPa):	70	70
Initial Leak Test Flow Rate (cc/min):	280	470
Final Leak Test Vacuum (kPa):	70	70
Final Leak Test Flow Rate (cc/min):	180	280
Moisture Collected (g):	28.0	
Moisture Content (%):	1.1	1.1
TCR DGM Sample Volume (m^3):	5.9082	10.8990
Sampling Plane Mean Velocity (m/s):	NA	NA
TCR Isokinetic Deviation (%):	NA	NA
Actual Isokinetic Deviation (%):	NA	NA
Duct Volumetric Flow Rates		
Moist (m^3/h):	NA	NA
Moist Standards (m^3/h):	NA	NA
Dry Standard (m^3/h):	NA	NA
Mean Temperatures		
At Sampling Plane (^{o}C):	NA	NA
At DGM (^{o}C):	32.6	32.3
Ambient Pressure (kPa):	100.916	100.974
Static Pressure (Pa)	NA	NA
Stack Absolute Pressure (kPa)	100.916	100.974
Gas meter pressure (kPa)	60.287	44.101

- **Combustion Zone Methanol Raw Sampling Data**

Sample Description:	MeOH Run 1	MeOH Run 2	MeOH Run 3	Averages
Sampling Date:	7/02/2012	7/02/2012	7/02/2012	
Filter ID:	NA	NA	NA	
Sampling Period:	13:00 - 1400	14:30 - 15:30	16:00 - 17:00	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	1.0113	1.0113	1.0113	
Intial DGM Reading	1.5084	1.5780	1.6310	
Final DGM Reading	1.5700	1.6310	1.6932	
DGM Sample Volume (m^3):	0.0616	0.0530	0.0622	
DGM Std. Sample Volume (m^3):	0.0571	0.0482	0.0566	
Initial Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Final Leak Test Vacuum (Bar):	-0.70	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Moisture Collected (g):	NA	NA	NA	
Moisture Content (%):	1.6	1.6	1.6	
TCR DGM Sample Volume (m^3):				
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	
TCR Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^{o}C):	NA	NA	NA	
At DGM (^{o}C):	23.5	29.5	29.5	
Ambient Pressure (kPa):	100.94	100.94	100.94	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

Evaporation Zone Methanol Raw Sampling Data

Sample Description:	MeOH Run 4	MeOH Run 5	MeOH Run 6	Averages
Sampling Date:	8/02/2012	8/02/2012	8/02/2012	
Filter ID:	NA	NA	NA	
Sampling Period:	10:05 - 11:05	11:30 - 12:30	12:55 - 13:55	
Total Sample Time (minutes)	60	60	60	
Nozzle Diameter (mm)	NA	NA	NA	
Nozzle Area (m2)	NA	NA	NA	
DGM Calibration Factor	1.0113	1.0113	1.0113	
Intial DGM Reading	1.6935	1.7536	1.8140	
Final DGM Reading	1.7535	1.8135	1.8733	
DGM Sample Volume (m^3):	0.0600	0.0599	0.0593	
DGM Std. Sample Volume (m^3):	0.0551	0.0541	0.0528	
Initial Leak Test Vacuum (Bar):	-0.80	-0.80	-0.80	
Initial Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Final Leak Test Vacuum (Bar):	-0.70	-0.80	-0.80	
Final Leak Test Flow Rate (cc/min):	Pass	Pass	Pass	
Moisture Collected (g):	NA	NA	NA	
Moisture Content (%):	1.3	1.3	1.3	
TCR DGM Sample Volume (m^3):	NA	NA	NA	
Sampling Plane Mean Velocity (m/s):	NA	NA	NA	
Isokinetic Deviation (%):	NA	NA	NA	
Actual Isokinetic Deviation (%):	NA	NA	NA	
Duct Volumetric Flow Rates				
Moist (m^3/h):	NA	NA	NA	
Moist Standards (m^3/h):	NA	NA	NA	
Dry Standard (m^3/h):	NA	NA	NA	
Mean Temperatures				
At Sampling Plane (^oC):	NA	NA	NA	
At DGM (^oC):	27.0	32.0	36.5	
Ambient Pressure (kPa):	101.04	101.04	101.04	
Static Pressure (Pa)	NA	NA	NA	
Stack Absolute Pressure (kPa)	NA	NA	NA	

TRC PCDD/PCDF/PAH Run 1
Constant Flow sampling 07/02/2012 12:47:40

MACHINE INFORMATION

Master Firmware	v1.7.0000
Master Serial Number	11420234P
Slave Firmware	v0.7.7000
Slave Serial Number	11420234P
Last calibration date	18/10/2011

CV GAMMA [#] CALIBRATION

Point	Sensor	Calibrated
1	0	1000

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'_a avg $[^m/_{sec}]$	qV_n avg $[^{lt}/_{min}]$	$v'_{N\ avg}$ $[^m/_{sec}]$	ρn avg $[^{kg}/_{m^3}]$	V_{gn} [lt]	V_{dgm} [lt]
7/02/2012 12:48:30	1	1	35	1:00:00	91.755	100.916	0.534	2.602	2.234	1.302	195.35	339.9
7/02/2012 14:27:51	2	1	35	1:00:00	45.453	100.916	1.087	17.902	15.374	1.302	1081.27	2718.4
7/02/2012 15:59:18	3	1	0	1:00:00	43.654	100.916	1.401	17.907	15.385	1.302	1083.35	2849.9

NORMALIZATION FACTOR

T_{norm}	[K]	273
P_{norm}	[kPa]	101.3

AVERAGE VALUES

Total Points		[#]	3	
Flowrate Deviation	DF	[%]	-2.2	[-1.000; 1.000]
Ambient Pressure	P_{amb}	[kPa]	100.916	[100.916; 100.916]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	3:00:00	
Total encoder impulses		[#]	118164	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	2.36	
Volume at dgm conditions	V_{dgm}	[m^3]	5.9082	
Gas meter temperature	t_{gm}	[°C]	32.603	[28.628; 36.050]
Gas Meter Pressure	P_{dgm}	[kPa]	60.287	[31.326; 100.315]

TRC PAH Run 1

Constant Flow sampling 08/02/2012 10:06:19

MACHINE INFORMATION

Master Firmware	v1.7.0000
Master Serial Number	11420234P
Slave Firmware	v0.7.7000
Slave Serial Number	11420234P
Last calibration date	18/10/2011

CV GAMMA [#] CALIBRATION

Point	Sensor	Calibrated
1	0	1000

POINT LIST

start ts [timestamp]	Port [###]	Point [###]	Distance [cm]	Elapsed Time [hh:mm:ss]	P_{line} avg [kPa]	P_{amb} avg [kPa]	v'_a avg [$^m/_{sec}$]	qV_n avg [$^{lt}/_{min}$]	$v'_{N\,avg}$ [$^m/_{sec}$]	ρn avg [$^{kg}/_{m^3}$]	V_{gn} [lt]	V_{dgm} [lt]
8/02/2012 10:06:30	1	1	35	1:00:00	46.022	100.953	1.915	17.726	15.192	1.302	1063.43	2629.65
8/02/2012 11:31:32	2	1	35	1:00:00	43.531	100.982	2.624	17.908	15.339	1.302	1079.47	2828.8
8/02/2012 12:56:32	3	1	35	1:00:00	42.595	100.982	2.547	17.892	15.328	1.302	1081.83	2909.1
8/02/2012 13:59:51	4	1	35	0:54:02	44.257	100.982	2.602	17.797	15.253	1.302	976.24	2531.45

NORMALIZATION FACTOR

T_{norm}	[K]	273	
P_{norm}	[kPa]	101.3	

AVERAGE VALUES

Total Points		[#]	4	
Flowrate Deviation	DF	[%]	-0.9	[-1.000; 0.069]
Ambient Pressure	P_{amb}	[kPa]	100.974	[0.000; 100.982]

SAMPLED VOLUMES

Elapsed time	et	[hh:mm:ss]	3:54:02	
Total encoder impulses		[#]	217980	
Standard Volume [T_{norm} P_{norm}]	V_{gn}	[m^3]	4.201	
Volume at dgm conditions	V_{dgm}	[m^3]	10.899	
Gas meter temperature	t_{gm}	[°C]	32.347	[22.284; 36.123]
Gas Meter Pressure	P_{dgm}	[kPa]	44.101	[8.792; 100.787]

Constant Flow Sampling

TRC Aldehyde Combustion Run 1

12/02/07 12:53 Tue

Port	Point	Distance	(cm)	ET (hh:mm:ss)	Flow q'Va	Volume Vgn
1	1	3.0		1:00:00	24.202	1.1884

FINAL REPORT

Method : EPA

DUCT AND GAS SPECIFICATION

Ambient pressure kPa : 100.94

SAMPLED VOLUMES

Dry at gas meter	Vg	m^3 :		1.2616
Dry derived	Vdn	m^3 :	0.0000	0.0000
Dry std. condition	Vgn	m^3 :		1.1884
Wet at measure plain	V'ga	m^3 :		1.4521
Average flow	q'Va	l/min :		24.202
Total derived time	ETd	hh:mm:ss :	00:00:00	0:00:00
Total elapsed time	ETt	hh:mm:ss :	01:00:00	1:00:00

AVERAGE VALUES

Gas meter temperature tg °C : 36.97

Constant Flow Sampling

TRC Aldehyde Combustion Run 2

12/02/07 14:33 Tue

Port	Point	Distance (cm)	ET (hh:mm:ss)	Flow q'Va	Volume Vgn
1	1	3.0	1:00:00	24.455	1.1947

FINAL REPORT

Method   : EPA

DUCT AND GAS SPECIFICATION

```
Ambient pressure           kPa :
100.94
```

SAMPLED VOLUMES

```
Dry at gas meter     Vg     m^3
:                                1.2819
Dry derived          Vdn    m^3
:   0.0000                       0.0000
Dry std. condition   Vgn    m^3
:                                1.1947
Wet at measure plain V'ga   m^3
:                                1.4673
Average flow  q'Va        l/min
:                                24.455
Total derived time ETd hh:mm:ss  0:00:0
:   00:00:00                          0
Total elapsed time ETt hh:mm:ss  1:00:0
:   01:00:00                          0
```

AVERAGE VALUES

```
Gas meter temperature    tg  °C
:                                  40.3
```

Constant Flow Sampling

TRC Aldehyde Combustion Run 3

12/02/07 16:04Tue

Port	Point	Distance	(cm)	ET (hh:mm:ss)	Flow q'Va	Volume Vgn
1	1	3		1:00:00	24.318	1.189

FINAL REPORT

Method : EPA

DUCT AND GAS SPECIFICATION

Ambient pressure		kPa :	100.94	

SAMPLED VOLUMES

Dry at gas meter	Vg	m^3 :		1.2757
Dry derived	Vdn	m^3 :	0.0000	0
Dry std. condition	Vgn	m^3 :		1.189
Wet at measure plain	V'ga	m^3 :		1.4591
Average flow q'Va		l/min :		24.318
Total derived time	ETd	hh:mm:ss :	00:00:00	0:00:00
Total elapsed time	ETt	hh:mm:ss :	01:00:00	1:00:00

AVERAGE VALUES

Gas meter temperature	tg	°C :	40.26

Constant Flow Sampling

TRC Aldehyde Evaporation Run 1

12/02/08 10:11 Wed

Port	Point	Distance	(cm)	ET (hh:mm:ss)	Flow q'Va	Volume Vgn
1	1	3		0.0417	24.068	1.1916

FINAL REPORT

```
Method    : EPA
```

DUCT AND GAS SPECIFICATION

```
Ambient pressure           kPa :   101.04
```

SAMPLED VOLUMES

```
Dry at gas meter     Vg     m^3 :               1.2516
Dry derived          Vdn    m^3 :   0.0000      0.0000
Dry std. condition   Vgn    m^3 :               1.1916
Wet at measure plain V'ga   m^3 :               1.4441
Average flow  q'Va       l/min :               24.068
Total derived time ETd hh:mm:ss :
00:00:00                                      0:00:00
Total elapsed time ETt hh:mm:ss :
01:00:00                                      1:00:00
```

AVERAGE VALUES

```
Gas meter temperature    tg  °C :                33.99
```

Constant Flow Sampling

```
TRC Aldehyde Evaporation Run 2

12/02/08 11:37 Wed
```

```
                                                     ET           Flow      Volume
   Port          Point       Distance       (cm)   (hh:mm:ss)     q'Va        Vgn

     1             1             3                  0.0417       24.27      1.1917
```

FINAL REPORT

```
Method    : EPA
```

DUCT AND GAS SPECIFICATION

```
Ambient pressure            kPa :   101.04
```

SAMPLED VOLUMES

```
Dry at gas meter     Vg     m^3 :              1.2705
Dry derived          Vdn    m^3 :   0.0000     0.0000
Dry std. condition   Vgn    m^3 :              1.1917
Wet at measure plain V'ga   m^3 :              1.4562
Average flow  q'Va       l/min :               24.27
Total derived time ETd hh:mm:ss :
00:00:00                                         0.00
Total elapsed time ETt hh:mm:ss :
01:00:00                                      1:00:00
```

AVERAGE VALUES

```
Gas meter temperature    tg  °C :               38.59
```

Constant Flow Sampling

TRC Aldehyde Evaporation Run 3

12/02/08 13:02 Wed

Port	Point	Distance	(cm)	ET (hh:mm:ss)	Flow q'Va	Volume Vgn
1	1	3		1:00:00	24.361	1.1911

FINAL REPORT

Method   : EPA

DUCT AND GAS SPECIFICATION

```
Ambient pressure            kPa :   101.04
```

SAMPLED VOLUMES

```
Dry at gas meter     Vg     m^3 :             1.2819
Dry derived          Vdn    m^3 :   0.0000         0
Dry std. condition   Vgn    m^3 :             1.1911
Wet at measure plain V'ga   m^3 :             1.4617
Average flow  q'Va       l/min :             24.361
Total derived time ETd hh:mm:ss :
00:00:00                                       0.00
Total elapsed time ETt hh:mm:ss :
01:00:00                                    1:00:00
```

AVERAGE VALUES

```
Gas meter temperature    tg  °C :              41.55
```

Appendix B Contaminants Mass Determinations

This Appendix contains 8 pages including cover.

Combustion Zone Particulate Mass Determinations

Sampling Run	Sample ID	Filter ID/ Rinse Vol (ml)	Initial Weight (g)	Final Weight (g)	Mass (g)	Net Mass (g)
PM Run 1	ST0201/42	ST0395	0.0577	0.0602	0.0025	0.0024
PM Run 2	ST0201/43	ST0396	0.0592	0.0606	0.0014	0.0013
PM Run 3	ST0201/44	ST0397	0.0582	0.0583	0.0001	0.0000
Filter Blank	ST0201/45	ST0398	0.0600	0.0601	0.0001	

Combustion Zone Oxides of Sulphur Titration Results, 7 February 2012

Project NO.	ST0201							
Sample (Aliquote 15 ml)	Sample	$Ba(ClO_4)_2$ - Titrant ml (Burette)						
		Start	End	Total	Average	Aliquote Size (ml)	Date of Titration	Lab Number
SO3 Run 1(80% Isopropanol)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/34
	1B	1.40	1.40	0.00			19/02/2011	
SO3 Run 2 (80% Isopropanol)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/36
	1B	1.40	1.40	0.00			19/02/2011	
SO3 Run 3 (80% Isopropanol)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/38
	1B	1.40	1.40	0.00			19/02/2011	
SO2 Run 1 (3% H2O2)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/35
	1B	1.40	1.40	0.00			19/02/2011	
SO2 Run 2 (3% H2O2)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/37
	1B	1.40	1.40	0.00			19/02/2011	
SO2 Run 3 (3% H2O2)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/39
	1B	1.40	1.40	0.00			19/02/2011	
SO3 Blank (80% Isopropanol)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/40
	1B	1.40	1.40	0.00			19/02/2011	
SO2 Blank (3% H2O2)	1A	1.40	1.40	0.00	0.00	40.00	19/02/2011	ST0201/41
	1B	1.40	1.40	0.00			19/02/2011	

Note: Replicate titrations must agree within 1% or 0.2 ml whichever is greater.

[1] To start with use 15 ml aliquote for titration. If the concentration is too high or low, modify the volume of aiquote accordingly.

Combustion Zone Oxides of Sulphur Mass Determinations, 7 February 2012

Project NO.	**ST0201**						
Sample	**Lab Numbe**	**Mass of SO2 or SO3 (g)**	**Normality of Barium Solution**	Vt	Vtb	Vsoln	Va
SO3 Run 1(80% Isopropanol)	ST0201/34	0.00000	0.009221311	0.00	0.00	150	40.00
SO3 Run 2 (80% Isopropanol)	ST0201/36	0.00000	0.009221311	0.00	0.00	120	40.00
SO3 Run 3 (80% Isopropanol)	ST0201/38	0.00000	0.009221311	0.00	0.00	130	40.00
S03 Average Concentration		0.00000					
SO2 Run 1 (3% H2O2)	ST0201/35	0.00000	0.009221311	0.00	0.00	400	40.00
SO2 Run 2 (3% H2O2)	ST0201/37	0.00000	0.009221311	0.00	0.00	390	40.00
SO2 Run 3 (3% H2O2)	ST0201/39	0.00000	0.009221311	0.00	0.00	420	40.00
SO2 Average Concentration		0.0000					

SO3 Mass = K3[N(Vt-Vtb)(Vsoln/Va)]

SO2 Mass = K4[N(Vt-Vtb)(Vsoln/Va)]

N = Normality of Barium standard titrant (ml)
Vt = Volume of Barium titrant used for sample (ml)
Vtb = Volume of Barium tirant used for blank (ml)
Vsoln = Total volume of solution in which the SO2 or SO3 sample is contained (ml)
Va = Volume of sample aliquot titrated (ml)

K3 = 0.04904
K4 = 0.03203

■ Combustion Zone VOC Mass Determinations 7 February 2012

Analyte	Run 1		ug/l of spiked compound	R value	Run 2		ug/l of spiked compound	R value	Run 3		ug/l of spiked compound	R value	Travel Spike	Lab Blank	Lab Blank	
	Sample Result ug	Spike Result ug			Sample Result ug	Spike Result ug			Sample Result ug	Spike Result ug			Lab Result ug	Lab Result ug	Lab Result ug	% Recovery
Chloroform	ldl	19	518	1.0	ldl	18	539	0.8	ldl	19	601	0.8	19.6	<4.0	4.0	98
1,1,1-Trichloroethane	ldl	19.5	646	1.0	ldl	19	671	0.9	ldl	20	739	1.0	20	<0.4	0.4	100
1,2-Dichloroethane	ldl	18.6	616	0.9	ldl	18.2	642	0.9	ldl	19.3	713	1.0	19.4	<0.4	0.4	97
Carbon tetrachloride	ldl	19	629	1.0	ldl	18.7	660	0.9	ldl	19.1	705	1.0	19.6	<0.4	0.4	98
1,1-Dichloropropene	ldl	18.8	623	1.0	ldl	18.6	657	1.0	ldl	19	701	1.0	18.6	<0.4	0.4	93
Benzene	11.6	30	656	1.0	0.5	19.5	686	1.0	ldl	25	926	1.3	18.8	<0.4	0.4	94
Trichloroethylene	ldl	36	1204	1.0	ldl	36	1281	1.0	ldl	37	1376	1.0	35.8	<0.4	0.4	179
1,2-Dichloropropane	ldl	19.7	653	1.0	ldl	19.6	692	1.0	ldl	21	776	1.0	20	<0.4	0.4	100
Dibromomethane	ldl	20	663	1.0	ldl	19.4	685	0.9	ldl	21	776	1.0	20.4	<0.4	0.4	102
Bromodichloromethane	ldl	19.2	636	1.0	ldl	18.1	639	0.9	ldl	19.6	724	1.0	19.4	<0.4	0.4	97
cis-1,3-Dichloropropene	ldl	18.2	602	0.9	ldl	17.3	610	0.9	ldl	18.7	690	0.9	19.4	<0.4	0.4	97
Toluene	6.9	26.2	672	1.0	1.5	21.5	731	1.0	ldl	21	776	1.0	19.8	1.2	0.4	99
trans-1,3-Dichloropropene	ldl	18.4	609	0.9	ldl	17.2	606	0.9	ldl	18.7	690	1.0	19.2	<0.4	0.4	96
1,1,2-Trichloroethane	ldl	18.2	602	1.0	ldl	16.1	567	0.9	ldl	17.4	641	0.9	18.2	<0.4	0.4	91
1,3-Dichloropropane	ldl	20	663	0.9	ldl	19.1	674	0.9	ldl	20	739	0.9	21.8	<0.4	0.4	109
Dibromochloromethane	ldl	19	629	1.0	ldl	17.6	621	0.9	ldl	18.7	690	0.9	19.4	<0.4	0.4	97
Tetrachloroethlyene	ldl	19.8	656	1.0	ldl	19.7	696	1.0	ldl	20	739	1.0	20.2	<0.4	0.4	101
1,2-Dibromoethane	ldl	19.1	633	0.9	ldl	18.6	657	0.9	ldl	19.6	724	1.0	20	<0.4	0.4	100
Chlorobenzene	ldl	18.6	616	1.0	ldl	18.5	653	1.0	ldl	19.6	724	1.0	18.8	<0.4	0.4	94
1,1,1,2-Tetrachloroethane	ldl	19.5	646	1.0	ldl	17.8	628	0.9	ldl	19.3	713	1.0	19.4	<0.4	0.4	97
Ethylbenzene	0.5	20	660	1.0	ldl	19.8	700	1.0	ldl	20	739	1.0	19.8	<0.4	0.4	99
m-, p-Xylene	2.7	41	1302	2.0	0.8	39.3	1388	2.0	ldl	40	1489	2.0	19.4	<0.4	0.4	97
o-Xylene	0.8	19.2	624	1.0	0.2	18.7	665	1.0	ldl	19.4	716	1.0	18.8	<0.4	0.4	94
Styrene	ldl	9.3	302	0.6	ldl	10.7	373	0.8	ldl	9.6	349	0.7	13.8	<0.4	0.4	69
Bromoform	ldl	18.3	606	1.0	ldl	16	563	0.8	ldl	17.2	634	0.9	18.8	<0.4	0.4	94
iso-Propylbenzene (Cumene)	ldl	20	663	1.0	ldl	20	707	1.0	ldl	21	776	1.0	20.2	<0.4	0.4	101
1,1,2,2-Tetrachloroethane	ldl	ldl	0	0.0	ldl	ldl	0	0.0	ldl	ldl	0	0.0	0.2	<0.4	0.4	1
1,2,3-Trichloropropane	ldl	19.7	653	1.0	ldl	18.5	653	0.9	ldl	19.6	724	1.0	19.8	<0.4	0.4	99
Bromobenzene	ldl	18.8	623	1.0	ldl	18.6	657	1.0	ldl	18.9	698	1.0	18.8	<0.4	0.4	94
2-Chlorotoluene	ldl	18	596	0.9	ldl	18	635	1.0	ldl	18.7	690	1.0	18.6	<0.4	0.4	93
n-Propylbenzene	ldl	19.8	656	1.0	ldl	19.5	689	1.0	ldl	20	739	1.0	19.8	<0.4	0.4	99
4-Chlorotoluene	ldl	18.4	609	0.9	ldl	18.5	653	0.9	ldl	19	701	1.0	19.2	<0.4	0.4	96
1,3,5-Trimethylbenzene	ldl	19.6	650	1.0	ldl	19.5	689	1.0	ldl	20	739	1.0	19.8	<0.4	0.4	99
tert-Butylbenzene	ldl	19.9	660	1.0	ldl	20	707	1.0	ldl	21	776	1.0	20.4	<0.4	0.4	102
1,2,4-Trimethylbenzene	ldl	19.1	633	1.0	ldl	18.8	664	1.0	ldl	19.4	716	1.0	19.4	<0.4	0.4	97
1,3-Dichlorobenzene	ldl	17.8	589	1.0	ldl	17.5	617	1.0	ldl	18.6	686	1.0	18	<0.4	0.4	90
sec-Butylbenzene	ldl	19.9	660	1.0	ldl	19.8	700	1.0	ldl	20	739	1.0	20.2	<0.4	0.4	101
1,4-Dichlorobenzene	ldl	17.2	569	0.9	ldl	17.6	621	1.0	ldl	18.7	690	1.0	18	<0.4	0.4	90
4-Isopropyltoluene (p-Cymene)	ldl	20	663	1.0	ldl	20	707	1.0	ldl	20	739	1.0	20	<0.4	0.4	100
1,2-Dichlorobenzene	ldl	16.6	548	0.9	ldl	16.8	592	0.9	ldl	17.7	653	1.0	17.4	<0.4	0.4	87
n-Butylbenzene	ldl	19.6	650	1.0	ldl	18.9	667	1.0	ldl	19.8	731	1.0	19.4	<0.4	0.4	97
1,2-Dibromo-3-chloropropane	ldl	15.2	501	0.9	ldl	12.1	423	0.7	ldl	12.2	446	0.8	15.8	<0.4	0.4	79
1,2,4-Trichlorobenzene	ldl	16	528	0.9	ldl	15.6	549	0.9	ldl	16.5	608	1.0	16.6	<0.4	0.4	83
Naphthalene	0.4	6.6	211	1.0	ldl	7.6	262	1.2	ldl	6.7	240	1.0	6.2	<0.4	0.4	31
1,2,3-Trichlorobenzene	ldl	14.8	488	0.9	ldl	15.1	531	0.9	ldl	16.1	593	1.0	15.6	<0.4	0.4	78
Hexachlorobutadiene	ldl	19.5	646	1.0	ldl	19	671	1.0	ldl	19.6	724	1.0	19.4	<0.4	0.4	97
MIBK (methylisobutyl ketone)	ldl	ldl	0	0.0	ldl	ldl	0	0.0	ldl	ldl	0	0.0	ldl	<4.0	4.0	ldl

▪ Combustion Zone VOC R Determinations 7 February 2012

		Analyitical procedure acceptable if 0.7 ≤ R ≤ 1.3				Corrected for R values		
Analyte	Average R value		Molecular Weight of Carbon g	Molecular Weight g	LOD	Run 1 Conc. (ppm)	Run 2 Conc. (ppm)	Run 3 Conc. (ppm)
Chloroform	0.86	Yes	12	119.40	4.0	<LOD	<LOD	<LOD
1,1,1-Trichloroethane	0.96	Yes	24	133.40	0.4	<LOD	<LOD	<LOD
1,2-Dichloroethane	0.95	Yes	24	98.96	0.4	<LOD	<LOD	<LOD
Carbon tetrachloride	0.95	Yes	12	153.82	0.4	<LOD	<LOD	<LOD
1,1-Dichloropropene	0.99	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
Benzene	1.30	Yes	72	78.11	0.4	0.109	0.005	<LOD
Trichloroethylene	1.01	Yes	24	131.39	0.4	<LOD	<LOD	<LOD
1,2-Dichloropropane	0.99	Yes	36	113.00	0.4	<LOD	<LOD	<LOD
Dibromomethane	0.97	Yes	12	173.83	0.4	<LOD	<LOD	<LOD
Bromodichloromethane	0.96	Yes	12	163.80	0.4	<LOD	<LOD	<LOD
cis-1,3-Dichloropropene	0.91	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
Toluene	1.02	Yes	84	92.14	0.4	0.057	0.013	<LOD
trans-1,3-Dichloropropene	0.93	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
1,1,2-Trichloroethane	0.93	Yes	24	133.40	0.4	<LOD	<LOD	<LOD
1,3-Dichloropropane	0.89	Yes	36	113.00	0.4	<LOD	<LOD	<LOD
Dibromochloromethane	0.93	Yes	12	208.28	0.4	<LOD	<LOD	<LOD
Tetrachloroethlyene	0.97	Yes	24	165.80	0.4	<LOD	<LOD	<LOD
1,2-Dibromoethane	0.94	Yes	24	187.86	0.4	<LOD	<LOD	<LOD
Chlorobenzene	0.99	Yes	72	112.56	0.4	<LOD	<LOD	<LOD
1,1,1,2-Tetrachloroethane	0.96	Yes	24	167.85	0.4	<LOD	<LOD	<LOD
Ethylbenzene	0.99	Yes	96	106.16	0.4	0.004	<LOD	<LOD
m-, p-Xylene	1.00	Yes	96	106.16	0.4	0.010	0.003	<LOD
o-Xylene	1.00	Yes	96	106.16	0.4	0.006	0.002	<LOD
Styrene	0.69	No	84	104.15	0.4	N/A	N/A	N/A
Bromoform	0.90	Yes	12	252.73	0.4	<LOD	<LOD	<LOD
iso-Propylbenzene (Cumene)	0.99	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
1,1,2,2-Tetrachloroethane	0.00	No	24	167.85	0.4	N/A	N/A	N/A
1,2,3-Trichloropropane	0.96	Yes	36	174.40	0.4	<LOD	<LOD	<LOD
Bromobenzene	0.98	Yes	72	157.01	0.4	<LOD	<LOD	<LOD
2-Chlorotoluene	0.96	Yes	84	126.59	0.4	<LOD	<LOD	<LOD
n-Propylbenzene	0.98	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
4-Chlorotoluene	0.95	Yes	84	126.59	0.4	<LOD	<LOD	<LOD
1,3,5-Trimethylbenzene	0.98	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
tert-Butylbenzene	0.98	Yes	120	134.22	0.4	<LOD	<LOD	<LOD
1,2,4-Trimethylbenzene	0.97	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
1,3-Dichlorobenzene	0.98	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
sec-Butylbenzene	0.97	Yes	120	134.22	0.4	<LOD	<LOD	<LOD
1,4-Dichlorobenzene	0.97	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
4-Isopropyltoluene (p-Cymene)	0.98	Yes	120	134.21	0.4	<LOD	<LOD	<LOD
1,2-Dichlorobenzene	0.96	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
n-Butylbenzene	0.99	Yes	120	166.22	0.4	<LOD	<LOD	<LOD
1,2-Dibromo-3-chloropropane	0.81	Yes	36	236.33	0.4	<LOD	<LOD	<LOD
1,2,4-Trichlorobenzene	0.95	Yes	72	181.45	0.4	<LOD	<LOD	<LOD
Naphthalene	1.07	Yes	120	128.17	0.4	0.002	<LOD	<LOD
1,2,3-Trichlorobenzene	0.96	Yes	72	181.45	0.4	<LOD	<LOD	<LOD
Hexachlorobutadiene	0.98	Yes	48	260.76	0.4	<LOD	<LOD	<LOD
MIBK (methylisobutyl ketone)	0.00	No	72	100.16	4.0	N/A	N/A	N/A

▪ Combustion Zone VOC Results (expressed as carbon), 7 February 2012

Analyte	LOD expressed as carbon (ppm)	R1 result expressed as carbon (ppm)	R2 result expressed as carbon (ppm)	R3 result expressed as carbon (ppm)
Chloroform	0.21	<LOD	<LOD	<LOD
1,1,1-Trichloroethane	0.02	<LOD	<LOD	<LOD
1,2-Dichloroethane	0.02	<LOD	<LOD	<LOD
Carbon tetrachloride	0.02	<LOD	<LOD	<LOD
1,1-Dichloropropene	0.02	<LOD	<LOD	<LOD
Benzene	0.02	0.100	0.005	<LOD
Trichloroethylene	0.02	<LOD	<LOD	<LOD
1,2-Dichloropropane	0.02	<LOD	<LOD	<LOD
Dibromomethane	0.02	<LOD	<LOD	<LOD
Bromodichloromethane	0.02	<LOD	<LOD	<LOD
cis-1,3-Dichloropropene	0.02	<LOD	<LOD	<LOD
Toluene	0.02	0.052	0.012	<LOD
trans-1,3-Dichloropropene	0.02	<LOD	<LOD	<LOD
1,1,2-Trichloroethane	0.02	<LOD	<LOD	<LOD
1,3-Dichloropropane	0.02	<LOD	<LOD	<LOD
Dibromochloromethane	0.02	<LOD	<LOD	<LOD
Tetrachloroethlyene	0.02	<LOD	<LOD	<LOD
1,2-Dibromoethane	0.02	<LOD	<LOD	<LOD
Chlorobenzene	0.02	<LOD	<LOD	<LOD
1,1,1,2-Tetrachloroethane	0.02	<LOD	<LOD	<LOD
Ethylbenzene	0.02	0.003	<LOD	<LOD
m-, p-Xylene	0.02	0.009	0.003	<LOD
o-Xylene	0.02	0.005	0.001	<LOD
Styrene	0.02	N/A	N/A	N/A
Bromoform	0.02	<LOD	<LOD	<LOD
iso-Propylbenzene (Cumene)	0.02	<LOD	<LOD	<LOD
1,1,2,2-Tetrachloroethane	0.02	N/A	N/A	N/A
1,2,3-Trichloropropane	0.02	<LOD	<LOD	<LOD
Bromobenzene	0.02	<LOD	<LOD	<LOD
2-Chlorotoluene	0.02	<LOD	<LOD	<LOD
n-Propylbenzene	0.02	<LOD	<LOD	<LOD
4-Chlorotoluene	0.02	<LOD	<LOD	<LOD
1,3,5-Trimethylbenzene	0.02	<LOD	<LOD	<LOD
tert-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,2,4-Trimethylbenzene	0.02	<LOD	<LOD	<LOD
1,3-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
sec-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,4-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
4-Isopropyltoluene (p-Cymen	0.02	<LOD	<LOD	<LOD
1,2-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
n-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,2-Dibromo-3-chloropropane	0.02	<LOD	<LOD	<LOD
1,2,4-Trichlorobenzene	0.02	<LOD	<LOD	<LOD
Naphthalene	0.02	0.00	<LOD	<LOD
1,2,3-Trichlorobenzene	0.02	<LOD	<LOD	<LOD
Hexachlorobutadiene	0.02	<LOD	<LOD	<LOD
MIBK (methylisobutyl ketone)	0.21	N/A	N/A	N/A
Total ppm (expressed as carbon)		0.171	0.020	<LOD

■ Evaporation Zone VOC Mass Determinations 8 February 2012

Analyte	Run 1		ug/l of spiked compound	R value	Run 2		ug/l of spiked compound	R value	Run 3		ug/l of spiked compound	R value	Travel Spike	Lab Blank	Lab Blank	
	Sample Result ug	Spike Result ug			Sample Result ug	Spike Result ug			Sample Result ug	Spike Result ug			Lab Result ug	Lab Result ug	Lab Result ug	% Recovery
Chloroform	Idl	19	557	1.0	Idl	19	632	0.8	Idl	19	602	0.8	19.6	<4.0	4.0	98
1,1,1-Trichloroethane	Idl	19.8	704	1.0	Idl	19.6	762	1.0	Idl	18.6	687	0.9	20	<0.4	0.4	100
1,2-Dichloroethane	Idl	18.8	667	1.0	Idl	18.7	726	0.9	Idl	17.8	657	0.9	19.4	<0.4	0.4	97
Carbon tetrachloride	Idl	18.7	664	0.9	Idl	18.6	722	0.9	Idl	17.9	661	0.9	19.6	<0.4	0.4	98
1,1-Dichloropropene	Idl	19.1	678	1.0	Idl	18.7	726	1.0	Idl	17.7	653	0.9	18.6	<0.4	0.4	93
Benzene	Idl	21	747	1.1	Idl	19.6	762	1.0	1.2	19.3	691	1.0	18.8	<0.4	0.4	94
Trichloroethylene	Idl	36	1290	1.0	Idl	37	1448	1.0	Idl	36	1340	1.0	35.8	<0.4	0.4	179
1,2-Dichloropropane	Idl	19.8	704	1.0	Idl	20	777	1.0	Idl	19.2	709	0.9	20	<0.4	0.4	100
Dibromomethane	Idl	20	711	1.0	Idl	20	777	1.0	Idl	19.8	732	1.0	20.4	<0.4	0.4	102
Bromodichlorometha	Idl	19.6	696	1.0	Idl	19.3	750	1.0	Idl	18.3	676	0.9	19.4	<0.4	0.4	97
cis-1,3-Dichloroprope	Idl	18.4	653	0.9	Idl	17.6	683	0.9	Idl	17.1	631	0.9	19.4	<0.4	0.4	97
Toluene	0.4	24	856	1.0	Idl	22	856	1.1	3.1	21	702	0.9	19.8	1.2	0.4	99
trans-1,3-Dichloropro	Idl	18.6	660	0.9	Idl	17.5	679	0.9	Idl	17.3	638	0.9	19.2	<0.4	0.4	96
1,1,2-Trichloroethane	Idl	17.7	628	1.0	Idl	18.1	702	1.0	Idl	17.1	631	0.9	18.2	<0.4	0.4	91
1,3-Dichloropropane	Idl	21	747	0.9	Idl	20	777	0.9	Idl	19.4	717	0.9	21.8	<0.4	0.4	109
Dibromochlorometha	Idl	18.8	667	1.0	Idl	19	738	1.0	Idl	18.3	676	0.9	19.4	<0.4	0.4	97
Tetrachloroethlyene	Idl	20	711	1.0	Idl	20	777	1.0	Idl	19.4	717	0.9	20.2	<0.4	0.4	101
1,2-Dibromoethane	Idl	20	711	1.0	Idl	19	738	0.9	Idl	18.9	698	0.9	20	<0.4	0.4	100
Chlorobenzene	Idl	19.2	682	1.0	Idl	18.6	722	1.0	Idl	18	664	0.9	18.8	<0.4	0.4	94
1,1,1,2-Tetrachloroeth	Idl	19.2	682	1.0	Idl	19.1	742	1.0	Idl	18.3	676	0.9	19.4	<0.4	0.4	97
Ethylbenzene	Idl	20	711	1.0	Idl	20	777	1.0	Idl	19.4	717	1.0	19.8	<0.4	0.4	99
m-, p-Xylene	Idl	40	1435	2.0	Idl	40	1567	2.0	1.1	38	1396	1.9	19.4	<0.4	0.4	97
o-Xylene	Idl	19.2	682	1.0	Idl	19	738	1.0	0.4	18.2	672	1.0	18.8	<0.4	0.4	94
Styrene	Idl	9	313	0.6	Idl	7.4	280	0.5	Idl	7.5	270	0.5	13.8	<0.4	0.4	69
Bromoform	Idl	18.8	667	1.0	Idl	18	698	0.9	Idl	17.9	661	0.9	18.8	<0.4	0.4	94
iso-Propylbenzene (C	Idl	20	711	1.0	Idl	21	817	1.0	Idl	20	739	1.0	20.2	<0.4	0.4	101
1,1,2,2-Tetrachloroeth	Idl	Idl	0	0.0	Idl	Idl	0	0.0	Idl	Idl	0	0.0	0.2	<0.4	0.4	1
1,2,3-Trichloropropan	Idl	20	711	1.0	Idl	19.2	746	1.0	Idl	18.7	691	0.9	19.8	<0.4	0.4	99
Bromobenzene	Idl	18.9	671	1.0	Idl	18.6	722	1.0	Idl	17.6	649	0.9	18.8	<0.4	0.4	94
2-Chlorotoluene	Idl	18.5	657	1.0	Idl	17.7	687	0.9	Idl	17.1	631	0.9	18.6	<0.4	0.4	93
n-Propylbenzene	Idl	19.8	704	1.0	Idl	20	777	1.0	Idl	19.3	713	1.0	19.8	<0.4	0.4	99
4-Chlorotoluene	Idl	19.2	682	1.0	Idl	17.8	691	0.9	Idl	17.4	642	0.9	19.2	<0.4	0.4	96
1,3,5-Trimethylbenze	Idl	19.8	704	1.0	Idl	19.8	769	1.0	Idl	18.9	698	0.9	19.8	<0.4	0.4	99
tert-Butylbenzene	Idl	21	747	1.0	Idl	21	817	1.0	Idl	19.6	724	0.9	20.4	<0.4	0.4	102
1,2,4-Trimethylbenze	Idl	19.4	689	1.0	Idl	18.9	734	1.0	Idl	18.2	672	0.9	19.4	<0.4	0.4	97
1,3-Dichlorobenzene	Idl	18	638	1.0	Idl	17.1	663	0.9	Idl	16.4	604	0.9	18	<0.4	0.4	90
sec-Butylbenzene	Idl	20	711	1.0	Idl	20	777	1.0	Idl	19.7	728	1.0	20.2	<0.4	0.4	101
1,4-Dichlorobenzene	Idl	17.6	624	1.0	Idl	16.8	651	0.9	Idl	16.4	604	0.9	18	<0.4	0.4	90
4-Isopropyltoluene (p	Idl	20	711	1.0	Idl	21	817	1.0	Idl	20	739	1.0	20	<0.4	0.4	100
1,2-Dichlorobenzene	Idl	17	602	1.0	Idl	15.6	604	0.9	Idl	15.5	571	0.9	17.4	<0.4	0.4	87
n-Butylbenzene	Idl	19.8	704	1.0	Idl	19.5	758	1.0	Idl	19.1	706	1.0	19.4	<0.4	0.4	97
1,2-Dibromo-3-chloro	Idl	13.7	483	0.8	Idl	12.7	489	0.8	Idl	13	477	0.8	15.8	<0.4	0.4	79
1,2,4-Trichlorobenzen	Idl	15.7	555	0.9	Idl	13.9	537	0.8	Idl	14.2	522	0.8	16.6	<0.4	0.4	83
Naphthalene	Idl	4.9	164	0.7	Idl	4.5	166	0.7	Idl	4.7	165	0.7	6.2	<0.4	0.4	31
1,2,3-Trichlorobenzen	Idl	14.6	515	0.9	Idl	13.1	505	0.8	Idl	12.7	465	0.8	15.6	<0.4	0.4	78
Hexachlorobutadiene	Idl	19.6	696	1.0	Idl	19.9	773	1.0	Idl	19.1	706	1.0	19.4	<0.4	0.4	97
MIBK (methylisobutyl	Idl	Idl	0	0.0	Idl	Idl	0	0.0	Idl	Idl	0	0.0	Idl	<4.0	4.0	Idl

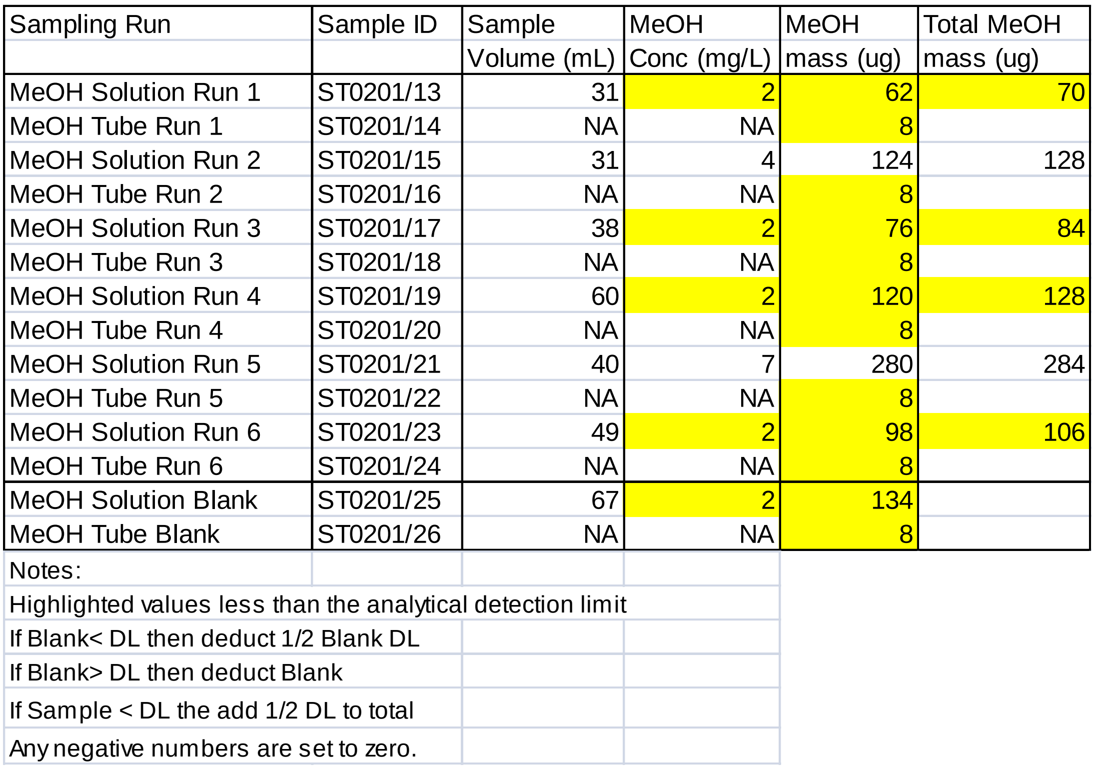
Evaporation Zone VOC R Determinations 8 February 2012

		Analyitical procedure acceptable if 0.7 ≤ R ≤ 1.3				Corrected for R values		
Analyte	Average R value		Molecular Weight of Carbon g	Molecular Weight g	LOD	Run 1 Conc. (ppm)	Run 2 Conc. (ppm)	Run 3 Conc. (ppm)
Chloroform	0.88	Yes	12	119.40	4.0	<LOD	<LOD	<LOD
1,1,1-Trichloroethane	0.95	Yes	24	133.40	0.4	<LOD	<LOD	<LOD
1,2-Dichloroethane	0.93	Yes	24	98.96	0.4	<LOD	<LOD	<LOD
Carbon tetrachloride	0.92	Yes	12	153.82	0.4	<LOD	<LOD	<LOD
1,1-Dichloropropene	0.98	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
Benzene	1.30	Yes	72	78.11	0.4	<LOD	<LOD	0.013
Trichloroethylene	1.01	Yes	24	131.39	0.4	<LOD	<LOD	<LOD
1,2-Dichloropropane	0.97	Yes	36	113.00	0.4	<LOD	<LOD	<LOD
Dibromomethane	0.96	Yes	12	173.83	0.4	<LOD	<LOD	<LOD
Bromodichloromethane	0.97	Yes	12	163.80	0.4	<LOD	<LOD	<LOD
cis-1,3-Dichloropropene	0.90	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
Toluene	1.01	Yes	84	92.14	0.4	0.004	<LOD	0.030
trans-1,3-Dichloropropene	0.91	Yes	36	110.97	0.4	<LOD	<LOD	<LOD
1,1,2-Trichloroethane	0.95	Yes	24	133.40	0.4	<LOD	<LOD	<LOD
1,3-Dichloropropane	0.91	Yes	36	113.00	0.4	<LOD	<LOD	<LOD
Dibromochloromethane	0.95	Yes	12	208.28	0.4	<LOD	<LOD	<LOD
Tetrachloroethlyene	0.96	Yes	24	165.80	0.4	<LOD	<LOD	<LOD
1,2-Dibromoethane	0.95	Yes	24	187.86	0.4	<LOD	<LOD	<LOD
Chlorobenzene	0.97	Yes	72	112.56	0.4	<LOD	<LOD	<LOD
1,1,1,2-Tetrachloroethane	0.96	Yes	24	167.85	0.4	<LOD	<LOD	<LOD
Ethylbenzene	0.98	Yes	96	106.16	0.4	<LOD	<LOD	<LOD
m-, p-Xylene	1.00	Yes	96	106.16	0.4	<LOD	<LOD	0.005
o-Xylene	0.98	Yes	96	106.16	0.4	<LOD	<LOD	0.003
Styrene	0.55	No	84	104.15	0.4	N/A	N/A	N/A
Bromoform	0.95	Yes	12	252.73	0.4	<LOD	<LOD	<LOD
iso-Propylbenzene (Cumene)	0.99	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
1,1,2,2-Tetrachloroethane	0.00	No	24	167.85	0.4	N/A	N/A	N/A
1,2,3-Trichloropropane	0.96	Yes	36	174.40	0.4	<LOD	<LOD	<LOD
Bromobenzene	0.96	Yes	72	157.01	0.4	<LOD	<LOD	<LOD
2-Chlorotoluene	0.94	Yes	84	126.59	0.4	<LOD	<LOD	<LOD
n-Propylbenzene	0.98	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
4-Chlorotoluene	0.93	Yes	84	126.59	0.4	<LOD	<LOD	<LOD
1,3,5-Trimethylbenzene	0.97	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
tert-Butylbenzene	0.99	Yes	120	134.22	0.4	<LOD	<LOD	<LOD
1,2,4-Trimethylbenzene	0.95	Yes	108	120.19	0.4	<LOD	<LOD	<LOD
1,3-Dichlorobenzene	0.94	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
sec-Butylbenzene	0.97	Yes	120	134.22	0.4	<LOD	<LOD	<LOD
1,4-Dichlorobenzene	0.92	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
4-Isopropyltoluene (p-Cymene)	1.00	Yes	120	134.21	0.4	<LOD	<LOD	<LOD
1,2-Dichlorobenzene	0.90	Yes	72	174.00	0.4	<LOD	<LOD	<LOD
n-Butylbenzene	0.99	Yes	120	166.22	0.4	<LOD	<LOD	<LOD
1,2-Dibromo-3-chloropropane	0.81	Yes	36	236.33	0.4	<LOD	<LOD	<LOD
1,2,4-Trichlorobenzene	0.86	Yes	72	181.45	0.4	<LOD	<LOD	<LOD
Naphthalene	0.71	Yes	120	128.17	0.4	<LOD	<LOD	<LOD
1,2,3-Trichlorobenzene	0.84	Yes	72	181.45	0.4	<LOD	<LOD	<LOD
Hexachlorobutadiene	0.99	Yes	48	260.76	0.4	<LOD	<LOD	<LOD
MIBK (methylisobutyl ketone)	0.00	No	72	100.16	4.0	N/A	N/A	N/A

Evaporation Zone VOC Results (expressed as carbon), 8 February 2012

Analyte	LOD expressed as carbon (ppm)	R1 result expressed as carbon (ppm)	R2 result expressed as carbon (ppm)	R3 result expressed as carbon (ppm)
Chloroform	0.22	<LOD	<LOD	<LOD
1,1,1-Trichloroethane	0.02	<LOD	<LOD	<LOD
1,2-Dichloroethane	0.02	<LOD	<LOD	<LOD
Carbon tetrachloride	0.02	<LOD	<LOD	<LOD
1,1-Dichloropropene	0.02	<LOD	<LOD	<LOD
Benzene	0.02	<LOD	<LOD	0.012
Trichloroethylene	0.02	<LOD	<LOD	<LOD
1,2-Dichloropropane	0.02	<LOD	<LOD	<LOD
Dibromomethane	0.02	<LOD	<LOD	<LOD
Bromodichloromethane	0.02	<LOD	<LOD	<LOD
cis-1,3-Dichloropropene	0.02	<LOD	<LOD	<LOD
Toluene	0.02	0.003	<LOD	0.03
trans-1,3-Dichloropropene	0.02	<LOD	<LOD	<LOD
1,1,2-Trichloroethane	0.02	<LOD	<LOD	<LOD
1,3-Dichloropropane	0.02	<LOD	<LOD	<LOD
Dibromochloromethane	0.02	<LOD	<LOD	<LOD
Tetrachloroethlyene	0.02	<LOD	<LOD	<LOD
1,2-Dibromoethane	0.02	<LOD	<LOD	<LOD
Chlorobenzene	0.02	<LOD	<LOD	<LOD
1,1,1,2-Tetrachloroethane	0.02	<LOD	<LOD	<LOD
Ethylbenzene	0.02	<LOD	<LOD	<LOD
m-, p-Xylene	0.02	<LOD	<LOD	0.004
o-Xylene	0.02	<LOD	<LOD	0.003
Styrene	0.02	N/A	N/A	N/A
Bromoform	0.02	<LOD	<LOD	<LOD
iso-Propylbenzene (Cumene)	0.02	<LOD	<LOD	<LOD
1,1,2,2-Tetrachloroethane	0.02	N/A	N/A	N/A
1,2,3-Trichloropropane	0.02	<LOD	<LOD	<LOD
Bromobenzene	0.02	<LOD	<LOD	<LOD
2-Chlorotoluene	0.02	<LOD	<LOD	<LOD
n-Propylbenzene	0.02	<LOD	<LOD	<LOD
4-Chlorotoluene	0.02	<LOD	<LOD	<LOD
1,3,5-Trimethylbenzene	0.02	<LOD	<LOD	<LOD
tert-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,2,4-Trimethylbenzene	0.02	<LOD	<LOD	<LOD
1,3-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
sec-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,4-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
4-Isopropyltoluene (p-Cymen	0.02	<LOD	<LOD	<LOD
1,2-Dichlorobenzene	0.02	<LOD	<LOD	<LOD
n-Butylbenzene	0.02	<LOD	<LOD	<LOD
1,2-Dibromo-3-chloropropane	0.02	<LOD	<LOD	<LOD
1,2,4-Trichlorobenzene	0.02	<LOD	<LOD	<LOD
Naphthalene	0.02	<LOD	<LOD	<LOD
1,2,3-Trichlorobenzene	0.02	<LOD	<LOD	<LOD
Hexachlorobutadiene	0.02	<LOD	<LOD	<LOD
MIBK (methylisobutyl ketone)	0.22	N/A	N/A	N/A
Total ppm (expressed as carbon)		0.003	<LOD	0.047

Methanol Determinations, 7 and 8 February 2012

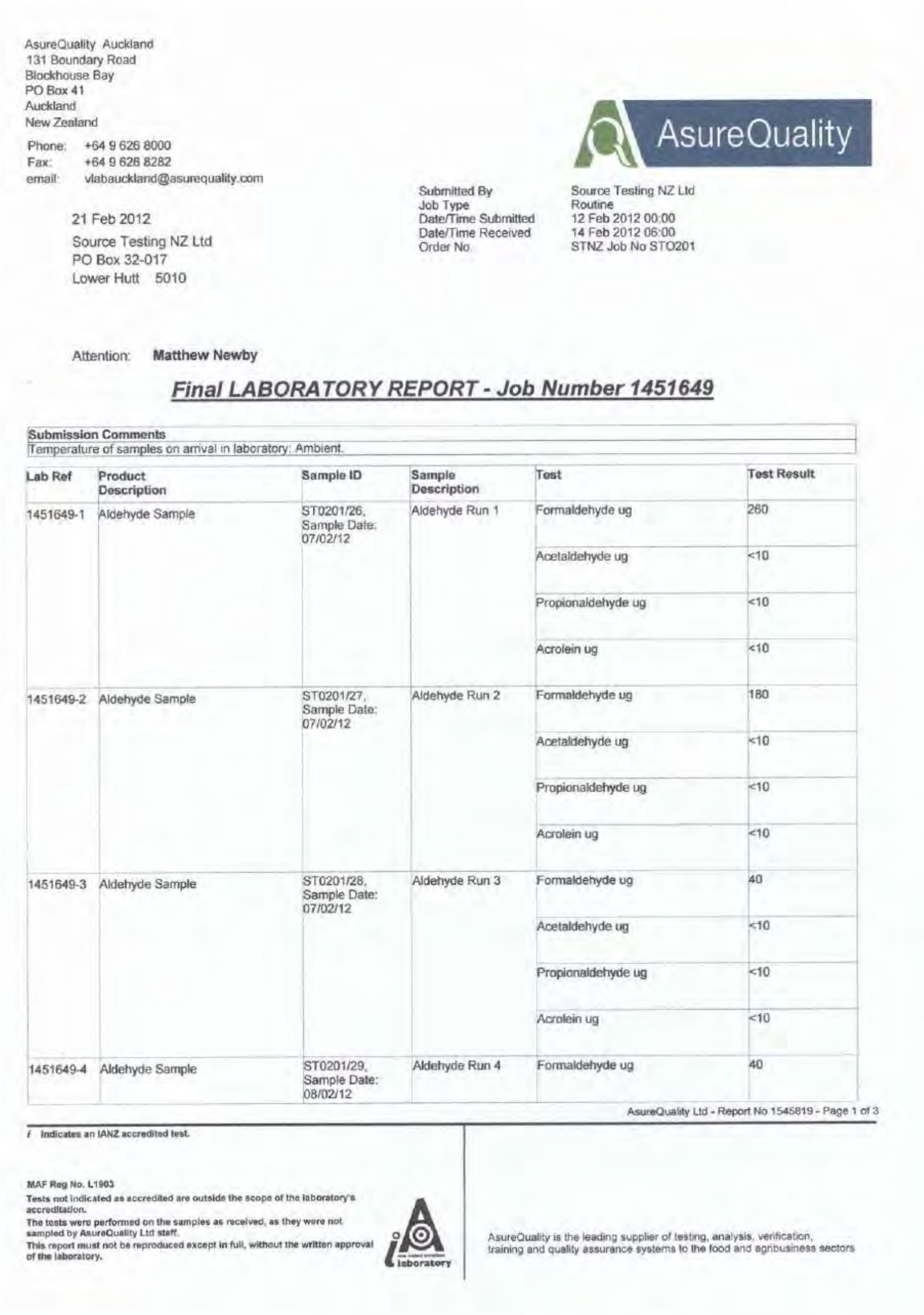


Sampling Run	Sample ID	Sample Volume (mL)	MeOH Conc (mg/L)	MeOH mass (ug)	Total MeOH mass (ug)
MeOH Solution Run 1	ST0201/13	31	2	62	70
MeOH Tube Run 1	ST0201/14	NA	NA	8	
MeOH Solution Run 2	ST0201/15	31	4	124	128
MeOH Tube Run 2	ST0201/16	NA	NA	8	
MeOH Solution Run 3	ST0201/17	38	2	76	84
MeOH Tube Run 3	ST0201/18	NA	NA	8	
MeOH Solution Run 4	ST0201/19	60	2	120	128
MeOH Tube Run 4	ST0201/20	NA	NA	8	
MeOH Solution Run 5	ST0201/21	40	7	280	284
MeOH Tube Run 5	ST0201/22	NA	NA	8	
MeOH Solution Run 6	ST0201/23	49	2	98	106
MeOH Tube Run 6	ST0201/24	NA	NA	8	
MeOH Solution Blank	ST0201/25	67	2	134	
MeOH Tube Blank	ST0201/26	NA	NA	8	

Notes:
Highlighted values less than the analytical detection limit
If Blank< DL then deduct 1/2 Blank DL
If Blank> DL then deduct Blank
If Sample < DL the add 1/2 DL to total
Any negative numbers are set to zero.

Appendix C Raw Analytical Reports

This Appendix contains 23 pages including cover



AsureQuality Auckland
131 Boundary Road
Blockhouse Bay
PO Box 41
Auckland
New Zealand

Phone: +64 9 626 8000
Fax: +64 9 626 8282
email: vlabauckland@asurequality.com

AsureQuality

Submitted By	Source Testing NZ Ltd
Job Type	Routine
Date/Time Submitted	12 Feb 2012 00:00
Date/Time Received	14 Feb 2012 06:00
Order No.	STNZ Job No STO201

21 Feb 2012

Source Testing NZ Ltd
PO Box 32-017
Lower Hutt 5010

Attention: **Matthew Newby**

Final LABORATORY REPORT - Job Number 1451649

Submission Comments
Temperature of samples on arrival in laboratory: Ambient.

Lab Ref	Product Description	Sample ID	Sample Description	Test	Test Result
1451649-1	Aldehyde Sample	ST0201/26, Sample Date: 07/02/12	Aldehyde Run 1	Formaldehyde ug	260
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-2	Aldehyde Sample	ST0201/27, Sample Date: 07/02/12	Aldehyde Run 2	Formaldehyde ug	180
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-3	Aldehyde Sample	ST0201/28, Sample Date: 07/02/12	Aldehyde Run 3	Formaldehyde ug	40
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-4	Aldehyde Sample	ST0201/29, Sample Date: 08/02/12	Aldehyde Run 4	Formaldehyde ug	40

AsureQuality Ltd - Report No 1545819 - Page 1 of 3

i Indicates an IANZ accredited test.

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Lab Ref	Product Description	Sample ID	Sample Description	Test	Test Result
1451649-4	Aldehyde Sample	ST0201/29, Sample Date: 08/02/12	Aldehyde Run 4	Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-5	Aldehyde Sample	ST0201/30, Sample Date: 08/02/12	Aldehyde Run 5	Formaldehyde ug	30
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-6	Aldehyde Sample	ST0201/31, Sample Date: 08/02/12	Aldehyde Run 6	Formaldehyde ug	40
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-7	Aldehyde Sample	ST0201/32, Sample Date: 08/02/12	Aldehyde Blank	Formaldehyde ug	<10
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10
1451649-8	Aldehyde Sample	ST0201/33, Sample Date: 08/02/12	Aldehyde Spike (100microgm)	Formaldehyde ug	5735
				Acetaldehyde ug	<10
				Propionaldehyde ug	<10
				Acrolein ug	<10

Comment	
Lab Ref: 1451649-8	Formaldehyde - Recovery was equal to 114.7%

Method Reference			
	Formaldehyde	i	USEPA 0011
	Acetaldehyde	i	EPA 0011
	Propionaldehyde	i	EPA 0011
	Acrolein		EPA 0011

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K. Mupnar

Kanthi Mupnar
Bench Co-ordinator

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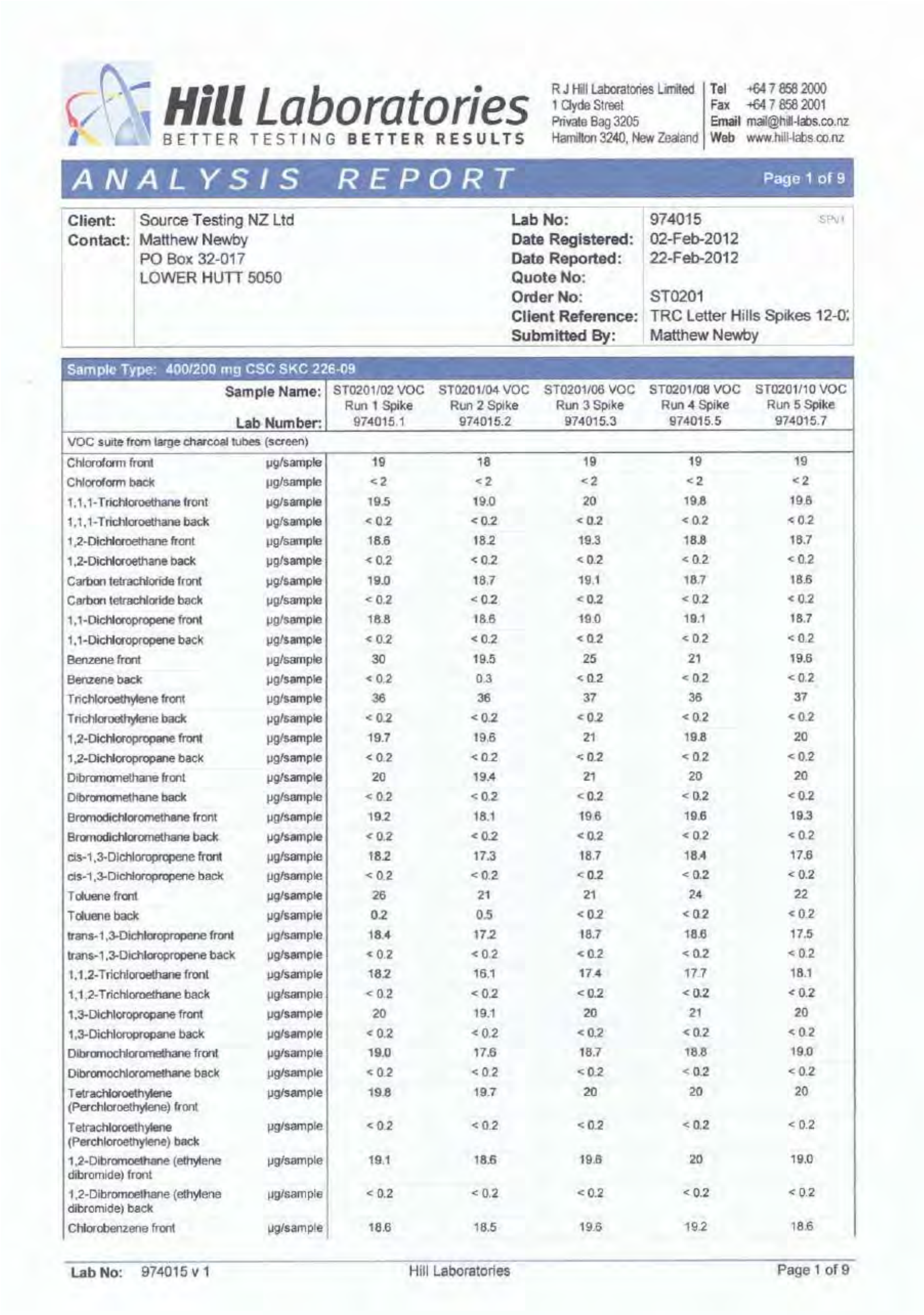


Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Page 1 of 9

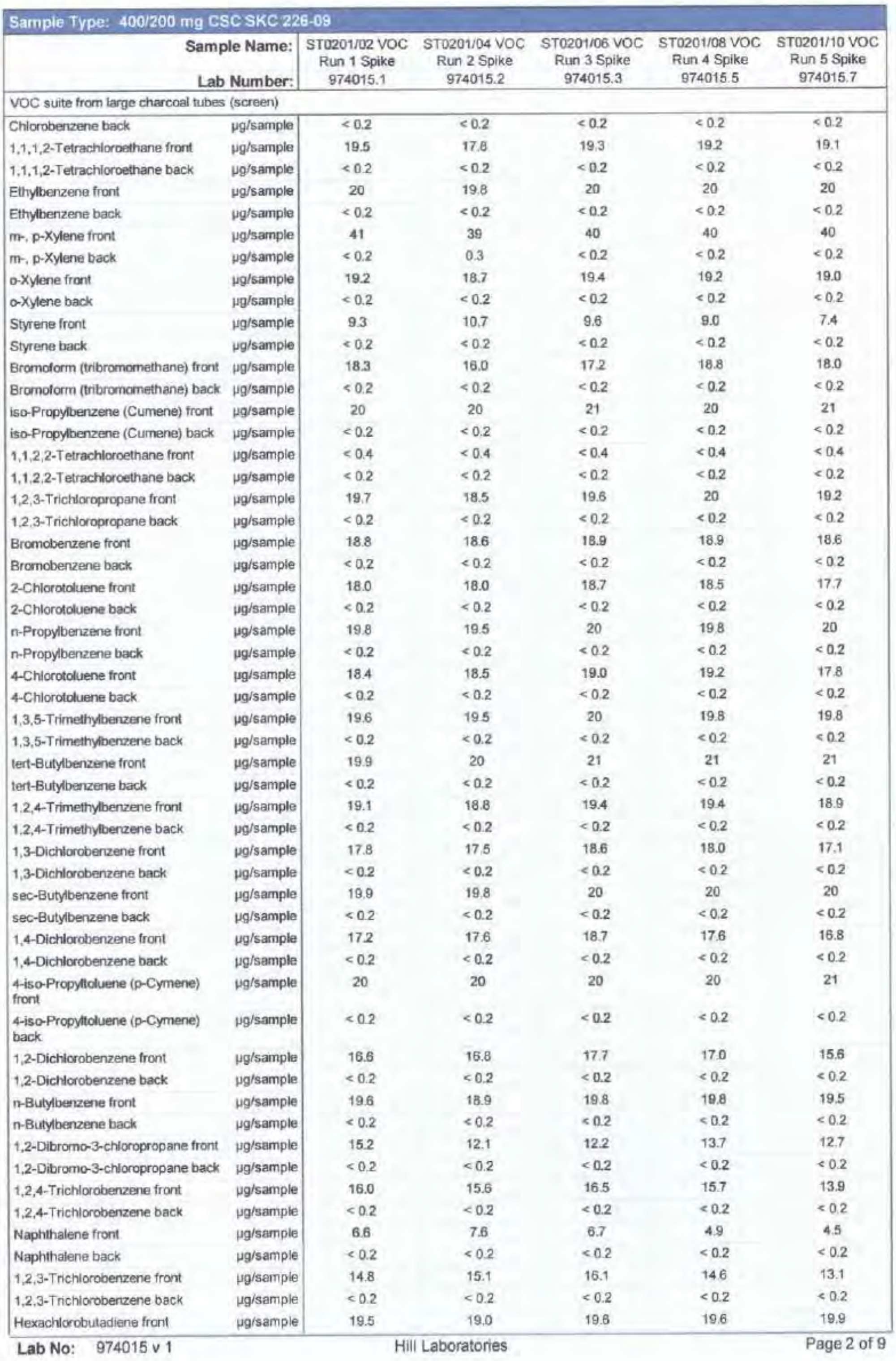
Client: Source Testing NZ Ltd
Contact: Matthew Newby
PO Box 32-017
LOWER HUTT 5050

Lab No: 974015
Date Registered: 02-Feb-2012
Date Reported: 22-Feb-2012
Quote No:
Order No: ST0201
Client Reference: TRC Letter Hills Spikes 12-0
Submitted By: Matthew Newby

Sample Type: 400/200 mg CSC SKC 226-09

Sample Name: **Lab Number:**		ST0201/02 VOC Run 1 Spike 974015.1	ST0201/04 VOC Run 2 Spike 974015.2	ST0201/06 VOC Run 3 Spike 974015.3	ST0201/08 VOC Run 4 Spike 974015.5	ST0201/10 VOC Run 5 Spike 974015.7
VOC suite from large charcoal tubes (screen)						
Chloroform front	µg/sample	19	18	19	19	19
Chloroform back	µg/sample	< 2	< 2	< 2	< 2	< 2
1,1,1-Trichloroethane front	µg/sample	19.5	19.0	20	19.8	19.6
1,1,1-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichloroethane front	µg/sample	18.6	18.2	19.3	18.8	18.7
1,2-Dichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Carbon tetrachloride front	µg/sample	19.0	18.7	19.1	18.7	18.6
Carbon tetrachloride back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1-Dichloropropene front	µg/sample	18.8	18.6	19.0	19.1	18.7
1,1-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Benzene front	µg/sample	30	19.5	25	21	19.6
Benzene back	µg/sample	< 0.2	0.3	< 0.2	< 0.2	< 0.2
Trichloroethylene front	µg/sample	36	36	37	36	37
Trichloroethylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichloropropane front	µg/sample	19.7	19.6	21	19.8	20
1,2-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Dibromomethane front	µg/sample	20	19.4	21	20	20
Dibromomethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromodichloromethane front	µg/sample	19.2	18.1	19.6	19.6	19.3
Bromodichloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
cis-1,3-Dichloropropene front	µg/sample	18.2	17.3	18.7	18.4	17.6
cis-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toluene front	µg/sample	26	21	21	24	22
Toluene back	µg/sample	0.2	0.5	< 0.2	< 0.2	< 0.2
trans-1,3-Dichloropropene front	µg/sample	18.4	17.2	18.7	18.6	17.5
trans-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,2-Trichloroethane front	µg/sample	18.2	16.1	17.4	17.7	18.1
1,1,2-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3-Dichloropropane front	µg/sample	20	19.1	20	21	20
1,3-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Dibromochloromethane front	µg/sample	19.0	17.6	18.7	18.8	19.0
Dibromochloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tetrachloroethylene (Perchloroethylene) front	µg/sample	19.8	19.7	20	20	20
Tetrachloroethylene (Perchloroethylene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dibromoethane (ethylene dibromide) front	µg/sample	19.1	18.6	19.6	20	19.0
1,2-Dibromoethane (ethylene dibromide) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chlorobenzene front	µg/sample	18.6	18.5	19.6	19.2	18.6

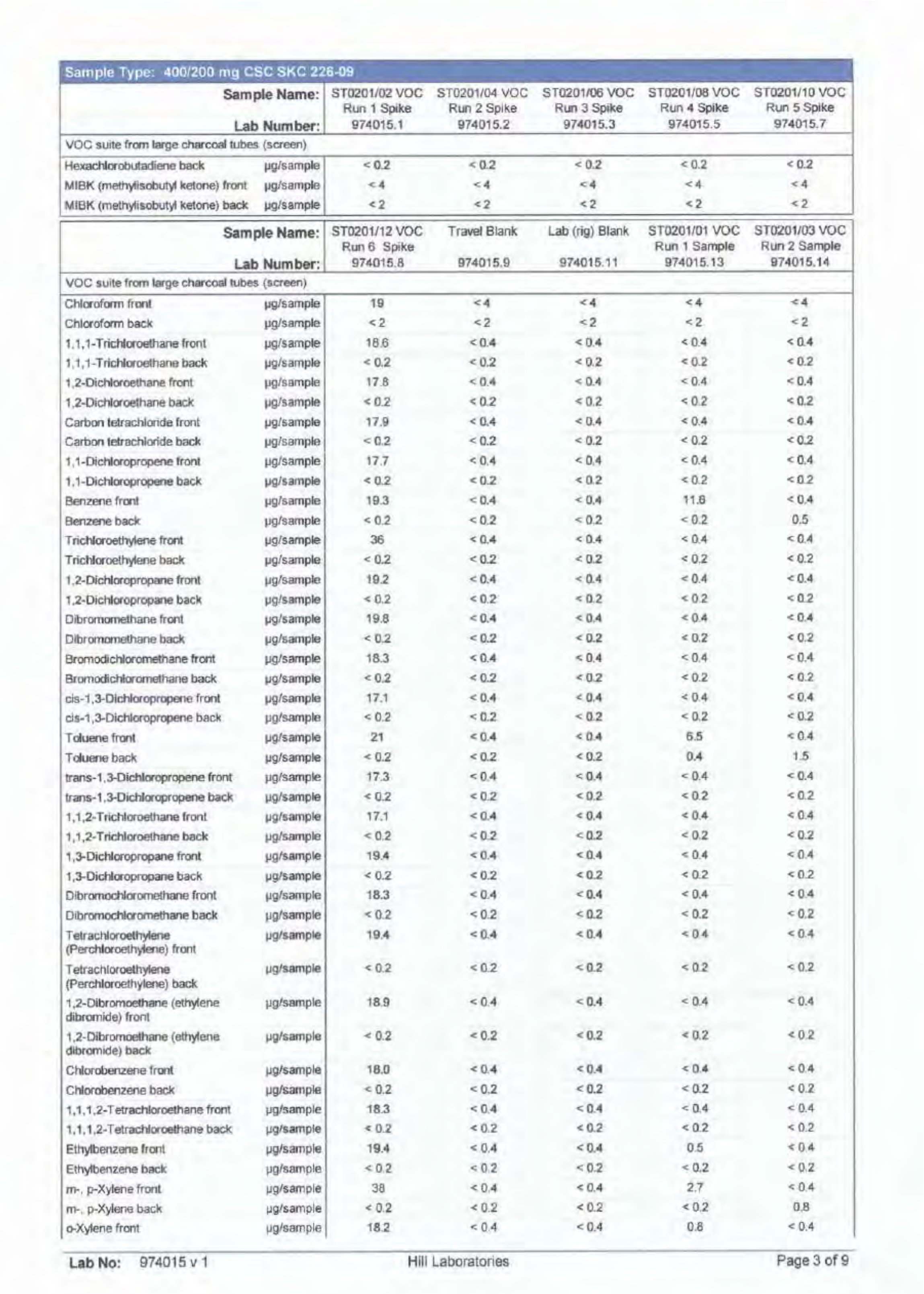
Lab No: 974015 v 1 Hill Laboratories Page 1 of 9



Sample Type: 400/200 mg CSC SKC 226-09

Sample Name: Lab Number:		ST0201/02 VOC Run 1 Spike 974015.1	ST0201/04 VOC Run 2 Spike 974015.2	ST0201/06 VOC Run 3 Spike 974015.3	ST0201/08 VOC Run 4 Spike 974015.5	ST0201/10 VOC Run 5 Spike 974015.7
VOC suite from large charcoal tubes (screen)						
Chlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,1,2-Tetrachloroethane front	µg/sample	19.5	17.8	19.3	19.2	19.1
1,1,1,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Ethylbenzene front	µg/sample	20	19.8	20	20	20
Ethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
m-, p-Xylene front	µg/sample	41	39	40	40	40
m-, p-Xylene back	µg/sample	< 0.2	0.3	< 0.2	< 0.2	< 0.2
o-Xylene front	µg/sample	19.2	18.7	19.4	19.2	19.0
o-Xylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Styrene front	µg/sample	9.3	10.7	9.6	9.0	7.4
Styrene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromoform (tribromomethane) front	µg/sample	18.3	16.0	17.2	18.8	18.0
Bromoform (tribromomethane) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
iso-Propylbenzene (Cumene) front	µg/sample	20	20	21	20	21
iso-Propylbenzene (Cumene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,2,2-Tetrachloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
1,1,2,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,3-Trichloropropane front	µg/sample	19.7	18.5	19.6	20	19.2
1,2,3-Trichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromobenzene front	µg/sample	18.8	18.6	18.9	18.9	18.6
Bromobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Chlorotoluene front	µg/sample	18.0	18.0	18.7	18.5	17.7
2-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
n-Propylbenzene front	µg/sample	19.8	19.5	20	19.8	20
n-Propylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
4-Chlorotoluene front	µg/sample	18.4	18.5	19.0	19.2	17.8
4-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3,5-Trimethylbenzene front	µg/sample	19.6	19.5	20	19.8	19.8
1,3,5-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
tert-Butylbenzene front	µg/sample	19.9	20	21	21	21
tert-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,4-Trimethylbenzene front	µg/sample	19.1	18.8	19.4	19.4	18.9
1,2,4-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3-Dichlorobenzene front	µg/sample	17.8	17.5	18.6	18.0	17.1
1,3-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
sec-Butylbenzene front	µg/sample	19.9	19.8	20	20	20
sec-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,4-Dichlorobenzene front	µg/sample	17.2	17.6	18.7	17.6	16.8
1,4-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
4-iso-Propyltoluene (p-Cymene) front	µg/sample	20	20	20	20	21
4-iso-Propyltoluene (p-Cymene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichlorobenzene front	µg/sample	16.6	16.8	17.7	17.0	15.6
1,2-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
n-Butylbenzene front	µg/sample	19.6	18.9	19.8	19.8	19.5
n-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dibromo-3-chloropropane front	µg/sample	15.2	12.1	12.2	13.7	12.7
1,2-Dibromo-3-chloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,4-Trichlorobenzene front	µg/sample	16.0	15.6	16.5	15.7	13.9
1,2,4-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Naphthalene front	µg/sample	6.6	7.6	6.7	4.9	4.5
Naphthalene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,3-Trichlorobenzene front	µg/sample	14.8	15.1	16.1	14.6	13.1
1,2,3-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Hexachlorobutadiene front	µg/sample	19.5	19.0	19.6	19.6	19.9

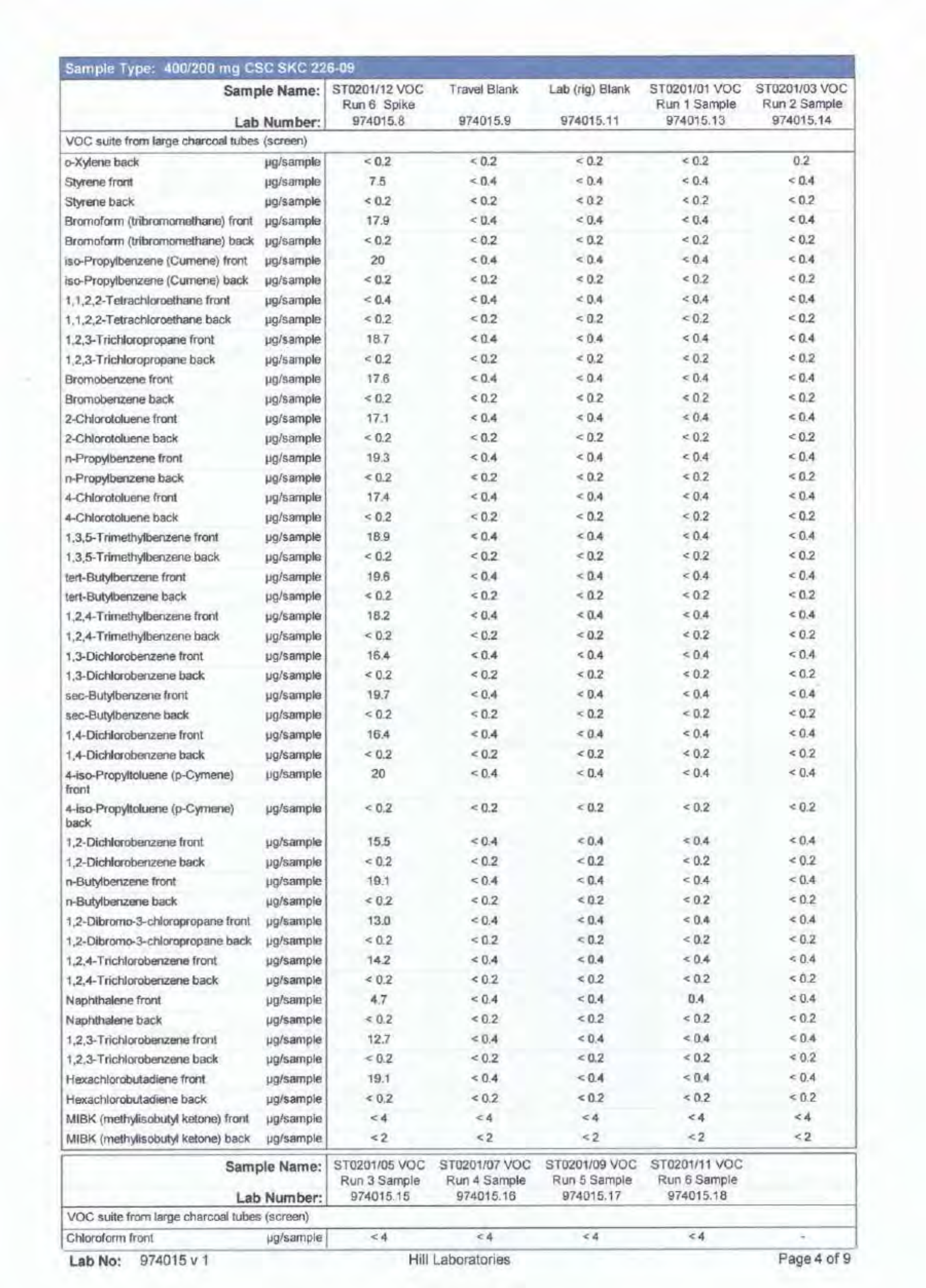
Lab No: 974015 v 1 Hill Laboratories Page 2 of 9



Sample Type: 400/200 mg CSC SKC 226-09

Sample Name: Lab Number:		ST0201/02 VOC Run 1 Spike 974015.1	ST0201/04 VOC Run 2 Spike 974015.2	ST0201/06 VOC Run 3 Spike 974015.3	ST0201/08 VOC Run 4 Spike 974015.5	ST0201/10 VOC Run 5 Spike 974015.7
VOC suite from large charcoal tubes (screen)						
Hexachlorobutadiene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
MIBK (methylisobutyl ketone) front	µg/sample	< 4	< 4	< 4	< 4	< 4
MIBK (methylisobutyl ketone) back	µg/sample	< 2	< 2	< 2	< 2	< 2

Sample Name: Lab Number:		ST0201/12 VOC Run 6 Spike 974015.8	Travel Blank 974015.9	Lab (rig) Blank 974015.11	ST0201/01 VOC Run 1 Sample 974015.13	ST0201/03 VOC Run 2 Sample 974015.14
VOC suite from large charcoal tubes (screen)						
Chloroform front	µg/sample	19	< 4	< 4	< 4	< 4
Chloroform back	µg/sample	< 2	< 2	< 2	< 2	< 2
1,1,1-Trichloroethane front	µg/sample	18.6	< 0.4	< 0.4	< 0.4	< 0.4
1,1,1-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichloroethane front	µg/sample	17.8	< 0.4	< 0.4	< 0.4	< 0.4
1,2-Dichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Carbon tetrachloride front	µg/sample	17.9	< 0.4	< 0.4	< 0.4	< 0.4
Carbon tetrachloride back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1-Dichloropropene front	µg/sample	17.7	< 0.4	< 0.4	< 0.4	< 0.4
1,1-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Benzene front	µg/sample	19.3	< 0.4	< 0.4	11.6	< 0.4
Benzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	0.5
Trichloroethylene front	µg/sample	36	< 0.4	< 0.4	< 0.4	< 0.4
Trichloroethylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichloropropane front	µg/sample	19.2	< 0.4	< 0.4	< 0.4	< 0.4
1,2-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Dibromomethane front	µg/sample	19.8	< 0.4	< 0.4	< 0.4	< 0.4
Dibromomethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromodichloromethane front	µg/sample	18.3	< 0.4	< 0.4	< 0.4	< 0.4
Bromodichloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
cis-1,3-Dichloropropene front	µg/sample	17.1	< 0.4	< 0.4	< 0.4	< 0.4
cis-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Toluene front	µg/sample	21	< 0.4	< 0.4	6.5	< 0.4
Toluene back	µg/sample	< 0.2	< 0.2	< 0.2	0.4	1.5
trans-1,3-Dichloropropene front	µg/sample	17.3	< 0.4	< 0.4	< 0.4	< 0.4
trans-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,2-Trichloroethane front	µg/sample	17.1	< 0.4	< 0.4	< 0.4	< 0.4
1,1,2-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3-Dichloropropane front	µg/sample	19.4	< 0.4	< 0.4	< 0.4	< 0.4
1,3-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Dibromochloromethane front	µg/sample	18.3	< 0.4	< 0.4	< 0.4	< 0.4
Dibromochloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Tetrachloroethylene (Perchloroethylene) front	µg/sample	19.4	< 0.4	< 0.4	< 0.4	< 0.4
Tetrachloroethylene (Perchloroethylene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dibromoethane (ethylene dibromide) front	µg/sample	18.9	< 0.4	< 0.4	< 0.4	< 0.4
1,2-Dibromoethane (ethylene dibromide) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chlorobenzene front	µg/sample	18.0	< 0.4	< 0.4	< 0.4	< 0.4
Chlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,1,2-Tetrachloroethane front	µg/sample	18.3	< 0.4	< 0.4	< 0.4	< 0.4
1,1,1,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Ethylbenzene front	µg/sample	19.4	< 0.4	< 0.4	0.5	< 0.4
Ethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
m-, p-Xylene front	µg/sample	38	< 0.4	< 0.4	2.7	< 0.4
m-, p-Xylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	0.8
o-Xylene front	µg/sample	18.2	< 0.4	< 0.4	0.8	< 0.4



Sample Type: 400/200 mg CSC SKC 226-09

Sample Name: **Lab Number:**		ST0201/12 VOC Run 6 Spike 974015.8	Travel Blank 974015.9	Lab (rig) Blank 974015.11	ST0201/01 VOC Run 1 Sample 974015.13	ST0201/03 VOC Run 2 Sample 974015.14
VOC suite from large charcoal tubes (screen)						
o-Xylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	0.2
Styrene front	µg/sample	7.5	< 0.4	< 0.4	< 0.4	< 0.4
Styrene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromoform (tribromomethane) front	µg/sample	17.9	< 0.4	< 0.4	< 0.4	< 0.4
Bromoform (tribromomethane) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
iso-Propylbenzene (Cumene) front	µg/sample	20	< 0.4	< 0.4	< 0.4	< 0.4
iso-Propylbenzene (Cumene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,1,2,2-Tetrachloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
1,1,2,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,3-Trichloropropane front	µg/sample	18.7	< 0.4	< 0.4	< 0.4	< 0.4
1,2,3-Trichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Bromobenzene front	µg/sample	17.6	< 0.4	< 0.4	< 0.4	< 0.4
Bromobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
2-Chlorotoluene front	µg/sample	17.1	< 0.4	< 0.4	< 0.4	< 0.4
2-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
n-Propylbenzene front	µg/sample	19.3	< 0.4	< 0.4	< 0.4	< 0.4
n-Propylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
4-Chlorotoluene front	µg/sample	17.4	< 0.4	< 0.4	< 0.4	< 0.4
4-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3,5-Trimethylbenzene front	µg/sample	18.9	< 0.4	< 0.4	< 0.4	< 0.4
1,3,5-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
tert-Butylbenzene front	µg/sample	19.6	< 0.4	< 0.4	< 0.4	< 0.4
tert-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,4-Trimethylbenzene front	µg/sample	18.2	< 0.4	< 0.4	< 0.4	< 0.4
1,2,4-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,3-Dichlorobenzene front	µg/sample	16.4	< 0.4	< 0.4	< 0.4	< 0.4
1,3-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
sec-Butylbenzene front	µg/sample	19.7	< 0.4	< 0.4	< 0.4	< 0.4
sec-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,4-Dichlorobenzene front	µg/sample	16.4	< 0.4	< 0.4	< 0.4	< 0.4
1,4-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
4-iso-Propyltoluene (p-Cymene) front	µg/sample	20	< 0.4	< 0.4	< 0.4	< 0.4
4-iso-Propyltoluene (p-Cymene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dichlorobenzene front	µg/sample	15.5	< 0.4	< 0.4	< 0.4	< 0.4
1,2-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
n-Butylbenzene front	µg/sample	19.1	< 0.4	< 0.4	< 0.4	< 0.4
n-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2-Dibromo-3-chloropropane front	µg/sample	13.0	< 0.4	< 0.4	< 0.4	< 0.4
1,2-Dibromo-3-chloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,4-Trichlorobenzene front	µg/sample	14.2	< 0.4	< 0.4	< 0.4	< 0.4
1,2,4-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Naphthalene front	µg/sample	4.7	< 0.4	< 0.4	0.4	< 0.4
Naphthalene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
1,2,3-Trichlorobenzene front	µg/sample	12.7	< 0.4	< 0.4	< 0.4	< 0.4
1,2,3-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Hexachlorobutadiene front	µg/sample	19.1	< 0.4	< 0.4	< 0.4	< 0.4
Hexachlorobutadiene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
MIBK (methylisobutyl ketone) front	µg/sample	< 4	< 4	< 4	< 4	< 4
MIBK (methylisobutyl ketone) back	µg/sample	< 2	< 2	< 2	< 2	< 2

Sample Name: **Lab Number:**		ST0201/05 VOC Run 3 Sample 974015.15	ST0201/07 VOC Run 4 Sample 974015.16	ST0201/09 VOC Run 5 Sample 974015.17	ST0201/11 VOC Run 6 Sample 974015.18	
VOC suite from large charcoal tubes (screen)						
Chloroform front	µg/sample	< 4	< 4	< 4	< 4	-

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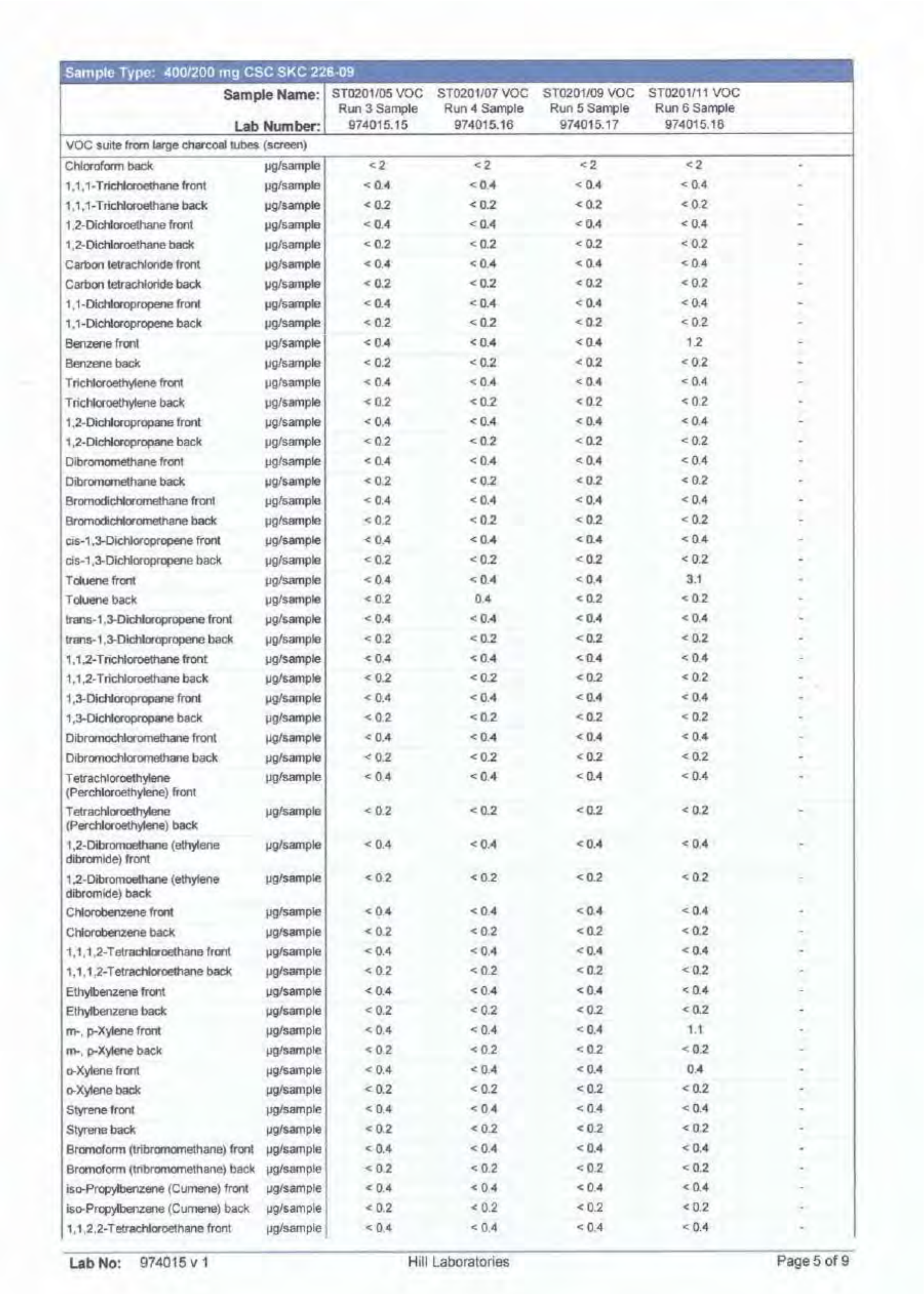

Sample Type: 400/200 mg CSC SKC 226-09

Sample Name:		ST0201/05 VOC Run 3 Sample	ST0201/07 VOC Run 4 Sample	ST0201/09 VOC Run 5 Sample	ST0201/11 VOC Run 6 Sample	
Lab Number:		974015.15	974015.16	974015.17	974015.18	
VOC suite from large charcoal tubes (screen)						
Chloroform back	µg/sample	< 2	< 2	< 2	< 2	-
1,1,1-Trichloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,1,1-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2-Dichloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2-Dichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Carbon tetrachloride front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Carbon tetrachloride back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,1-Dichloropropene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,1-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Benzene front	µg/sample	< 0.4	< 0.4	< 0.4	1.2	-
Benzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Trichloroethylene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Trichloroethylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2-Dichloropropane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Dibromomethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Dibromomethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Bromodichloromethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Bromodichloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
cis-1,3-Dichloropropene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
cis-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Toluene front	µg/sample	< 0.4	< 0.4	< 0.4	3.1	-
Toluene back	µg/sample	< 0.2	0.4	< 0.2	< 0.2	-
trans-1,3-Dichloropropene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
trans-1,3-Dichloropropene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,1,2-Trichloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,1,2-Trichloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,3-Dichloropropane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,3-Dichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Dibromochloromethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Dibromochloromethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Tetrachloroethylene (Perchloroethylene) front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Tetrachloroethylene (Perchloroethylene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2-Dibromoethane (ethylene dibromide) front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2-Dibromoethane (ethylene dibromide) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Chlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Chlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,1,1,2-Tetrachloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,1,1,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Ethylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Ethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
m-, p-Xylene front	µg/sample	< 0.4	< 0.4	< 0.4	1.1	-
m-, p-Xylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
o-Xylene front	µg/sample	< 0.4	< 0.4	< 0.4	0.4	-
o-Xylene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Styrene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Styrene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Bromoform (tribromomethane) front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Bromoform (tribromomethane) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
iso-Propylbenzene (Cumene) front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
iso-Propylbenzene (Cumene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,1,2,2-Tetrachloroethane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-

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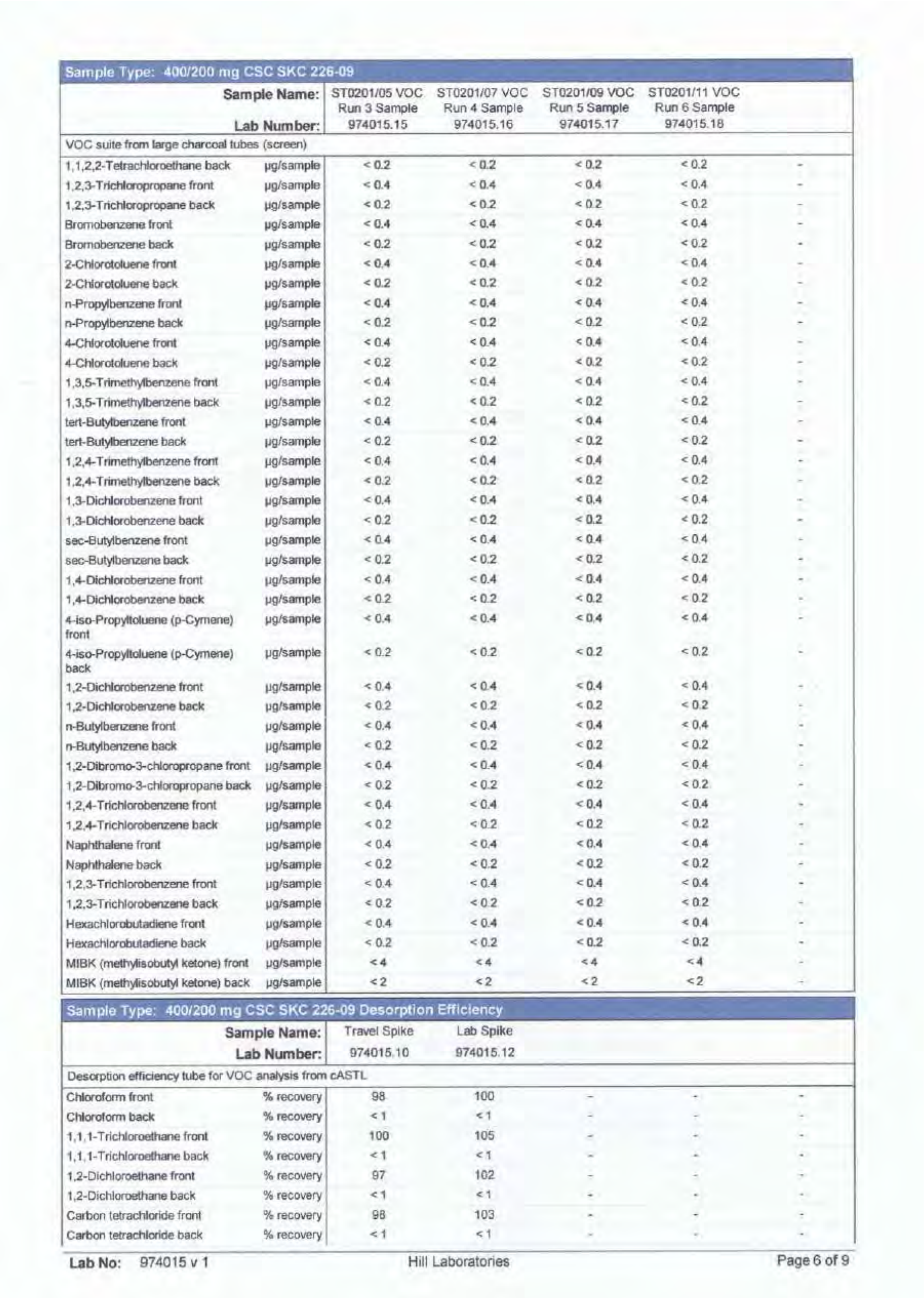

Sample Type: 400/200 mg CSC SKC 226-09

Sample Name:		ST0201/05 VOC Run 3 Sample	ST0201/07 VOC Run 4 Sample	ST0201/09 VOC Run 5 Sample	ST0201/11 VOC Run 6 Sample	
Lab Number:		974015.15	974015.16	974015.17	974015.18	
VOC suite from large charcoal tubes (screen)						
1,1,2,2-Tetrachloroethane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2,3-Trichloropropane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2,3-Trichloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Bromobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Bromobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
2-Chlorotoluene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
2-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
n-Propylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
n-Propylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
4-Chlorotoluene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
4-Chlorotoluene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,3,5-Trimethylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,3,5-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
tert-Butylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
tert-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2,4-Trimethylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2,4-Trimethylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,3-Dichlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,3-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
sec-Butylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
sec-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,4-Dichlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,4-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
4-iso-Propyltoluene (p-Cymene) front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
4-iso-Propyltoluene (p-Cymene) back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2-Dichlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2-Dichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
n-Butylbenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
n-Butylbenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2-Dibromo-3-chloropropane front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2-Dibromo-3-chloropropane back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2,4-Trichlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2,4-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Naphthalene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Naphthalene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
1,2,3-Trichlorobenzene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
1,2,3-Trichlorobenzene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
Hexachlorobutadiene front	µg/sample	< 0.4	< 0.4	< 0.4	< 0.4	-
Hexachlorobutadiene back	µg/sample	< 0.2	< 0.2	< 0.2	< 0.2	-
MIBK (methylisobutyl ketone) front	µg/sample	< 4	< 4	< 4	< 4	-
MIBK (methylisobutyl ketone) back	µg/sample	< 2	< 2	< 2	< 2	-

Sample Type: 400/200 mg CSC SKC 226-09 Desorption Efficiency

Sample Name:		Travel Spike	Lab Spike			
Lab Number:		974015.10	974015.12			
Desorption efficiency tube for VOC analysis from cASTL						
Chloroform front	% recovery	98	100	-	-	-
Chloroform back	% recovery	< 1	< 1	-	-	-
1,1,1-Trichloroethane front	% recovery	100	105	-	-	-
1,1,1-Trichloroethane back	% recovery	< 1	< 1	-	-	-
1,2-Dichloroethane front	% recovery	97	102	-	-	-
1,2-Dichloroethane back	% recovery	< 1	< 1	-	-	-
Carbon tetrachloride front	% recovery	98	103	-	-	-
Carbon tetrachloride back	% recovery	< 1	< 1	-	-	-

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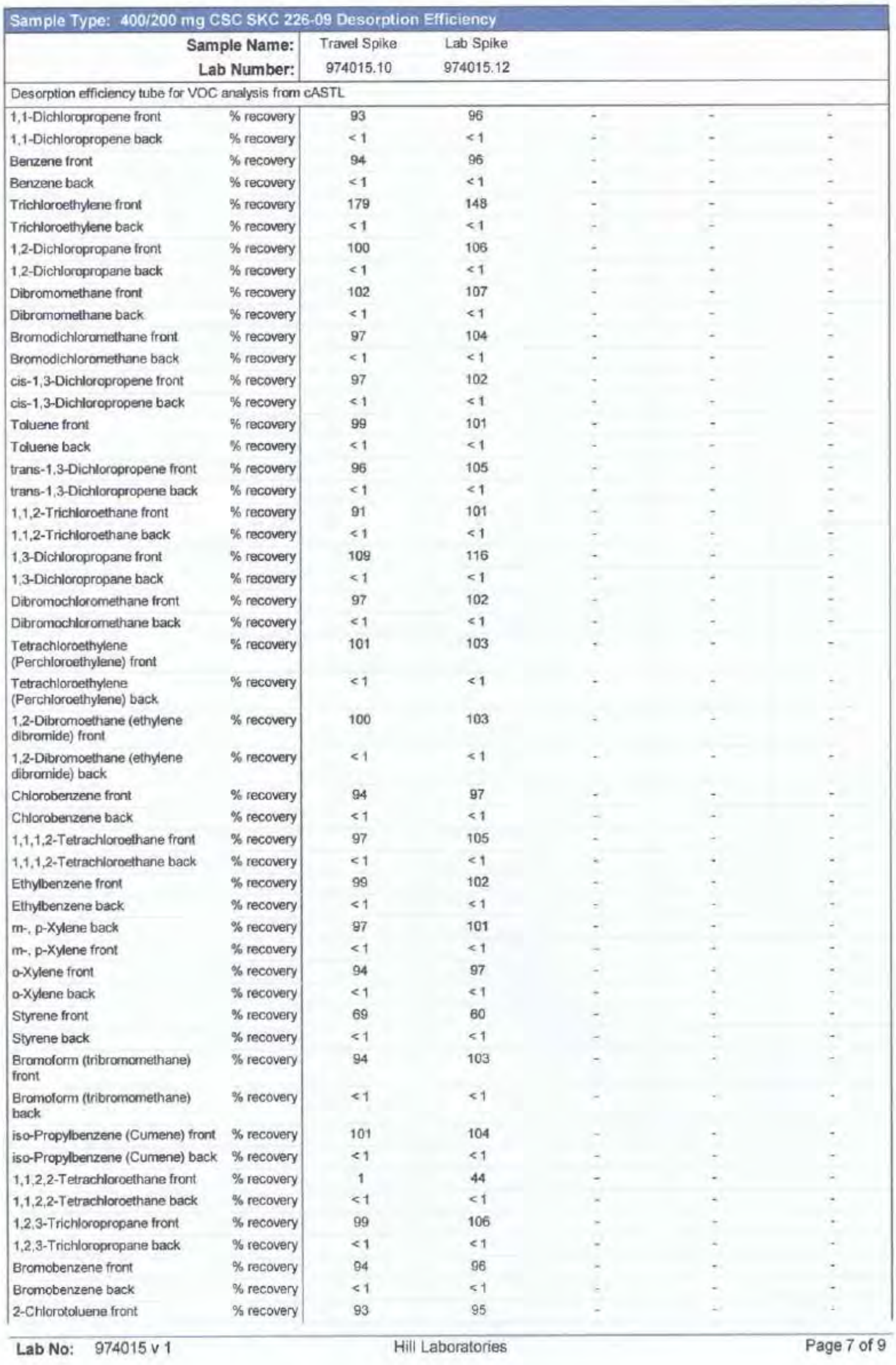

Sample Type: 400/200 mg CSC SKC 226-09 Desorption Efficiency

	Sample Name:	Travel Spike	Lab Spike			
	Lab Number:	974015.10	974015.12			
Desorption efficiency tube for VOC analysis from cASTL						
1,1-Dichloropropene front	% recovery	93	96	-	-	-
1,1-Dichloropropene back	% recovery	< 1	< 1	-	-	-
Benzene front	% recovery	94	96	-	-	-
Benzene back	% recovery	< 1	< 1	-	-	-
Trichloroethylene front	% recovery	179	148	-	-	-
Trichloroethylene back	% recovery	< 1	< 1	-	-	-
1,2-Dichloropropane front	% recovery	100	106	-	-	-
1,2-Dichloropropane back	% recovery	< 1	< 1	-	-	-
Dibromomethane front	% recovery	102	107	-	-	-
Dibromomethane back	% recovery	< 1	< 1	-	-	-
Bromodichloromethane front	% recovery	97	104	-	-	-
Bromodichloromethane back	% recovery	< 1	< 1	-	-	-
cis-1,3-Dichloropropene front	% recovery	97	102	-	-	-
cis-1,3-Dichloropropene back	% recovery	< 1	< 1	-	-	-
Toluene front	% recovery	99	101	-	-	-
Toluene back	% recovery	< 1	< 1	-	-	-
trans-1,3-Dichloropropene front	% recovery	96	105	-	-	-
trans-1,3-Dichloropropene back	% recovery	< 1	< 1	-	-	-
1,1,2-Trichloroethane front	% recovery	91	101	-	-	-
1,1,2-Trichloroethane back	% recovery	< 1	< 1	-	-	-
1,3-Dichloropropane front	% recovery	109	116	-	-	-
1,3-Dichloropropane back	% recovery	< 1	< 1	-	-	-
Dibromochloromethane front	% recovery	97	102	-	-	-
Dibromochloromethane back	% recovery	< 1	< 1	-	-	-
Tetrachloroethylene (Perchloroethylene) front	% recovery	101	103	-	-	-
Tetrachloroethylene (Perchloroethylene) back	% recovery	< 1	< 1	-	-	-
1,2-Dibromoethane (ethylene dibromide) front	% recovery	100	103	-	-	-
1,2-Dibromoethane (ethylene dibromide) back	% recovery	< 1	< 1	-	-	-
Chlorobenzene front	% recovery	94	97	-	-	-
Chlorobenzene back	% recovery	< 1	< 1	-	-	-
1,1,1,2-Tetrachloroethane front	% recovery	97	105	-	-	-
1,1,1,2-Tetrachloroethane back	% recovery	< 1	< 1	-	-	-
Ethylbenzene front	% recovery	99	102	-	-	-
Ethylbenzene back	% recovery	< 1	< 1	-	-	-
m-, p-Xylene back	% recovery	97	101	-	-	-
m-, p-Xylene front	% recovery	< 1	< 1	-	-	-
o-Xylene front	% recovery	94	97	-	-	-
o-Xylene back	% recovery	< 1	< 1	-	-	-
Styrene front	% recovery	69	60	-	-	-
Styrene back	% recovery	< 1	< 1	-	-	-
Bromoform (tribromomethane) front	% recovery	94	103	-	-	-
Bromoform (tribromomethane) back	% recovery	< 1	< 1	-	-	-
iso-Propylbenzene (Cumene) front	% recovery	101	104	-	-	-
iso-Propylbenzene (Cumene) back	% recovery	< 1	< 1	-	-	-
1,1,2,2-Tetrachloroethane front	% recovery	1	44	-	-	-
1,1,2,2-Tetrachloroethane back	% recovery	< 1	< 1	-	-	-
1,2,3-Trichloropropane front	% recovery	99	106	-	-	-
1,2,3-Trichloropropane back	% recovery	< 1	< 1	-	-	-
Bromobenzene front	% recovery	94	96	-	-	-
Bromobenzene back	% recovery	< 1	< 1	-	-	-
2-Chlorotoluene front	% recovery	93	95	-	-	-

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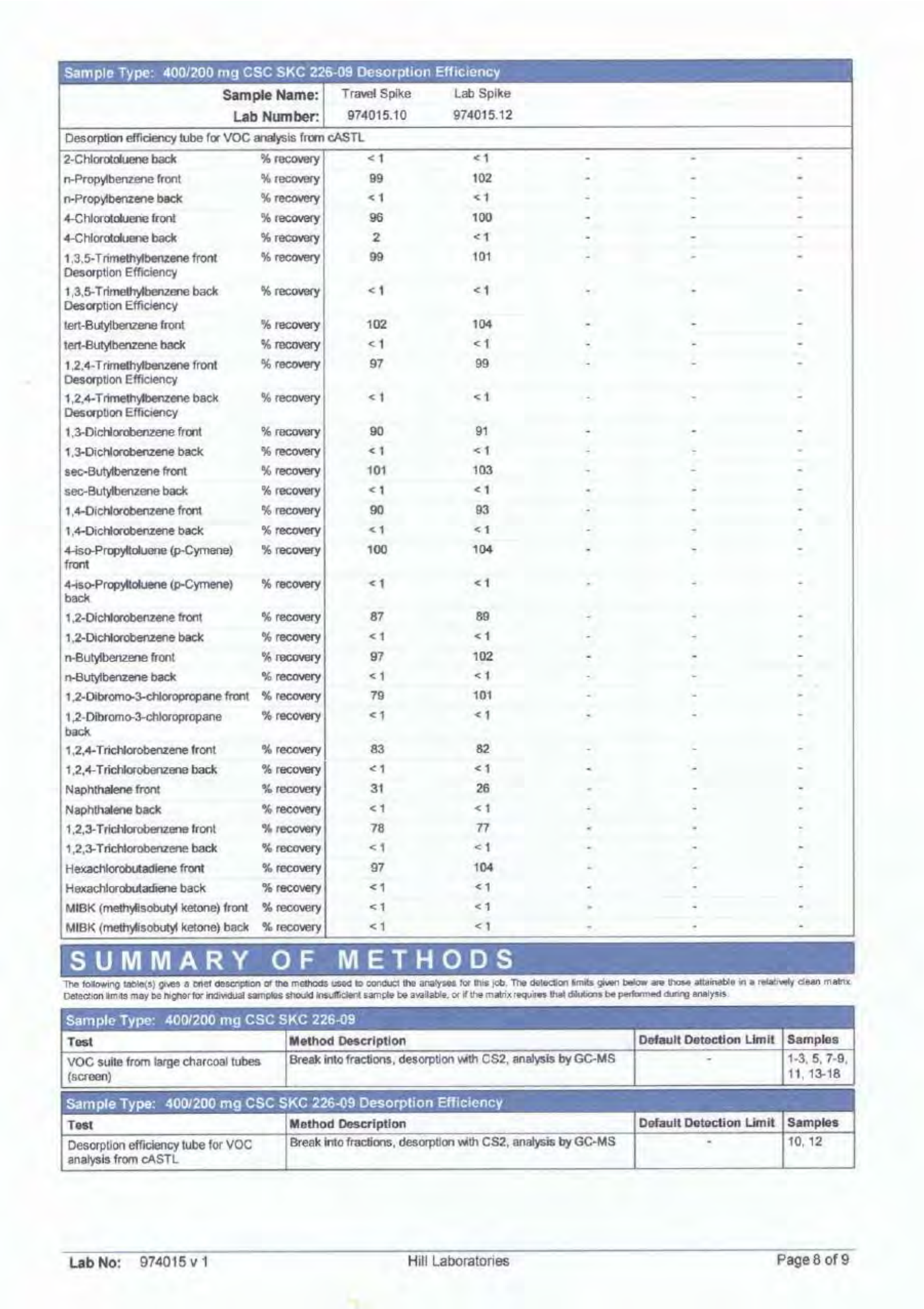

Sample Type: 400/200 mg CSC SKC 226-09 Desorption Efficiency

Sample Name:		Travel Spike	Lab Spike			
Lab Number:		974015.10	974015.12			
Desorption efficiency tube for VOC analysis from cASTL						
2-Chlorotoluene back	% recovery	< 1	< 1	-	-	-
n-Propylbenzene front	% recovery	99	102	-	-	-
n-Propylbenzene back	% recovery	< 1	< 1	-	-	-
4-Chlorotoluene front	% recovery	96	100	-	-	-
4-Chlorotoluene back	% recovery	2	< 1	-	-	-
1,3,5-Trimethylbenzene front Desorption Efficiency	% recovery	99	101	-	-	-
1,3,5-Trimethylbenzene back Desorption Efficiency	% recovery	< 1	< 1	-	-	-
tert-Butylbenzene front	% recovery	102	104	-	-	-
tert-Butylbenzene back	% recovery	< 1	< 1	-	-	-
1,2,4-Trimethylbenzene front Desorption Efficiency	% recovery	97	99	-	-	-
1,2,4-Trimethylbenzene back Desorption Efficiency	% recovery	< 1	< 1	-	-	-
1,3-Dichlorobenzene front	% recovery	90	91	-	-	-
1,3-Dichlorobenzene back	% recovery	< 1	< 1	-	-	-
sec-Butylbenzene front	% recovery	101	103	-	-	-
sec-Butylbenzene back	% recovery	< 1	< 1	-	-	-
1,4-Dichlorobenzene front	% recovery	90	93	-	-	-
1,4-Dichlorobenzene back	% recovery	< 1	< 1	-	-	-
4-iso-Propyltoluene (p-Cymene) front	% recovery	100	104	-	-	-
4-iso-Propyltoluene (p-Cymene) back	% recovery	< 1	< 1	-	-	-
1,2-Dichlorobenzene front	% recovery	87	89	-	-	-
1,2-Dichlorobenzene back	% recovery	< 1	< 1	-	-	-
n-Butylbenzene front	% recovery	97	102	-	-	-
n-Butylbenzene back	% recovery	< 1	< 1	-	-	-
1,2-Dibromo-3-chloropropane front	% recovery	79	101	-	-	-
1,2-Dibromo-3-chloropropane back	% recovery	< 1	< 1	-	-	-
1,2,4-Trichlorobenzene front	% recovery	83	82	-	-	-
1,2,4-Trichlorobenzene back	% recovery	< 1	< 1	-	-	-
Naphthalene front	% recovery	31	26	-	-	-
Naphthalene back	% recovery	< 1	< 1	-	-	-
1,2,3-Trichlorobenzene front	% recovery	78	77	-	-	-
1,2,3-Trichlorobenzene back	% recovery	< 1	< 1	-	-	-
Hexachlorobutadiene front	% recovery	97	104	-	-	-
Hexachlorobutadiene back	% recovery	< 1	< 1	-	-	-
MIBK (methylisobutyl ketone) front	% recovery	< 1	< 1	-	-	-
MIBK (methylisobutyl ketone) back	% recovery	< 1	< 1	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: 400/200 mg CSC SKC 226-09

Test	Method Description	Default Detection Limit	Samples
VOC suite from large charcoal tubes (screen)	Break into fractions, desorption with CS2, analysis by GC-MS	-	1-3, 5, 7-9, 11, 13-18

Sample Type: 400/200 mg CSC SKC 226-09 Desorption Efficiency

Test	Method Description	Default Detection Limit	Samples
Desorption efficiency tube for VOC analysis from cASTL	Break into fractions, desorption with CS2, analysis by GC-MS	-	10, 12

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental Division

1C Quadrant Drive, Waiwhetu
POBox 31242, Lower Hutt 5010
Wellington, New Zealand

64 4 5708800
64 4 5708176
www.asurequality.com

Certificate of Analysis

Date Issued:	28 Feb 2012
Client:	Source Testing NZ Ltd PO Box 32 017 Maungaraki Lower Hutt
Attention:	Matthew Newby
Date Received:	13 Feb 2012
AsureQuality Lab. Reference:	106665
Sample Type(s):	Emission
Analysis:	**Polychlorinated dibenzo-p-dioxins (PCDDs)** **Polychlorinated dibenzofurans (PCDFs)**
Method:	Based on USEPA Method 23 (Isotope Dilution)

Results are reported in nanograms (ng), determined on an as received basis to three significant figures. The DL value is reported to three significant figures. Results have been corrected for internal standard recoveries. The sum of PCDDs and PCDFs is calculated and reported to three significant figures as a lower, medium and upper bound.

The total toxic equivalence (TEQ) was calculated for each sample using both WHO toxic equivalency factors (WHO-TEFs; Van den Berg et al., 2005) and international toxic equivalency factors (I-TEFs; Kutz et al., 1990). The total WHO-TEQ and I-TEQ level is reported as a lower, medium, and upper bound to three significant figures.

Unless requested, original samples will be disposed of eight weeks from the date of this report.

Comments:

Andrew Steedman
Scientist
AsureQuality Limited

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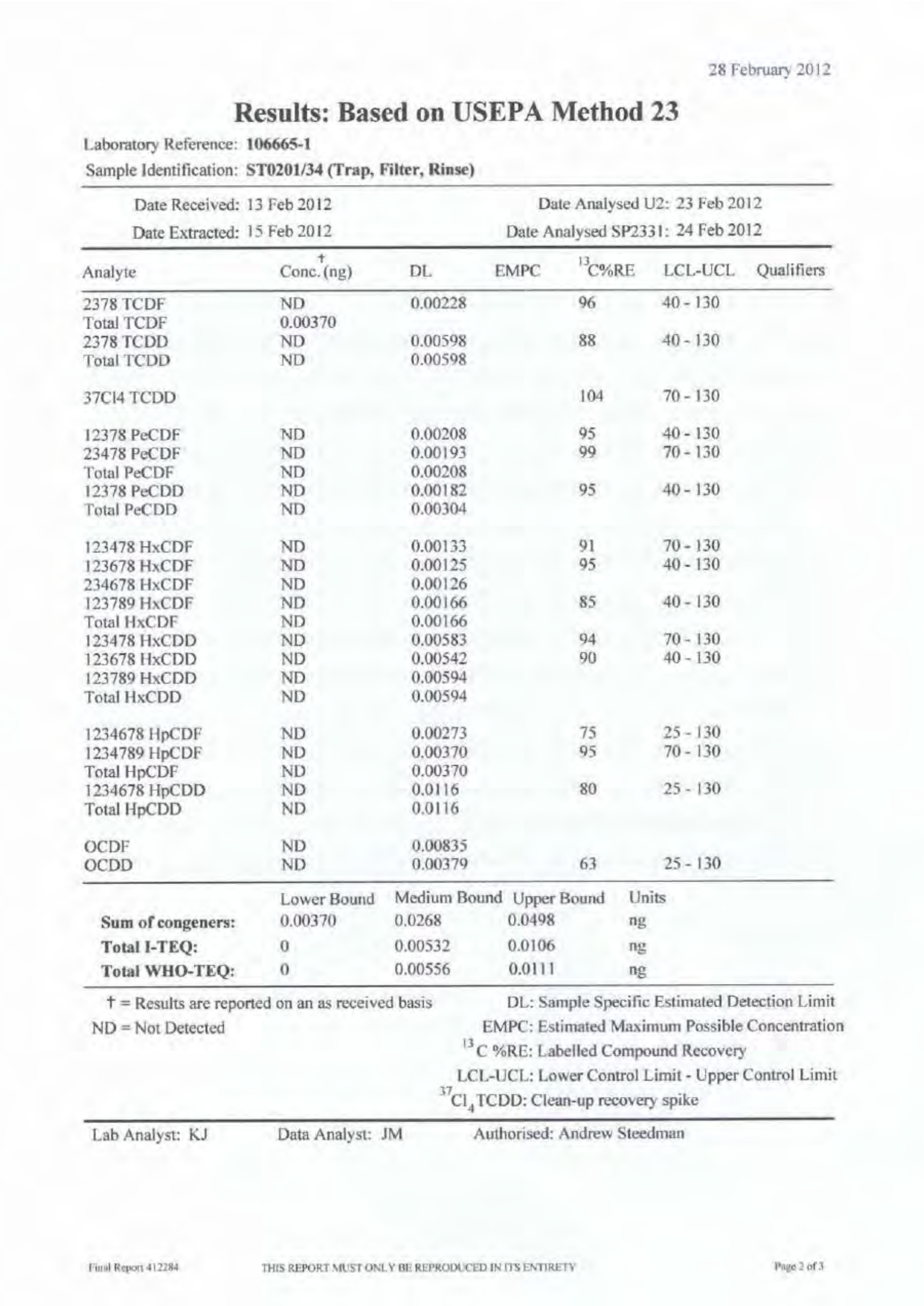

28 February 2012

Results: Based on USEPA Method 23

Laboratory Reference: **106665-1**
Sample Identification: **ST0201/34 (Trap, Filter, Rinse)**

Date Received: 13 Feb 2012
Date Extracted: 15 Feb 2012
Date Analysed U2: 23 Feb 2012
Date Analysed SP2331: 24 Feb 2012

Analyte	† Conc. (ng)	DL	EMPC	^{13}C%RE	LCL-UCL	Qualifiers
2378 TCDF	ND	0.00228		96	40 - 130	
Total TCDF	0.00370					
2378 TCDD	ND	0.00598		88	40 - 130	
Total TCDD	ND	0.00598				
37Cl4 TCDD				104	70 - 130	
12378 PeCDF	ND	0.00208		95	40 - 130	
23478 PeCDF	ND	0.00193		99	70 - 130	
Total PeCDF	ND	0.00208				
12378 PeCDD	ND	0.00182		95	40 - 130	
Total PeCDD	ND	0.00304				
123478 HxCDF	ND	0.00133		91	70 - 130	
123678 HxCDF	ND	0.00125		95	40 - 130	
234678 HxCDF	ND	0.00126				
123789 HxCDF	ND	0.00166		85	40 - 130	
Total HxCDF	ND	0.00166				
123478 HxCDD	ND	0.00583		94	70 - 130	
123678 HxCDD	ND	0.00542		90	40 - 130	
123789 HxCDD	ND	0.00594				
Total HxCDD	ND	0.00594				
1234678 HpCDF	ND	0.00273		75	25 - 130	
1234789 HpCDF	ND	0.00370		95	70 - 130	
Total HpCDF	ND	0.00370				
1234678 HpCDD	ND	0.0116		80	25 - 130	
Total HpCDD	ND	0.0116				
OCDF	ND	0.00835				
OCDD	ND	0.00379		63	25 - 130	

	Lower Bound	Medium Bound	Upper Bound	Units
Sum of congeners:	0.00370	0.0268	0.0498	ng
Total I-TEQ:	0	0.00532	0.0106	ng
Total WHO-TEQ:	0	0.00556	0.0111	ng

† = Results are reported on an as received basis
ND = Not Detected

DL: Sample Specific Estimated Detection Limit
EMPC: Estimated Maximum Possible Concentration
^{13}C %RE: Labelled Compound Recovery
LCL-UCL: Lower Control Limit - Upper Control Limit
$^{37}Cl_4$ TCDD: Clean-up recovery spike

Lab Analyst: KJ   Data Analyst: JM   Authorised: Andrew Steedman

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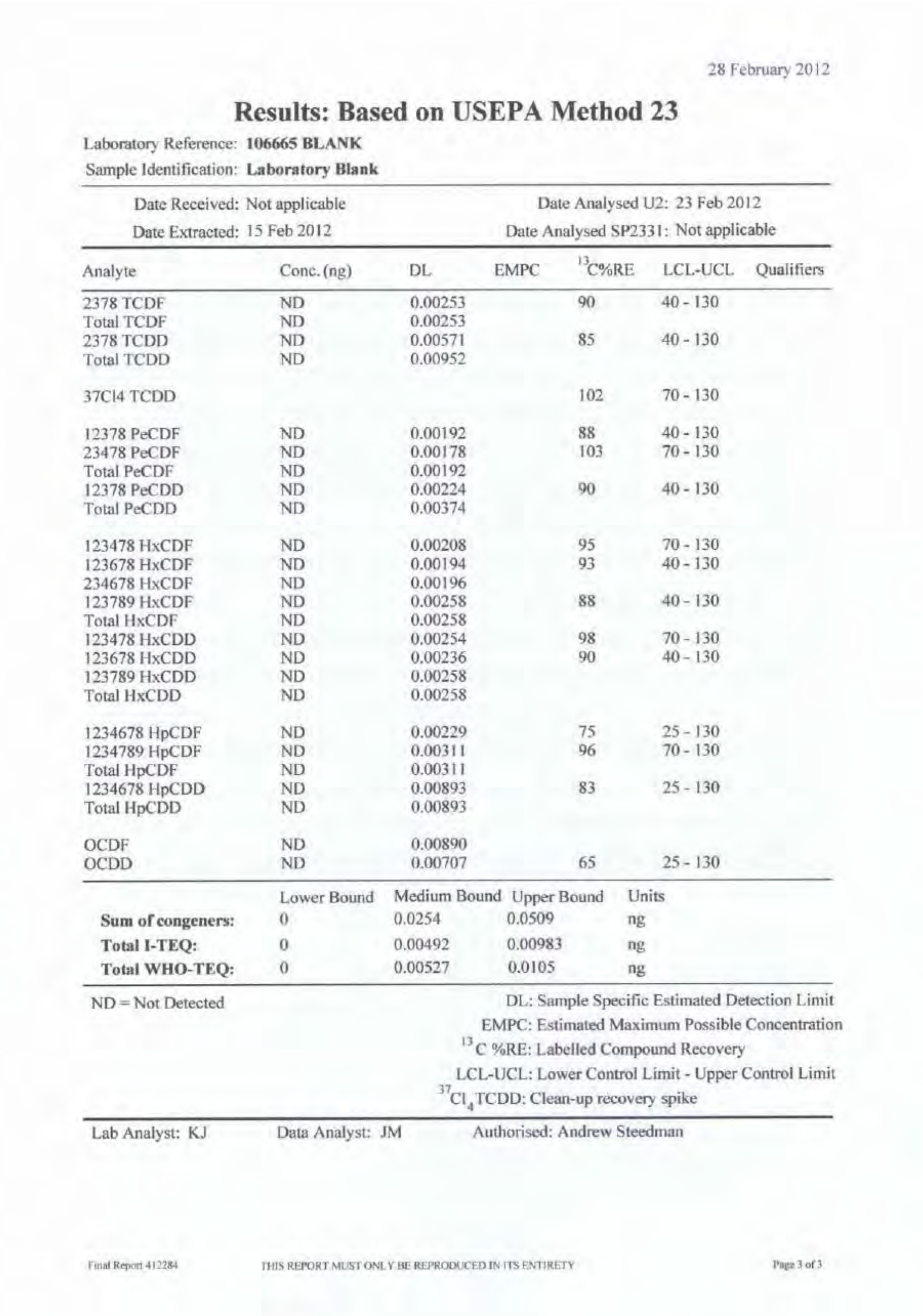

28 February 2012

Results: Based on USEPA Method 23

Laboratory Reference: **106665 BLANK**
Sample Identification: **Laboratory Blank**

Date Received: Not applicable
Date Extracted: 15 Feb 2012
Date Analysed U2: 23 Feb 2012
Date Analysed SP2331: Not applicable

Analyte	Conc. (ng)	DL	EMPC	^{13}C%RE	LCL-UCL	Qualifiers
2378 TCDF	ND	0.00253		90	40 - 130	
Total TCDF	ND	0.00253				
2378 TCDD	ND	0.00571		85	40 - 130	
Total TCDD	ND	0.00952				
37Cl4 TCDD				102	70 - 130	
12378 PeCDF	ND	0.00192		88	40 - 130	
23478 PeCDF	ND	0.00178		103	70 - 130	
Total PeCDF	ND	0.00192				
12378 PeCDD	ND	0.00224		90	40 - 130	
Total PeCDD	ND	0.00374				
123478 HxCDF	ND	0.00208		95	70 - 130	
123678 HxCDF	ND	0.00194		93	40 - 130	
234678 HxCDF	ND	0.00196				
123789 HxCDF	ND	0.00258		88	40 - 130	
Total HxCDF	ND	0.00258				
123478 HxCDD	ND	0.00254		98	70 - 130	
123678 HxCDD	ND	0.00236		90	40 - 130	
123789 HxCDD	ND	0.00258				
Total HxCDD	ND	0.00258				
1234678 HpCDF	ND	0.00229		75	25 - 130	
1234789 HpCDF	ND	0.00311		96	70 - 130	
Total HpCDF	ND	0.00311				
1234678 HpCDD	ND	0.00893		83	25 - 130	
Total HpCDD	ND	0.00893				
OCDF	ND	0.00890				
OCDD	ND	0.00707		65	25 - 130	

	Lower Bound	Medium Bound	Upper Bound	Units
Sum of congeners:	0	0.0254	0.0509	ng
Total I-TEQ:	0	0.00492	0.00983	ng
Total WHO-TEQ:	0	0.00527	0.0105	ng

ND = Not Detected

DL: Sample Specific Estimated Detection Limit
EMPC: Estimated Maximum Possible Concentration
^{13}C %RE: Labelled Compound Recovery
LCL-UCL: Lower Control Limit - Upper Control Limit
$^{37}Cl_4$TCDD: Clean-up recovery spike

Lab Analyst: KJ Data Analyst: JM Authorised: Andrew Steedman

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AsureQuality
1C Quadrant Drive, Waiwhetu
POBox 31242, Lower Hutt 5010
Wellington, New Zealand
T 64 4 5706800
F 64 4 5708176
W www.asurequality.com

Certificate of Analysis

Date Issued:	28 Feb 2012
Client:	Source Testing NZ Ltd PO Box 32 017 Maungaraki Lower Hutt
Attention:	Matthew Newby
Date Received:	13 Feb 2012
AsureQuality Lab. Reference:	106665
Sample Type(s):	Emission
Analysis:	**Polycyclic Aromatic Hydrocarbons (PAHs)**
Method:	Based on CARB Method 429 (Isotope Dilution)

Results are reported in nanograms (ng) on an as received basis and have been corrected for internal standard recoveries. The sum of the target PAHs is calculated and reported as lower, medium, and upperbound levels. All values are reported to three significant figures.

The Toxic Benzo[a]pyrene Equivalent (TEQ) was calculated for each sample using both CARB (California Air Resources Board) potency equivalence factors [CARB, 1994] and USEPA (United States Environmental Protection Agency) toxic equivalency factors [USEPA, 1993]. The TEQ is reported as a lower, medium, and upperbound level to three significant figures.

The concept of 'lowerbound' requires using zero for the contribution of each non-detected congener to the Total Target PAH and TEQ. The concept of 'mediumbound' requires using half of the detection limit for the contribution of each non-detected congener to the Total Target PAH and TEQ. The concept of 'upperbound' requires using the detection limit for the contribution of each non-detected congener to the Total Target PAH and TEQ.

Unless requested, original samples will be disposed of eight weeks from the date of this report.

Comments:

Andrew Steedman
Scientist
AsureQuality Limited

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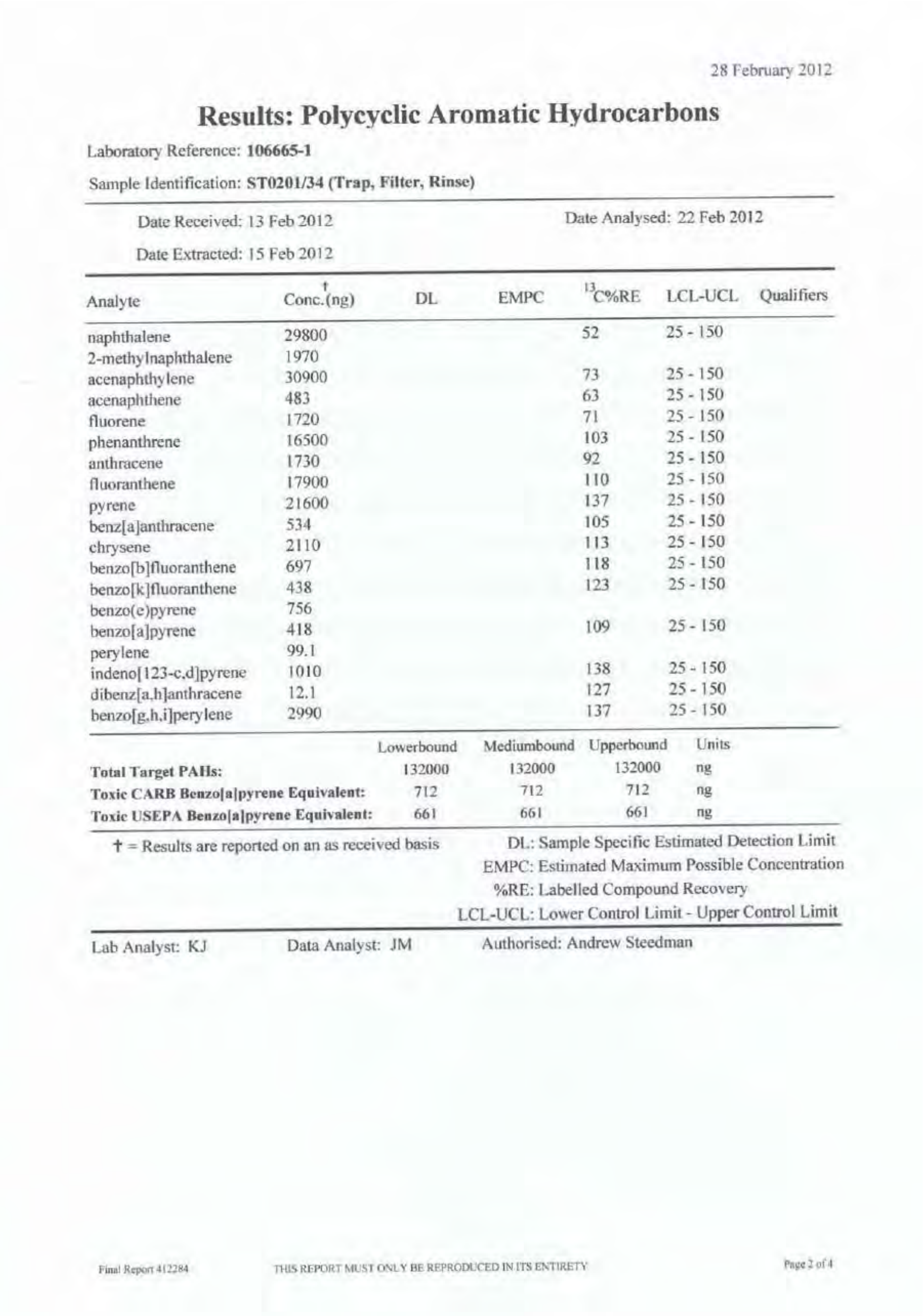

28 February 2012

Results: Polycyclic Aromatic Hydrocarbons

Laboratory Reference: **106665-1**

Sample Identification: **ST0201/34 (Trap, Filter, Rinse)**

Date Received: 13 Feb 2012
Date Analysed: 22 Feb 2012
Date Extracted: 15 Feb 2012

Analyte	Conc. (ng) †	DL	EMPC	^{13}C%RE	LCL-UCL	Qualifiers
naphthalene	29800			52	25 - 150	
2-methylnaphthalene	1970					
acenaphthylene	30900			73	25 - 150	
acenaphthene	483			63	25 - 150	
fluorene	1720			71	25 - 150	
phenanthrene	16500			103	25 - 150	
anthracene	1730			92	25 - 150	
fluoranthene	17900			110	25 - 150	
pyrene	21600			137	25 - 150	
benz[a]anthracene	534			105	25 - 150	
chrysene	2110			113	25 - 150	
benzo[b]fluoranthene	697			118	25 - 150	
benzo[k]fluoranthene	438			123	25 - 150	
benzo(e)pyrene	756					
benzo[a]pyrene	418			109	25 - 150	
perylene	99.1					
indeno[123-c,d]pyrene	1010			138	25 - 150	
dibenz[a,h]anthracene	12.1			127	25 - 150	
benzo[g,h,i]perylene	2990			137	25 - 150	

	Lowerbound	Mediumbound	Upperbound	Units
Total Target PAHs:	132000	132000	132000	ng
Toxic CARB Benzo[a]pyrene Equivalent:	712	712	712	ng
Toxic USEPA Benzo[a]pyrene Equivalent:	661	661	661	ng

† = Results are reported on an as received basis

DL: Sample Specific Estimated Detection Limit
EMPC: Estimated Maximum Possible Concentration
%RE: Labelled Compound Recovery
LCL-UCL: Lower Control Limit - Upper Control Limit

Lab Analyst: KJ
Data Analyst: JM
Authorised: Andrew Steedman

Final Report 412284
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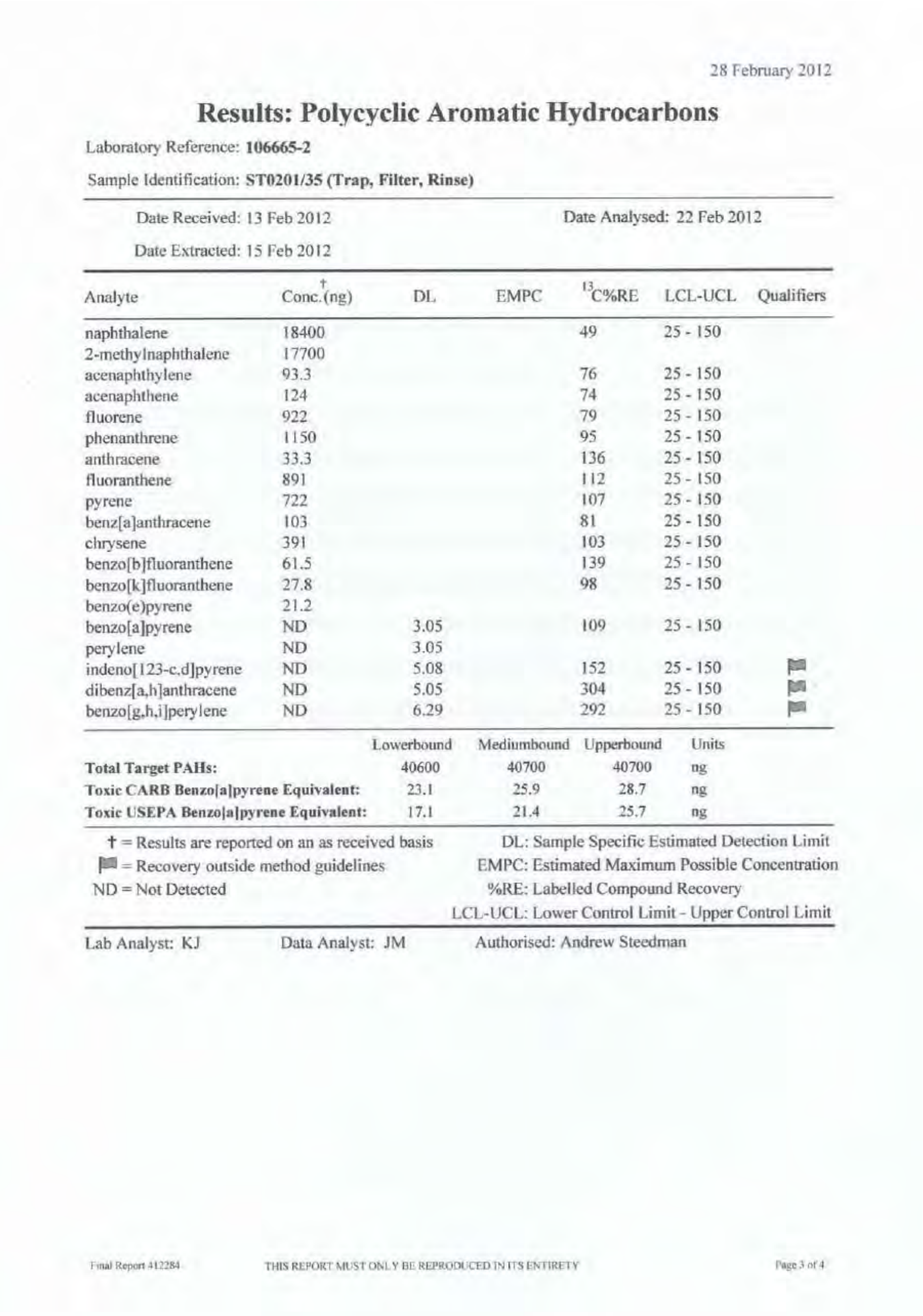
Page 2 of 4



28 February 2012

Results: Polycyclic Aromatic Hydrocarbons

Laboratory Reference: **106665-2**

Sample Identification: **ST0201/35 (Trap, Filter, Rinse)**

Date Received: 13 Feb 2012 Date Analysed: 22 Feb 2012

Date Extracted: 15 Feb 2012

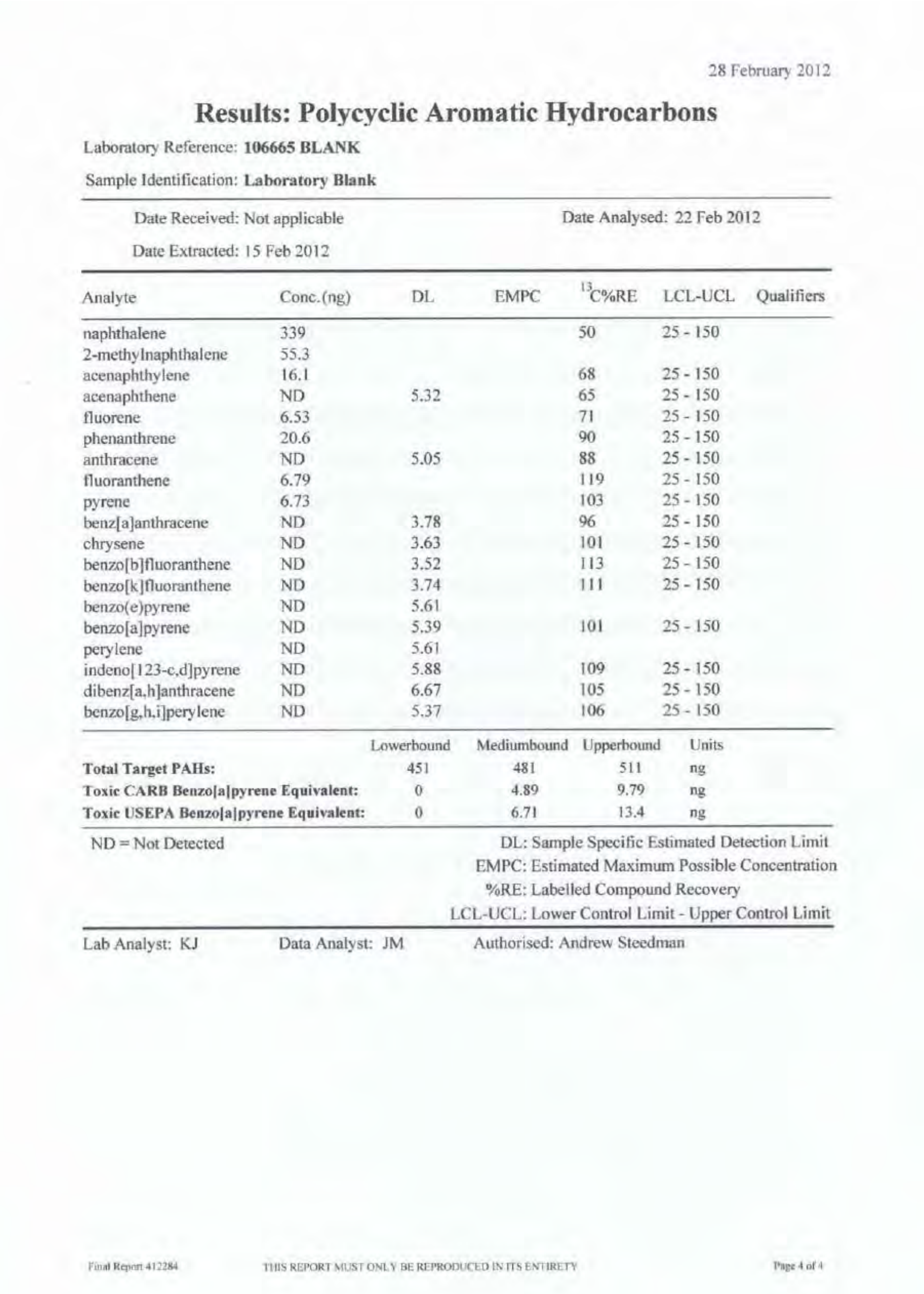
Analyte	Conc. (ng) †	DL	EMPC	^{13}C%RE	LCL-UCL	Qualifiers
naphthalene	18400			49	25 - 150	
2-methylnaphthalene	17700					
acenaphthylene	93.3			76	25 - 150	
acenaphthene	124			74	25 - 150	
fluorene	922			79	25 - 150	
phenanthrene	1150			95	25 - 150	
anthracene	33.3			136	25 - 150	
fluoranthene	891			112	25 - 150	
pyrene	722			107	25 - 150	
benz[a]anthracene	103			81	25 - 150	
chrysene	391			103	25 - 150	
benzo[b]fluoranthene	61.5			139	25 - 150	
benzo[k]fluoranthene	27.8			98	25 - 150	
benzo(e)pyrene	21.2					
benzo[a]pyrene	ND	3.05		109	25 - 150	
perylene	ND	3.05				
indeno[123-c,d]pyrene	ND	5.08		152	25 - 150	⚑
dibenz[a,h]anthracene	ND	5.05		304	25 - 150	⚑
benzo[g,h,i]perylene	ND	6.29		292	25 - 150	⚑

	Lowerbound	Mediumbound	Upperbound	Units
Total Target PAHs:	40600	40700	40700	ng
Toxic CARB Benzo[a]pyrene Equivalent:	23.1	25.9	28.7	ng
Toxic USEPA Benzo[a]pyrene Equivalent:	17.1	21.4	25.7	ng

† = Results are reported on an as received basis
⚑ = Recovery outside method guidelines
ND = Not Detected

DL: Sample Specific Estimated Detection Limit
EMPC: Estimated Maximum Possible Concentration
%RE: Labelled Compound Recovery
LCL-UCL: Lower Control Limit - Upper Control Limit

Lab Analyst: KJ Data Analyst: JM Authorised: Andrew Steedman



28 February 2012

Results: Polycyclic Aromatic Hydrocarbons

Laboratory Reference: **106665 BLANK**

Sample Identification: **Laboratory Blank**

Date Received: Not applicable
Date Analysed: 22 Feb 2012
Date Extracted: 15 Feb 2012

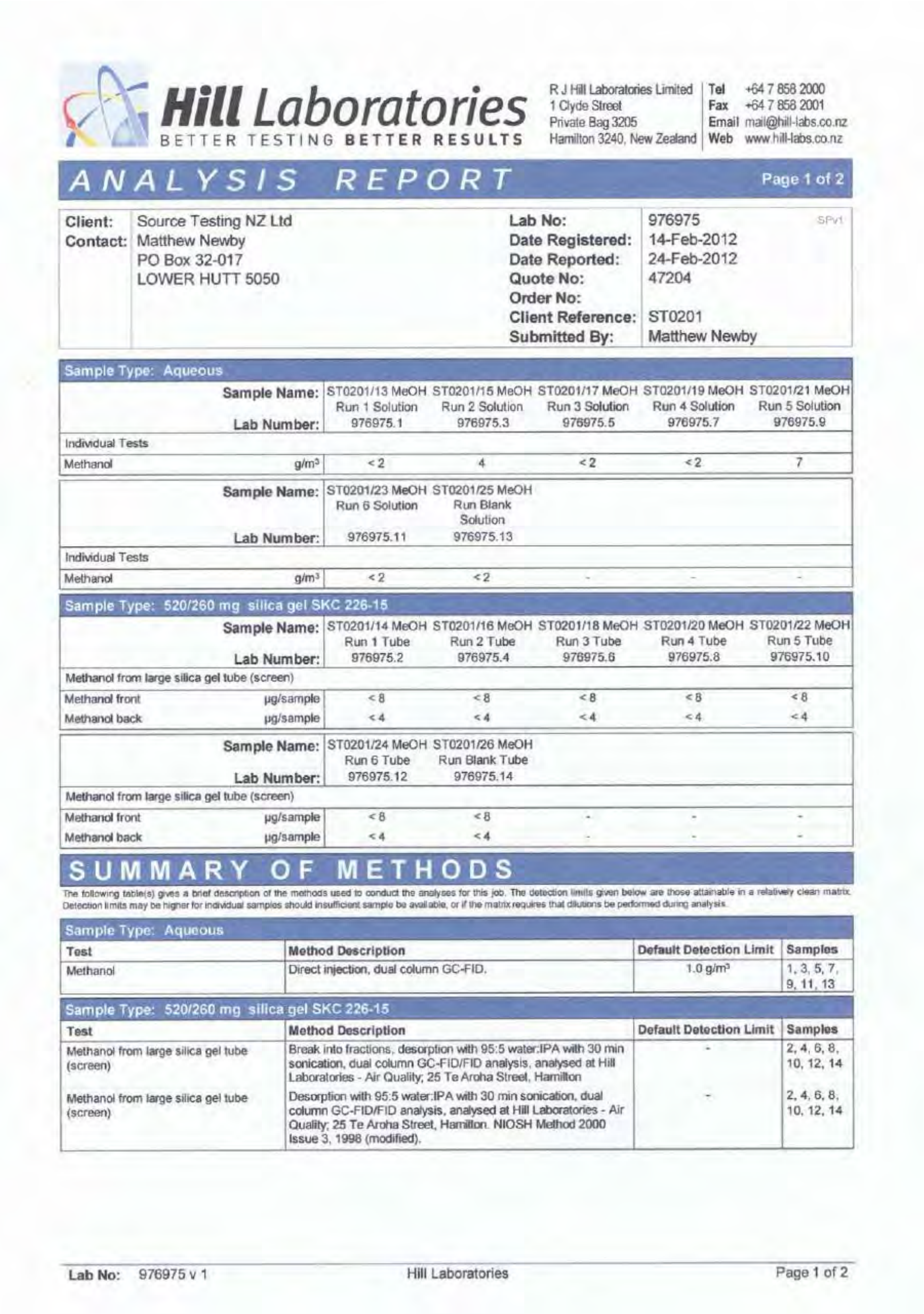
Analyte	Conc. (ng)	DL	EMPC	^{13}C%RE	LCL-UCL	Qualifiers
naphthalene	339			50	25 - 150	
2-methylnaphthalene	55.3					
acenaphthylene	16.1			68	25 - 150	
acenaphthene	ND	5.32		65	25 - 150	
fluorene	6.53			71	25 - 150	
phenanthrene	20.6			90	25 - 150	
anthracene	ND	5.05		88	25 - 150	
fluoranthene	6.79			119	25 - 150	
pyrene	6.73			103	25 - 150	
benz[a]anthracene	ND	3.78		96	25 - 150	
chrysene	ND	3.63		101	25 - 150	
benzo[b]fluoranthene	ND	3.52		113	25 - 150	
benzo[k]fluoranthene	ND	3.74		111	25 - 150	
benzo(e)pyrene	ND	5.61				
benzo[a]pyrene	ND	5.39		101	25 - 150	
perylene	ND	5.61				
indeno[123-c,d]pyrene	ND	5.88		109	25 - 150	
dibenz[a,h]anthracene	ND	6.67		105	25 - 150	
benzo[g,h,i]perylene	ND	5.37		106	25 - 150	

	Lowerbound	Mediumbound	Upperbound	Units
Total Target PAHs:	451	481	511	ng
Toxic CARB Benzo[a]pyrene Equivalent:	0	4.89	9.79	ng
Toxic USEPA Benzo[a]pyrene Equivalent:	0	6.71	13.4	ng

ND = Not Detected

DL: Sample Specific Estimated Detection Limit
EMPC: Estimated Maximum Possible Concentration
%RE: Labelled Compound Recovery
LCL-UCL: Lower Control Limit - Upper Control Limit

Lab Analyst: KJ
Data Analyst: JM
Authorised: Andrew Steedman



Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Page 1 of 2

SPv1

Client:	Source Testing NZ Ltd	**Lab No:**	976975
Contact:	Matthew Newby	**Date Registered:**	14-Feb-2012
	PO Box 32-017	**Date Reported:**	24-Feb-2012
	LOWER HUTT 5050	**Quote No:**	47204
		Order No:	
		Client Reference:	ST0201
		Submitted By:	Matthew Newby

Sample Type: Aqueous

Sample Name:		ST0201/13 MeOH Run 1 Solution	ST0201/15 MeOH Run 2 Solution	ST0201/17 MeOH Run 3 Solution	ST0201/19 MeOH Run 4 Solution	ST0201/21 MeOH Run 5 Solution
Lab Number:		976975.1	976975.3	976975.5	976975.7	976975.9
Individual Tests						
Methanol	g/m³	< 2	4	< 2	< 2	7

Sample Name:		ST0201/23 MeOH Run 6 Solution	ST0201/25 MeOH Run Blank Solution			
Lab Number:		976975.11	976975.13			
Individual Tests						
Methanol	g/m³	< 2	< 2	-	-	-

Sample Type: 520/260 mg silica gel SKC 226-15

Sample Name:		ST0201/14 MeOH Run 1 Tube	ST0201/16 MeOH Run 2 Tube	ST0201/18 MeOH Run 3 Tube	ST0201/20 MeOH Run 4 Tube	ST0201/22 MeOH Run 5 Tube
Lab Number:		976975.2	976975.4	976975.6	976975.8	976975.10
Methanol from large silica gel tube (screen)						
Methanol front	µg/sample	< 8	< 8	< 8	< 8	< 8
Methanol back	µg/sample	< 4	< 4	< 4	< 4	< 4

Sample Name:		ST0201/24 MeOH Run 6 Tube	ST0201/26 MeOH Run Blank Tube			
Lab Number:		976975.12	976975.14			
Methanol from large silica gel tube (screen)						
Methanol front	µg/sample	< 8	< 8	-	-	-
Methanol back	µg/sample	< 4	< 4	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Methanol	Direct injection, dual column GC-FID.	1.0 g/m³	1, 3, 5, 7, 9, 11, 13

Sample Type: 520/260 mg silica gel SKC 226-15

Test	Method Description	Default Detection Limit	Samples
Methanol from large silica gel tube (screen)	Break into fractions, desorption with 95:5 water:IPA with 30 min sonication, dual column GC-FID/FID analysis, analysed at Hill Laboratories - Air Quality; 25 Te Aroha Street, Hamilton	-	2, 4, 6, 8, 10, 12, 14
Methanol from large silica gel tube (screen)	Desorption with 95:5 water:IPA with 30 min sonication, dual column GC-FID/FID analysis, analysed at Hill Laboratories - Air Quality; 25 Te Aroha Street, Hamilton. NIOSH Method 2000 Issue 3, 1998 (modified).	-	2, 4, 6, 8, 10, 12, 14

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Page 1 of 1

Client:	Source Testing NZ Ltd	**Lab No:**	981479 SPv1
Contact:	Matthew Newby PO Box 32-017 LOWER HUTT 5050	**Date Registered:**	27-Feb-2012
		Date Reported:	27-Feb-2012
		Quote No:	
		Order No:	
		Client Reference:	ST0201
		Submitted By:	Matthew Newby

Sample Type: Miscellaneous impinger not specified by client or not known

Sample Name:		ST0201/13 MeOH Run 1 Solution [976975.1]	ST0201/15 MeOH Run 2 Solution [976975.3]	ST0201/17 MeOH Run 3 Solution [976975.5]	ST0201/19 MeOH Run 4 Solution [976975.7]	ST0201/21 MeOH Run 5 Solution [976975.9]
Lab Number:		981479.1	981479.2	981479.3	981479.4	981479.5
Total Liquid Volume on Receipt	mL	31	31	38	60	40

Sample Name:		ST0201/23 MeOH Run 6 Solution [976975.11]	ST0201/25 MeOH Run Blank Solution [976975.13]			
Lab Number:		981479.6	981479.7			
Total Liquid Volume on Receipt	mL	49	67	-	-	-

Analyst's Comments

These samples were originally booked in under job number 976975. This report has been issued to report the volumes of the impinger samples from job 976975.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Miscellaneous impinger not specified by client or not known

Test	Method Description	Default Detection Limit	Samples
Total liquid volume on receipt	Sample volume (measuring cylinder).	1.0 mL	1-7

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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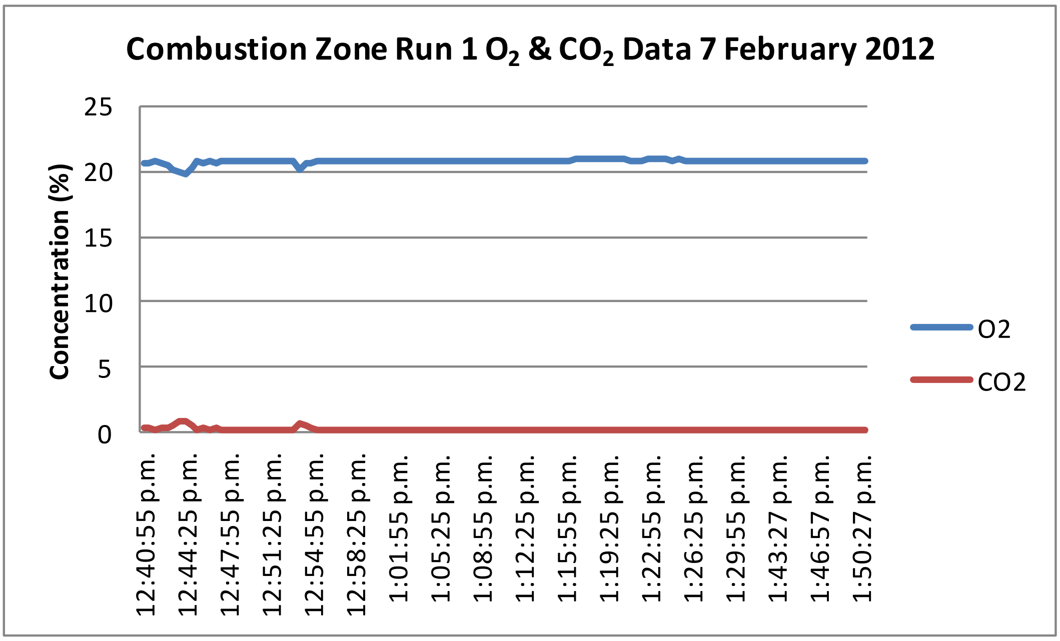
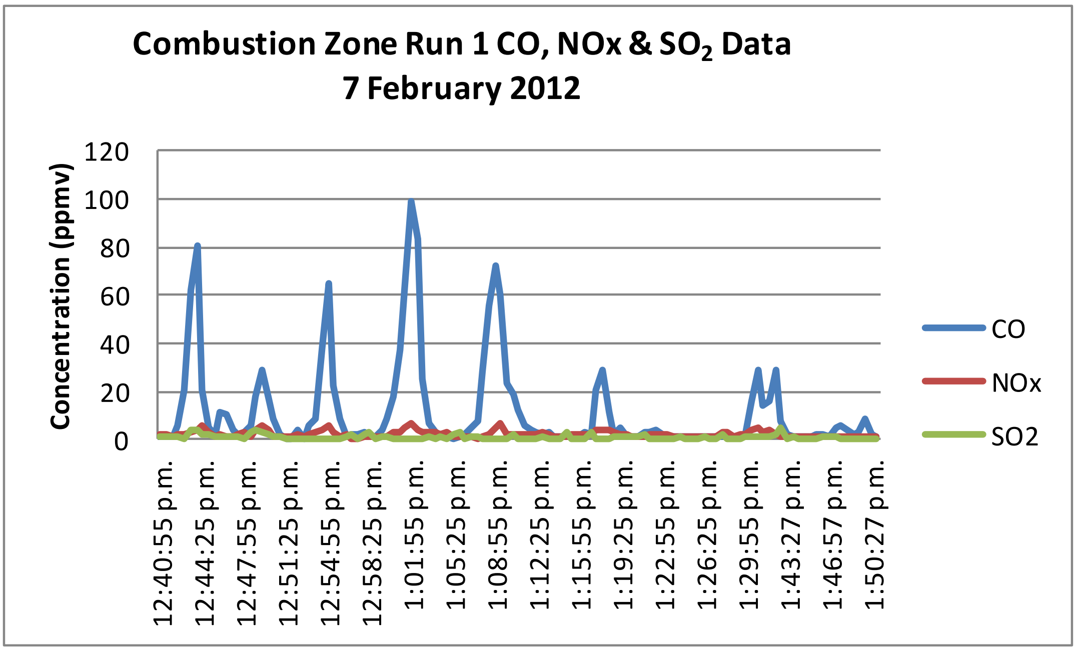
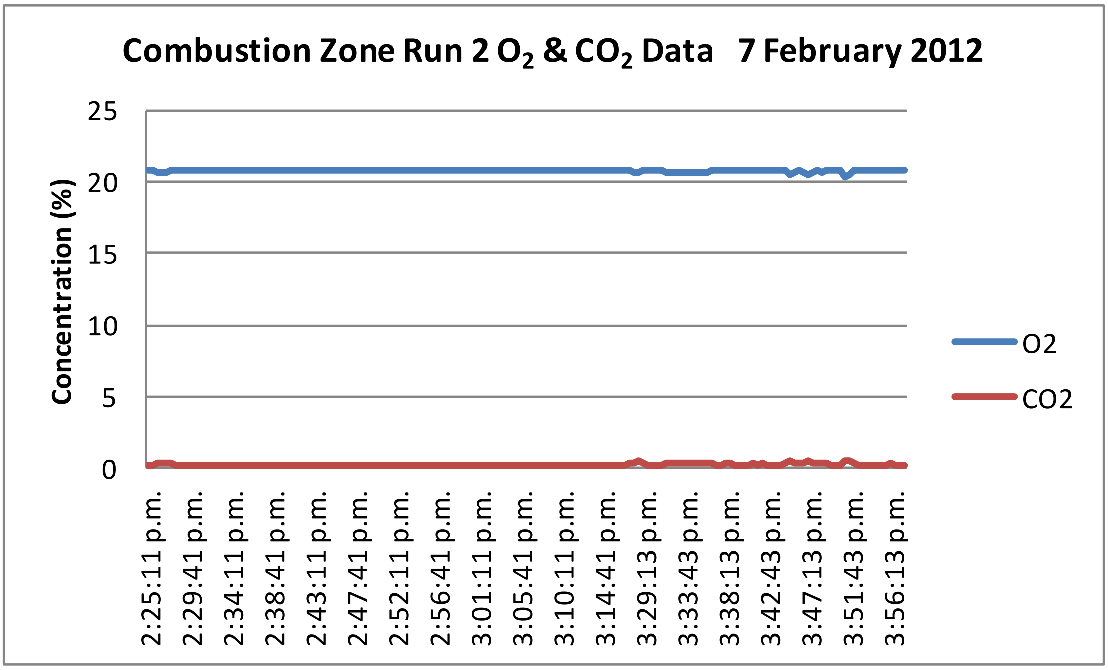
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

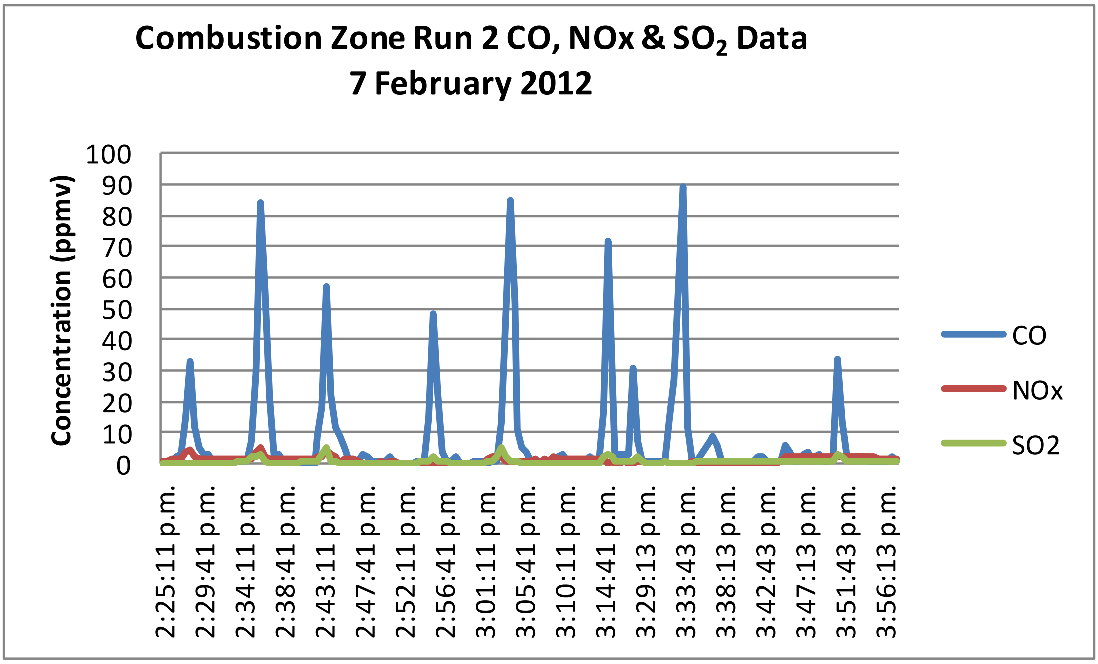
Appendix D Combustion Gas Data Graphs

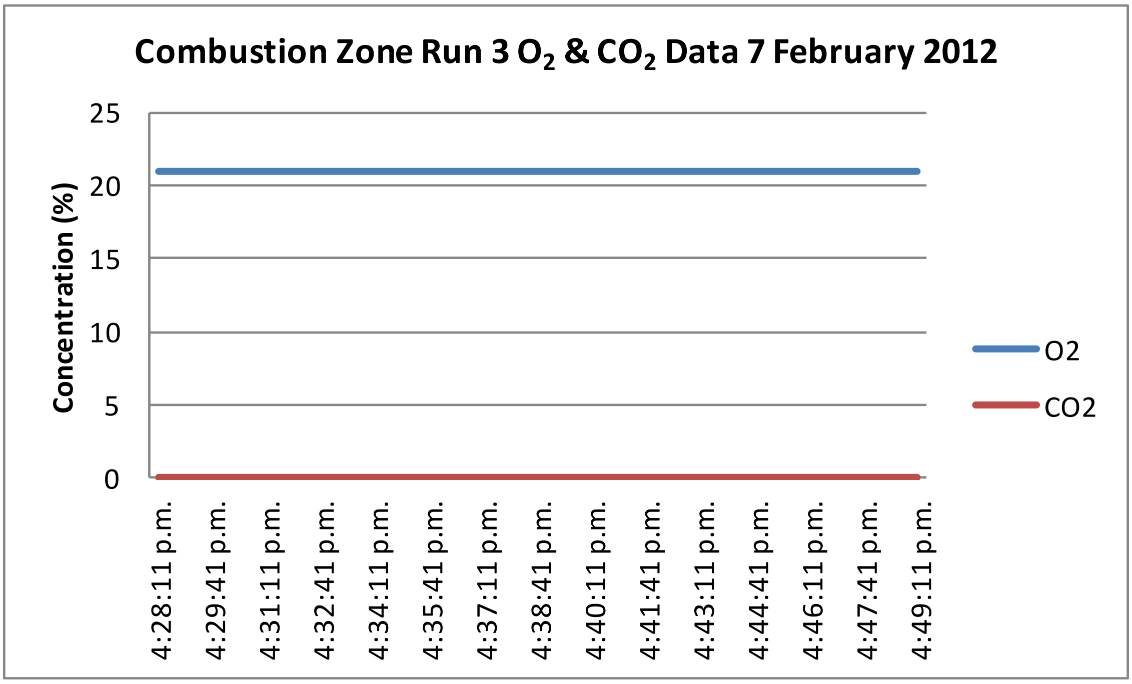
This Appendix contains 4 pages including cover.

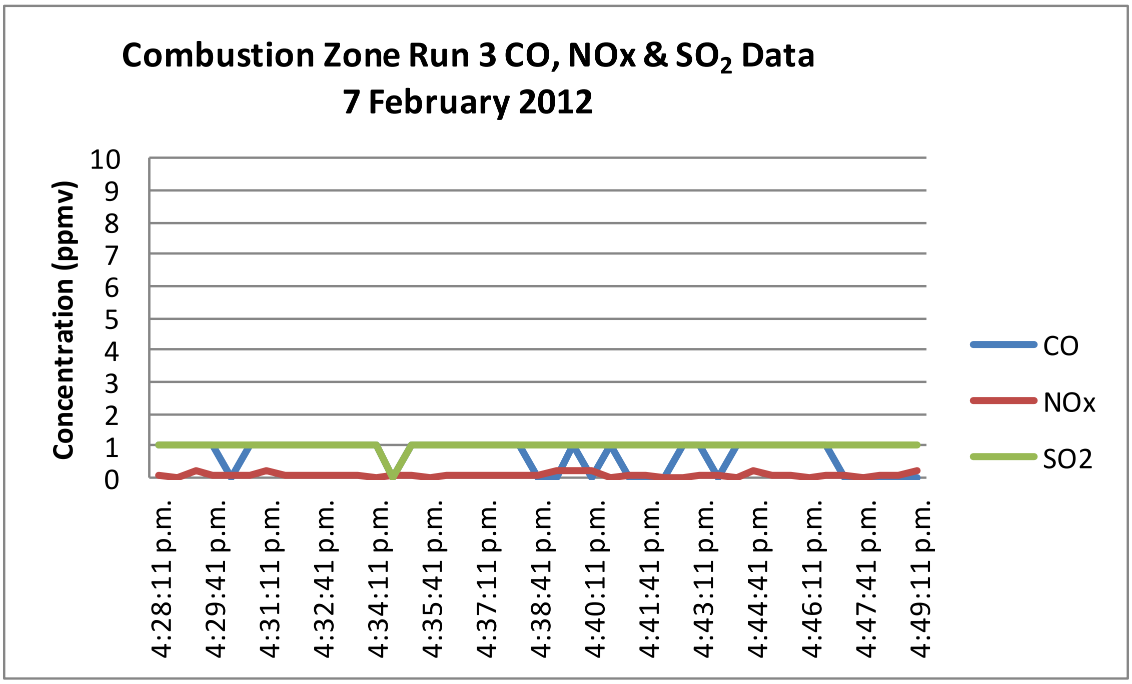

Combustion Zone Run 1 O₂ & CO₂ Data 7 February 2012
Concentration (%)
25
20
15
10
5
0
12:40:55 p.m.
12:44:25 p.m.
12:47:55 p.m.
12:51:25 p.m.
12:54:55 p.m.
12:58:25 p.m.
1:01:55 p.m.
1:05:25 p.m.
1:08:55 p.m.
1:12:25 p.m.
1:15:55 p.m.
1:19:25 p.m.
1:22:55 p.m.
1:26:25 p.m.
1:29:55 p.m.
1:43:27 p.m.
1:46:57 p.m.
1:50:27 p.m.
O2
CO2


Combustion Zone Run 1 CO, NOx & SO₂ Data
7 February 2012
Concentration (ppmv)
120
100
80
60
40
20
0
12:40:55 p.m.
12:44:25 p.m.
12:47:55 p.m.
12:51:25 p.m.
12:54:55 p.m.
12:58:25 p.m.
1:01:55 p.m.
1:05:25 p.m.
1:08:55 p.m.
1:12:25 p.m.
1:15:55 p.m.
1:19:25 p.m.
1:22:55 p.m.
1:26:25 p.m.
1:29:55 p.m.
1:43:27 p.m.
1:46:57 p.m.
1:50:27 p.m.
CO
NOx
SO2


Combustion Zone Run 2 O₂ & CO₂ Data 7 February 2012
Concentration (%)
25
20
15
10
5
0
2:25:11 p.m.
2:29:41 p.m.
2:34:11 p.m.
2:38:41 p.m.
2:43:11 p.m.
2:47:41 p.m.
2:52:11 p.m.
2:56:41 p.m.
3:01:11 p.m.
3:05:41 p.m.
3:10:11 p.m.
3:14:41 p.m.
3:29:13 p.m.
3:33:43 p.m.
3:38:13 p.m.
3:42:43 p.m.
3:47:13 p.m.
3:51:43 p.m.
3:56:13 p.m.
O2
CO2


Combustion Zone Run 2 CO, NOx & SO₂ Data
7 February 2012
Concentration (ppmv)
100
90
80
70
60
50
40
30
20
10
0
2:25:11 p.m.
2:29:41 p.m.
2:34:11 p.m.
2:38:41 p.m.
2:43:11 p.m.
2:47:41 p.m.
2:52:11 p.m.
2:56:41 p.m.
3:01:11 p.m.
3:05:41 p.m.
3:10:11 p.m.
3:14:41 p.m.
3:29:13 p.m.
3:33:43 p.m.
3:38:13 p.m.
3:42:43 p.m.
3:47:13 p.m.
3:51:43 p.m.
3:56:13 p.m.
CO
NOx
SO2


Combustion Zone Run 3 O2 & CO2 Data 7 February 2012
Concentration (%)
25
20
15
10
5
0
O2
CO2
4:28:11 p.m.
4:29:41 p.m.
4:31:11 p.m.
4:32:41 p.m.
4:34:11 p.m.
4:35:41 p.m.
4:37:11 p.m.
4:38:41 p.m.
4:40:11 p.m.
4:41:41 p.m.
4:43:11 p.m.
4:44:41 p.m.
4:46:11 p.m.
4:47:41 p.m.
4:49:11 p.m.


Combustion Zone Run 3 CO, NOx & SO2 Data
7 February 2012
Concentration (ppmv)
10
9
8
7
6
5
4
3
2
1
0
CO
NOx
SO2
4:28:11 p.m.
4:29:41 p.m.
4:31:11 p.m.
4:32:41 p.m.
4:34:11 p.m.
4:35:41 p.m.
4:37:11 p.m.
4:38:41 p.m.
4:40:11 p.m.
4:41:41 p.m.
4:43:11 p.m.
4:44:41 p.m.
4:46:11 p.m.
4:47:41 p.m.
4:49:11 p.m.

Appendix IV

Ambient air quality survey

Memorandum

To Director of Environmental Quality, Gary Bedford
From Scientific Officer – Air Quality, Brian Cheyne
Document 1023534 (PDF Document 1040675)
Date 25 March 2012
Corrected January 2019 following receipt of finalised laboratory report

Ambient air quality survey during flaring of hydro-carbon residuals within the well hydro-fracturing wastes

Introduction

Figure 1 Flaring of natural gas above fracture fluids (water-based with volatile compounds)

On 7-8 February 2012 the Taranaki Regional Council carried out an ambient air quality survey at a hydrocarbon well exploration site. The well had been hydraulically fractured, with recovery of fracturing fluids. Normal oilfield practice is to dispose of this material offsite, but under non-standard conditions the recovered fluids may have to be flared. Exploration companies and the Council considered it desirable to obtain reference emission and ambient data from a simulated flare, in order to base environmental assessments of flaring practice upon actual data. A flaring simulation was therefore conducted on 7-8 February 2012, with the active assistance of the exploration company concerned. The event was monitored both for emissions (reported separately) and for downwind (ambient) air quality (reported herein).

The composition of the recovered fracturing fluids is reported separately. In summary, the fluids consisted of water and ceramic beads or sand to about 98%, together with various biocides, friction reducing additives, scale inhibitors, clay stabilisers, surfactants, gelling agents, and cleaners. Some of the latter are volatile and potentially flammable. Disposal by flaring consists of discharging the fluids into a flare pit (see photograph 1), where a natural gas-fuelled flare is used to provide heat to evaporate the fluid to dryness while providing a means to combust any flammable vapours. Emissions from the pit therefore consist of a mixture of products of combustion and vapour from the surface of the fluids.

The ambient survey involved the measurements by portable meter and passive absorption tubes of the following parameters - fine particulates (PM1, 2.5 and 10), carbon monoxide (CO), carbon dioxide (CO2), formaldehyde (HCHO), and volatile organic compounds focusing on benzene, toluene, ethyl benzene and xylene (BTEX). The findings of this study are presented in this memorandum.

Methodology[1]

- Ambient PM 1, 2.5, and 10 monitoring was conducted using a portable data logging TSI 'DustTrak DRX' at multiple locations downwind from the flare pit over a six hour period on 7 February 2012. Sampling was conducted by setting up the monitor approximately one meter from ground level at various locations. The instrument was logging an instantaneous measurement every second, and then converting this data to generate one minute averages, over the duration of the sampling period. Readings were as generated by the instrument i.e. no correction factors were applied to compensate for any differences between the factory calibration of light scattering vs particulate mass and reflectivity, and conditions encountered during this study

- Ambient CO and CO2 monitoring was undertaken using a portable data logging TSI 7565 'Q-Trak IAQ' analyser at multiple locations downwind from the flaring pit over a six hour period adjacent to DustTrak monitor. The Q-Trak CO/CO2 monitor also was logging an instantaneous measurement every second, and then converting this data to generate one minute averages, over the duration of the sampling period

- Ambient Formaldehyde (HCHO) monitoring was conducted at five stationary sites around the well exploration site using UMEX-100 passive samplers deployed for a period of approximately 8 hours.

- Ambient Volatile Organic Compounds (VOC) sampling was conducted at the same five stationary sites side by side with formaldehyde samplers using 3M passive absorption badges.

Meteorological conditions

The meteorological data presented in this memorandum were collected at the nearest meteorological site, located in New Plymouth airport (approximately 10 km due west along the coast). The wind rose covering the period from 1200 to 1700 on 7 February is presented in Figure 2. In addition, for the site wind direction observations, a wind sock was erected next to the flaring pit.

The wind data displays a stable moderate/fresh breeze from south to south-east[2]

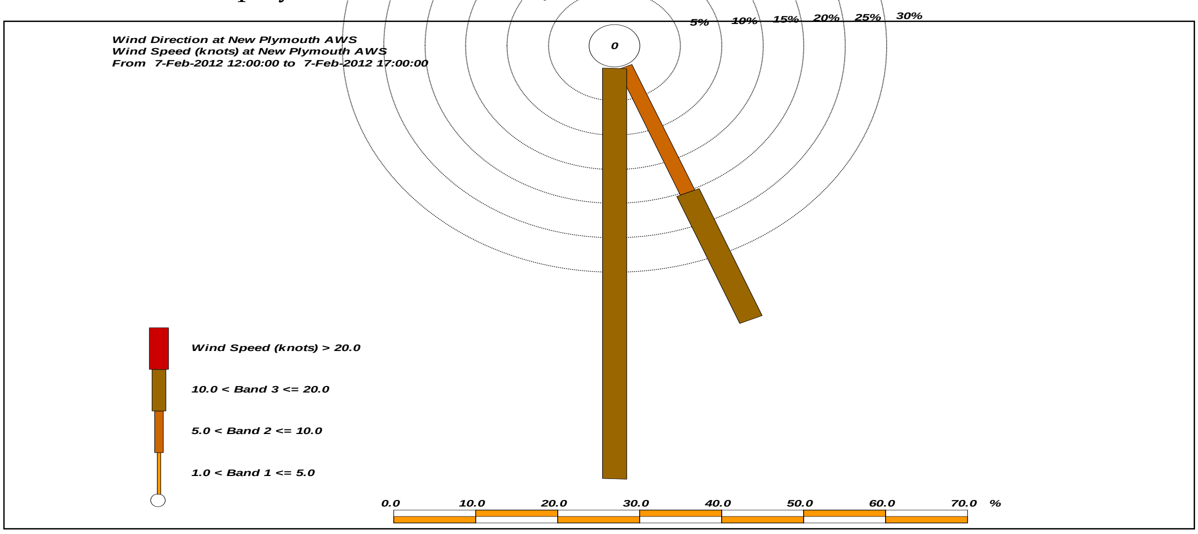


Figure 2 New Plymouth Airport wind data

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[1] For reference on the manufacturer specifications and methodologies refer to Appendix 3

[2] As defined by Meteorological Service of New Zealand Ltd

PM1, 2.5 and 10 monitoring

Results

The sampling locations of the DustTrak are presented in Appendix 1 and details of the sampling results are summarised in Table 1.

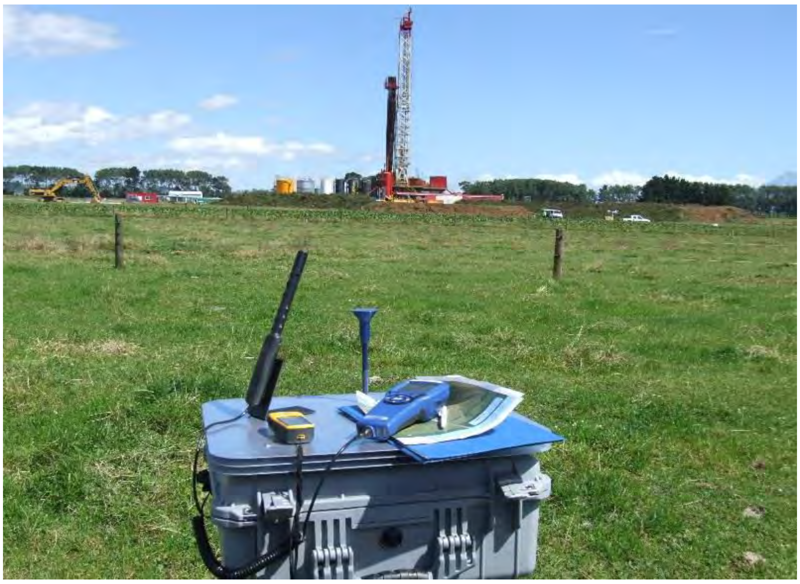

Figure 3 DustTrak and Q-Trak set up at Site (e)

Table 1 Sites, sampling periods, and results for carbon monoxide, carbon dioxide, and particulate measurements

Site ID		GPS	Start Stop (NZST)	Time sampl. (min)	CO (ppm)	CO2 (ppm)	PM1 µg/m³	PM2.5 µg/m³	PM10 µg/m³	PM2.5 µg/m³ 24 hour equiv	PM10 µg/m³ 24 hour equiv
a	Min Max Mean	1713592 5682646	11:50 13:00	70	Nil	296 371 312	No Data	No Data	No Data	No Data	No Data
b	Min Max Mean	1713562 5682694	13:10 13:57	47	Nil	333 382 349	0.00 1.00 0.04	0.00 2.00 0.84	2.00 12.00 2.72	0.47	1.52
c	Min Max Mean	1713603 5682707	14:02 14:29	27	Nil	347 370 358	0.00 13.34 0.55	0.00 14.30 0.80	2.00 19.00 5.05	0.41	2.57
d	Min Max Mean	1713637 5682709	14:47 14:58	11	Nil	342 354 348	0.00 2.00 0.87	2.00 4.00 2.26	5.00 38.00 12.71	0.99	5.55
e	Min Max Mean	1713550 5682755	15:07 15:39	32	Nil	336 350 344	0.00 10.41 0.22	1.00 12.26 1.35	4.00 14.41 5.87	0.71	3.07
f	Min Max Mean	1713601 5682770	15:44 16:03	19	Nil	339 361 344	0.00 0.00 0.00	1.00 2.00 1.17	3.09 11.00 5.97	0.56	2.86
g	Min Max Mean	1713661 5682782	16:09 16:45	36	Nil	336 361 346	0.00 0.00 0.00	1.00 2.00 1.02	6.00 18.00 9.7	0.54	5.18

The results in Table 1 represent the average ambient concentration when taken over the entire period of exposure. It is recognised that in fact the ambient concentration will have varied during this period. In particular, it is noted that the period of measurement was shorter than the comparable guideline, and so the 24-hour average if measured during the study would be lower than that shown in Table 1 for the actual period of exposure (up to 570 minutes).

The issue is therefore that of estimating an indicative maximum concentration over the time period of interest. For comparison with the Ministry for the Environment guideline for PM10 and WHO guideline for PM2.5, from the average concentration measured, it is desirable to calculate an indicative theoretical maximum 24 hour concentration that may have occurred should the emission have continued for a full 24 hours. There are mathematical equations used by air quality scientists to predict the maximum concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, variations in activity processes, diurnal variation, etc. Nevertheless, they are conservative (they tend to over-estimate) and have some recognition of validity as a screening tool. One formula in general use[3] is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^p$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from shorter time periods to longer time periods, using p = 0.17 gives the most conservative estimate (i.e. the highest calculated result for time period t2 given a measured concentration for time period t1).

Using the 'worst case' factor of p = 0.17, the monitoring data reported herein has also been converted to equivalent 'maximum' 24 hour exposure levels (Table 1).

Standard and guidelines for particulate

In September 2004 the Ministry for the Environment promulgated the National Environmental Standards (NES) relating to certain air pollutants. The NES for PM10 is 50µg/m^3 (24-hour average). The World Health Organization (WHO) in 2006 set a guideline for PM2.5 of 25µg/m^3 (24-hour average). Guideline values for PM1.0 have not been sighted.

Discussion

The highest PM10 result for the entire dataset across all sites was 38.0µg/m^3 (1 minute average) and the mean of all results for 1 minute averages was 6.61µg/m^3 , which is equal numerically to 13.2% of the NES of 50µg/m^3 (24 hour average). The highest PM2.5 result for the entire dataset across all sites was 14.3/m^3 (1 minute average), and the mean of all results for 1 minute averages was 1.32µg/m^3. This is equal numerically to 5.3% of the WHO guideline for PM2.5 of 25µg/m^3 (24 hour average).

PM1.0 levels never reached more than a trivial level.

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[3] *Workbook of atmospheric dispersion estimates*, United States Environmental Protection Agency, 1970, author B Turner

Carbon monoxide

Ministry for the Environment ambient guideline

The NES for CO is 10 mg/m^3 expressed as a running 8-hour mean.

Results

The sampling locations of the Q-Trak are presented in Appendix 1 and details of the sampling results are summarised in Table 1.

There was no ambient carbon monoxide detected during the entire monitoring period.

The range of the meter used was 0-500 ppm. Under ambient conditions, 1 ppm CO is equivalent to 1.14 mg/m^3. Arbitrarily using 1% of full scale deflection as the limit of detection for the meter, this suggests the limit of detection could be taken as being 5 ppm (5.7 mg/m^3).

Carbon dioxide

Background

The background level of carbon dioxide in New Zealand's atmosphere is around 390ppm by volume. CO2 is not classified as toxic or harmful at natural concentrations.

Results

The sampling locations of the Q-Trak are presented in Appendix 1 and details of the sampling results are summarised in Table 1.

Discussion

Carbon dioxide was measured at seven locations downwind of the flaring pit. The average CO2 concentration for the entire dataset was 343ppm, with a lowest value of 296ppm and a highest value of 382ppm. Mean results were largely consistent across all sites. These findings would suggest that there were no influences on ambient CO2 concentrations from the flaring activities.

Formaldehyde

Ministry for the Environment ambient guideline

Formaldehyde appears on the MfE list of toxic air pollutants, due to its classification as a probable carcinogen. MfE cites a guideline value for formaldehyde of 100µg/m^3, intended to prevent acute effects. Formaldehyde is an odorant with an odour detection threshold of 60µg/m^3, at which level there is little or no concern about human discomfort. The threshold of irritation (skin, eyes, and respiratory tract) is reported to be as low as 100µg/m^3 after short-term exposure, but significant increases in symptoms of irritation start at levels above 300µg/m^3 in healthy subjects. In order to avoid complaints of sensitive people about air quality, the formaldehyde concentration should be below 100µg/m^3 as a 30-minute average, and this is recommended as an air quality guideline value.

Summary of method

Passive absorption samplers that absorb the target gas into activated filter paper and are subsequently analysed using ion chromatography, are employed to determine the average concentration of the gas in the air during the time of exposure. Formaldehyde concentration is reported as µg/m³ (mass of formaldehyde per volume of air).

Results

The site locations of the HCHO passive samplers are presented in Appendix 2 and details of the sampling results are summarised in Table 2. The wellsite is not recorded on the aerial photograph used for showing site locations.

Figure 4 HCHO and BTEX samplers at site 2

The results in Table 2 represent the average ambient concentration when taken over the entire period of exposure. It is recognised that in fact the ambient concentration will have varied during this period. In particular, it is noted that the period of measurement was longer than the comparable guideline, and so the highest 30-minute average during the study would be higher than that shown in Table 2 as the average for the entire period (up to 570 minutes).

The issue is therefore that of estimating an indicative maximum concentration over the time period of interest. For comparison with the Ministry for the Environment guideline for formaldehyde, from the average concentration measured, it is desirable to calculate an indicative theoretical maximum 30 minutes concentration that may have occurred during the exposure period. There are mathematical equations used by air quality scientists to predict the maximum concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, variations in activity processes, diurnal variation, etc. Nevertheless, they are conservative (they tend to over-estimate) and have some recognition of validity as a screening tool. One formula in general use is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^p$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from longer time periods to shorter time periods, using p = 0.20 gives the most conservative estimate (i.e. the highest calculated result for time period t2 given a measured concentration for time period t1).

Using the 'worst case' factor of p = 0.20, the monitoring data reported below has also been converted to equivalent 'maximum' 30-minutes exposure levels (Table 2).

Please note: the same calculation methodology is used for the BTEX results recalculation which is discussed in the following section.

Table 2 Results of ambient formaldehyde monitoring

Site	Where	Time: start stop	Time total Min.	Formaldehyde	
				Lab. Results (µg/m³)	30 min Calc. (µg/m³)
1	70 m. downwind	08:18 16:37	499	11.4	20.0
2	Cnr. SH3 and side road, 300m away, approx cross-wind	07:40 17:10	570	3.1	5.59
3	House 400 m. NW (veering west of downwind)	07:55 17:15	560	3.2	5.75
4	90m. directly upwind	08:06 17:00	534	6.7	11.9
5	140 m. downwind	08:38 16:42	484	2.9	5.06
MfE guidelines 2002 (30 min average)					100

Discussion

Results from the formaldehyde survey ranged from 2.9 to 11.4 µg/m, and the calculated 'equivalent' 30-minute exposure concentrations of 5.06 – 20.0µg/m³ are well below the Ministry for the Environment's (MfE) ambient guideline of 100µg/m³. Even allowing for the arbitrary basis of the calculated equivalent concentrations, the survey showed that there is no evidence of an elevation in background formaldehyde concentrations beyond a distance of 140 metres, and at a distance of within 70 metres levels of formaldehyde still remain far below the guideline value.

BTEX

One group of emissions associated with condensate development and production are those linked with hydrocarbons themselves, which may be composed of methane, ethane, and liquid condensate, which may include volatile organic compounds (VOCs). The VOCs that are especially impactful on health are benzene, toluene, ethyl benzene, and xylene (which has three isomers: o-xylene, m-xylene and p-xylene). These particular VOC are collectively referred to as BTEX.

Guidelines

In New Zealand, benzene is the only member of the BTEX group subject to a national guideline value. The Ministry for the Environment guideline, based on benzene's known mutagenic and carcinogenic properties, is 10µg/ m³ as an annual average, reducing to 3.6µg/m³ in 2010. There are no national ambient air quality guidelines for toluene, ethylbenzene or xylene. The Ministry for the Environment had prepared an internal technical document "Health Effects of Eleven Hazardous Air Contaminants and Recommended Evaluation Criteria" (October 2000) that suggested a 1 hour average value of 22 µg/m³ for Benzene, 500 µg/m³ for Toluene and 1000 µg/m³ for Xylene as recommended guidelines values. However, these recommendations were not carried through to the final Ministry for the Environment guidelines published in 2002.

Results

The site locations of the BTEX passive samplers are presented in Appendix 2 and details of the sampling results are summarised in Table 3. In this study concentrations of o-, p-, and m-xylene were summed and reported as xylene total. The laboratory analysis includes a step of measuring the quantity of BTEX compounds collected on the passive badges, and converting this to an equivalent ambient concentration. When analysis of the field blank shows the presence of BTEX compounds, it is appropriate to consider subtracting this blank result from the quantities detected on the remaining samples (those actually deployed in the field survey), before calculating causal ambient concentrations. Unadjusted results give the maximum concentration that could have been present; results adjusted for blank corrections will give a result closer to the more likely 'actual' result. In Table 3 below, the adjusted results are shown alongside the uncorrected results. A conservative approach will be to consider the 'actual' concentration lies between the two figures. *(Text added in January 2019)*

The results in Table 3 represent the average ambient concentration when taken over the entire period of exposure. It is recognised that in fact the ambient concentration will have varied during this period. In particular, it is noted that the period of measurement was longer than the comparable guideline, and so the highest 60-minute average within the study period would be higher than that shown in Table 3 applying across the entire period (up to 570 minutes).

The issue is therefore that of estimating an indicative maximum concentration over the time period of interest. For comparison with the Ministry for the Environment guideline values for the various BTEX, from the average concentration measured, it is desirable to calculate an indicative theoretical maximum 60 minutes concentration that may have occurred during the exposure period.

Using the same approach as outlined above for formaldehyde, and using the 'worst case' factor of p = 0.20, the monitoring data reported in Table 3 has also been converted to equivalent 'maximum' 60-minutes exposure levels, and this data is included in Table 3.

Table 3 Actual and recalculated BTEX results around well site

Site	Where	Time: start stop	Time total Min.	Benzene			Toluene			Ethyl Benzene			o,m,p – Xylene Total		
				Lab. Results	1 hr. Calc[1].	1 hr. Calc[2].	Lab. Results	1 hr. Calc[1].	1 hr. Calc[2].	Lab. Results	1 hr. Calc[1].	1 hr. Calc[2].	Lab. Results	1 hr. Calc[1].	1 hr. Calc[2].
1	70 m. downwind	08:18 16:37	499	12.2	18.6	11.1-18.6	32.5	49.7	41.1-49.7	3.06	4.7	1.0-4.7	16.6	25.4	14.7-25.4
2	Cnr. SH3 and side road, approx 300m crosswind	07:40 17:10	570	<4.08	<6.4	<6.4	8.4	13.2	5.0-13.2	<2.01	3.1	<3.7	<6.00	9.4	<10.7
3	House 400 m. NW	07:55 17:15	560	<4.15	<6.5	<6.5	4.5	7.03	<8.1	<2.04	3.1	<3.7	<6.02	9.4	<10.7
4	90m. upwind	08:06 17:00	534	<4.36	<6.75	<6.8	11.9	18.4	10.2-18.4	<2.14	3.3	<3.7	<6.32	9.8	<10.7
5	140 m. downwind	08:38 16:42	484	8.43	12.8	5.3-12.8	12.5	19.0	10.8-19.0	<2.37	3.6	<3.7	<7.04	10.7	<10.7
Blank				<4.8	<7.5	-	<5.3	<8.2		<2.4	<3.7		<7.0	<10.7	
MfE recommended guidelines (2000), one -hour average.				-	22		-	500		-	None		-	1000	

* All results in $\mu g/m^3$

Calc[1] 1-hour average ambient concentration, no blank correction

Calc[2] 1-hour average ambient concentration adjusted for blank recovery (*This data added in January 2019)*

Discussion

Results (average exposure over the duration of the survey) from the BTEX survey ranged from <4.08-12.2 µg/m³ for benzene, <4.5-32.5 µg/m³ for toluene, <2.01-3.06 µg/m³ for ethyl benzene, and <6.00-16.6 µg/m³ for xylenes. For all individual species, the highest concentrations were detected at the location closest to and downwind of the flare pit (70 metres), and the second highest concentrations were detected at the location 140 metres downwind, indicating that the flare was a major source.

The variations in measured concentrations (without applying a correction for the blanks) were considerable. In the case of benzene, the highest concentration was 3 times higher than the lowest; for toluene more than 7 times; for ethyl benzene less than 1.5 times higher; and for xylenes 2.8 times higher. This implies that the flare pit was a significant source of toluene emissions, less so for benzene and xylene, and only a minor source at most for ethyl benzene. For benzene and toluene, the results at the location 140 metres downwind were still significantly higher than the background levels; whereas for ethyl benzene and xylene, concentrations 140 metres downwind were approaching or the same as background concentrations. If a correction for laboratory blank detections is taken into account, then only the site 70 metres downwind of the flarepit showed a detectable increase in levels of ethyl benzene and xylenes.

The calculated ‘equivalent’ 60-minute exposure concentrations range from <6.4-18.8 µg/m³ for benzene, <7.03-49.7 µg/m³ for toluene, and <9.4-25.4 µg/m³ for xylenes.

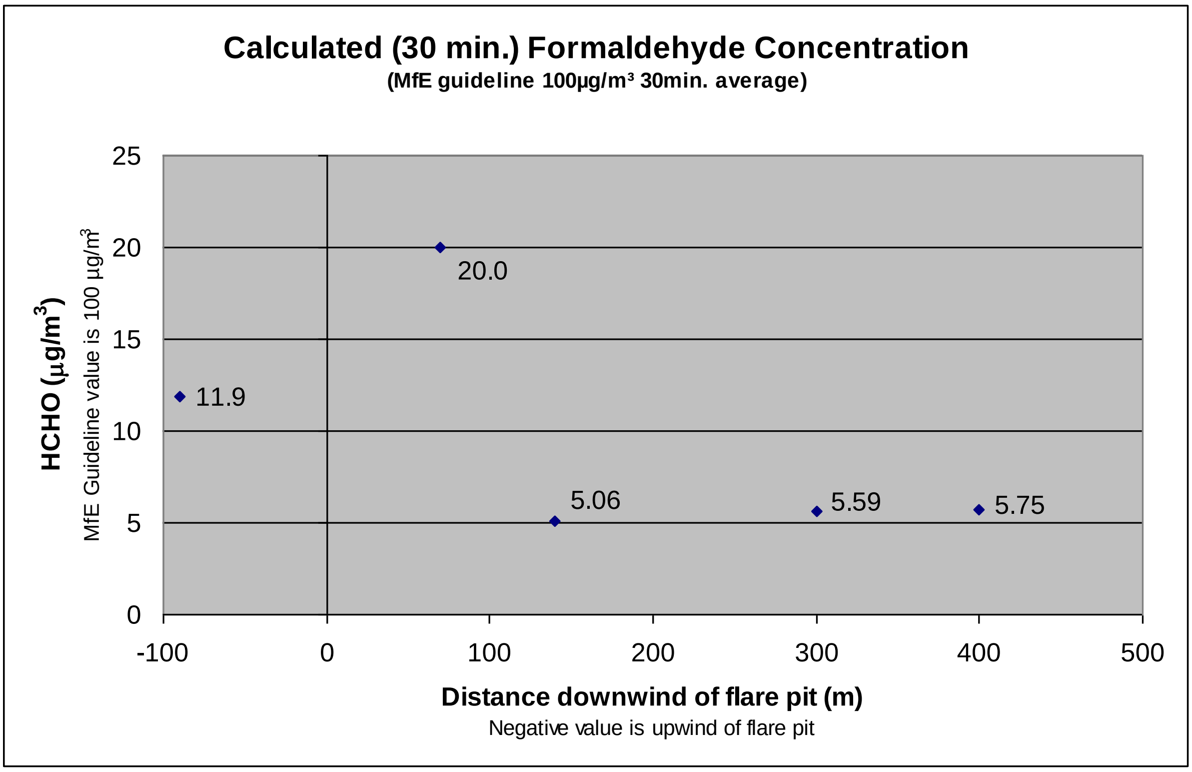
These results are below (benzene) or well below (toluene, xylene) the respective MfE 60-minute guideline values of 22 µg/m³ for benzene (85%), 500 µg/m³ for toluene (10%), and 1000 µg/m³ for xylene (2.5%).

Even allowing for the arbitrary basis of the calculated equivalent concentrations, the survey showed that at a distance of within 70 metres levels of BTEX still remain below guideline values.

The survey showed that in terms of BTEX that approach most closely guideline values, benzene is of most interest; in terms of highest concentrations, toluene is of most interest.

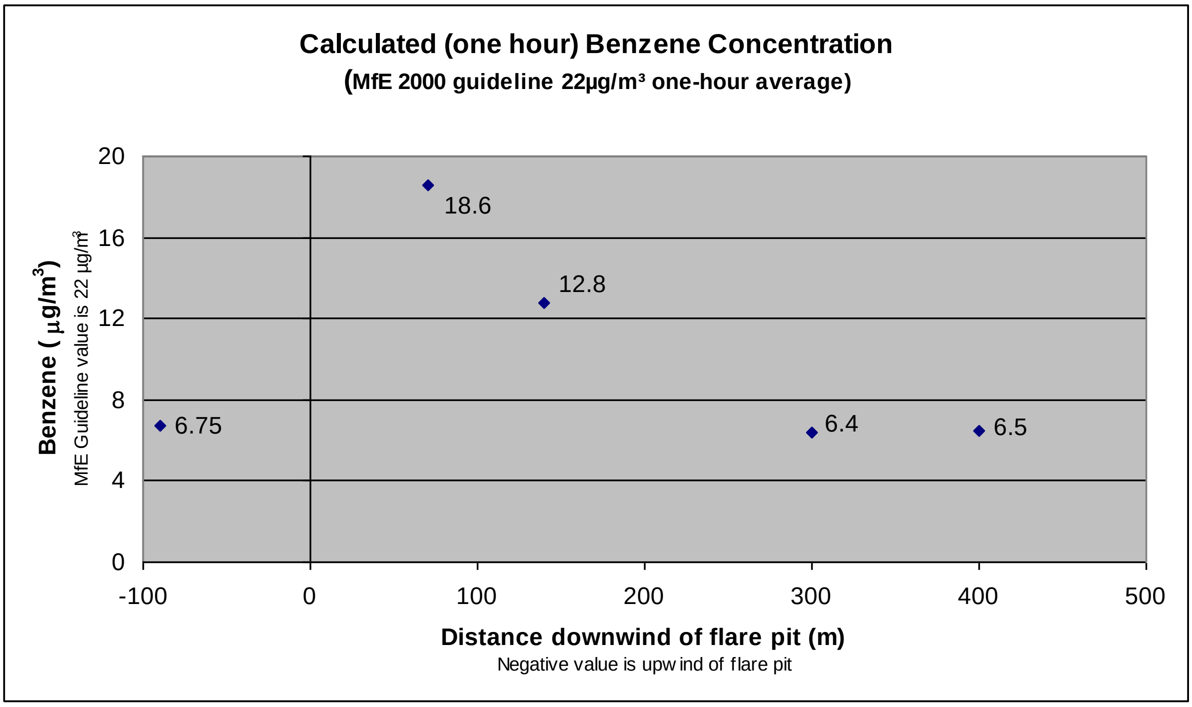
Graphs

Formaldehyde



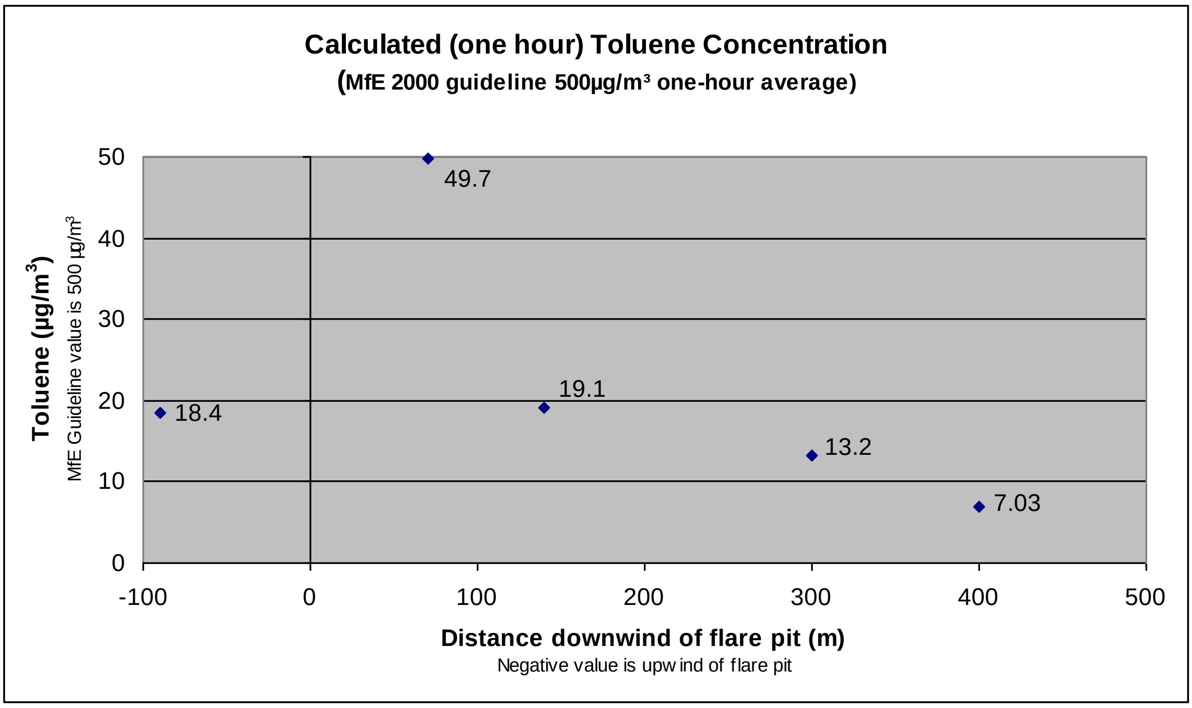
Graph 1 Formaldehyde concentrations with relation to the distance from the flare pit

Benzene (nb numerical data not corrected for detection of benzene in blank. See Table 3)



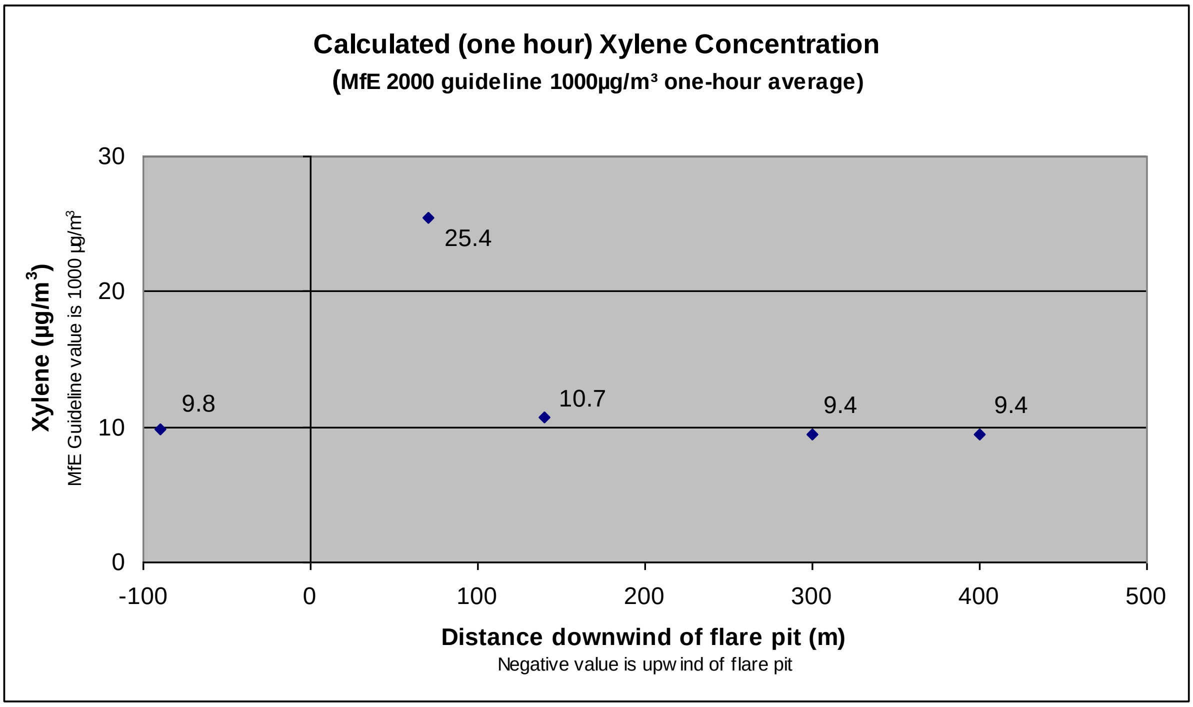
Graph 2 Benzene concentrations with relation to the distance from the flare pit

Toluene (nb numerical data not corrected for detection of toluene in blank. See Table 3)



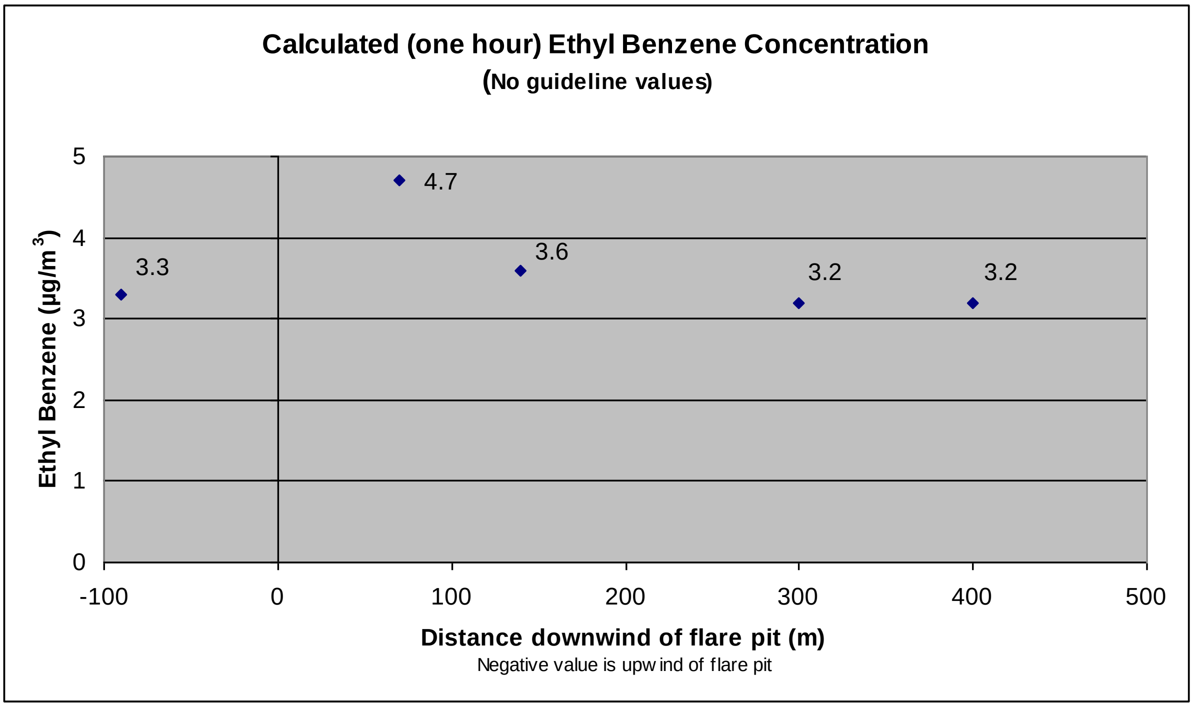
Graph 3 Toluene concentrations with relation to the distance from the flare pit

Xylene (nb numerical data not corrected for detection of xylene in blank. See Table 3)



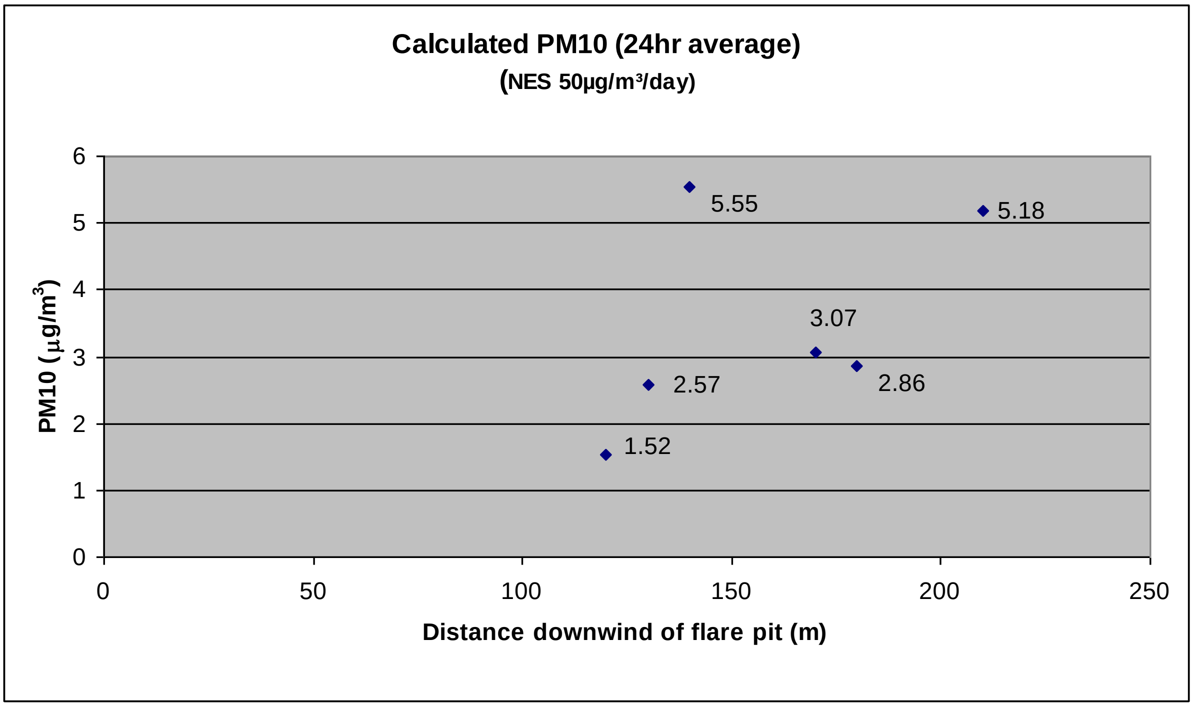
Graph 4 Xylene Total concentrations with relation to the distance from the flare pit

Ethyl Benzene (nb numerical data not corrected for detection of ethyl benzene in blank. See Table 3)



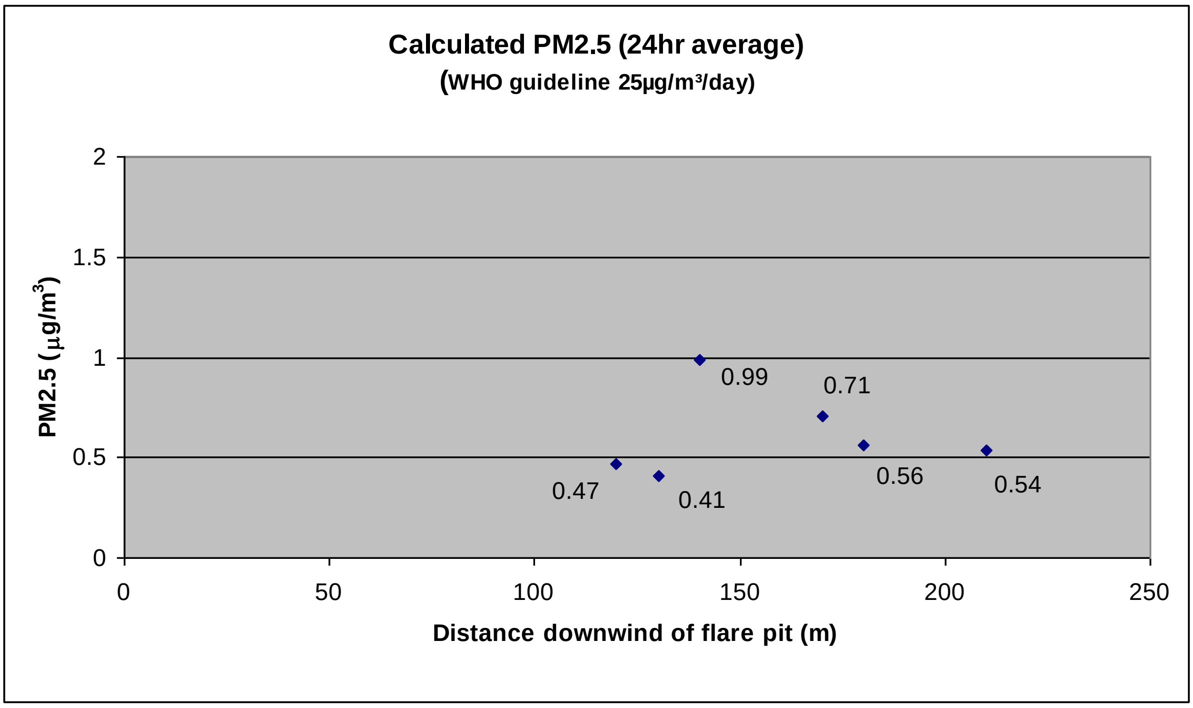
Graph 5 Ethyl Benzene concentrations with relation to the distance from the flare pit

PM10



Graph 6 Downwind PM10 values with relation to the distance from the flare pit

PM2.5

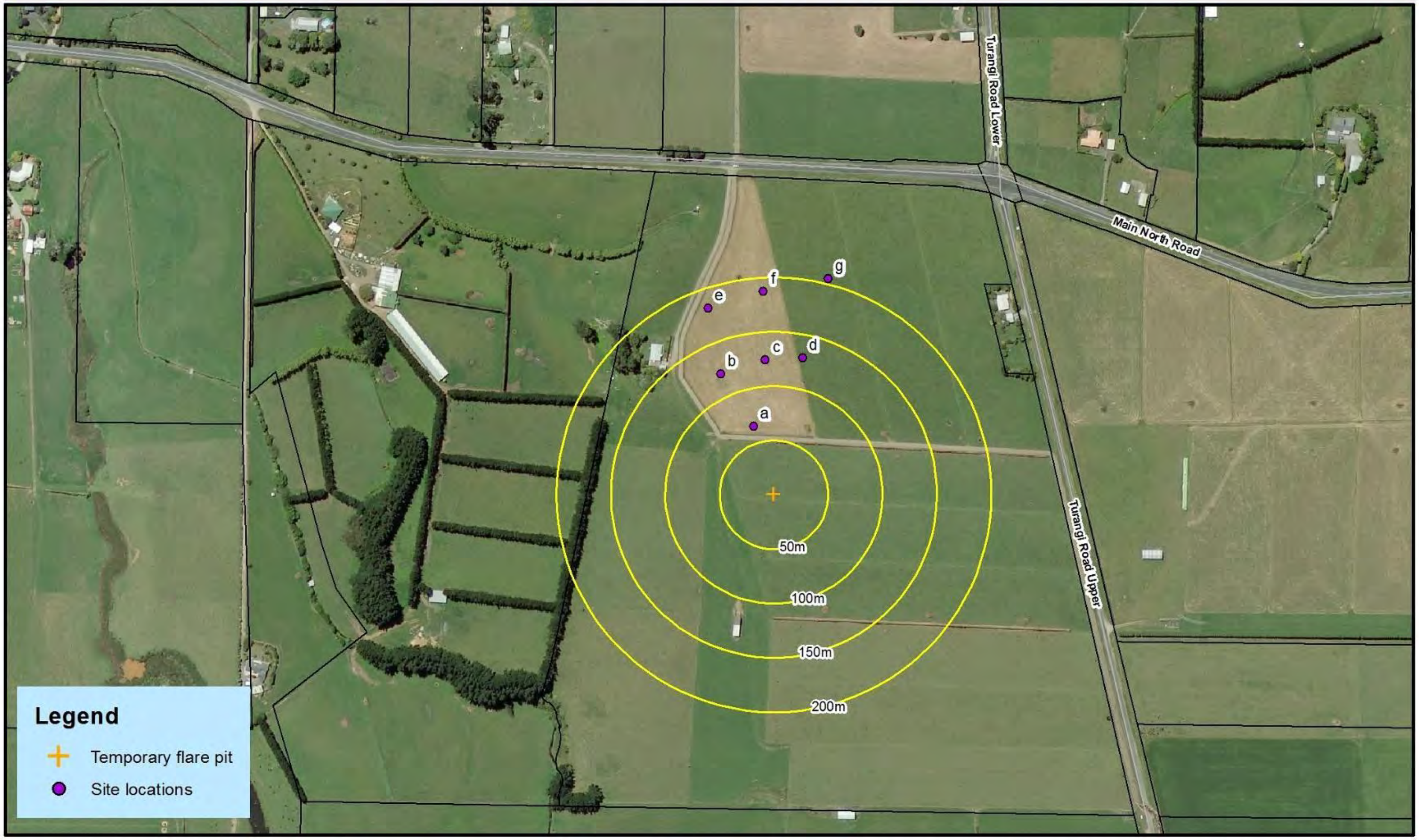


Graph 7 Downwind PM2.5 values with relation to the distance from the flare pit

Appendix I

Well Site CO, CO2 and PM (1, 2.5, 10)
Site Locations

Well Site CO, CO_2 and PM (1, 2.5, 10) Site Locations



SCALE 1:4,500

DATE:08 February 2012

Taranaki Regional Council

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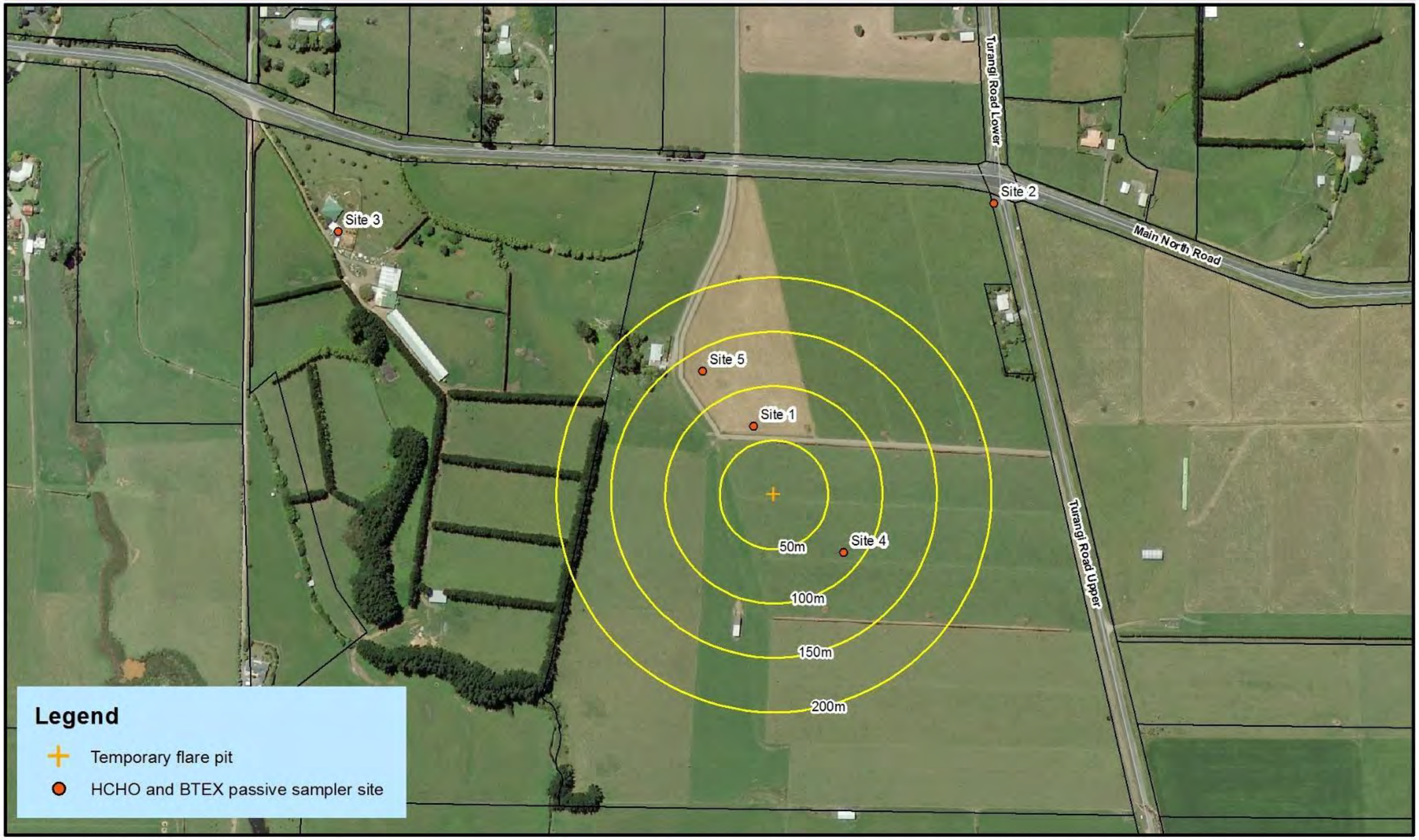
Aerial photography was flown in 2007.

Appendix II

Well Site HCHO and BTEX Passive Samplers Site Locations

Well Site HCHO and BTEX Passive Samplers



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DATE:08 February 2012

Taranaki Regional Council

Aerial photography was flown in 2007.

Appendix III

Manufacturer specifications of equipment and samplers used

Appendix III (a)

3M Organic Vapour Monitor

Technical Data Bulletin

OH&ESD

Organic Vapor Monitor Sampling and Analysis Guide

3M™ Organic Vapor Monitors 3500/3510 and 3M™ Organic Vapor Monitors 3520/3530

3M manufactures a variety of organic vapor monitors. The 3M Organic Vapor Monitors 3500 and 3510 are identical in that they contain a single charcoal adsorbent pad. The 3500 monitor is designed to be analyzed by the user or by an independent laboratory. The 3510 includes a prepaid analysis from 3M for up to three compounds per monitor. The 3M Organic Vapor Monitors 3520 and 3530 are also identical in that they both contain two adsorbent pads. The 3520 monitor is designed to be analyzed by the user or by an independent laboratory. The 3530 includes a prepaid analysis from 3M for up to three compounds per monitor.

This Guide summarizes information on sampling and analysis of the 3M organic vapor monitors. The Guide is divided into 4 sections, see below:

For more Information
Technical Assistance:
1-800-243-4630
Sales Assistance: 1-800-896-4223
Fax-on-Demand: 1-800-646-1655
Internet: www.3M.com/occsafety
Material Safety Data Sheets
(MSDS): 1-651-737-7222

Section 1.0: Sampling Information

1.1 Standards

Most countries have occupational exposure limits (OEL) for chemical substances in the workplace. In the United States the ACGIH Threshold Limit Values (TLV) and the OSHA Permissible Exposure Limit (PEL) standards are the most cited contaminant airborne standards. TLVs are guidelines and are not legal standards in the U.S. but are legally enforceable in some countries. They are reviewed on a periodic basis and changed or reviewed if sufficient data warrants.

There are three categories for TLVs. First, "Threshold Limit Value-Time Weighted Average (TLV-TWA)—the time weighted average concentration for a normal 8-hour workday and a 40 hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects." Second, Threshold Limit Value-Short Term Exposure Limit (TLV-STEL)—the concentration to which workers can be exposed continuously for a short period of time without suffering 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury." The STEL is defined as a 15 minute TWA exposure which should not be exceeded at any time during a workday even if the 8 hour TWA is within the TLV-TWA. Third, Threshold Limit Value-Ceiling (TLV-C) — the concentration that should not be exceeded during any part of the working exposure."

The OSHA standards (PELs) can be found in Federal Register 29 CFR 1910 and are legally enforceable standards in the U.S. OSHA PELs have the same three categories as TLVS.

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The 3M organic vapor monitors can be used to sample 8 hour TLV-TWAs and PELs. The organic vapor monitors can also be used to sample TLV-STELs and PEL-STELs if during the 15 minute sampling period, the monitor collects a sufficient quantity of contaminant for analysis. The organic vapor monitor is generally not recommended for sampling periods less than 15 minutes.

1.2 Sampling Time

Sampling a full workshift is recommended in order to determine the workers' daily exposure level to organic contaminants. When monitoring some organic contaminants, sampling shorter than a full shift may be required in order to be within the recommended capacity of the organic vapor monitor. Under these circumstances, sequential sampling with several monitors can be performed to assess the 8 hour exposure. For information on recommended sampling time and capacity see section 4.

To quantitatively confirm the presence and concentration of a contaminant in the atmosphere, most analysts require a minimum of 10 micrograms for G.C. analysis. A sampling period of at least 15 minutes is recommended even when 10 micrograms of the contaminant could be collected in a shorter period.

1.3 Accuracy

3M™ Organic Vapor Monitors are simple to use, but they do have limitations just like all types of sampling devices. Therefore, prior to using the monitor, the user must understand the limitations of this sampling device. Accurate results can be obtained if they are used within their performance limitations and if the analytical laboratory conducting the analysis can accurately provide correct information. Some of the more common sampling errors are overloading the sorbent pad, sampling for contaminants that cannot be captured and retained by carbon, and the laboratory using incorrect recovery coefficients. It is vital that the organic vapor monitor be used within its performance limits and the analytical laboratory has experience in analyzing organic vapor industrial hygiene samples.

For further assistance and information on accuracy and validation you may contact OH&ESD Technical Service in the U.S. at 1-800-243-4630. In other countries, contact the local 3M subsidiary.

1.4 Sampling Strategy

The first step in developing a sampling strategy is to establish the purpose and objective. Some examples of typical objectives are: evaluating worker exposure levels, evaluating high exposure periods during the workday, evaluating control measures such as ventilation, screening work groups to identify high risk groups, measuring worst case exposures, regulatory monitoring to ensure that all workers' exposure levels are below OSHA PELs, and long term environmental monitoring. After the purpose and objectives have been outlined the study can be designed. The American Industrial Hygiene Association (AIHA) manual[1] on exposure assessment discusses the concept of homogeneous exposure group (HEG) and outlines methods for defining HEGs. The manual reviews the following approaches: task based approach, job-description based approach, and chemical based approach. Each separate and unique HEG should be evaluated. After the study has been designed, samples then can be taken. Patty's Industrial Hygiene and Toxicology[2] also contains information regarding sampling strategy and exposure assessments.

1. *Hawkens, N.C., Norwood, S.K., Rock, J.C. (1991): "A Strategy for Occupational Exposure Assessment," American Industrial Hygiene Association, Fairfax, VA.*
2. *Harris, R.L., Cralley, L.J. Cralley, L.V.: Patty's Industrial Hygiene and Toxicology, Vol. III, Par A, Wiley-Interscience Publication, 1994.*

1.5 Unsuitable Compounds

The organic vapor monitor is not recommended for the following compounds because of adverse or inadequate interactions with the sorbent material.

Ammonia
Carbon Monoxide
Ethylene Oxide (3)
Formaldehyde (4)
Hydrogen Sulfide
Isocyanates
Methane, Ethane, Propane
Methyl Alcohol (Methanol)
Methyl Chloride
Methyl, Dimethyl, Trimethyl Amines
Organic Solids
Sulfur Dioxide

Compounds not on this list or in Section 4 should be handled by consultation with 3M OH&ESD Technical Service at 1-800-243-4630 or contact your local 3M subsidiary.

3. *Ethylene Oxide can be monitored using 3M™ Ethylene Oxide Monitor 3550/3551.*
4. *Formaldehyde can be monitored using 3M™ Formaldehyde Monitor 3720/3721.*

1.6 Analytical Laboratory

The following compounds can be analyzed using the 3510 or 3530 monitor sold with a prepaid analysis. A more extensive list of compounds which may be sampled using the 3M™ Organic Vapor Monitors 3500 or 3520 is contained in Section 4.

Section 2.0: Analysis Procedure

2.1 Procedure to Calculate Contaminant Concentrations

The time weighted average concentration of the environment sampled can be calculated by knowing the length of the sampling period, the contaminant weight determined by gas chromatography, the recovery coefficient, and the calculation constant, either A or B. The calculation constant "A" is used to calculate the concentration when expressed in units of milligrams per cubic meter (mg/m^3) and constant "B" when expressed in units of parts per million (ppm). The calculation constants A and B have been determined for every contaminant found in Section 4.

3510/3530 Compound List

†Acetone (2) (c)
Acetonitrile (2) (c)
Acrylonitrile (8)
Allyl Alcohol (8)
Amyl Acetate (8)
n-Amyl Alcohol
s-Amyl Alcohol
Benzene (8)
Benzyl Chloride (8)
Bromoform (8)
1-Bromopropane (m)
n-Butyl Acetate (8)
s-Butyl Acetate (8)
t-Butyl Acetate (8)
Butyl Acrylate (8)
n-Butyl Alcohol (8)
s-Butyl Alcohol (8)
t-Butyl Alcohol (8)
Butyl Cellosolve Acetate
Butyl Cellosolve (8)
Butyl Glycidyl Ether (8)
p-tert Butyl Toluene (8)
Camphor (8)
Carbon Tetrachloride (8)
Cellosolve (8)
Cellosolve Acetate (8)
Chlorobenzene (8)
Chloroform (8)
o-Chlorostyrene (8)
o-Chlorotoluene (8)
Cumene (8)
Cyclohexane (6)
Cyclohexanol (8)
Cyclohexanone (8)
Cyclohexene (8)
n-Decane
Diacetone Alcohol (8)
o-Dichlorobenzene (8)
p-Dichlorobenzene (8)
trans-1,2-Dichloroethylene (6)
Diisobutyl Ketone (DIBK) (8)
p-Dioxane (8)
Dipropylene Glycol Methyl Ether Acetate
Enflurane (8)
Epichlorohydrin (8)
Ethoxy Perfluorobutane (HFE-7200)
Ethyl Acetate (6)
Ethyl Acrylate (8)
Ethyl Benzene (8)
Ethylene Chlorohydrin (8)
Ethylene Dichloride (EDC) (8)
Ethyl Ether (4) (c)
Furfural (8)
Halothane (8)
n-Heptane (8)
n-Hexane (8)
iso-Amyl Acetate (8)
iso-Butyl Alcohol (8)
Isoflurane (Forane)
Isopar G
Isophorone (8)
Isopropyl Acetate (7)
Isopropyl Alcohol (m) (c)
Mesitylene (8)
Mesityl Oxide (8)
Methoxy Perfluorobutane (HFE-7100)
Methyl Acrylate (8)
Methyl t-Butyl Ether (MTBE) (8)
Methyl Butyl Ketone (MBK) (8)
Methyl Cellosolve (8)
Methyl Cellosolve Acetate (8)
Methylene Chloride (m) (3530 only)
†Methyl Ethyl Ketone (MEK) (8)
Methyl Isobutyl Ketone (MIBK) (8)
Methyl Methacrylate (8)
Methyl Propyl Ketone (8)
Naptha (VM&P) (8)
n-Octane (8)
Perchloroethylene (8)
Phenyl Ether (8)
n-Propyl Acetate (8)
n-Propyl Alcohol (6)
Propylene Dichloride (8)
Propylene Glycol Mono Methyl Ether (8)
Propylene Glycol Mono Methyl Ether Acetate
Stoddard Solvent (8)
Styrene (8)
1,1,2,2-Tetrachloroethane (8)
Tetrahydrofuran (8)
Toluene (8)
1,1,1-Trichloroethane (Methyl Chloroform) (m)
Trichloroethylene (8)
1,1,2-Trichloro-1,2,2-trifluoroethane (1) (c)
†Vinyl Acetate (8)
Vinyl Toluene (8)
Xylene (8)
Total Hydrocarbons as n-Hexane

The number in parenthesis is the recommended sampling period in hours. This time has been estimated using the capacity of the 3510 organic vapor monitor, a relative humidity of <50% and the 1998 ACGIH TLVs. Use of the 3530 allows the sampling time to increase.

(c) Because of their high vapor pressures (low boiling points), the (c) compounds are best sampled initially with the 3520 or 3530 monitor (with back-up section). Subsequent sampling may be done with the 3500/3510 monitor if determined, by 3520 results, that contaminant concentrations are within the 3500/3510 capacity limits.

†NOTE: certain compounds (e.g. acetone, methyl ethyl ketone, vinyl acetate, etc.) may show a decreased recovery when sampled in high relative humidity. Refrigerate and/or expedite for analysis to help ensure accurate results.

(m) See technical bulletin.

$$A = \frac{1000}{\text{sampling rate}}$$

$$B = \frac{1000 \times 24.45}{\text{sampling rate} \times \text{molecular weight}}$$

The following information is needed in order to calculate the contaminant concentration:

- Contaminant identity
- Sampling time in minutes **(t)**
- Calculation Constant A or B from Section 4
- Contaminant weight in micrograms **(W),** corrected for blank
- Recovery coefficient **(r)**
- Temperature effects

Air temperature will slightly influence the sampling rate of the diffusion monitor. All formulas calculate the time weighted average concentrations at a sampling temperature of 25°C (77°F) and pressure of 760 mm. The expressions can be multiplied by the following temperature correction factors (CF_T) for samples collected at temperatures other than 25°C (77°F). No correction is needed for differences in pressure.

Sampling Temperature -
Temperature Correction Factor

(C)	(F)	(CF_T)
44	111	0.97
37	99	0.98
31	88	0.99
25	77	1.00
19	66	1.01
13	55	1.02
7	45	1.03
2	36	1.04
-3	27	1.05
-8	18	1.06

From the above table, every 10–11°F above or below 77°F requires one percent correction at the calculated time-weighted average concentration.

2.2 Procedure for the 3M™ Organic Vapor Monitor 3500

The time-weighted average concentration of contaminant in milligrams per cubic meter can be calculated from the following expression:

$$C(\text{mg/m}^3) = \frac{\text{W (micrograms)} \times \text{A}}{\text{r} \times \text{t (minutes)}}$$

The time-weighted average concentration of contaminant in parts per million (ppm) can be calculated from the following expression:

$$C(\text{ppm}) = \frac{\text{W (micrograms)} \times \text{B}}{\text{r} \times \text{t (minutes)}}$$

If the temperature correction is desired, the time-weighted average concentration can be calculated by multiplying by CF_T.

Example Calculation
Contaminant: Benzene
Length of Sampling
Time **(t):** 420 minutes
Temperature **(T):** 75F
Calculation Constant **A:** 28.2
B: 8.82
Contaminant Weight **(W):**
27.2 micrograms
Recovery Coefficient **(r):** 0.97

Using Calculation Constant A (mg/m^3)

$$C(\text{mg/m}^3) = \frac{27.2 \text{ micrograms} \times 28.2}{0.97 \times 420 \text{ minutes}}$$

C = 1.88 mg/m^3

Using Calculation Constant B (ppm)

$$C(\text{ppm}) = \frac{27.2 \text{ micrograms} \times 8.82}{0.97 \times 420 \text{ minutes}}$$

C = 0.59 ppm

2.3 Procedure for 3M™ Organic Vapor Monitor 3520

After analysis of the primary and secondary sorbent pads the validity of the sample can be determined. Validity of the sample can be determined by evaluating the ratio of the contaminant weight (W_S) on the secondary sorbent pad to the contaminant weight (W_P) on the primary sorbent pad. The sample is valid if the following criteria is met:

$$\frac{W_S}{W_P} \leq 0.50$$

W_P: weight collected on the primary pad corrected for blank (micrograms)
W_S: weight collected on the secondary pad corrected for blank (micrograms)

If the sample is valid then the total concentration of the sample can be determined with the following equations:

$$C(\text{mg/m}^3) = \frac{(W_P + 2.2 \times W_S) \times \text{A}}{\text{r} \times \text{t (minutes)}}$$

$$C(\text{ppm}) = \frac{(W_P + 2.2 \times W_S) \times \text{B}}{\text{r} \times \text{t (minutes)}}$$

Section 3.0: Recovery Coefficient

3.1 Recommended Procedure to Determine Recovery Coefficients

We encourage the user to verify the recovery coefficients, since laboratory and analysis techniques can affect recovery coefficients. The recovery coefficient is determined by vapor-state spiking of monitors. The following procedures are recommended for spiking 3M organic vapor monitors:

1. Remove plastic ring and white film from a monitor.

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2. Place a 2.5 cm diameter filter paper on spacer plate.
3. Apply the elution cap. Snap onto the monitor to assure tight seal.
4. Calculate the amount of material to be spiked. The following formula will calculate the spiked amount, in milligrams, that corresponds to the amount that would be collected by an organic vapor monitor at sampling conditions chosen. By varying the chosen concentration levels and exposure times, a recovery coefficient curve can be generated.
   $W = (K_O) \times (C) \times (t) \times (10^{-6}\ m^3/cm^3)$

Where:

W = Amount of liquid injection in milligrams
K_O = Sampling rate of monitor cm^3/min.
C = Average concentration in mg/m^3
t = Sampling time in minutes

For compounds that are solid at room temperature, prepare a solution in Carbon Disulfide such that no more than a 5 microliter injection is needed to spike the required number of milligrams of compound. A suggested starting point would be to assume an average concentration equal to the PEL (Permissible Exposure Limit) or OEL (Occupational Exposure Limit) and an 8 hour exposure period, as long as the amount in milligrams does not exceed the recommended capacity of the monitor.

5. Spike the known quantity of the organic material with a microliter syringe through the center port onto the filter paper. Close the ports.
6. Allow the monitor to sit 16-24 hours to allow total vapor phase transfer of the organic material from the filter paper to the sorbent before elution.
7. Remove filter paper from monitor.
8. Proceed with elution and determination of amount recovered by G.C. analysis.

Section 4.0: Sampling and Analysis Tables

3M™ Organic Vapor Monitor Sampling and Analytical information is contained in the following table. The table outlines sampling rates, recommended sampling periods for a variety of organic compounds, capacity information, recovery information and calculation constants.

4.1 Sampling Rates

The sampling rates are tabulated as cubic centimeters/minute. The sampling rates for (*) compounds have been verified experimentally in the laboratory. The sampling rates given for the remaining compounds in this table were determined from empirical relationships outlined in a publication on "Sampling Rate Validation" available from 3M on request. Sampling rates for compounds not found in the Guide are available upon request. The top section of the 3520 organic vapor monitor has the same dimensions as the 3500 organic vapor monitor; therefore, the sampling rate is the same.

4.2 Length of Sampling Period

The recommended maximum sampling period has been estimated using the capacity of the 3500/3510 organic vapor monitor, at a relative humidity of <50% and the 1998 American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values. Full work shift sampling periods are recommended as the most comprehensive measures of worker exposure. When sampling some organic contaminants, sampling periods shorter than a full workshift are required in order not to exceed the recommended capacity of the monitor. Under these circumstances, sequential sampling with several monitors can be performed to determine the full shift exposure. In order to determine the time weighted average (TWA) concentration over a work shift with sequential sampling the following calculation can be used:

$$ppm = \frac{C_1 \times T_1 + C_2 \times T_2 + ...C_n \times T_n}{T_1 + T_2 + ...T_n}$$

For those compounds where the recommended length of the sampling period for the 3M™ Organic Vapor Monitor 3500/3510 is less than a full workshift, the length of the sampling period can be increased by using the 3M™ Organic Vapor Monitor 3520/3530.

4.3 Capacity

The capacity of the monitor for each individual compound is a function of molecular structure, vapor pressure, environmental conditions, etc. The capacity values listed in the Guide were determined for the 3500 under dry conditions (<50%RH), and were then used to estimate the length of a recommended sampling period for concentrations equal to the 1998 TLVs. The capacity and sampling time under high relative humidity may be reduced significantly.

Because of the back up section, the effective capacity of the 3M™ Organic Vapor Monitor 3520/3530 is greater than the values listed for the 3500/3510. When sampling environments containing high concentrations, mixtures, high relative humidity, and/or compounds listed with a (c) in the table, we recommend using the 3520/3530.

When sampling contaminants listed in the table with the 3500/3510, the combined weights of the contaminants collected should not exceed the listed value for the single contaminant with lowest capacity. For the 3520/3530, the weight (W_S) collected by the secondary adsorbent on the back-up section can be compared with the weight (W_P) collected by the primary adsorbent to determine sample validity. The ratio W_S/W_P must be equal to or less than 0.50 for a valid sample.

4.4 Recovery Coefficients (Desorption Efficiency)

The collected sample is removed from the activated carbon wafer for analysis by desorption with Carbon Disulfide (CS_2) or other suitable solvents as noted. In order for the laboratory to accurately determine the amount of contaminant collected by the adsorbent, it is necessary to know the efficiency of the desorption process.

Recovery coefficient or desorption efficiency is determined by adding a known weight of contaminant onto the adsorbent and measuring the weight of contaminant recovered by the desorbing solvent. The recovery coefficient is calculated by dividing the recovered weight of contaminant by the known amount. Refer to Section 3 for details on determining recovery coefficients.

We recommend that recoveries listed in this table be used only as a guideline, and that laboratories perform their own recovery studies. Industrial hygiene literature/methods should be consulted for elution solvents which exhibit improved recovery when CS_2 is not adequate.

NOTE: Certain compounds (e.g. acetone, methyl ethyl ketone, vinyl acetate, etc.) may show a decreased recovery when sampled in high relative humidity. Refrigerate and/or expedite for analysis to help ensure accurate results.

Please see Technical Data Bulletin #125 “Storage and Recovery” for more information.

	Sampling Rate (cc/min)	Recommended Sampling Time (Hrs.)	Capacity (mg)	Recovery Coefficient	Calculation Constant A (mg/m^3)	Calculation Constant B (ppm)
* Acetone (c)	40.1	2	7	0.91 (i)	24.9	10.50
Acetonitrile (c)	48.2	2	0.5	1.02 (e)	20.7	12.36
* Acrylonitrile (m)	43.8	8	1.4	0.99 (d)	22.8	10.52
Allyl Alcohol	40.4	8	5	0.74 (d)	24.8	10.42
Allyl Chloride	35.1	8	3	0.86	28.5	9.10
* n-Amyl Acetate	26.0	8	>25	0.98	38.5	7.22
* n-Amyl Alcohol (1-Pentanol)	31.2		24	0.96 (d)	32.1	8.89
s-Amyl Alcohol	31.2		>25	0.98 (d)	32.1	8.89
* Benzene	35.5	8	22	0.97	28.2	8.82
Benzyl Chloride	27.2	8	>25	0.89	36.8	7.10
Bromoform	29.3	8	>25	1.02	34.1	3.30
* 1-Bromopropane	31.7	(m)	(m)	1.02	31.5	6.27
* 1,3-Butadiene (c)	42.8	(m)	(m)	0.75 (d)	23.4	10.56
n-Butyl Acetate	31.6	8	>25	1.07	31.6	6.66
* s-Butyl Acetate	28.6	8	>25	0.98	35.0	7.36
t-Butyl Acetate	29.4	8	23	0.98	34.0	7.16
Butyl Acrylate	27.3	8	>25	1.06	36.6	6.99
* n-Butyl Alcohol	34.3	8	21	0.95 (d)	29.2	9.62
s-Butyl Alcohol	34.8	8	19	0.89 (d)	28.7	9.48
t-Butyl Alcohol	35.2	8	15	0.74	28.4	9.37
* Butyl Cellosolve	28.2	8	>25	0.91 (d)	35.5	7.34
* Butyl Cellosolve Acetate	24.3		>25	0.90	41.2	6.28
Butyl Glycidyl Ether	27.0	8	25	0.93	37.0	6.96
* p-tert-Butyltoluene	20.7	8	25	1.07	48.3	7.97
Camphor	21.4	8	>25	0.92	46.7	7.50
Carbon Disulfide (c)	42.8	8	2.7	0.76 (h)	23.4	7.50
Carbon Tetrabromide	26.6	8	>5	0.99 (h)	37.6	2.77
* Carbon Tetrachloride	30.2	8	>25	0.95	33.1	5.26
* Cellosolve	32.4	8	>25	0.84 (d)	30.9	8.37
* Cellosolve Acetate	26.6	8	>25	0.73	37.6	6.96
* Chlorobenzene	29.3	8	>25	0.96	34.1	7.41
* Chlorobromomethane	34.4	8	18	0.90	29.1	5.49
Chloroform	33.5	8	21	0.95	29.9	6.11
Chloroprene	32.2				31.1	8.58
o-Chlorostyrene	26.0	8	>25	0.78	38.5	6.78
* 2-Chloro-1,1,1,2-tetrafluoroethane (HCFC 124)	35.8		5	0.87 (f)	27.9	5.00
o-Chlorotoluene	27.3	8	>25	0.92	36.6	7.07
* Cumene	24.5	8	>25	1.01	40.8	8.30
* Cyclohexane	32.4	6	13	1.02	30.9	8.97
* Cyclohexanol	29.5	8	22	1.02 (d)	33.9	8.27
* Cyclohexanone	28.9	8	22	0.85	34.6	8.62
* Cyclohexene	32.3	8	21	0.99	31.0	9.21
Cyclopentadiene	39.5				25.3	9.36
Cyclopentane (c)	36.2	1	5	1.02	27.6	9.63

(c) 3M 3520 Organic Vapor Monitor Recommended
(d) Methylene Chloride
(e) 50% Dimethylformamide in carbon disulfide
(f) Isopropanol
(g) Acetonitrile
(h) Toluene
(i) Refrigerate and/or expedite for analysis to help ensure accurate results.
(k) Trichloroethylene
(m) See technical bulletin
* Laboratory verified sampling rate

continued	Sampling Rate (cc/min)	Recommended Sampling Time (Hrs.)	Capacity (mg)	Recovery Coefficient	Calculation Constant A (mg/m³)	Calculation Constant B (ppm)
* n-Decane	23.1		>25	1.05	43.3	7.44
* Diacetone Alcohol	28.2	8	>25	0.94 (d)	35.5	7.46
* o-Dichlorobenzene	27.8	8	>25	0.87	36.0	5.98
* p-Dichlorobenzene	27.8	8	>25	0.74	36.0	5.98
1,1-Dichloroethane	33.2	8	13	0.92	30.1	7.44
* 1,2-Dichloroethylene	35.2	6	10	0.96	28.4	7.17
Dichloroethyl Ether	26.1	8	>25	0.95	38.3	6.55
1,1-Dichloro-1-nitroethane	28.5				35.1	5.96
* 1,1-Dichloro-2,2,2-trifluoroethane (HCFC-123)	30.9				32.4	5.17
Dicyclopentadiene	23.6	8	>25	0.96	42.4	7.84
Diethyl Ketone	32.7	8	24	0.98	30.6	8.68
* Diisobutyl Ketone	24.6	8	>25	1.03	40.7	6.99
Dimethylacetamide	32.0	8	>25	0.84 (d)	31.3	8.77
Dimethyl Formamide	35.5	8	>25	0.65 (d)	28.2	9.42
p-Dioxane	34.5	8	21	0.91	29.0	8.04
Dipropylene Glycol Methyl Ether	25.3	8	23	0.82	39.5	6.52
Dipropylene Glycol Methyl Ether Acetate	22.8			0.93	43.9	5.64
Dipropyl Ketone (4-Heptanone)	27.8	8	25	0.66	36.0	7.70
Divinyl Benzene	23.3	8	20	0.47	42.9	8.06
* n-Dodecane	21.5		>25	1.09	46.5	6.68
Enflurane	28.3	8	8	0.88	35.3	4.68
Epichlorohydrin	29.6	8	20	0.85	33.8	8.93
* 1-Ethoxynonafluorobutane (HFE-7200)	24.1		>25	0.82 (k)	41.5	3.84
* Ethyl Acetate	34.5	6	20	0.99	29.0	8.04
Ethyl Acrylate	32.2	8	>25	0.93	31.1	7.58
* Ethyl Alcohol (c)	43.7	1	3.5	0.98 (g)	22.9	12.14
Ethyl Benzene	27.3	8	24	0.96	36.6	8.44
* Ethyl Bromide	36.4	8	6	0.94	27.5	6.18
Ethyl Butyl Ketone	28.0	8	>25	0.68	35.7	7.65
Ethylene Chlorohydrin	33.9	8	11	0.82 (d)	29.5	8.96
* Ethylene Dibromide	29.6		21	0.93	33.8	4.40
* Ethylene Dichloride	33.2	8	16	0.98	30.1	7.44
Ethyl Ether (c)	36.8	4	12	0.96	27.2	8.96
Ethyl Formate	38.8	8	8	0.65	25.8	8.51
Furfural	34.3	8	>25	0.62 (d)	29.2	7.42
Furfuryl Alcohol	30.6	8	>25	0.71 (d)	32.7	8.14
* Gasoline	30.5	8	>25	0.94	32.8	7.49
Glycidol	37.1				27.0	8.90
Halothane	30.2	8	10	1.07	33.1	4.10
* n-Heptane	28.9	8	>25	1.04	34.6	8.44
Hexachlorobutadiene	22.9				43.7	4.09
Hexachlorocyclopentadiene	22.1				45.2	4.06

(c) 3M 3520 Organic Vapor Monitor Recommended
(d) Methylene Chloride
(e) 50% Dimethylformamide in carbon disulfide
(f) Isopropanol
(g) Acetonitrile
(h) Toluene
(i) Refrigerate and/or expedite for analysis to help ensure accurate results.
(k) Trichloroethylene
(m) See technical bulletin
* Laboratory verified sampling rate

continued	Sampling Rate (cc/min)	Recommended Sampling Time (Hrs.)	Capacity (mg)	Recovery Coefficient	Calculation Constant A (mg/m^3)	Calculation Constant B (ppm)
Hexachloroethane	26.7	8	25	0.95	37.5	3.87
* n-Hexane	32.0	8	24	1.07	31.3	8.87
* Hexane Isomers	32.0	7	24	1.03	31.3	8.87
Isoamyl Acetate	27.2	8	>25	0.97	36.8	6.90
* Isoamyl Alcohol	32.3	8	22	0.95 (d)	31.0	8.59
* Isobutyl Acetate	31.0	8	25	1.02	32.3	6.79
* Isobutyl Alcohol	35.9	8	19	0.93 (d)	27.9	9.19
Isoflurane (Forane)	28.3		7	0.88	35.3	4.68
Isooctyl Alcohol	25.1	8	23	0.80	39.8	7.48
Isopar G	24.4		>25	0.98	41.0	7.42
* Isophorone	21.7	8	>25	0.75	46.1	8.15
Isopropoxyethanol	29.5	8	23	0.92	33.9	7.96
Isopropyl Acetate	31.7	7	15	0.96	31.5	7.55
* Isopropyl Alcohol (c)	39.4	(m)	(m)	0.96 (g)	25.4	10.33
Isopropyl Ether (c)	31.2	8	21	1.03	32.1	7.67
Isopropyl Glycidyl Ether	29.1	8	23	0.97	34.4	7.23
* Mesitylene	26.3	8	>25	1.05	38.0	7.73
* Mesityl Oxide	31.2	8	>25	0.89	32.1	7.98
1-Methoxynonafluorobutane (HFE-7100)	25.3		18	0.85 (k)	39.5	3.87
* Methyl Acetate (c)	37.0	2	3	0.92	27.0	8.92
Methyl Acrylate	35.8	8	11	0.87	27.9	7.93
Methylal (c)	37.9	1	10	0.97	26.4	8.48
Methyl Amyl Ketone	27.9	8	24	0.98	35.8	7.67
Methyl Bromide (c)	40.9				24.4	6.30
* Methyl t-Butyl Ether (MTBE)	30.8	8	17	0.98	32.5	9.01
* Methyl Butyl Ketone	29.7	8	24	1.00	33.7	8.22
* Methyl Cellosolve	36.3	8	>25	0.78 (d)	27.5	8.85
* Methyl Cellosolve Acetate	29.0	8	>25	0.65	34.5	7.14
* Methyl Cyclohexane	28.9	7	20	1.03	34.6	8.62
Methyl Cyclohexanol	25.3	8	>25	0.83	39.5	8.46
* Methylene Chloride (c)	37.9	(m)	(m)	0.87	26.4	7.60
* Methyl Ethyl Ketone	36.3	8	18	0.91 (i)	27.5	9.34
Methyl Formate (c)	45.0	1	0.5	0.76 (d)	22.2	9.05
5-Methyl-3-heptanone	26.4	8	24	0.83	37.9	7.22
Methyl Iodide	36.7				27.2	4.69
Methyl Isoamyl Ketone	28.0	8	>25	1.01	35.7	7.65
Methyl Isobutyl Carbinol	29.2	8	21	0.81	34.2	8.19
* Methyl Isobutyl Ketone	30.0	8	>25	0.99	33.3	8.14
Methyl Isopropyl Ketone	32.8	8	24	0.91	30.5	8.65
Methyl Methacrylate	31.8	8	>25	0.98	31.4	7.68
* Methyl Propyl Ketone	33.0	8	24	0.93	30.3	8.60
1-Methyl-2-pyrrolidinone	28.8			0.81 (d)	34.7	8.56
* alpha-Methyl Styrene	25.0	8	25	1.02	40.0	8.28

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(k) Trichloroethylene
(m) See technical bulletin
* Laboratory verified sampling rate

3M™ Technical Data Bulletin – Organic Vapor Monitors

continued	Sampling Rate (cc/min)	Recommended Sampling Time (Hrs.)	Capacity (mg)	Recovery Coefficient	Calculation Constant A (mg/m³)	Calculation Constant B (ppm)
* Naphtha(VM&P)	33.2	8	24	0.92	30.1	7.36
Naphthalene	24.6	8	>25	0.42	40.7	7.75
* n-Nonane	24.6	8	>25	1.09	40.7	7.75
* n-Octane	26.6	8	25	1.05	37.6	8.05
* n-Pentane (c)	35.3	3	12	0.98	28.3	9.60
2,4-Pentanedione	31.7		>25	0.81	31.5	7.70
* Perchloroethylene	28.3	8	>25	1.03	35.3	5.21
Phenyl Ether	20.3	8	>25	0.90	49.3	7.08
Phenyl Glycidyl Ether	22.2	8	19	0.73	45.0	7.33
* n-Propyl Acetate	30.1	8	25	1.00	33.2	7.95
* n-Propyl Alcohol	39.7	6	8	0.85 (d)	25.2	10.25
* Propylene Dichloride	30.6	8	20	1.02	32.7	7.07
* Propylene Glycol Monomethyl Ether (PGME)	32.4	8	>25	0.86 (d)	30.9	8.37
* Propylene Glycol Monomethyl Ether Acetate (PGMEA)	25.2		>25	1.01	39.7	7.34
* Propylene Oxide (c)	37.7	8	2	0.97	26.5	11.17
n-Propyl Nitrate	33.3	8	25	1.02	30.0	6.99
Resorcinol	25.8				38.8	8.61
Stoddard Solvent	24.3	8	21	0.98	41.2	6.99
* Styrene	28.9	8	>25	0.88	34.6	8.12
1,1,1,2-Tetrachloro-2,2-difluoroethane (c)	27.5				36.4	4.36
1,1,2,2-Tetrachloro-1,2-difluoroethane (c)	28.2				35.5	4.25
1,1,2,2-Tetrachloroethane	28.4	8	>25	0.92	35.2	5.13
* 1,1,1,2-Tetrafluoroethane (HFC 134a)	37.1		2	0.61 (f)	27.0	6.46
Tetrahydrofuran	37.2	8	15	1.01	26.9	9.11
* Toluene	31.4	8	>25	1.00	31.8	8.45
* 1,1,1-Trichloroethane (Methyl Chloroform)	30.9	(m)	>25	1.00	32.4	5.93
* 1,1,2-Trichloroethane	29.7	8	>25	0.95	33.7	6.17
* Trichloroethylene	31.1	8	>25	1.01	32.2	5.98
1,2,3-Trichloropropane	27.4	8	>25	0.99	36.5	6.05
1,1,2-Trichloro-1,2,2-trifluoroethane (c)	29.1	1	11	0.92	34.4	4.48
Vinyl Acetate	35.8	8	9	0.98 (i)	27.9	7.93
Vinyl Bromide	37.0				27.0	6.18
* Vinyl Chloride (c)	40.8				24.5	9.59
* 4-Vinyl-1-cyclohexene	27.9	8	>25	1.01	35.8	8.10
Vinylidene Chloride	35.1	8	4	1.00	28.5	7.19
Vinyl Toluene	25.1	8	>25	0.86	39.8	8.24
* Xylene	27.3	8	>25	0.97	36.6	8.44

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(k) Trichloroethylene
(m) See technical bulletin
* Laboratory verified sampling rate

3M™ Technical Data Bulletin – Organic Vapor Monitors

For more information, please contact:

3M Occupational Health and Environmental Safety Division (OH&ESD)

In the U.S., contact:

Sales Assistance
1-800-896-4223
Technical Assistance
1-800-243-4630
Fax On Demand
1-800-646-1655
Internet
http://www.3M.com/occsafety
For other 3M products
1-800-3M HELPS

In Canada, contact:
3M Canada Company, OH&ESD
P.O. Box 5757
London, Ontario N6A 4T1
Sales Assistance
1-800-265-1840, ext. 6137
Technical Assistance (Canada only)
1-800-267-4414
Fax On Demand
1-800-646-1655
Internet
http://www.3M.com/CA/occsafety

Technical Assistance In Mexico
01-800-712-0646
5270-2255, 5270-2119 (Mexico City only)
Technical Assistance In Brazil
0800-132333
Fax On Demand O.U.S. Locations
1-651-732-6530

3M

Occupational Health and Environmental Safety Division
3M Center, Building 235-2E-91
St. Paul, MN 55144-1000

Appendix III (b)

UMEX-100
Formaldehyde Passive Sampler

1 Formaldehyde by Passive Sampler (OSHA Method 1007)

The UME^{X} passive sampler for formaldehyde contains a tape treated with 2,4-dinitrophenylhydrazine (DNPH) for collection of formaldehyde. Samplers are provided in individual aluminised pouches that can be used to transport the sampler to a laboratory after sampling. For convenience and quality control assurance against contamination, each sampler incorporates a "blank/ correction" section in addition to the active sampling section so there is no need to send extra samplers to the laboratory.

Because of the UME^{X} 100 Sampler's relatively high sampling rate and sensitive analysis, it can be used for 15-minute (STEL) sampling in the ppm range, personal monitoring up to 8 hours, and 24-hour or 7-day static monitoring of contaminants found in indoor environments.

Advantages of using passive samplers include:-

- The passive samplers give a much lower detection limit than using sorbent tubes or impinger collection methods.
- Can sample for up to a week.
- No pump/training required to use.

Sampling Rate for Formaldehyde	28.6 ml/min with a RSD of 18% (for 15-min to 8-hrs or 24-hrs*) 20.4 ml/min (7 days) *
Detection Principle	Formation of stable DNPH (2,4 dinitrophenylhydrazine) in the presence of formaldehyde
Concentration Range	5 ppb to 5 ppm
Lower Detection Limits	**15-min:** 200 ppb (0.24 mg/m^{3}) **8-hrs:** 5 ppb (0.006 mg/m^{3}) **24-hrs*:** 2 ppb (0.002 mg/m^{3}) **7 days* :** 0.2 ppb (0.0002 mg/m^{3}) * Sampling periods between 24 hours and 7 days have not been evaluated.

Appendix III (c)

TSI Q-Trak CO/CO2 monitor

Appendix A

Specifications

Specifications are subject to change without notice.

CO_2

Sensor type	Non-Dispersive Infrared (NDIR)
Range	0 to 5000 ppm
Accuracy	±(3% of reading + 50 ppm) at 25°C (Add uncertainty of ±0.36% of reading per °C [±0.2% of reading per °F] for change in temperature.)
Resolution	1 ppm

Temperature Sensor

Type	Thermistor
Range	0 to 50°C (32 to 122°F)
Accuracy	±0.6°C (1.0°F)
Resolution	0.1°C (0.1°F)
Response time	30 seconds (90% of final value, air velocity at 2 m/s)
Display units	°C or °F (user selectable)

Humidity

Sensor type	Thin-film capacitive
Range	5 to 95% RH
Accuracy	±3% RH (includes ±1% hysteresis.)
Resolution	0.1% RH
Response time	20 seconds (for 63% of final value)

CO Sensor

Sensor type	Electro-chemical
Range	0 to 500 ppm
Accuracy	±3% of reading or 3 ppm whichever is greater [add ±0.5%/°C (0.28%/°F) away from calibration temperature]
Resolution	1 ppm
Response time	<60 seconds to 90% of final value.

Appendix III (d)

TSI DustTrak DRX Dust Monitor

Specifications

Specifications are subject to change without notice.

Sensor Type	90° light scattering
Range	8533 Desktop 0.001 to 150 mg/m^3 8534 Handheld 0.001 to 150 mg/m^3
Display	Size Segregated Mass Fractions for PM_1, $PM_{2.5}$, Respirable, PM_{10} and Total. All displayed
Resolution	±0.1% of reading of 0.001 mg/m^3, whichever is greater
Zero Stability	±0.002 mg/m^3 24 hours at 10 sec time constant
Particle Size Range	Approximately 0.1 to 15 µm
Flow Rate	3.0 L/min
Flow Accuracy	±5% Internal flow controlled
Temperature Coefficient	+0.001 mg/m^3 per °C
Operational Temp	0 to 50°C
Storage Temp	-20 to 60°C
Operational Humidity	0-95% RH, non-condensing
Time Constant	Adjustable 1 to 60 seconds
Data Logging	<45 days at 1 minute samples
Log Interval	1 second to 1 hour
Physical Size (HWD)	Handheld: 4.9 x 4.75 x 12.45 in. Desktop: 5.3 x 8.5 x 8.8 in.
Weight	Handheld: 2.9 lb, 3.3 lb with battery Desktop: 3.45 lb, 4.45 lb – 1 battery, 5.45 lb – 2 batteries
Communications	8533: USB (Host and Device) and Ethernet. Stored data accessible using thumb drive 8534: USB (Host and Device). Stored data accessible using thumb drive.
Power—AC	AC power adapter included. 115 to 240 VAC