# Volatile Organic Compounds Monitoring in Perth

## Baseline Air Toxics Project

January 2000

Department of
Environmental Protection

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# EXECUTIVE SUMMARY

The Department of Environmental Protection (DEP) conducted a baseline study of airborne volatile organic compounds (VOCs) in Perth from March 1997 to November 1998. The principal aim of the project was to assess Perth's ambient air for its VOC composition and concentration. VOCs are a subset of the group of air pollutants called air toxics or hazardous air pollutants. The contribution of some of the more reactive components to smog formation was also studied.

One hundred and fifty-seven air samples were collected from the Perth metropolitan area and analysed by gas chromatography-mass spectrometry (GC-MS). The study involved the collection of air samples from four DEP air quality monitoring stations and two other sites in the Perth metropolitan area. Intensive, year-round sampling was conducted at Duncraig, a suburb of Perth and at Queen's Buildings in the Perth Central Business District (CBD). The other sampling sites were Swanbourne, on the coast; and Hope Valley, downwind of the Kwinana industrial area. A few samples were collected from North Fremantle, down-wind of petroleum storage tanks; and from Gooseberry Hill, on the Darling Scarp.

The highest annual average concentrations of VOCs were observed in the Perth CBD. Toluene and benzene were the principal components of all the samples. For the most abundant compounds, the 24-hour averages and ranges (minimum and maximum shown in brackets) for combined sites in the study period were: benzene 1.44(0.1, 17.6) ppb, toluene 2.56(0.1, 30.0) ppb, (m+p)-xylene 1.46(0.1, 16.7) ppb, o-xylene 0.63(0.1, 5.86) ppb and ethylbenzene 0.44(0.1, 4.84) ppb. It should be noted that it was not possible to sample in all locations and in all seasons across the metropolitan area (with the exception of Duncraig and Queen's Buildings). The annual average concentrations were however, calculated using data from all sites and including event samples, to take account of the additional information. As a result, the annual average may over- or underestimate the annual average for Perth. Benzene, toluene and xylene concentrations tended to peak during the winter months, especially at Duncraig. The increases were found to be statistically significant. Statistically significant correlations were observed for benzene/ toluene concentrations and nitric oxide/ carbon monoxide concentrations at both the Queen's Buildings and Duncraig sites.

A range of unsaturated hydrocarbon VOCs were detected in the samples, but were not quantified. While contributing to the formation of photochemical smog, they were not classified as air toxics.

The major sources of VOCs in air include motor vehicle exhausts, petroleum facilities and combustion processes. The concentrations of benzene, ethylbenzene, toluene, xylenes and trimethylbenzenes were found in the CBD in similar proportions reported in the motor vehicles emission inventory for Perth. Petroleum storage facilities in North Fremantle may contribute significantly to some air toxics concentrations in Perth, since air samples collected downwind of the tanks had high air toxics concentrations. Correspondingly very low air toxics concentrations were measured on the Darling Scarp.

The concentrations of air toxics measured in Perth are consistent with results reported in larger cities, while being generally less than currently accepted international standards. Elevated concentrations were observed in winter, which need to be confirmed. This study has provided important data for use in environmental health and ecological risk assessment.

## ACKNOWLEDGMENTS


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The various contributions from the DEP (Air Quality Management) staff and the CCWA (Environmental Chemistry) staff during the course of the project are acknowledged.

The contributions from the following people and organisations are also acknowledged:

- NSW EPA Chemistry laboratory staff, for analysing the inter-laboratory samples.
- The proprietors of the Hillcrest Senior Citizens' Residence, for permitting sample collection from their property in North Fremantle.
- Mr and Mrs Jim Hansen for permitting sample collection from their property at Gooseberry Hill.

Thanks are also due to Mr Jack Chiodo of the Victorian EPA and the staff of the Toxicology Section of the Health Department of WA for reviewing this report.

# TABLE OF CONTENTS

# 1. INTRODUCTION

## 1.1 HISTORY

Volatile organic compounds (VOCs) occur in ambient air in trace concentrations, yet remain important air pollutants. In addition to being photochemical smog precursors, some VOCs can pose significant risks to human health, particularly the so-called “air toxics” VOCs, of which some are known or suspected carcinogens or known to result in other serious human health and/or environmental effects (OECD, 1995; WHO, 1987). Air toxics are also known as Hazardous Air Pollutants (HAPs). The HAPs comprise volatile organic compounds, semivolatile organic compounds such as polycyclic aromatic hydrocarbons and inorganic compounds such as metals. Chlorofluorocarbons are not considered to be detrimental to human health at the levels observed in ambient air, but are damaging to the environment and hence are traditionally considered as air toxics. In this report the terms “VOCs” and “air toxics” are used interchangeably, even though VOCs are only one subset of air toxics.

During the past few years, the Department of Environmental Protection (DEP) has measured the concentrations of organic compounds in Perth’s airshed for a variety of reasons. During the Perth Photochemical Smog Study (PPSS, 1996), ambient organic compound concentrations were measured as part of the emissions inventory validation process (Carras *et al.*, 1995; Galbally *et al.*, 1995). The organic compounds targeted were those known to participate in photochemical smog formation, such as the hydrocarbons.

Motor vehicles were identified as major organic emission sources in Perth and the petroleum refinery at Kwinana was a major single industrial source. The effect of these emissions, in conjunction with NOx emissions, were manifested in elevated concentrations of ozone during summer, which sometimes exceeded national and international guidelines (PPSS, 1996). Some elevated concentrations of organic compounds were reported during the Perth Haze Study (Gras, 1996).

In order to assess the potential for risks to human and ecological health, information is required on the toxicity and ambient concentrations of all such pollutants present in air. Air pollutants such as ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide and particulate matter are routinely monitored on a continuous basis, in Perth, by the DEP. However, since VOCs usually occur in air at extremely low concentrations in the parts-per-billion (ppb) range or below, exist in different phases and are numerous, monitoring them routinely has not been conducted due to the complexities and costs involved. As a result, there has not been a comprehensive study in Perth on VOCs.

Therefore, a study was undertaken to determine the number and concentrations of VOCs in Perth’s airshed and the potential for increases in organic emissions from a variety of sources.

## 1.2 SCOPE OF PROJECT

The aim of the project was to determine the range of volatile organic compounds and to measure their concentrations at varying locations.

Objectives of the study were to:

- Develop, trial and validate a methodology for VOC collection and analysis.
- Use this method to collect air samples from identified sites in Perth.
- Identify “air toxics” in Perth air, which were quantifiable in the parts-per-billion (ppb) concentration range.
- Develop a comprehensive quality-assured electronic database of VOCs that are toxic and/or ozone precursors.
- Recommend future directions for VOC monitoring in Perth.

# 2. VOLATILE ORGANIC COMPOUNDS MONITORING

The US EPA TO-14 method was chosen for determining volatile organic compounds (VOCs) in air samples (US EPA, 1988; McClenny *et al.*, 1991). The method targets 40 compounds "air toxics" for identification and quantitative analysis. It is one of several methods that can be used for determining ambient VOC concentrations. Another common method utilises the absorption of VOCs onto solid substrates, but the TO-14 method has been shown to be superior to that method, in terms of method precision (US EPA, 1987).

The TO-14 method involved the field collection of air samples into canisters, which were transported to laboratories. The air samples were analysed by gas chromatography/mass spectrometry, after pre-concentration to levels above the detection limits of the analytical instrument.

Table 1 shows the list of air toxics normally determined using the TO-14 method. The list of air toxics is made up of chlorofluorocarbons (CFCs), aromatic hydrocarbons and chlorinated hydrocarbons (both aliphatic and aromatic), but excludes low molecular hydrocarbons and also oxygenated compounds such as the polar organic compounds.

4-Ethyltoluene was not determined in Perth due to the fact that it was not in the calibration standard used for analysis. VOCs found in the samples, other than the air toxics, were identified where possible, but not quantified.

**Table 1: List of Toxic Volatile Organic Compounds**

| | |
|---|---|
| Freon-12 (Dichlorodifluoromethane) | *trans*-1,3-Dichloropropene |
| Methyl chloride (Chloromethane) | 1,1,2-Trichloroethane |
| Freon-114 (1,2-Dichlorotetrafluoroethane) | Toluene |
| Vinyl chloride (Chloroethylene) | 1,2-Dibromoethane (EDB) |
| Methyl bromide (Bromomethane) | Tetrachloroethylene (Perchloroethylene) |
| Ethyl chloride (Chloroethane) | Chlorobenzene |
| Freon-11 (Trichlorofluoromethane) | Ethylbenzene |
| Vinylidene chloride (1,1-Dichloroethene) | m-Xylene |
| Dichloromethane (Methylene Chloride) | p-Xylene |
| Freon-113(1,1,2-Trichloro-1,2,2-trifluoroethane) | Styrene |
| 1,1-Dichloroethane | 1,1,2,2-Tetrachloroethane |
| *cis*-1,2-Dichloroethylene | o-Xylene |
| Chloroform | 4-ethyltoluene* |
| 1,2-Dichloroethane (Ethylene dichloride) | 1,3,5-Trimethylbenzene |
| Methyl chloroform (1,1,1-Trichloroethane) | 1,2,4-Trimethylbenzene |
| Benzene | 1,3-Dichlorobenzene |
| Carbon tetrachloride | 1,4-Dichlorobenzene |
| 1,2-Dichloropropane | 1,2-Dichlorobenzene |
| Trichloroethylene (Trichloroethene) | 1,2,4-Trichlorobenzene |
| *cis*-1,3-Dichloropropene | Hexachloro-1,3-butadiene |

*(*4-ethyltoluene was not determined in Perth)*

## 2.1 SAMPLING SITES

Air samples were collected from the six sites shown in Figure 1 below. Four of the sites (Duncraig, Queen's Buildings, Swanbourne and Hope Valley) were part of the DEP network of air quality monitoring stations (AQMS) in the Perth metropolitan area.

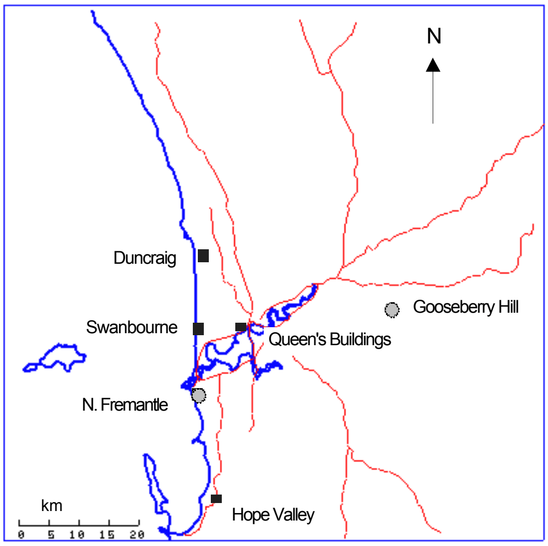



**Figure 1: VOC Monitoring Sites**

The VOC sampling sites were:

*Queen's Buildings (QB)*, on William Street, is in the Central Business District (CBD). Intensive year-round sampling was conducted at this site. The Queen's Buildings site is situated in a heavily trafficked area of the CBD. Historically this site has recorded the highest NOx and carbon monoxide concentrations in Perth.

*Duncraig (DU)*, in a suburban area to the north of Perth, is about 500 m from the Mitchell Freeway. Intensive year-round sampling was also conducted at this site. The Duncraig site is heavily impacted by wood fire heater emissions during winter, and records very high NOx and CO concentrations. It also monitors motor vehicle emissions from the nearby freeway. Since VOCs are normally associated with these types of pollutants, it was decided to collect air samples from here during all seasons.

*Hope Valley (HV)*, to the south of Perth, is downwind of the Kwinana industrial area on the afternoon sea breeze. Less intensive sampling was conducted here. Hope Valley monitors industrial emissions, such as sulphur dioxide and NOx, from the Kwinana industrial area. However, very low pollutant levels are detected at this site during the winter season. The fall in pollutant levels could be attributed to the predominance of the northeasterly winds over southwesterly winds during the winter in Perth. Thus VOC sampling here during this period was not thought to be cost effective.

*Swanbourne (SW)*, in a coastal area, is close to the West Coast highway, and downwind of the CBD, where it picks up motor vehicle emissions on the morning easterly. This was a less-intensive sampling site and samples were not collected in winter for similar reasons as at HV.

*North Fremantle (NF)*, a site on Harvest Street, is not part of the DEP air quality monitoring network. Only a few samples were taken here. The 1992 Perth emissions inventory indicated that significant amounts of organic compounds were emitted from petroleum storage tanks situated in North Fremantle. In order to monitor these emissions, samples were collected at a site downwind of the storage tanks, on the southwesterly wind. The site chosen was on the second floor of a building on an elevated site on Harvest Road, North Fremantle.

*Gooseberry Hill (GH)*, a residential site on the Darling Scarp, is also not part of the DEP air quality network. A few samples were taken from this site. These samples were expected to contain emissions from natural vegetation and very little industrial emissions. Though not considered as toxic pollutants, biogenics are of interest since they contribute to photochemical smog formation. This site also served as a background site.

## 2.2 SAMPLING PROCEDURE

All the sites had an automatic sampler for collecting air samples into stainless steel canisters (SUMMA canisters). These were 6-litre stainless steel canisters, with their inside walls made passive, using the SUMMA electropolishing method. In addition, the DEP air quality monitoring sites (QB, DU, HV and SW) had continuous monitoring instruments for measuring meteorological parameters such as temperature, wind speed, wind direction or relative humidity and air pollutants such as carbon monoxide or NOx. After collection, the VOC samples were transported to the Chemistry Centre of WA (CCWA) for chemical analyses by gas chromatography/mass spectrometry (GC-MS).

### 2.2.1 Samplers

Air sampling at all the sites was done with Ambient Volatile Organic Canister Sampler (AVOCS) instruments, model #97-323, from Graseby Andersen. These automatic samplers were installed on the walls of the air quality monitoring sheds at Duncraig (DU), Queen's Buildings (QB), Swanbourne (SW) and Hope Valley (HV). The 24" vertical sampling wands that came with the AVOCS instruments were replaced with 2-metre stainless steel wands. These inlet wands were long enough to protrude through the roof of the sheds to a height of 1 metre (a total of 4 metres above the ground). The QB station, however, was on the second floor of the building. Here, the sampling wand extended 2 metres horizontally through the window, and was about 10 m above the street level. The inside walls of the sampling wands were electropolished and their ends fitted with the stainless steel shrouds that came with the original wands. A fifth sampler was used on a mobile basis: it was fitted onto a portable metal frame and could be co-located with the other samplers or stationed temporarily at the North Fremantle or Gooseberry Hill sites.

When the AVOCS instrument was in operation, an extraction pump (manifold fan) drew ambient air through the sampling wand into a vertical manifold tube (Figure 2). Some of the air flowing through the manifold tube was sampled from the side of the manifold by the sampling pump. This sampled air flowed at the set flow rate through a 2 micron stainless steel particulate filter, then through the sampling pump, a mass flow controller and finally into the attached canister. The solenoid valves were opened or shut to direct the flow of sampled air into the appropriate canister or purge valve. A pressure transducer, the mass flow controller and a cooling fan or the heater controlled the sampling rate. All the thermocouples, pressure gauges and mass flow meters in the AVOCS instruments were routinely calibrated according to the manufacturer's specifications.

The AVOCS instrument recorded the canister pressure at the time the run was initiated, then at the start of the actual sampling period and finally at the end of the sampling period. The difference between the first and the second pressures recorded, an indication of  the leakage in the system, was normally less than 1% of the final pressure.

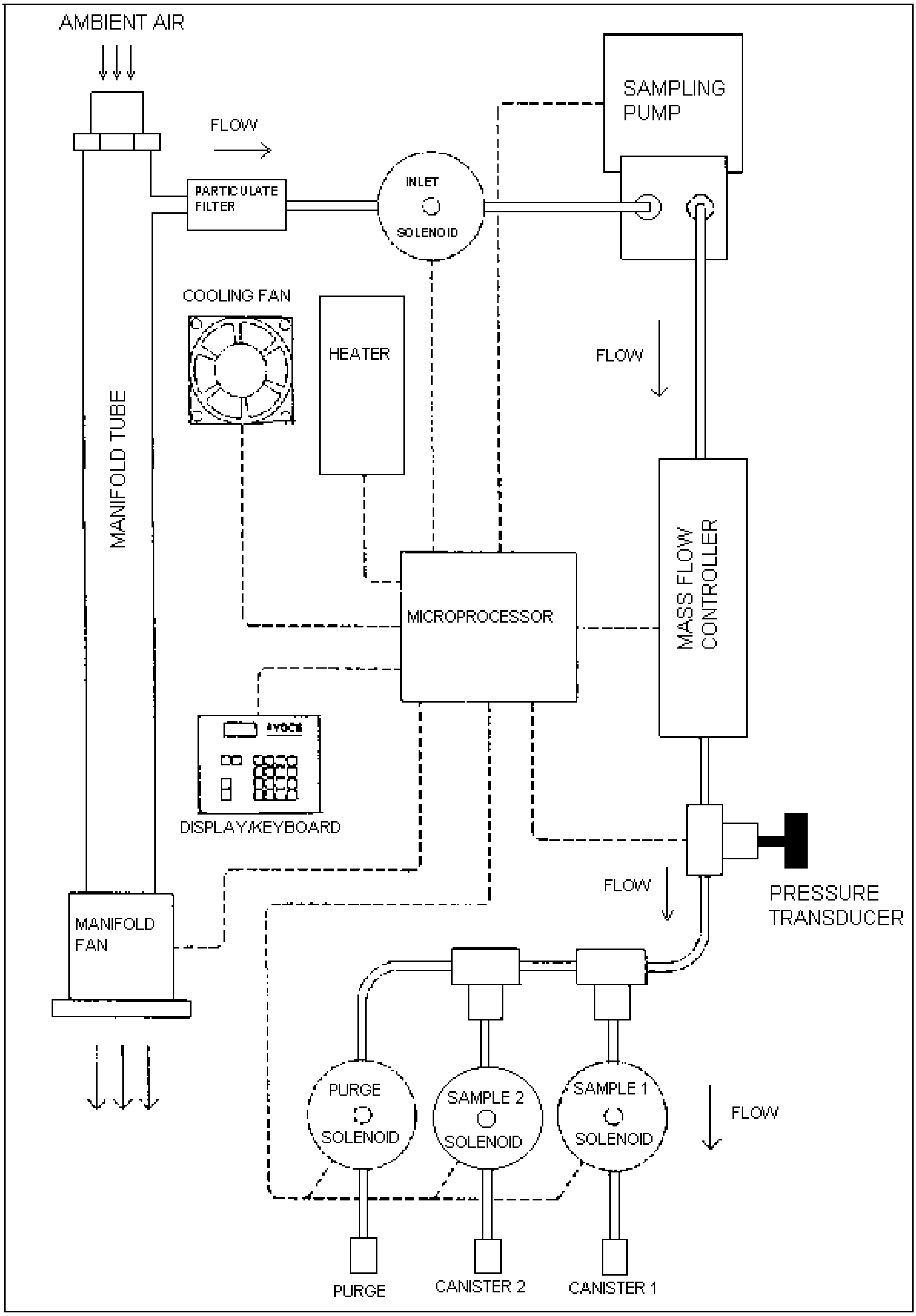



**Figure 2: Schematic Diagram of the AVOCS Instrument** (source: AVOCS Operator's Manual, Graseby Andersen, Smyrna, GA)

The AVOCS instruments flagged samples that were over pressurised, aborted before the end of the sampling period, or experienced power failure during sampling. All the AVOCS instruments were "certified clean" as per the TO-14 method, which required that any target compounds present should not have concentrations greater than 0.2 ppb.

### 2.2.2 Canisters

Twenty-four hour time-integrated samples were collected into the 6-litre stainless steel SUMMA canisters, using a flow rate of 8 ml/min. This brought the canister pressure from vacuum to about 200 kPa (~2 atmospheres absolute).

The SUMMA canisters were purchased from Graseby-Andersen and also from Scientific Instrumentation Specialists. It has been shown that several volatile organic compounds can remain stable up to a period of 30 days in this type of canisters (Oliver and Pleil, 1986). Prior to use in the field, the SUMMA canisters were batch cleaned on an ENTECH Canister Cleaning System (model #3000SL) located at the CCWA. The computer-controlled cleaning system was used to batch clean the canisters at about 100 $^{o}$C, using cycles of high vacuum, leak testing and pressurising with humidified nitrogen gas. In the final cycle, the canisters are evacuated to a vacuum of less than 1 mtorr. Ultra-high purity (UHP) nitrogen gas from BOC Gases Ltd. was used for canister cleaning. Normally the canisters were certified cleaned if one canister from the batch, used as a blank, passed the TO-14 certification criteria.

## 2.3 SAMPLING SCHEDULE

The majority of the samples were collected, continuously over 24-hour periods, on a 12-day cycle. Occasionally technical problems such as the lack of a sufficient number of canisters occur, resulting in the rescheduling of sample collection. When the technical problem was resolved, concurrent samples were collected from all operative samplers.

During the first few months of the project, different sampling regimes were investigated. For example: a sample could be collected for a duration of less than 24 hours, during a period associated with high pollutant emissions, such as peak traffic hours. These were referred to as "event" samples. Other event samples were collected when the AVOCS instrument was linked via an electronic interface to a continuous monitor such as a NOx analyser. The AVOCS interface (which was custom built) controlled the AVOCS instrument to direct sampled air into the canister only when the analyser detected pollutants levels above a set threshold value. To maintain a consistent data set of 24-h VOC concentrations, the concentrations of the event samples were extrapolated to 24-hour averages as described in the section on Data Reduction (Appendix A).

## 2.4 SAMPLE ANALYSIS

After collection, the pressurised samples in the canisters were sent to the Chemistry Centre of Western Australia (CCWA) for chemical analysis. The air toxics in the samples were identified and quantified by gas chromatography/mass spectrometry (GC-MS), using a Varian Saturn 2000 GC/MS/MS ion-trap instrument. The organic components of the samples in the canisters were transferred onto the GC column after cryogenic pre-concentration and cryo-focusing of the sample. Separation of the components was effected on a GC column (60 m x 0.32 mm, DB1), which was temperature programmed (from 0 $^{o}$C to 240 $^{o}$C, at 7 $^{o}$C /min). The mass selective detector gave conclusive identification of both targeted and unknown components. An autosampler attached to the GC-MS allowed unattended batch analyses of up to 16 samples.

Calibration standards were prepared for each batch of samples by serial dilution of a standard gas mixture containing 1 ppm (Matheson Gas Products) or 100 ppb (Scotty Gases) each of all the TO-14 compounds listed in Table 1. Dilution was done with UHP nitrogen from BOC Gases Ltd.

The standard gas mixtures did not contain 4-ethyltoluene—hence it was not determined in Perth.

Other quality assurance/quality control procedures in place included daily tuning of the GC-MS with 4-bromofluoro-benzene. The results of duplicate sampling and inter-laboratory analyses of samples to obtain precision and accuracy data are described in Appendix B.

Blank samples were analysed to verify the integrity of the cleaned canisters, and replicate sample analyses were performed to check the integrity of the GC-MS.

## 2.5 STATISTICAL ANALYSIS OF DATA

The associations of ambient toluene and benzene concentrations with season, temperature, relative humidity, nitric oxide and carbon monoxide concentrations were analysed with multivariate linear regression. Data for each of the two sites, QB and DU, were divided into 4 seasons—summer (December to February), spring (March to May), winter (June to August) and autumn (September to November). The analyses were performed using the statistical computer software package SPSS Base 8.0 (SPSS, 1998). For statistical purposes, any compounds not detected above 0.2 ppb were assigned a default value of 0.1 ppb (half the limit of determination). The analytical limit of detection was 0.1 ppb.

# 3. RESULTS OF VOC CANISTER SAMPLING

## 3.1 AVERAGE CONCENTRATIONS

A total of 157 samples were collected and analysed during the course of the study from March 1997 to November 1998. Fifty-four samples were collected from each of Duncraig (DU) and Queen's Buildings (QB) sites, twenty-three from Hope Valley (HV) and eighteen from Swanbourne (SW). Four samples were collected each at North Fremantle and Gooseberry Hill from February to March 1998. Samples were not collected from HV or SW during the winter months. Most samples were collected on a 1-day in 12 cycle and represented 24-hour integrated samples. Quality assurance samples such as blanks and duplicates are not included in the 157 samples. Figure 3 shows the average 24-hour air toxics concentrations, over the sampling period, obtained from each of the air quality monitoring sites.

Benzene, toluene and the xylenes were the most abundant compounds at all the sites (Figure 3). Freon-12 and 1,2,4-trimethylbenzene were also present at significant levels at all the sites. The remaining compounds had low average 24-hour concentrations. Queen's Buildings in the CBD, had the highest air toxics concentrations, and next was Duncraig (a suburb of Perth). Typically, average 24-hour air toxics concentrations at Swanbourne and Hope Valley were very low.

The average 24-hour concentrations reported have been calculated on the assumption that any pollutants detected in the samples, were always present at concentrations of at least half the limit of determination (>0.1ppb). it was not possible to resolve the peaks of the two isomers m-xylene and p-xylene, hence their concentrations were reported as that of one compound: "(m+p)- xylene".

In Table 2, the annual average 24-hour concentrations for Perth were calculated from 24-hour concentrations obtained from all the sites (including NF and GH) during the sampling period March 1997 to November 1998. These values were weighted very much towards DU and QB data (since most of the samples were obtained from these sites). It was not possible to undertake a comprehensive sampling program at all sites, and for all seasons, hence all data (including those that were extrapolated to 24-hour averages) were included in the calculation of the annual average for the Perth region. Inclusion of these data may over- or underestimate annual averages for Perth. For example, the extrapolated event sample data represent lower limit values (see Appendix A).

The minimum, maximum and 90$^{th}$ percentile 24-hour average concentrations are included in the Table 2. The minimum concentrations for the compounds listed in the table are at the limits of detection. The annual average concentrations ranged from 0.18 ppb for methyl chloride, Freon-114 and *cis*-dichloroethylene, to 2.56 ppb for toluene. The maximum 24-hour concentrations ranged from 0.78 ppb for Freon-114, to 30.0 ppb for toluene. The values for the 90$^{th}$ percentile concentrations ranged from 0.10 ppb for methyl chloride and *cis*-dichloroethylene, to 5.00 ppb for toluene.

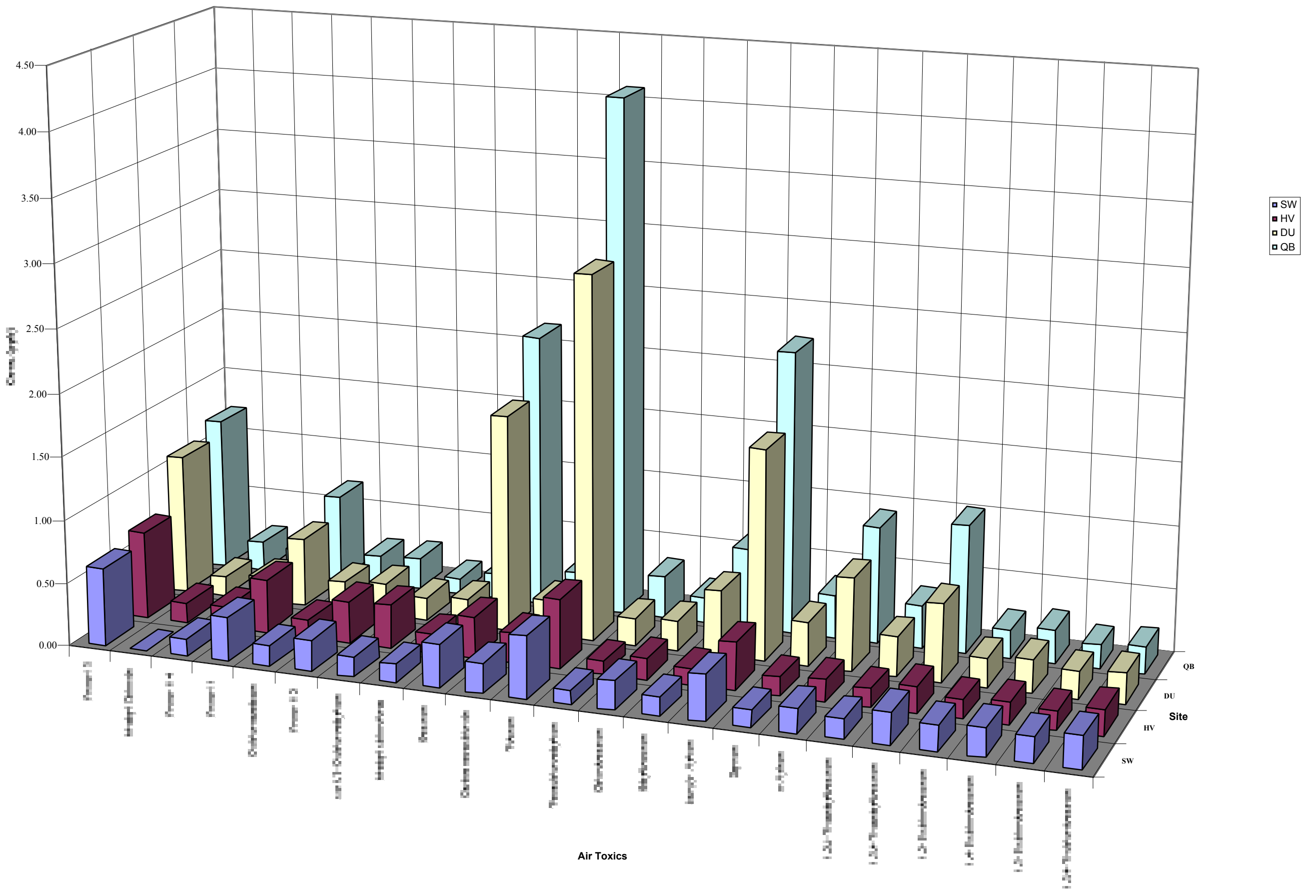



**Figure 3: Average 24-hour Air Toxics Concentrations at Air Quality Monitoring Sites (March 1997 to November 1998)**

**Table 2: Annual Average, Maximum, 90th Percentile and Minimum 24-h Concentrations of Air Toxics Detected in Perth**

| Air Toxics | Concentration (ppb) | | | |
|---|---|---|---|---|
| | Annual Average | Maximum | 90th Percentile | Minimum* |
| **Freon-12** | 1.00 | 11.7 | 1.46 | 0.10 |
| **Methyl Chloride** | 0.18 | 5.60 | 0.10 | 0.10 |
| **Freon-114** | 0.18 | 0.78 | 0.44 | 0.10 |
| **Freon-11** | 0.54 | 3.00 | 1.22 | 0.10 |
| **Dichloromethane** | 0.21 | 1.72 | 0.61 | 0.10 |
| **Freon-113** | 0.26 | 1.14 | 0.74 | 0.10 |
| **cis-1,2-Dichloroethylene** | 0.18 | 2.06 | 0.10 | 0.10 |
| **Methyl chloroform** | 0.19 | 0.84 | 0.33 | 0.10 |
| **Benzene** | 1.44 | 17.6 | 2.95 | 0.10 |
| **Carbon tetrachloride** | 0.26 | 1.06 | 0.67 | 0.10 |
| **Toluene** | 2.56 | 30.0 | 5.00 | 0.10 |
| **Tetrachloroethylene** | 0.22 | 1.57 | 0.35 | 0.10 |
| **Chlorobenzene** | 0.21 | 1.16 | 0.32 | 0.10 |
| **Ethylbenzene** | 0.44 | 4.84 | 0.82 | 0.10 |
| **(m+p)- Xylene** | 1.46 | 16.7 | 2.81 | 0.10 |
| **Styrene** | 0.28 | 2.10 | 0.63 | 0.10 |
| **o-Xylene** | 0.63 | 5.86 | 1.25 | 0.10 |
| **1,3,5-Trimethylbenzene** | 0.27 | 1.92 | 0.60 | 0.10 |
| **1,2,4-Trimethylbenzene** | 0.63 | 5.02 | 1.65 | 0.10 |
| **1,3-Dichlorobenzene** | 0.21 | 1.06 | 0.37 | 0.10 |
| **1,4-Dichlorobenzene** | 0.24 | 1.34 | 0.52 | 0.10 |
| **1,2-Dichlorobenzene** | 0.19 | 1.23 | 0.36 | 0.10 |
| **1,2,4-Trichlorobenzene** | 0.22 | 2.10 | 0.66 | 0.10 |

**Half the limit of determination*

**Table 3: Compounds not Detected or Rarely Detected**

| | | |
|---|---|---|
| Vinyl chloride* | Chloroform | trans-1,3-Dichloropropene |
| Methyl bromide | 1,2-Dichloroethane | 1,1,2-Trichloroethane |
| Ethyl chloride* | 1,2-Dichloropropane | 1,2-Dibromoethane |
| Vinylidene chloride | Trichloroethylene | 1,1,2,2-Tetrachloroethane |
| 1,1-Dichloroethane* | cis-1,3-Dichloropropene | Hexachloro-1,3-butadiene |

**Not detected*

A total of twenty-three air toxics were detected in air samples around Perth. Eight of these (toluene, benzene, (m+p)- xylene, o-xylene, 1,2,4-trimethylbenzene, ethylbenzene, Freon-12 and Freon-11), had significantly high average concentrations compared to the others. Toluene, benzene and the xylenes recorded very high maximum 24-h concentrations. Their corresponding 90$^{th}$ percentile concentrations were much lower (Table 2).

There were fifteen air toxics that had annual average 24-h concentrations well below 0.2 ppb at all the sites and were not detected in most of the samples (Table 3). Three compounds (vinyl chloride, ethyl chloride and 1,1-dichloroethane), were never detected in any of the samples. Details of the analytical results and sampling periods for each sampling location are provided in Appendix C. (Note that while values above the limit of detection (>0.1 ppb) are shown in the appendix, only values above the limit of determination (>0.2 ppb) were used for statistical calculation as described in Section 3.1.)

## 3.2 SEASONAL VARIATIONS

Quarterly averages have been calculated from 24-hour average concentrations. The quarters were selected to observe any seasonal trends and were categorised numerically as shown in Table 4.

Table 4 also shows the number of samples collected from the monitoring sites and analysed per season. Samples were collected from only one summer season during the period of sampling—autumn 1997 to spring 1998.

**Table 4: Quarterly Averaging of Data**

| Season | Summer 1996/97 | Autumn 1997 | Winter 1997 | Spring 1997 | Summer 1997/98 | Autumn 1998 | Winter 1998 | Spring 1998 |
|---|---|---|---|---|---|---|---|---|
| Quarter # | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| Months | Dec., Jan., Feb. | Mar., Apr., May | Jun., Jul., Aug. | Sep., Oct., Nov. | Dec., Jan., Feb. | Mar., Apr., May | Jun., Jul., Aug. | Sep., Oct., Nov. |
| DU * | - | 6 | 6 | 9 | 8 | 6 | 11 | 8 |
| QB* | - | 6 | 3 | 7 | 10 | 8 | 11 | 9 |
| HV* | - | 4 | - | - | 9 | 7 | - | 3 |
| SW* | - | 4 | - | - | 6 | 5 | - | 3 |
| GH* | - | - | - | - | - | 4 | - | - |
| NF* | - | - | - | - | 4 | - | - | - |

**Number of samples collected at the sites per quarter*

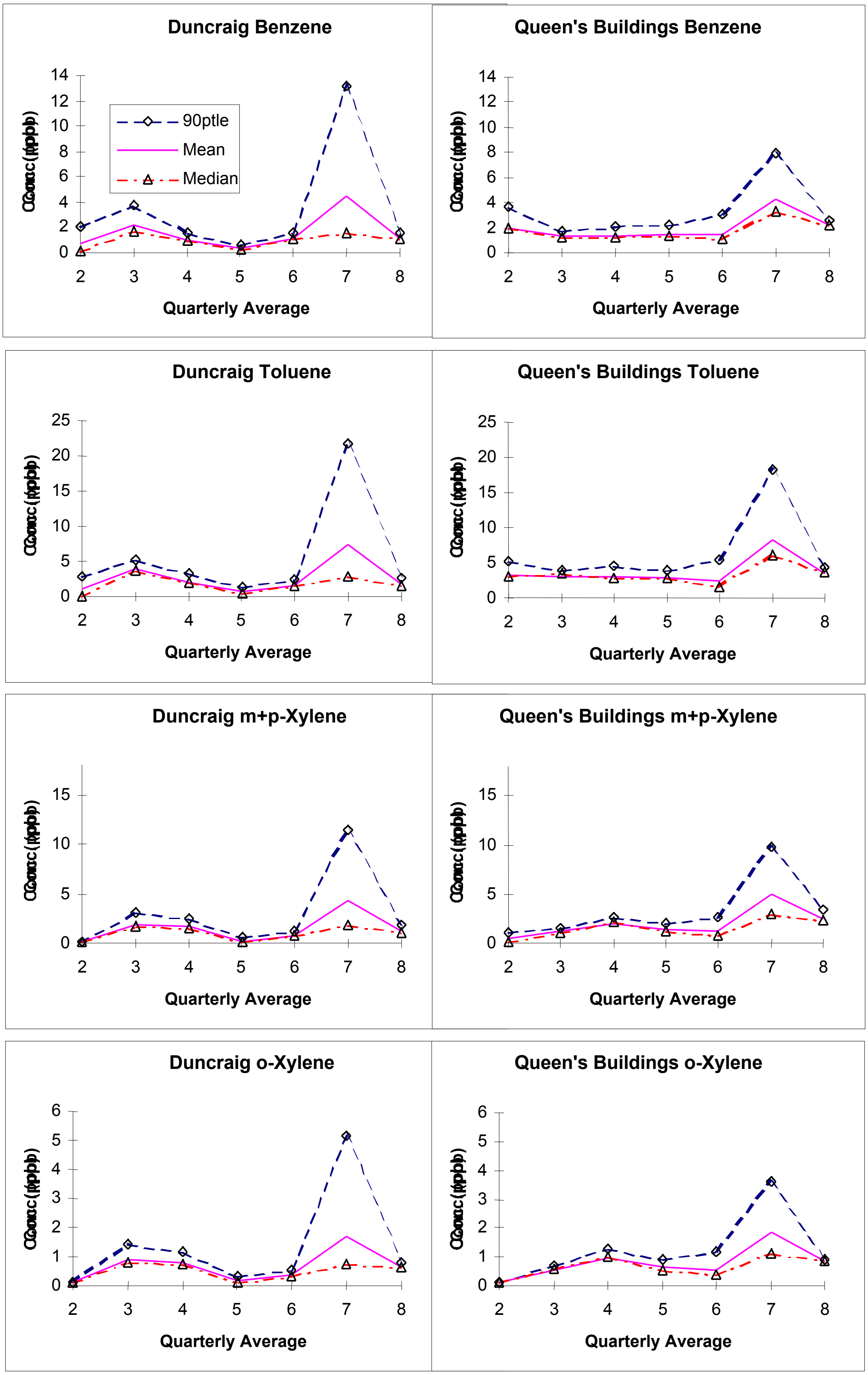



**Figure 4: Trends in Benzene, Toluene and Xylene Concentrations**

### 3.2.1 BTX Concentrations at Duncraig

Seasonal variations in BTX (benzene, toluene, (m+p)-xylene and o-xylene) concentrations at Duncraig are shown Figure 4. The 90$^{th}$ percentile, average (mean) and median 24-hour concentrations for each quarter were calculated and are represented by diamonds, squares and triangles respectively in Figure 4.

During the months of June, July and August 1998 (7$^{th}$ Quarter), the 90$^{th}$ percentile value of the 24-hour benzene concentrations at Duncraig was 13.1 ppb, the average was 4.46 ppb and the median was 1.61 ppb.

The data for Duncraig depicts seasonal variations in the BTX concentrations. For example, the mean benzene concentration rose above 2 ppb in the winter months but fell below 1 ppb in summer. Statistically significant differences were found between ambient levels of benzene in winter and ambient levels of benzene in summer, spring or autumn. After adjusting for season, temperature, relative humidity, nitric oxide (NO) and carbon monoxide (CO) concentrations, these associations remained significant.

Statistically significant positive associations were also observed for toluene and xylene concentrations and both season and CO or NO concentrations.

### 3.2.2 BTX Concentrations at Queen's Buildings

Seasonal variations in BTX concentrations at Queen's Buildings (in the CBD) are also shown in Figure 4. Here, the mean and median benzene concentrations did not increase significantly during the first winter of sampling (3$^{rd}$ quarter), however there was a slight rise in these parameters, during the second winter (7$^{th}$ quarter). The average benzene concentration remained just below 2 ppb for most of the seasons.

There were no statistically significant seasonal differences in the ambient levels of benzene at Queen's Buildings in the CBD. After adjusting for season, temperature, relative humidity, NO and CO concentrations, no statistically significant associations were found for any of the adjusted variables and the ambient benzene level.

In the case of toluene, there were statistically significant differences between the ambient levels of toluene at Queen's Buildings in winter and toluene levels in spring. Although winter toluene levels were observed to be greater than levels for other seasons, the differences were not statistically significant. After adjusting for season, temperature, relative humidity, NO and CO concentrations, a statistically significant positive association was observed only between toluene levels and NO levels. These low significant levels for QB can be attributed to the fact that only 3 samples were obtained from QB during the 3$^{rd}$ quarter, the concentrations of which may not have been representative of the whole season.

Xylene data appear to depict the same trends observed for benzene and toluene. The enhanced pollutant levels observed during the 7$^{th}$ quarter occurred on days when there were high haze levels, across the Perth metropolitan area. On these days, high carbon monoxide and nitric oxide levels were recorded at QB and DU.

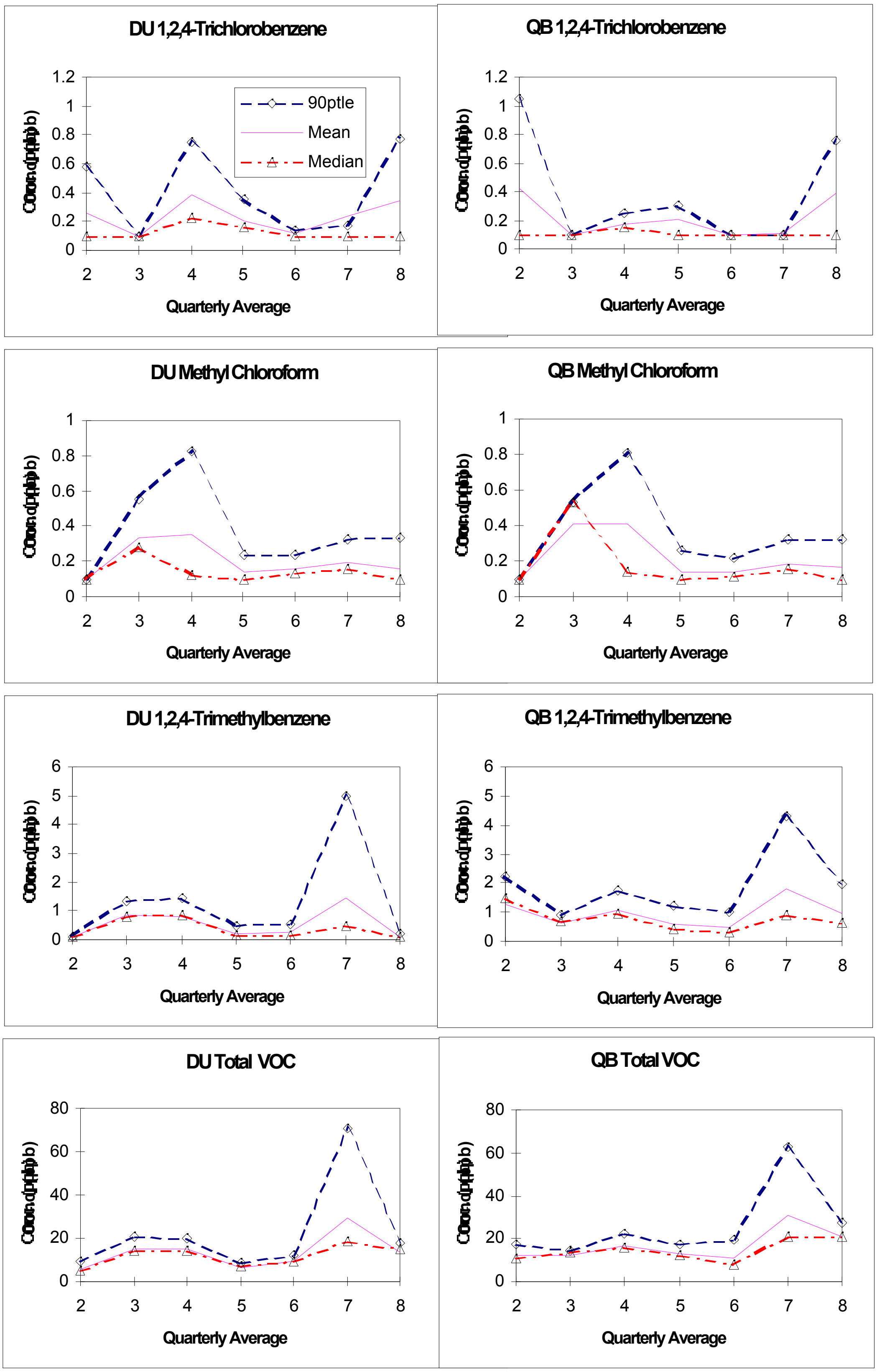



**Figure 5: Trends in Trichlorobenzene, Methyl Chloroform, 1,2,4-Trimethylbenzene and Total VOC Concentrations**

### 3.2.3 Trichlorobenzene, Methyl Chloroform and Total VOC Concentrations

The seasonal variations for trichlorobenzene, methyl chloroform (1,1,1-trichloroethane) and 1,2,4-trimethylbenzene for Duncraig and Queen's Buildings are shown in Figure 5. Total VOC data are also plotted for both sites.

Trichlorobenzene and methyl chloroform were present in most of the samples, they are not expected to be emitted from combustion sources, but from industrial solvent sources such as dry cleaning operations. Trichlorobenzene appears to peak in spring at both sites. Methyl chloroform peaked only during the first spring season then the concentrations remained constant for the seasons following. There were no enhancements in the concentration of both compounds during the 7th quarter as was observed for most of the other pollutants.

1,2,4-Trimethylbenzene is a highly reactive ozone precursor. The low concentration levels of this compound during summer were consistent with its ability to participate in smog formation reactions during that period. Its concentration was generally greater than the concentration of its more reactive isomer, 1,3,5-trimethylbenzene.

Seasonal variations in the total VOC (air toxics) concentrations are shown in the lower part of Figure 5. Typically, average values of the total VOC concentrations were below 20 ppb, and tended to peak during winter. The highest VOC concentrations were measured during the 7th quarter, which was the winter of 1998. They were measured on days of stagnant meteorological conditions. Stagnant meteorological conditions are normally associated with higher pollutant concentrations, since wind speeds are very low and wind direction meanders. Hence there is little pollutant dispersion.

## 3.3 DARLING SCARP AND NORTH FREMANTLE DATA

Results of monitoring at North Fremantle and on Gooseberry Hill, on the Darling Scarp are summarised in Table 5. Four samples were collected from each of the sites, from March and April 1998. The average and range of the 24-hour concentrations for each of the air toxics detected at significant levels are shown in the table.

With the exception of toluene, (m+p)-xylene, Freon-12 (dichlorofluoromethane) and Freon-11 (trichlorofluoromethane), all the TO-14 compounds detected at Gooseberry Hill (GH) had average 24-h concentrations below the limit of determination (LoD). The aromatic compounds were at concentrations close to background levels. The high CFC concentrations may be attributed to nearby emissions from air conditioners.

The average 24-h toluene concentrations measured at the North Fremantle (NF) site, downwind of the petroleum storage tanks was 0.66 ppb, benzene was 0.37 ppb—these values are above background levels. The high values obtained for the maximum 24-h concentrations of the aromatic hydrocarbons could be attributed to emissions from the petroleum storage tanks in the area.

**Table 5: Average 24-hour Air Toxics concentration at North Fremantle & Gooseberry Hill (on the Darling Scarp)**

| AIR TOXICS | Concentrations (ppb) | | | | | |
|---|---|---|---|---|---|---|
| | N. Fremantle (NF) | | | Gooseberry Hill (GH) | | |
| | Average | Max | Min | Average | Max | Min |
| **Freon-12** | 0.62 | 0.69 | 0.52 | 0.53 | 0.62 | 0.40 |
| **Methyl Chloride** | 0.15 | 0.31 | 0.10 | - | - | - |
| **Freon-11** | 0.32 | 0.38 | 0.25 | 0.23 | 0.27 | 0.20 |
| **Dichloromethane** | 0.11 | 0.15 | 0.10 | 0.19 | 0.29 | 0.10 |
| **Freon-113** | - | - | - | 0.15 | 0.20 | 0.10 |
| **Methyl chloroform** | 0.11 | 0.13 | 0.10 | 0.16 | 0.22 | 0.10 |
| **Benzene** | 0.37 | 0.54 | 0.24 | 0.15 | 0.21 | 0.10 |
| **Carbon tetrachloride** | 0.12 | 0.15 | 0.10 | 0.10 | 0.10 | 0.10 |
| **Toluene** | 0.66 | 1.08 | 0.42 | 0.20 | 0.31 | 0.10 |
| **Chlorobenzene** | - | - | - | 0.10 | 0.10 | 0.10 |
| **Ethylbenzene** | 0.12 | 0.15 | 0.10 | 0.13 | 0.16 | 0.10 |
| **(m+p)- Xylene** | 0.41 | 0.51 | 0.33 | 0.25 | 0.43 | 0.10 |
| **Styrene** | - | - | - | 0.10 | 0.11 | 0.10 |
| **o-Xylene** | 0.19 | 0.25 | 0.14 | 0.10 | 0.11 | 0.10 |
| **1,2,4-Trimethylbenzene** | 0.14 | 0.16 | 0.10 | - | - | - |

## 3.4 OTHER VOCs DETECTED

Another aspect of the project was to identify any VOCs in the samples, which could be precursors of ozone formation. Several VOCs not on the TO-14 list were identified in the samples, these compounds which were not quantified, are listed in Table 6.

Mass spectra files obtained from the analytical laboratory were scrutinised for unknown peaks occurring in the mass chromatograms. To identify the unknown peaks, their mass spectra peaks were compared to reference spectra in the NIST92 mass spectra library (NIST, 1992).

Library searches were done after background subtraction of the mass chromatogram peaks.

The mass spectra peaks of the VOCs and the corresponding molecular weight (MWT) of the reference compounds are also listed on the table. The last column has a parameter indicating the degree to which the unknown VOC fitted the reference, on a scale of 1-1000. Generally any “fit “above 950 was considered a good fit. Only VOCs with “fits” close to 900 or above were listed in Table 6.

**Table 6: Other VOCs Detected in the Samples**

| VOC | Mass Peaks (m/e) | | MWT (amu) | Fit |
|---|---|---|---|---|
| | Base* | Others | | |
| **2-butene** | 56 | | 56 | 990 |
| **3-methylpentane** | 57 | | 80 | 929 |
| **1,3-pentadiene** | 53 | 63 | 68 | 934 |
| **methylbutadiene** | 53 | 67 | 68 | 904 |
| **methylbutene** | 55 | 70 | 70 | 947 |
| **methylhexane** | 71 | | 100 | 920 |
| **dimethylhydroxypropionaldehyde** | 56 | 72 | 102 | 910 |
| **methylhexene** | 56 | | 98 | 905 |
| **cyclohexane** | 56 | 69, 84 | 84 | 906 |
| **methylheptane** | 55 | 70 | 100 | 905 |
| **trimethylpentane** | 57 | | 114 | 943 |
| **methylhexane** | 57 | 71, 81 | 100 | 940 |
| **methylcyclohexane** | 55 | 83, 98 | 98 | 919 |
| **ethylmethyl cyclopentane** | 55 | 83 | 112 | 931 |
| **dimethylsulphide** | 61 | 79, 94 | 94 | 994 |
| **3-heptanone** | 57 | 114 | 114 | 959 |
| **ethylhexanal** | 57 | 72 | 128 | 943 |
| **propylbenzene** | 91 | 120 | 120 | 933 |
| **ethylhexanal** | 57 | 72 | 128 | 903 |
| **propylbenzene** | 91 | 120 | 120 | 978 |
| **cyclooctyl alcohol** | 56 | 69, 81 | 128 | 902 |
| **diphenylethanedione** | 51 | 77, 105 | 210 | 952 |
| **pentadecene** | 57 | | 210 | 901 |
| **indane** | 117 | | 118 | 941 |
| **eucalyptol** | 81 | 93, 108, 139 | 154 | 895 |

**The base peak is the most intense mass spectrum peak*

# 4. COMPARISON WITH OTHER CITIES

Air toxics concentrations obtained in Perth were similar to those reported in other cities in Australia. Similar types of compounds detected in Sydney were also found in Perth. Several of the compounds detected in this study were also in the Perth 1992 emissions inventory. These organic compounds contribute to ozone formation and are potential health hazards.

## 4.1 VOC CONCENTRATIONS IN OTHER CITIES

In Table 7 the ambient concentrations of benzene, toluene, ethylbenzene and the xylenes from Perth have been compared to data obtained from Sydney (NSW EPA, 1998), Melbourne (Torre *et al.*, 1996) and Auckland (Graham and Narsey, 1995). Each range quoted in the table, covers the average 24-hour concentrations computed for the various sampling locations in the cities (the number of sampling locations is in brackets). In the case of Melbourne, samples were obtained from one site—Dandenong, which is an industrial site in the city. Data from this site does not represent the Melbourne metropolitan area.

The data have been reported as 24-h time-integrated averages. Except for the Auckland study, samples were obtained using the TO-14 method, which involved collection of samples into stainless steel canisters, followed by pre-concentration and analysis by GC-MS. In the Auckland study, samples were collected by absorption onto a solid substrate then later removed and analysed by GC-MS.

VOC concentrations in Perth appear to be higher than the corresponding concentrations in Melbourne and Auckland, but are comparable to Sydney data. For most of the VOCs shown in Table 7, the upper concentration ranges for the Sydney data set fall above those observed for Perth. Sydney data represents a cross section of the city (18 sites) and Melbourne data are from an industrial site—Dandenong. The data obtained from Hope Valley (HV), in Perth, which is downwind of the Kwinana Industrial area, would be a better comparison for this Melbourne site. The maximum 24-h benzene and toluene concentrations recorded at HV were 1.05 ppb and 1.65 ppb respectively, which are below the corresponding values from the Dandenong industrial site.

**Table 7: Comparison of Perth VOC data with other Cities**

| Conc. (ppb) [#] | Toluene | Benzene | Ethyl-benzene | (m+p)-Xylene | o-Xylene |
|---|---|---|---|---|---|
| **Perth [6]** | 0.20 - 4.10 | 0.15 - 2.17 | 0.12 - 0.63 | 0.25 - 2.24 | 0.10 - 0.92 |
| **Sydney [18]** | 0.8 - 5.8 | 0.3 - 2.5 | 0.1 - 0.6 | 0.3 - 2.5 | 0.1 - 0.9 |
| **Melbourne [1*]** | 1.2 - 2.4 | 0.5 - 1.4 | 0.1 - 0.2 | 0.4 - 1.1 | 0.2 - 0.5 |
| **Auckland [2]** | 0.64 - 0.61 | 0.53 - 0.67 | 0.05 - 0.13 | 0.22 - 0.34** | |

*[#] Refers to the number of sites.*
**There were six samplers at this site*
***Combined concentration of all 3 isomers of xylene*

## 4.2 BENZENE CONCENTRATIONS

Historically, benzene has been the most measured volatile organic compound. This is because it is a known carcinogen and is ubiquitous in the ambient environment. The annual average benzene concentration calculated for Perth was compared to concentrations reported from data obtained in Sydney (NSW EPA, 1998), Toronto and Montreal (Dann and Wang, 1995), San Francisco and Los Angeles (ARB, 1998) in Figure 6. These studies used the SUMMA canister method for collecting 24-hour samples.

The annual average benzene concentration of 1.44 ppb in Perth was comparable to those reported for Sydney (1995-1996) and Los Angeles (1996). The Sydney data was based on a cross section of urban and suburban sites taken at different times of the year. The 24-h annual average benzene concentration at a CBD site in Sydney was 2.5 ppb, which was higher than the annual average for Perth's CBD. Data for Montreal was based on the average of one suburban and two urban sites. The maximum 24-h benzene concentration at the Montreal suburban site (Trembles) was 32.2 ppb, again which was much higher than the maximum recorded 24-h concentration of benzene for Perth, 17.6 ppb. The Toronto data was based on three urban sites, and the maximum 24-h benzene concentration reported was 5.39 ppb. San Francisco and Los Angeles data were each from one site only. It is not known whether these sites were industrial or residential sites, making direct comparison difficult. Nevertheless the data obtained for Perth are of concern given its size and population.

All the benzene concentrations shown in Figure 6, were less than the 5 ppb annual average standard recommended by The Expert Panel on Air Quality Standards in the United Kingdom (EPAQS, 1994). However, with the exception of Toronto and San Francisco data, the annual averages were all above a future target of 1 ppb, suggested by that same panel.

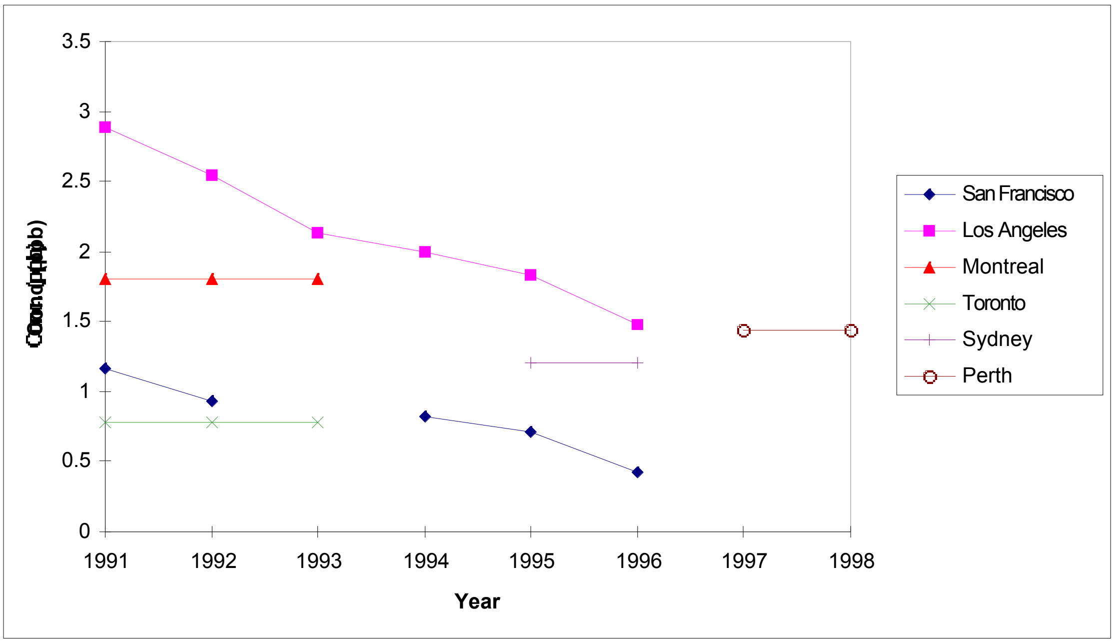



**Figure 6: Annual Average Benzene Concentrations calculated for Different Cities**

# 5. EMISSIONS INVENTORY

According to the 1992 Perth emissions inventory (Weir and Muriale, 1994), motor vehicles were a major source of hydrocarbon emissions, discharging a total of 27,000 tonnes per annum (tpa) into the Perth Airshed. A significant single source of organic emissions was the petroleum refinery in Kwinana (9,900 tpa), other industries and area-based sources contributed a total of 26,200 tpa. These organic emissions, in conjunction with NOx emissions from similar sources, result in ozone formation during summer.

The major organic emissions which impact the Perth CBD are motor vehicle exhaust and evaporative emissions. During the Perth Photochemical Smog Study, it was estimated that on an ozone event day, organic emissions in the CBD could be as high as 200 kg/m$^2$ (PPSS, 1996). Organic compound emissions in Perth's CBD can be speciated using motor vehicle emission profiles established for NSW and Victoria (Carnovale *et al.*, 1997).

**Table 8a: Profile of Aromatic Compounds Emissions in the Perth CBD**

| | Benzene | Ethylbenzene | Toluene | Xylenes | 1,2,4-TMB* |
|---|---|---|---|---|---|
| Emission Rate (kg-mole/m$^2$/day) | 0.10 | 0.03 | 0.17 | 0.14 | 0.03 |
| Ambient Concentration (ppb)** | 1.46 | 0.24 | 2.85 | 2.03 | 0.59 |
| Emissions Ratio | n/a | 0.3 | 1.7 | 1.4 | 0.3 |
| Concentration Ratio | n/a | 0.2 | 2.0 | 1.4 | 0.4 |

**1,2,4-Trimethylbenzene; **Average 24-h concentrations from Queen's Buildings, summer 1997/98 (5$^{th}$ quarter)*

In Table 8a, the calculated emissions of some speciated aromatic compounds are compared to the measured concentrations in the Perth CBD, using summer 1997/98 (5$^{th}$ quarter) data from Queen's Buildings. The bottom rows show the ratios of the emission rates and ambient concentrations of the individual compounds to benzene emission rate or concentration. All the aromatic compounds have similar emissions and concentration ratios, suggesting a consistency between the inventory profiles and measured concentrations.

Fugitive emissions from the petroleum refinery, at the Kwinana Industrial area, account for most of the organic emissions monitored at Hope Valley (HV). Table 8b shows that the emissions ratios from the emissions inventory for a Summer Weekday are different from concentration ratios calculated from average 24-h concentrations measured at HV during summer 1997/98 (5$^{th}$ quarter). The absence of speciation of "other aromatics" in the emissions inventory could have introduced large errors in the calculated ratios.

**Table 8b: Profile of Aromatic Compound Emissions from the Kwinana Industrial Area**

| | Benzene | Toluene | Xylenes | Other Aromatics* |
|---|---|---|---|---|
| Emission Rate (kg-mole/day) | 2.16 | 2.12 | 0.79 | 11.53 |
| Ambient Concentration (ppb)** | 0.35 | 0.54 | 0.40 | 0.56 |
| Emissions Ratio | n/a | 1.0 | 0.4 | 5.3 |
| Concentration Ratio | n/a | 1.5 | 1.1 | 1.6 |

**Comprises of ethylbenzene and the trimethylbenzenes for ambient concentration data*
***Average 24-h concentrations from Hope Valley, summer 1997/98 (5$^{th}$ quarter)*

# 6. ASSOCIATION OF VOC CONCENTRATIONS WITH OTHER POLLUTANTS AND METEOROLOGICAL PARAMETERS

Benzene and toluene showed seasonal variations at some sites. Statistical analysis of the data showed significant associations between some VOCs and nitric oxide (NO) and/or carbon monoxide (CO) concentrations at Duncraig and Queen's Buildings in the Perth CBD. Both sites have continuous CO and NOx analysers.

The normalised average 24-hour benzene and toluene concentrations from Duncraig and Queen's Buildings are plotted for each quarter, in Figure 7. Also plotted in Figure 7 are the carbon monoxide and nitric oxide data, also normalised. The 24-hour average average CO and NO concentrations were calculated for each quarter from 10-minute concentrations recorded by the CO and NOx analysers. The NO and CO data represent continuous monitoring data and the toluene and benzene data were averaged for days when the samples were taken. Data were normalised to aid in their comparison.

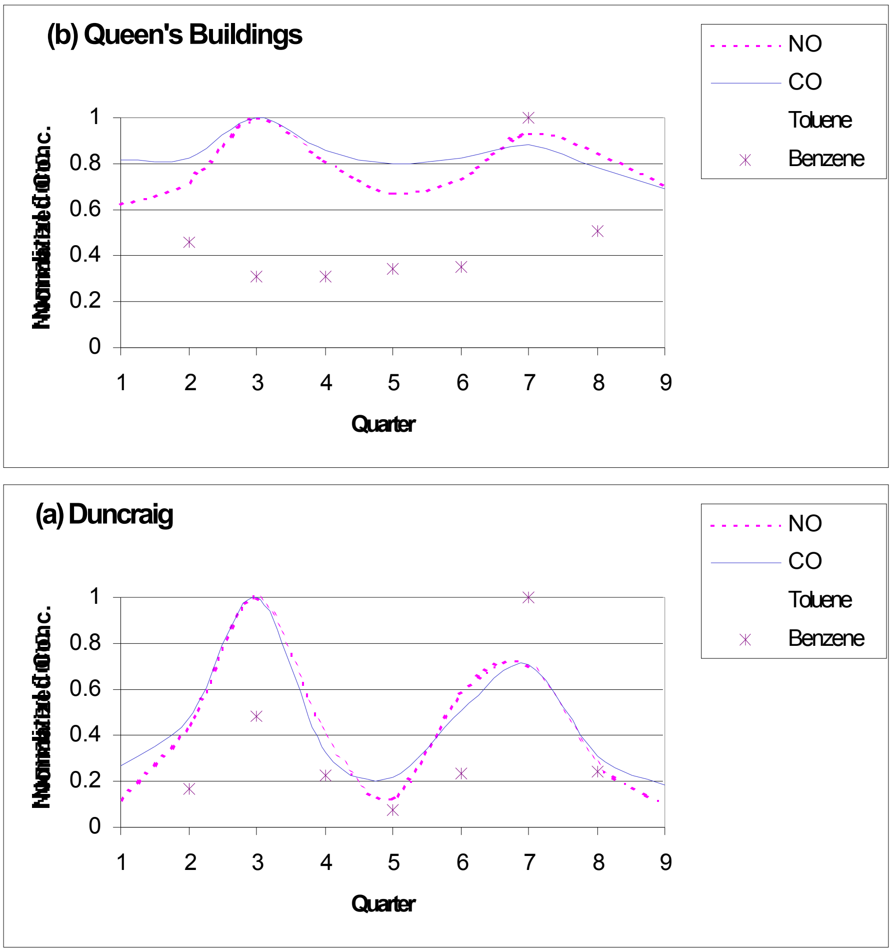



**Figure 7: Correlation of Toluene and Benzene with CO and NO data**

Nitric oxide and carbon monoxide data at both sites show seasonal variations with peaks in winter. Duncraig toluene and benzene data are consistent with these observations. However, toluene and benzene concentrations failed to peak at Queen's Buildings during the first winter (quarter #3).

There have been several studies that have reported good diurnal correlation between CO and VOC concentrations in cities. A correlation coefficient of 0.94 was reported for benzene and CO data collected during the morning peak hours in the California's South Coast Air Basin (Fujita *et al.*, 1992). Linear relationships were established between benzene and CO concentrations at several non-industrial sites in Canada (Dann and Wang, 1995).

At Duncraig, the Pearson correlation coefficient ($R^2$) for benzene and CO was 0.64 and a statistically negative association was found between benzene levels and temperature. For toluene and carbon monoxide, $R^2 = 0.63$, also a statistically negative association was found between toluene levels and temperature.

A lower correlation was obtained between benzene and CO at Queen's Buildings in the CBD ($R^2 = 0.40$). However, a better correlation was obtained between toluene and CO ($R^2 = 0.62$) at QB.

The variations in the values of the correlation coefficients at both sites can be attributed to the different kinds of emissions that impact the sites.

# 7. VOC REACTIVITY

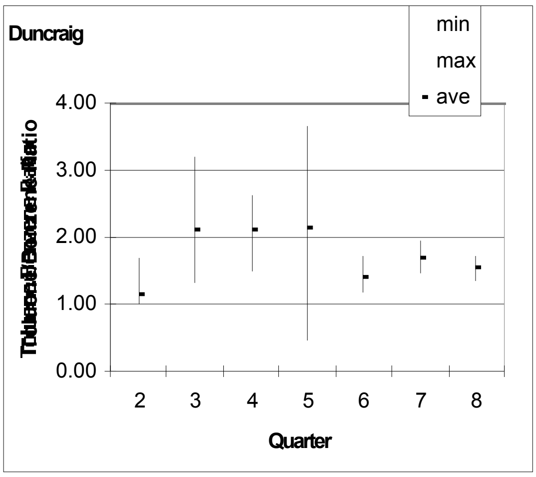
Among the VOCs quantified in this project, only the aromatic compounds such as BTX and the trimethylbenzenes are reactive enough to contribute to photochemical smog formation. The rate constant for reaction with the hydroxyl radical is a good indicator for the reactivity of organic pollutants in air.

Several of the compounds, which were not quantified (but presented in Table 6, Section 3.4) have the potential to react with the hydroxyl radical or other species in air that could lead to photochemical smog formation. Unsaturated hydrocarbons listed in Table 6 contribute considerably to photochemical smog formation in Perth. The smallest hydrocarbon detected was 2-butene (MWT = 56 amu). Other reactive low molecular weight hydrocarbons were expected to be in the samples, however, they were not detected, since the TO-14 method set the minimum of the mass spectrometer scanning range to 49 amu.

Benzene is more stable than toluene with respect to reaction with the hydroxyl radical, during smog formation reactions. Thus during the warm summer days, the ratio of toluene to benzene will change as the air masses age: aged air masses will have significantly lower toluene to benzene ratios than air masses with fresh emissions.

Figure 8 shows the seasonal trends in the toluene to benzene ratios for Duncraig and Queen's Buildings data. The vertical line represents the range of values and the dash represents the average ratio for each quarter (season). Ratios were calculated from parts-per-billion (ppb) ambient concentration data. As expected, the value of the ratio peaks around the winter months (Quarters 3 & 7) at both sites, after falling in the summer.

During the winter months, the toluene to benzene ratio at DU is lower than the ratio at QB. Both sites are impacted by motor vehicle emissions all year round but in addition, DU is severely impacted by wood fire smoke in winter (Gras, 1996). The lower toluene/benzene ratio at Duncraig, in winter, indicates that these wood fire emissions could have even higher benzene proportions than motor vehicle emissions.



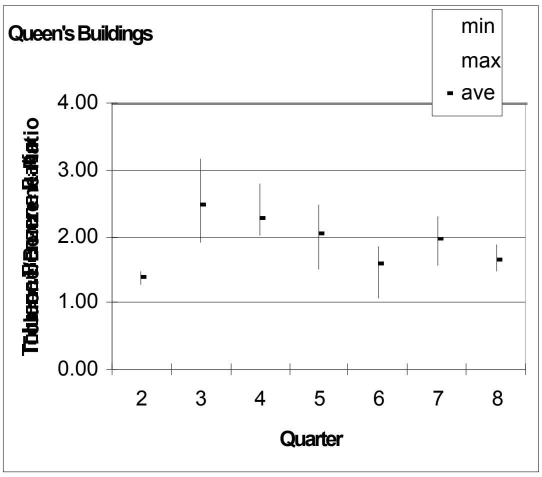




**Figure 8: Seasonal Variations of Toluene/Benzene Ratios**

**Table 9: Toluene /Benzene Ratios* in Perth**

| | Nov. to May | June to Oct. | Feb. 1994 |
|---|---|---|---|
| **Duncraig (DU)** | 1.69(0.76) | 1.87(0.47) | |
| **Perth CBD (QB)** | 1.75(0.35) | 2.05(0.38) | |
| **Fresh MV emissions (PPSS)**** | | | 1.82 (0.17) |

*Figures in parenthesis represent the standard deviations*
**Ratios were all calculated from ppb concentration data*
***From Galbally et al., 1995*

Toluene/benzene ratios have been summarised in Table 9, where the ratio, averaged for the warmer months (November through May) for each site, is compared to the corresponding average ratio for the cooler months (June through October). The ratio calculated for Perth air plumes containing fresh motor vehicle emissions is included in Table 9. This ratio was obtained in February 1994, by Galbally *et al.* (1995), during the intensive sampling period of the Perth Photochemical Smog Study (PPSS). The fresh motor vehicle emissions ratio is based on 11 ambient "in-traffic" samples collected while driving in the CBD, on the Freeway and on an arterial road during peak traffic times.

In general the June to October ratios were higher than the November to May ratios at both sites. The greater reactivity of toluene relative to benzene during the warmer months, when there was more photochemical activity, was reflected in the decrease in the toluene to benzene ratio from 1.87 to about 1.69 at Duncraig and from 2.05 to 1.75 in the Perth CBD (Table 9).

The ratios for the November to May period were similar at both sites. During this period both sites are impacted mostly by motor vehicle emissions. However, the PPSS ratio was expected to be greater since samples were obtained before peak smog times. The June to October toluene to benzene ratio for Duncraig was less than the corresponding ratio in the CBD, and this difference can be attributed to the additional impact of wood smoke emissions at Duncraig.

# 8. HEALTH IMPLICATIONS

There are no ambient standards in Australia against which the air toxics concentrations found in the Perth Study can be compared with, to assess the potential health impacts. The World Health Organisation (WHO 1987, 1994, 1996 & 1997), the Swedish Government (OECD, 1995) and The Expert Panel on Air Quality Standards in the United Kingdom (EPAQS, 1994) have provided guidelines for assessing health impacts of some toxic compounds. The guidelines are compared to the maximum 24-hour average and annual average concentrations of air toxics measured in Perth (Table 10).

**Table 10: Ambient Air Toxics Concentrations Compared to International Guidelines**

| | Concentrations (ppb) | | | | |
|---|---|---|---|---|---|
| | Perth Max 24-h Averages | WHO 24-h Average Guidelines[a] | Perth Annual Averages | Annual Average Guidelines | |
| Air Toxics | | | | Sweden[b] | UK[c] |
| Freon-12 | 11.7 | | 1.0 | | |
| Methyl Chloride | 5.6 | | 0.2 | | |
| Freon-114 | 0.8 | | 0.2 | | |
| Freon-11 | 3.0 | | 0.5 | | |
| Dichloromethane | 1.7 | 792 | 0.2 | 100-250 | |
| Freon-113 | 1.1 | | 0.3 | | |
| cis-1,2-Dichloroethylene | 2.1 | | 0.2 | | |
| Chloroform | 0.7 | 0.2 | 0.1 | | |
| 1,2-Dichloroethane | 0.3 | 159 | 0.1 | 100-150 | |
| Methyl chloroform | 0.8 | | 0.2 | | |
| Benzene | 17.6 | | 1.4 | 0.4 | 5 |
| Carbon tetrachloride | 1.1 | | 0.3 | | |
| Trichloroethylene | 0.9 | | 0.1 | 100-150 | |
| 1,1,2-Trichloroethane | 1.2 | | 0.1 | | |
| Toluene | 30.0 | 63.2* | 2.6 | 10-100 | |
| Tetrachloroethylene | 1.6 | 33.8 | 0.2 | 100-200 | |
| Chlorobenzene | 1.2 | | 0.2 | | |
| Ethylbenzene | 4.8 | 4644* | 0.4 | | |
| Xylenes | 22.6 | 1013.0 | 2.1 | | |
| Styrene | 2.1 | 55.9* | 0.3 | 10 | |
| Trimethylbenzenes | 6.9 | | 0.9 | | |
| 1,3-Dichlorobenzene | 1.1 | | 0.2 | | |
| 1,4-Dichlorobenzene | 1.3 | | 0.2 | | |
| 1,2-Dichlorobenzene | 1.2 | | 0.2 | | |
| 1,2,4-Trichlorobenzene | 2.1 | | 0.2 | | |

[a] *WHO guidelines quoted are for 24h averages except for compounds with asterisks (*) which are 1 week averages (WHO, 1987, 1994, 1996 & 1997)*
[b] *OECD, 1995*
[c] *EPAQS, 1994*

With exception of chloroform, there were no excursions of the maximum 24-h air toxics concentrations for Perth ambient data over any of the WHO guideline values for non-carcinogenic compounds (Table 10). The WHO guideline for chloroform is at the minimum limit of determination (LoD) for the TO-14 method (0.2 ppb), and most of the samples collected in Perth had chloroform concentrations below this LoD.

All the annual average concentrations, with the exception of the benzene concentration, are below the quoted guideline values from Sweden. However, as noted previously, the annual average benzene concentration in Perth (1.44 ppb) is below the 5 ppb annual average standard recommended by The Expert Panel on Air Quality Standards in the United Kingdom. It should be noted that the recommended UK standard is a running average value and will be calculated differently from the Perth annual average. Thus it appears that the ambient air toxics concentrations in Perth are all well below currently accepted guidelines.

Air toxics such as of chloroform, benzene, carbon tetrachloride and trichloroethylene are classified as human carcinogens or probable human carcinogens. The health endpoints resulting from human exposure to these carcinogens and other air toxics are summarised in the various monograms published by the World Health Organisation (WHO, 1987, 1994, 1996 & 1997).

# 9. SUMMARY OF FINDINGS

Queen's Buildings (QB) in the CBD had the highest annual average air toxics concentrations, though Duncraig (DU) tended to have higher BTX (benzene, toluene and xylene) concentrations during the winter season. Lower air toxics concentrations were obtained at Swanbourne (SW) and Hope Valley (HV). The concentrations of the BTX compounds tended to peak during the winter months at DU and QB. Toluene and benzene were the principal components of all the samples. The average concentrations and ranges (minimum and maximum shown in brackets) for combined sites in the study period for the most abundant compounds were: benzene 1.44(0.1, 17.6) ppb, toluene 2.56(0.1, 30.0) ppb, (m+p)-xylene 1.46(0.1, 16.7) ppb, o-xylene 0.63(0.1, 5.86) and ethylbenzene 0.44(0.1, 4.84) ppb. These values were similar to values reported in other Australian cities. These annual averages could be over- or underestimated for the Perth region, since data was included from sites with less frequent sampling, also data from event samples, which had been extrapolated to 24-hour averages, were included.

Multivariate linear regression analyses of Duncraig data found statistically significant associations for both toluene and benzene concentrations and season. However, no seasonal associations were found at QB. At Duncraig, statistically significant associations were found between toluene and CO; and between benzene levels and CO. A statistically significant association was found between toluene and CO only at QB.

The petroleum storage facilities in North Fremantle were probably the most likely sources contributing significantly to benzene and toluene concentrations in that area. Comparatively very low air toxics concentrations were measured on the Darling Scarp. Freon-12, possibly from household use, was the predominant component in Darling Scarp samples.

The aromatic hydrocarbons among the air toxics: benzene, ethylbenzene, toluene, xylenes and trimethylbenzenes were present at similar proportions to those reported in the Perth 1992 motor vehicle emissions inventory. However, the proportions of these aromatic compounds in samples taken at Hope Valley, which is downwind of the Kwinana Industrial area, were found to be different from their proportions in Kwinana Industries 1992 emissions inventory.

Duncraig had lower toluene/benzene ratios in winter than Queen's Buildings in the CBD. This may have resulted from significant wood fire emissions, known to produce some air toxics. Further, the summer months at both sites had lower toluene/benzene ratios than the cooler months, which is consistent with the greater depletion of toluene relative to benzene during the seasons with more photochemical activity.

Several volatile organic compounds (VOCs), which are not classified as air toxics, were detected in the samples, however, they were not quantified. These compounds included unsaturated hydrocarbons, which contribute substantially to ozone formation.

The annual average benzene concentration for Perth was estimated as 1.44 ppb, and is similar to the corresponding values for Los Angeles and Sydney. However, this value is within the standard suggested by The Expert Panel on Air Quality Standards in the United Kingdom. The concentration ranges and spatial distribution of air toxics need to be measured in more detail in Perth, followed by environmental health risk assessment to determine the nature of the risk.

# 10. CONCLUSIONS AND RECOMMENDATIONS

## 10.1 CONCLUSIONS

The study has produced a database of 24-hour integrated average air toxics concentrations in Perth. Most of the data were obtained from the Queen's Buildings site in the Perth CBD and from Duncraig, during the period March 1997 to November 1998. Data were also available for Swanbourne, Hope Valley, North Fremantle and Gooseberry Hill on the Darling Scarp.

The US EPA TO-14 method was used successfully to investigate up to forty air toxics in Perth. Twenty-three of the air toxics had annual average concentrations above or close to the limit of determination. The concentrations of several of these compounds have never been measured in Perth prior to this study.

Due to insufficient sampling across all seasons, there was insufficient power in the study to observe a strong seasonal influence on VOCs in Perth other than at Duncraig. Good correlations were obtained, at Duncraig, between toluene/benzene concentrations and those of other pollutants such as both carbon monoxide and nitric oxide, which are emitted from combustion sources such as motor vehicle exhausts and wood fire.

The aromatic hydrocarbons among the air toxics are expected to contribute to smog formation in Perth. They occur in Perth's CBD in ratios that are consistent with the motor vehicles emissions inventory.

This study has provided initial data on air pollutants in Perth for use in health risk assessment. The low concentrations of air toxics in Perth are consistent with results reported in similar cities, and are not expected to contribute significantly to health effects. The annual average benzene concentration is within acceptable health targets, but it is of some concern that it is similar to those measured in larger cities like Sydney and Los Angeles. Further elaboration of the risks posed by these substances is required.

## 10.2 RECOMMENDATIONS FOR FUTURE WORK

Over the past few years, the Department of Environmental Protection and the Chemistry Centre of WA have acquired the expertise and equipment to sample and analyse for volatile organic compounds in Perth air using the TO-14 method. The analytical methodology could be improved by use of a dynamic dilution apparatus or internal standards during the calibration of the GC-MS.

In this study, intensive monitoring was limited to two sites, Queen's Buildings in the Perth CBD and Duncraig, a suburb. The results obtained from these sites need to be confirmed and additional sampling from residential and industrial areas is required.

The list of compounds monitored should be reviewed to include new ones and/or exclude insignificant compounds. Hazardous air pollutants such as 1,3-butadiene, formaldehyde and benzo(a)pyrene are expected to be present in the Perth Airshed and should be included in the list of toxic pollutants measured in Perth. For example, benzo(a)pyrene and other PAHs were found at significant levels in particulate matter during the Perth Haze Study (Gras, 1996). Formaldehyde was among the speciated species in the Perth emissions inventory (PPSS, 1996). Appropriate methodologies for sampling and analysis are required to monitor these parameters in Perth's air.

Additional study is also required to further investigate the role of organic compounds which are precursors to ozone formation. This will provide data that can be used to further validate photochemical smog modelling in Perth. It is envisaged that another project will ensue from this report which will quantify these reactive compounds and determine their potential to form smog.

The VOCs identified in this study were consistent with the types expected from motor vehicles and wood fire smoke emissions. Finger printing of the sources is recommended to confirm that they are the source of the emissions.

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# 12. APPENDICES

## APPENDIX A: DATA REDUCTION

Two different types of samples were collected:

- Background samples—the normal type of samples, were 24-hour integrated samples, collected on a 12-day cycle when possible. A majority of the samples were background samples.
- Event samples were collected during suspected peak emission times, which sometimes occurred for less than 24 hours. At Queen's Buildings in the CBD, the peak emissions period was normally between 6 am and 7 pm; at Duncraig, the peak emissions period (in winter) was between 8 pm in the evening and 6 am the next day; at Hope Valley, peak emissions occurred when the wind was southwesterly. There were only 17 event samples in the database.

To get a consistent data set of 24-hour VOC concentrations, the concentrations from event samples were extrapolated to 24-hour averages by scaling the concentrations against the sampling times. The scaling factor accounted for dilution of the sample if sampling had continued during periods of low pollutant concentrations (when the sampler was not running). Scaling factors are reported in Appendix C with the detailed results. Some event samples were collected only when high pollutant levels were detected by a continuous monitor, during the period of sampling indicated in Appendix C. For these samples, the duration of sampling will be less than the period indicated in the appendix, since the sampler would have been turned off several times during that period, when ambient pollutant levels were low. Most other event samples were collected continuously for 8 to 12 hours. Event sample concentrations were multiplied by the scale factor to obtain 24-hour average concentrations.

The applicability of scaling factors was tested with a sampling experiment, whereby two AVOCS instruments were co-located at Queen's Buildings on 8 September 1998, to collect a background and an event sample respectively, on the same day. The background sampler run for 24 hours starting at 0000 h and the event sampler run from 0700 h, for 12 hours, at twice the sampling rate of the background sample, and spanned the peak traffic hours in the CBD. The theoretical scaling factor for the event sample was 0.5 (ie, 12h/24h).

This theoretical scaling factor of 0.5 can be compared to the experimental scaling factors, which were obtained from the ratios of the background to the corresponding event samples VOC concentrations. The VOC concentrations of the two samples are plotted in the graph, along with the experimental scaling factor (Figure A1). It appears that the extrapolation method is a good approximation for the aromatic hydrocarbons, and these are known to be emitted during peak hours.

The scaling factor should be valid if event sampling was done only during peak hours, and cumulative emissions during other hours were negligible when compared to the peak emissions. Nevertheless, since there are pollutant emissions during non-peak hours, these extrapolated concentrations should be considered as lower limits to the true 24-hour integrated averages.

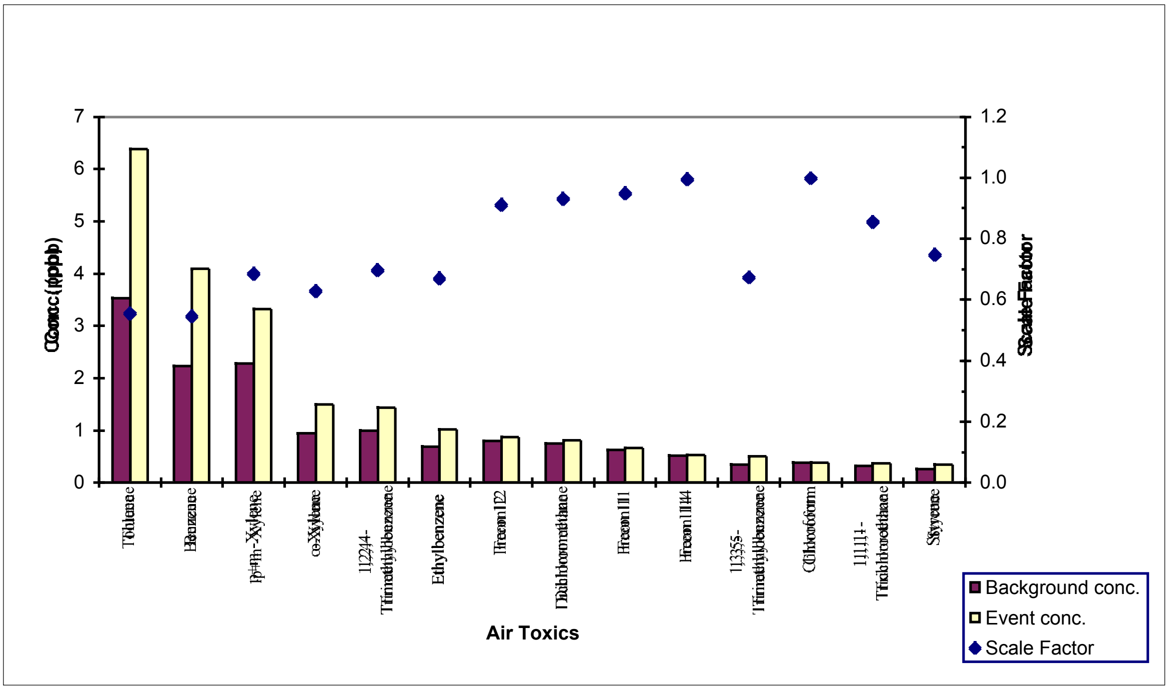


**Figure A1: Event and Background Samples from Co-located Samplers at QB (08/09/98)**

VOC emissions are associated with nitric oxide or carbon monoxide emissions from combustion sources. This method of extrapolating event sample concentrations to 24-hour concentrations can be justified by comparing the corresponding nitric oxide (NO) and carbon monoxide (CO) data from continuous monitoring analysers located at the sites where the event samples were collected.

Using the example for QB (08/09/98), the calculated ratios of the 12-h to the 24-h average CO and NO concentrations (Table A1) are similar to the scaling factor calculated from the ratio of the sampling periods. Scaling factors determined from sampling periods were used for extrapolation, since they provided lower limit values to the 24-hour average VOC concentrations than the scaling factors calculated from CO or NO concentrations.

**Table A1: Nitric Oxide and Carbon Monoxide Concentrations**

| | Continuous Monitor Concentration (ppb) | | Ratio (12h ave/ 24h ave) |
|---|---|---|---|
| | 12-h Average | 24-h Average | |
| **NO** | 199 | 110 | 0.55 |
| **CO** | 3200 | 1800 | 0.56 |

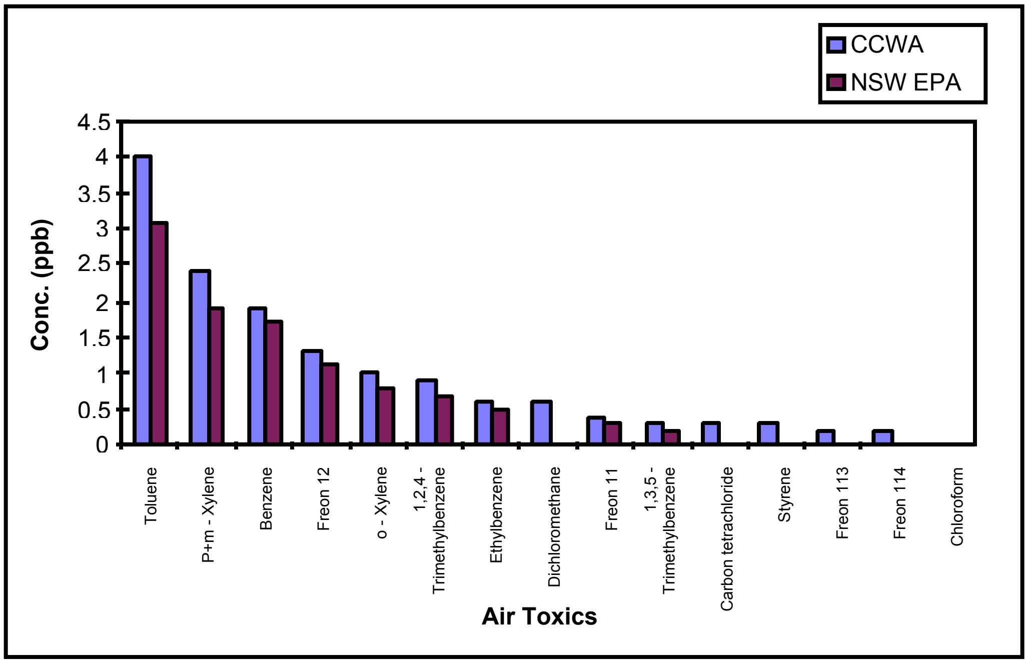


**Figure B1: Results of Inter-laboratory Analyses the Sample from QB (28/06/98)**

## APPENDIX B: DATA PRECISION AND ACCURACY

Several quality assurance procedures were used to determine the precision and accuracy of the VOC concentrations. Duplicate analyses were done on some samples to obtain the precision of sampling and analysis. Inter-laboratory samples were analysed to arrive at the degree of accuracy.

### Accuracy

Data accuracy can be affected by bias caused by improper calibration. Any bias in the data would be evident when results of the same samples analysed by different laboratories are compared. The Chemistry Centre (CCWA) and the NSW EPA analysed a set of samples in June 1997, and June 1998. Also, the CCWA, NSW EPA and VIC EPA laboratories analysed proficiency samples in November 1998.

Results of a sample from QB, analysed by the CCWA and NSW EPA are shown in the graph (Figure B1). With the exception of chloroform, there is a good agreement for air toxics with concentrations above 0.5 ppb for both laboratories. The CCWA data for this sample appear to be higher than the corresponding NSW EPA data by about 20%.

The CCWA proficiency sample results were on average about 30% higher than the expected results. This error is higher than was obtained from the previous inter-laboratory data. Using a dynamic dilution system for preparing the analytical standards, instead of the present static method that is labour intensive can reduce the error.

### Precision

The total precision in sampling and analysis will be reflected in the system variability which was calculated, for each target compound, from duplicate data obtained from co-located samplers. The system variability value represents the 95% confidence range of the concentrations. The system variability was calculated, for each compound, from the relative standard deviation of the pairs of data sets. Two data sets were obtained from Duncraig and one from Queen's Buildings.

The system variability for compounds normally present at significant levels (ie, above 0.5 ppb), such as benzene and toluene, were always less than 25%. The table below (Table B1) shows the results of duplicate sampling using co-located samplers at Duncraig on 19/05/98. The system variability, calculated for each air toxic, is presented in the last column. The most abundant components have errors in precision less than 20%.

**Table B1: Results of Duplicate Analyses of Samples from Duncraig (19/5/98)**

| Air toxics | Concentration (ppb) | | System Variability (%) |
|---|---|---|---|
| | Sample | Duplicate | |
| **Toluene** | 2.49 | 2.24 | 20 |
| **Benzene** | 1.32 | 1.46 | 21 |
| **Freon-12** | 0.92 | 1.02 | 19 |
| **(m+p) -Xylene** | 0.68 | 0.69 | 1 |
| **o-Xylene** | 0.57 | 0.55 | 7 |
| **1,2,4-Trimethylbenzene** | 0.51 | 0.49 | 9 |
| **Ethylbenzene** | 0.44 | 0.46 | 7 |
| **Freon-11** | 0.39 | 0.36 | 13 |
| **1,4-Dichlorobenzene** | 0.26 | 0.36 | 65 |
| **1,3,5-Trimethylbenzene** | 0.26 | 0.23 | 19 |
| **1,2-Dichlorobenzene** | 0.23 | 0.34 | 76 |
| **Tetrachloroethylene** | 0.22 | 0.29 | 58 |
| **Styrene** | 0.21 | 0.25 | 32 |
| **Carbon tetrachloride** | 0.21 | 0.17 | 45 |
| **1,3-Dichlorobenzene** | 0.20 | 0.26 | 54 |
| **Chlorobenzene** | 0.19 | 0.30 | 91 |
| **1,1,1-Trichloroethane** | 0.19 | 0.21 | 22 |
| **Freon-114** | 0.18 | 0.16 | 23 |
| **Chloroform** | 0.18 | 0.17 | 12 |

# APPENDIX C: DETAILED RESULTS BY SITE

## Duncraig (DU) Air Toxics Samples

| | | | | Start date | Start time | End date | End time | Flowrate | Scaling | |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Canister# | AVOCS# | (dd/mm/yy) | (hhmm) | (dd/mm/yy) | (hhmm) | (ml/min) | Factor | Quarter# |
| 12 | DU/103/970320 | 03103 | 407 | 20/03/97 | 0000 | 20/03/97 | 2400 | 8 | 1 | 2 |
| 16 | DU/096/970403 | 03096 | 407 | 03/04/97 | 0600 | 03/04/97 | 1800 | 16 | 0.5 | 2 |
| 20 | DU/099/970409 | 03099 | 407 | 09/04/97 | 1600 | 10/04/97 | 1100 | 16 | 0.5 | 2 |
| 24 | DU/105/970416 | 03105 | 407 | 16/04/97 | 1600 | 17/04/97 | 1100 | 20 | 0.4 | 2 |
| 26 | DU/099/970522 | 03099 | 407 | 22/05/97 | 1230 | 23/05/97 | 1230 | 8 | 1 | 2 |
| 28 | DU/103/970528 | 03103 | 407 | 28/05/97 | 1400 | 29/05/97 | 1400 | 8 | 1 | 2 |
| 29 | DU/104/970618E | 03104 | 407 | 18/06/97 | 2000 | 22/06/97 | 0800 | 20 | 0.5 | 3 |
| 31 | DU/096/970623E | 03096 | 407 | 23/06/97 | 1415 | 25/06/97 | 1410 | 20 | 0.3 | 3 |
| 32 | DU/092/970626E | 03092 | 407 | 26/06/97 | 1700 | 29/06/97 | 2130 | 10 | 0.3 | 3 |
| 33 | DU/093/970717E | 03093 | 407 | 17/07/97 | 1700 | 20/07/97 | 0510 | 8 | 0.5 | 3 |
| 35 | DU/106/970731 | 03106 | 407 | 31/07/97 | 1400 | 01/08/97 | 1400 | 8 | 1 | 3 |
| 37 | DU/103/970819 | 03103 | 407 | 19/08/97 | 1400 | 20/08/97 | 1400 | 8 | 1 | 3 |
| 39 | DU/093/970912 | 03093 | 407 | 12/09/97 | 1400 | 13/09/97 | 1400 | 8 | 1 | 4 |
| 40 | DU/105/970916E | 03105 | 407 | 16/09/97 | 1630 | 17/09/97 | 1300 | 16 | 0.5 | 4 |
| 41 | DU/092/970917E | 03092 | 407 | 17/09/97 | 1400 | 18/09/97 | 1130 | 8 | 1 | 4 |
| 43 | DU/106/970924 | 03106 | 407 | 24/09/97 | 1400 | 25/09/97 | 1400 | 8 | 1 | 4 |
| 45 | DU/096/971006 | 03096 | 407 | 06/10/97 | 1715 | 07/10/97 | 1715 | 8 | 1 | 4 |
| 47 | DU/099/971018 | 03099 | 407 | 18/10/97 | 1400 | 19/10/97 | 1400 | 8 | 1 | 4 |
| 49 | DU/093/971030 | 03093 | 407 | 30/10/97 | 1400 | 31/10/97 | 1400 | 8 | 1 | 4 |
| 52 | DU/096/971111 | 03096 | 407 | 11/11/97 | 1400 | 12/11/97 | 1400 | 8 | 1 | 4 |
| 54 | DU/105/971123 | 03105 | 407 | 23/11/97 | 1400 | 24/11/97 | 1400 | 8 | 1 | 4 |
| 57 | DU/716/971205 | 02716 | 407 | 05/12/97 | 1400 | 06/12/97 | 1400 | 8 | 1 | 5 |
| 60 | DU/096/971217 | 03096 | 407 | 17/12/97 | 1400 | 18/12/97 | 1400 | 8 | 1 | 5 |
| 64 | DU/106/971223 | 03106 | 407 | 23/12/97 | 1045 | 24/12/97 | 1045 | 8 | 1 | 5 |
| 68 | DU/096/980110 | 03096 | 407 | 10/01/98 | 1400 | 11/01/98 | 1400 | 8 | 1 | 5 |
| 72 | DU/105/980122 | 03105 | 407 | 22/01/98 | 1400 | 23/01/98 | 1400 | 8 | 1 | 5 |
| 76 | DU/106/980126 | 03106 | 407 | 26/01/98 | 1200 | 27/01/98 | 1200 | 8 | 1 | 5 |
| 81 | DU/743/980209 | 24743 | 407 | 09/02/98 | 1100 | 10/02/98 | 1100 | 8 | 1 | 5 |
| 82 | DU/099/980219 | 03099 | 407 | 19/02/98 | 1400 | 20/02/98 | 1400 | 8 | 1 | 5 |
| 93 | DU/092/980305 | 03092 | 407 | 05/03/98 | 1200 | 06/03/98 | 1200 | 8 | 1 | 6 |
| 96 | DU/498/980325 | 24498 | 407 | 25/03/98 | 1230 | 26/03/98 | 1230 | 8 | 1 | 6 |
| 106 | DU/104/980404 | 03104 | 407 | 04/04/98 | 1400 | 05/04/98 | 1400 | 8 | 1 | 6 |
| 108 | DU/716/980422 | 22716 | 407 | 22/04/98 | 1230 | 23/04/98 | 1230 | 8 | 1 | 6 |
| 112 | DU/092/980501 | 03092 | 407 | 01/05/98 | 1330 | 02/05/98 | 1330 | 8 | 1 | 6 |
| 119 | DU/716/980519 | 22716 | 407 | 19/05/98 | 1600 | 20/05/98 | 1600 | 8 | 1 | 6 |
| 123 | DU/099/980603 | 03099 | 407 | 03/06/98 | 1230 | 04/06/98 | 1230 | 8 | 1 | 7 |
| 126 | DU/093/980615 | 03093 | 407 | 15/06/98 | 1400 | 16/06/98 | 1400 | 8 | 1 | 7 |
| 127 | DU/103/980627 | 03103 | 407 | 27/06/98 | 1200 | 28/06/98 | 1200 | 8 | 1 | 7 |
| 129 | DU/099/980628 | 03099 | 407 | 28/06/98 | 1200 | 29/06/98 | 1200 | 8 | 1 | 7 |
| 132 | DU/092/980709 | 03092 | 407 | 09/07/98 | 1200 | 10/07/98 | 1200 | 8 | 1 | 7 |
| 135 | DU/097/980722 | 03097 | 407 | 22/07/98 | 1200 | 23/07/98 | 1200 | 8 | 1 | 7 |
| 137 | DU/106/980723 | 03106 | 407 | 23/07/98 | 1200 | 24/07/98 | 1200 | 8 | 1 | 7 |
| 139 | DU/498/980802 | 24498 | 407 | 02/08/98 | 1200 | 03/08/98 | 1200 | 8 | 1 | 7 |
| 140 | DU/092/980814 | 03092 | 407 | 14/08/98 | 1200 | 15/08/98 | 1200 | 8 | 1 | 7 |
| 143 | DU/497/980825 | 24497 | 407 | 25/08/98 | 1200 | 26/08/98 | 1200 | 8 | 1 | 7 |
| 145 | DU/498/980826 | 24498 | 407 | 26/08/98 | 1200 | 27/08/98 | 1200 | 8 | 1 | 7 |
| 148 | DU/104/980908 | 03104 | 407 | 08/09/98 | 0000 | 09/09/98 | 0000 | 8 | 1 | 8 |
| 151 | DU/098/980919 | 03098 | 407 | 19/09/98 | 1200 | 20/09/98 | 1200 | 8 | 1 | 8 |
| 153 | DU/093/981001 | 03093 | 407 | 01/10/98 | 1200 | 02/10/98 | 1200 | 8 | 1 | 8 |
| 155 | DU/092/981014 | 03092 | 407 | 14/10/98 | 0000 | 15/10/98 | 0000 | 8 | 1 | 8 |
| 158 | DU/099/981025 | 03099 | 411 | 25/10/98 | 1200 | 26/10/98 | 1200 | 8 | 1 | 8 |
| 163 | DU/097/981106 | 03097 | 411 | 06/11/98 | 1200 | 07/11/98 | 1200 | 8 | 1 | 8 |
| 166 | DU/091/981118 | 03091 | 411 | 18/11/98 | 1400 | 19/11/98 | 1400 | 8 | 1 | 8 |
| 168 | DU/098/981130 | 03098 | 411 | 30/11/98 | 1200 | 01/12/98 | 1200 | 8 | 1 | 8 |



"-": concentration is below 0.1 ppb

DUNCRAIG AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | | Methyl | | Vinyl | Methyl | Ethyl | | Vinylidene | Methylene |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Freon 12 | Chloride | Freon 114 | Chloride | Bromide | Chloride | Freon 11 | Chloride | Chloride |
| 12 | DU/103/970320 | - | - | - | | - | | - | - | - |
| 16 | DU/096/970403 | - | - | - | | - | | - | - | - |
| 20 | DU/099/970409 | - | - | - | | - | | - | - | - |
| 24 | DU/105/970416 | - | - | - | | - | | - | - | - |
| 26 | DU/099/970522 | - | - | - | | - | | 3.00 | - | - |
| 28 | DU/103/970528 | - | - | - | | - | | - | - | - |
| 29 | DU/104/970618E | 0.28 | - | - | | - | | - | - | - |
| 31 | DU/096/970623E | 0.11 | - | - | | - | | - | - | - |
| 32 | DU/092/970626E | 0.14 | - | - | | - | | - | - | - |
| 33 | DU/093/970717E | 0.24 | - | - | | - | | - | - | - |
| 35 | DU/106/970731 | - | - | - | | - | | - | - | - |
| 37 | DU/103/970819 | 0.24 | - | - | | - | | - | - | - |
| 39 | DU/093/970912 | 0.53 | - | - | | - | | 0.31 | 0.20 | - |
| 40 | DU/105/970916E | 0.47 | - | - | | - | | 0.19 | 0.20 | - |
| 41 | DU/092/970917E | 0.70 | - | - | | 0.12 | | 0.14 | 0.12 | - |
| 43 | DU/106/970924 | 0.66 | - | - | | - | | 0.29 | 0.11 | - |
| 45 | DU/096/971006 | 0.74 | - | - | | - | | 0.33 | - | - |
| 47 | DU/099/971018 | 0.48 | - | - | | - | | 0.26 | - | - |
| 49 | DU/093/971030 | 1.39 | - | 0.78 | | - | | 0.59 | - | - |
| 52 | DU/096/971111 | 1.31 | - | 0.78 | | 0.53 | | 0.59 | - | - |
| 54 | DU/105/971123 | 1.36 | - | 0.78 | | 0.52 | | 0.60 | - | - |
| 57 | DU/716/971205 | 0.60 | - | - | | - | | - | - | - |
| 60 | DU/096/971217 | 0.73 | - | 0.38 | | - | | 0.77 | - | - |
| 64 | DU/106/971223 | 0.82 | - | 0.39 | | - | | 0.80 | - | - |
| 68 | DU/096/980110 | 0.80 | - | - | | - | | 0.27 | - | 0.13 |
| 72 | DU/105/980122 | 0.73 | - | - | | - | | 0.21 | - | - |
| 76 | DU/106/980126 | 0.64 | - | - | | - | | 0.24 | - | - |
| 81 | DU/743/980209 | 0.58 | - | - | | - | | 0.19 | - | 0.14 |
| 82 | DU/099/980219 | 0.83 | - | - | | - | | 0.37 | - | - |
| 93 | DU/092/980305 | 0.81 | - | - | | - | | 0.46 | - | 0.30 |
| 96 | DU/498/980325 | 0.95 | - | 0.10 | | - | | 0.26 | - | 0.46 |
| 106 | DU/104/980404 | 0.51 | - | - | | - | | 0.23 | - | - |
| 108 | DU/716/980422 | 0.90 | - | - | | - | | 0.42 | - | 1.72 |
| 112 | DU/092/980501 | 0.62 | - | - | | - | | 0.27 | - | 0.16 |
| 119 | DU/716/980519 | 1.02 | - | 0.16 | | - | | 0.36 | - | - |
| 123 | DU/099/980603 | 0.86 | - | 0.17 | | - | | 0.34 | - | 0.28 |
| 126 | DU/093/980615 | 0.88 | - | 0.18 | | - | | 0.38 | - | 0.69 |
| 127 | DU/103/980627 | 3.55 | - | - | | - | | 1.29 | - | 0.21 |
| 129 | DU/099/980628 | 3.38 | - | - | | - | | 1.26 | - | 0.62 |
| 132 | DU/092/980709 | 2.99 | - | - | | - | | 1.24 | - | 0.19 |
| 135 | DU/097/980722 | 3.54 | - | - | | - | | 1.10 | - | 0.36 |
| 137 | DU/106/980723 | 3.37 | - | - | | - | | 1.19 | - | 0.53 |
| 139 | DU/498/980802 | 6.64 | - | - | | - | | 0.94 | - | - |
| 140 | DU/092/980814 | 0.73 | 1.05 | 0.52 | | - | | 0.40 | - | - |
| 143 | DU/497/980825 | 0.74 | - | - | | - | | 0.40 | - | - |
| 145 | DU/498/980826 | 4.59 | - | 0.53 | | - | | 0.44 | - | 0.76 |
| 148 | DU/104/980908 | 0.93 | - | 0.52 | | - | | 0.43 | - | 0.73 |
| 151 | DU/098/980919 | 0.83 | - | 0.52 | | - | | 0.42 | - | 0.74 |
| 153 | DU/093/981001 | 1.30 | - | 0.24 | | - | | 1.15 | - | - |
| 155 | DU/092/981014 | 1.38 | 2.34 | 0.25 | | - | | 1.18 | - | - |
| 158 | DU/099/981025 | 1.31 | - | 0.24 | | - | | 1.16 | - | - |
| 163 | DU/097/981106 | 1.40 | - | 0.24 | | - | | 1.17 | - | - |
| 166 | DU/091/981118 | 0.82 | - | - | | - | | 1.37 | - | 0.82 |
| 168 | DU/098/981130 | 0.71 | - | - | | - | | 1.25 | - | - |



“-“: concentration is below 0.1 ppb

DUNCRAIG AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | | 1,1-Dichloro- | 1,2-Dichloro- | | 1,2-Dichloro- | Methyl | | Carbon |
|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Freon 113 | ethane | ethylene | Chloroform | ethane | Chloroform | Benzene | tetrachloride |
| 12 | DU/103/970320 | - | | - | - | - | - | - | - |
| 16 | DU/096/970403 | - | | - | - | - | - | - | - |
| 20 | DU/099/970409 | - | | - | - | - | - | - | - |
| 24 | DU/105/970416 | - | | - | - | - | - | 0.88 | - |
| 26 | DU/099/970522 | - | | - | - | - | - | - | - |
| 28 | DU/103/970528 | - | | - | - | - | - | 3.20 | - |
| 29 | DU/104/970618E | - | | - | - | - | 0.28 | 3.90 | - |
| 31 | DU/096/970623E | - | | - | - | - | 0.17 | 1.12 | - |
| 32 | DU/092/970626E | - | | - | - | - | 0.17 | 1.04 | - |
| 33 | DU/093/970717E | - | | - | - | - | 0.29 | 3.54 | - |
| 35 | DU/106/970731 | - | | - | - | - | 0.53 | 0.95 | - |
| 37 | DU/103/970819 | - | | - | - | - | 0.57 | 2.36 | - |
| 39 | DU/093/970912 | 0.20 | | 0.47 | 0.14 | 0.20 | - | 0.46 | 0.22 |
| 40 | DU/105/970916E | - | | 0.24 | 0.11 | - | - | 0.59 | 0.12 |
| 41 | DU/092/970917E | 0.22 | | - | 0.19 | - | 0.14 | 1.74 | 0.24 |
| 43 | DU/106/970924 | 0.17 | | - | 0.18 | - | 0.12 | 1.09 | 0.21 |
| 45 | DU/096/971006 | 0.18 | | - | 0.14 | - | - | 0.71 | 0.18 |
| 47 | DU/099/971018 | 0.18 | | - | - | - | 0.11 | 0.37 | 0.19 |
| 49 | DU/093/971030 | 0.80 | | - | 0.57 | - | 0.81 | 1.44 | 0.66 |
| 52 | DU/096/971111 | 0.82 | | - | 0.57 | - | 0.82 | 1.00 | 0.67 |
| 54 | DU/105/971123 | 0.78 | | - | 0.67 | - | 0.84 | 1.57 | 0.67 |
| 57 | DU/716/971205 | - | | 2.06 | - | - | - | 0.13 | - |
| 60 | DU/096/971217 | 1.14 | | - | - | - | 0.21 | 0.18 | 0.28 |
| 64 | DU/106/971223 | 1.12 | | - | - | - | 0.30 | 0.21 | 0.29 |
| 68 | DU/096/980110 | - | | 1.40 | - | - | - | 0.52 | - |
| 72 | DU/105/980122 | - | | - | - | - | - | 0.11 | - |
| 76 | DU/106/980126 | 0.11 | | - | - | - | - | 0.18 | - |
| 81 | DU/743/980209 | - | | - | - | - | - | 0.39 | - |
| 82 | DU/099/980219 | 0.12 | | - | 0.13 | 0.20 | 0.10 | 0.84 | 0.16 |
| 93 | DU/092/980305 | 0.12 | | - | - | - | 0.15 | 0.73 | 0.21 |
| 96 | DU/498/980325 | 0.23 | | 0.15 | - | - | 0.27 | 1.55 | 0.14 |
| 106 | DU/104/980404 | - | | 0.67 | - | - | - | 0.36 | - |
| 108 | DU/716/980422 | 0.17 | | - | 0.14 | - | 0.12 | 1.58 | 0.24 |
| 112 | DU/092/980501 | 0.10 | | - | - | - | - | 0.53 | 0.15 |
| 119 | DU/716/980519 | 0.25 | | - | 0.17 | - | 0.21 | 1.46 | 0.17 |
| 123 | DU/099/980603 | 0.24 | | - | 0.13 | - | 0.20 | 0.79 | 0.15 |
| 126 | DU/093/980615 | 0.16 | | - | 0.14 | - | 0.16 | 1.15 | 0.22 |
| 127 | DU/103/980627 | - | | - | - | - | - | 4.50 | 0.48 |
| 129 | DU/099/980628 | 0.27 | | 0.18 | - | 0.27 | 0.14 | 5.11 | 0.52 |
| 132 | DU/092/980709 | - | | - | - | - | 0.13 | 3.11 | 0.42 |
| 135 | DU/097/980722 | - | | - | 0.39 | - | 0.16 | 17.62 | 0.43 |
| 137 | DU/106/980723 | - | | - | - | - | 0.13 | 13.18 | 0.42 |
| 139 | DU/498/980802 | - | | - | - | - | 0.12 | 1.61 | 0.39 |
| 140 | DU/092/980814 | 0.22 | | - | - | - | 0.32 | 0.36 | 0.23 |
| 143 | DU/497/980825 | 0.25 | | - | 0.40 | - | 0.33 | 1.16 | 0.24 |
| 145 | DU/498/980826 | 0.26 | | - | 0.37 | - | 0.33 | 0.44 | 0.26 |
| 148 | DU/104/980908 | 0.27 | | - | 0.45 | - | 0.34 | 1.89 | 0.25 |
| 151 | DU/098/980919 | 0.25 | | - | 0.39 | - | 0.33 | 0.94 | 0.24 |
| 153 | DU/093/981001 | 0.68 | | - | - | - | - | 0.90 | 1.04 |
| 155 | DU/092/981014 | 0.67 | | - | - | - | - | 1.44 | 1.04 |
| 158 | DU/099/981025 | 0.64 | | - | - | - | - | 0.97 | 1.04 |
| 163 | DU/097/981106 | 0.75 | | - | - | - | - | 1.09 | 1.04 |
| 166 | DU/091/981118 | - | | - | - | - | - | 1.23 | 0.11 |
| 168 | DU/098/981130 | - | | - | - | - | - | 0.11 | 0.12 |



“-“: concentration is below 0.1 ppb

DUNCRAIG AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2-Dichloro- propane | Trichloro- ethylene | cis-1,3-Dichloro- propylene | trans-1,3-Dichloro- propylene | 1,1,2-Trichloro- ethane | - Toluene | 1,2-Dibromo ethane (EDB) |
|---|---|---|---|---|---|---|---|---|
| 12 | DU/103/970320 | - | - | - | - | - | - | - |
| 16 | DU/096/970403 | - | - | - | - | - | - | - |
| 20 | DU/099/970409 | - | - | - | - | - | - | - |
| 24 | DU/105/970416 | - | - | - | - | - | 1.48 | - |
| 26 | DU/099/970522 | - | - | - | - | - | - | - |
| 28 | DU/103/970528 | - | - | - | - | - | 4.10 | - |
| 29 | DU/104/970618E | 0.14 | 0.17 | - | - | 0.41 | 5.14 | 0.21 |
| 31 | DU/096/970623E | - | 0.11 | - | 0.21 | - | 2.13 | - |
| 32 | DU/092/970626E | - | 0.14 | 0.36 | 0.21 | - | 3.09 | 0.15 |
| 33 | DU/093/970717E | - | 0.19 | - | - | - | 5.28 | 0.25 |
| 35 | DU/106/970731 | - | 0.38 | - | - | - | 3.03 | 0.48 |
| 37 | DU/103/970819 | - | 0.37 | - | - | - | 4.30 | - |
| 39 | DU/093/970912 | - | 0.51 | 0.25 | - | 0.13 | 0.94 | 0.75 |
| 40 | DU/105/970916E | - | 0.16 | - | 0.45 | - | 1.39 | 0.16 |
| 41 | DU/092/970917E | - | - | - | 0.30 | - | 3.76 | 0.20 |
| 43 | DU/106/970924 | - | 0.13 | - | - | - | 2.69 | 0.19 |
| 45 | DU/096/971006 | - | - | - | 0.30 | - | 1.86 | 0.18 |
| 47 | DU/099/971018 | - | 0.16 | 0.14 | 0.57 | 0.18 | 0.84 | 0.18 |
| 49 | DU/093/971030 | - | - | - | - | - | 2.15 | 0.93 |
| 52 | DU/096/971111 | - | - | - | - | - | 1.65 | - |
| 54 | DU/105/971123 | 0.48 | 0.89 | 0.94 | 0.78 | - | 3.09 | - |
| 57 | DU/716/971205 | - | - | - | - | - | 0.47 | - |
| 60 | DU/096/971217 | - | - | - | - | 0.38 | - | - |
| 64 | DU/106/971223 | - | - | - | - | 0.37 | - | - |
| 68 | DU/096/980110 | - | - | - | - | - | 1.23 | - |
| 72 | DU/105/980122 | - | - | - | - | - | 0.39 | - |
| 76 | DU/106/980126 | - | - | - | - | - | 0.43 | - |
| 81 | DU/743/980209 | - | - | - | - | - | 0.95 | - |
| 82 | DU/099/980219 | - | - | - | - | - | 1.51 | - |
| 93 | DU/092/980305 | - | - | - | - | - | 0.91 | - |
| 96 | DU/498/980325 | - | - | - | - | - | 2.67 | - |
| 106 | DU/104/980404 | - | - | - | - | - | 0.53 | - |
| 108 | DU/716/980422 | - | - | - | - | - | 2.10 | - |
| 112 | DU/092/980501 | 0.15 | - | - | - | - | 0.63 | - |
| 119 | DU/716/980519 | - | - | - | - | - | 2.24 | - |
| 123 | DU/099/980603 | - | - | - | - | - | 1.27 | - |
| 126 | DU/093/980615 | - | - | - | - | - | 1.95 | - |
| 127 | DU/103/980627 | - | - | - | - | - | 6.59 | - |
| 129 | DU/099/980628 | - | - | 0.27 | 0.50 | 0.15 | 8.12 | 0.48 |
| 132 | DU/092/980709 | - | - | - | - | - | 5.65 | - |
| 135 | DU/097/980722 | - | - | - | - | - | 29.96 | - |
| 137 | DU/106/980723 | - | - | - | - | - | 21.67 | - |
| 139 | DU/498/980802 | - | - | - | - | - | 2.76 | - |
| 140 | DU/092/980814 | - | - | - | - | - | 0.71 | - |
| 143 | DU/497/980825 | - | - | - | - | - | 1.80 | - |
| 145 | DU/498/980826 | - | - | - | - | - | 0.76 | - |
| 148 | DU/104/980908 | - | - | - | - | - | 3.21 | - |
| 151 | DU/098/980919 | - | 0.35 | - | - | 0.69 | 1.49 | - |
| 153 | DU/093/981001 | - | - | - | - | - | 1.21 | - |
| 155 | DU/092/981014 | - | - | - | - | - | 2.32 | - |
| 158 | DU/099/981025 | - | - | - | - | - | 1.38 | - |
| 163 | DU/097/981106 | - | - | - | - | - | 1.60 | - |
| 166 | DU/091/981118 | - | - | - | - | - | 1.81 | - |
| 168 | DU/098/981130 | - | - | - | - | - | 0.20 | - |



"-": concentration is below 0.1 ppb

# DUNCRAIG AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | Tetrachloro- | Chloro- | Ethyl- | (m+p)- | | Tetrachloro- | | 1,3,5-Trimethyl- |
|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | ethylene | benzene | benzene | -Xylene | Styrene | ethane | o-Xylene | benzene |
| 12 | DU/103/970320 | - | - | - | - | - | - | - | - |
| 16 | DU/096/970403 | - | - | - | - | - | - | - | - |
| 20 | DU/099/970409 | - | - | - | - | - | - | - | - |
| 24 | DU/105/970416 | - | - | - | - | - | - | - | - |
| 26 | DU/099/970522 | - | - | - | - | - | - | - | - |
| 28 | DU/103/970528 | - | - | - | - | 2.10 | - | - | - |
| 29 | DU/104/970618E | 0.39 | 0.24 | 0.87 | 2.76 | 0.37 | - | 1.40 | 0.96 |
| 31 | DU/096/970623E | 0.23 | 0.16 | 0.42 | 1.22 | 0.11 | - | 0.55 | 0.33 |
| 32 | DU/092/970626E | 0.25 | 0.17 | 0.48 | 1.44 | 0.15 | - | 0.70 | - |
| 33 | DU/093/970717E | 0.41 | 0.28 | 0.98 | 3.52 | 0.35 | - | 1.48 | 0.20 |
| 35 | DU/106/970731 | 0.77 | 0.54 | 0.61 | 0.60 | 0.19 | - | 0.29 | 0.22 |
| 37 | DU/103/970819 | 0.76 | 0.53 | 0.85 | 1.94 | 0.23 | - | 0.93 | 0.83 |
| 39 | DU/093/970912 | 0.33 | 0.90 | 0.65 | 1.62 | 0.56 | - | 0.73 | 0.43 |
| 40 | DU/105/970916E | - | 0.31 | 0.53 | 1.55 | 0.97 | - | 0.81 | 0.89 |
| 41 | DU/092/970917E | 0.13 | 0.26 | 0.71 | 2.58 | 0.49 | - | 1.28 | 0.48 |
| 43 | DU/106/970924 | 0.13 | 0.25 | 0.56 | 1.96 | 0.42 | - | 0.95 | 0.38 |
| 45 | DU/096/971006 | 0.12 | 0.25 | 0.45 | 1.54 | 0.27 | - | 0.76 | 0.26 |
| 47 | DU/099/971018 | 0.16 | 0.29 | 0.30 | 0.76 | 0.22 | - | 0.33 | 0.20 |
| 49 | DU/093/971030 | 1.53 | 0.33 | 0.31 | 1.26 | 0.57 | - | 0.73 | 0.23 |
| 52 | DU/096/971111 | - | 0.32 | 0.20 | 0.92 | 0.56 | - | 0.59 | 0.20 |
| 54 | DU/105/971123 | 1.55 | 0.39 | 0.66 | 2.36 | 0.72 | - | 1.16 | 0.54 |
| 57 | DU/716/971205 | - | - | - | - | - | - | - | - |
| 60 | DU/096/971217 | - | - | - | - | - | - | - | - |
| 64 | DU/106/971223 | - | - | - | - | 0.24 | - | - | - |
| 68 | DU/096/980110 | - | - | 0.15 | 0.51 | - | - | 0.30 | 0.24 |
| 72 | DU/105/980122 | - | - | - | - | - | - | - | - |
| 76 | DU/106/980126 | - | - | - | - | - | - | - | - |
| 81 | DU/743/980209 | - | - | - | - | - | - | - | - |
| 82 | DU/099/980219 | - | - | 0.17 | 0.65 | - | - | 0.33 | - |
| 93 | DU/092/980305 | - | - | 0.12 | 0.43 | 0.11 | - | 0.19 | - |
| 96 | DU/498/980325 | 0.14 | - | 0.43 | 1.11 | 0.17 | - | 0.54 | 0.21 |
| 106 | DU/104/980404 | - | - | - | 0.28 | - | - | 0.14 | - |
| 108 | DU/716/980422 | - | - | 0.29 | 1.08 | 0.11 | - | 0.49 | 0.19 |
| 112 | DU/092/980501 | - | - | 0.10 | 0.41 | - | - | 0.19 | - |
| 119 | DU/716/980519 | 0.29 | 0.30 | 0.46 | 1.37 | 0.25 | - | 0.55 | 0.23 |
| 123 | DU/099/980603 | 0.28 | 0.30 | 0.35 | 0.97 | 0.21 | - | 0.31 | 0.16 |
| 126 | DU/093/980615 | 0.20 | 0.18 | 0.36 | 1.12 | 0.19 | - | 0.40 | 0.20 |
| 127 | DU/103/980627 | - | 0.22 | 1.11 | 4.47 | 0.37 | - | 1.56 | 0.34 |
| 129 | DU/099/980628 | 0.27 | 0.71 | 1.43 | 4.91 | 0.69 | - | 2.08 | 1.16 |
| 132 | DU/092/980709 | - | 0.17 | 0.89 | 3.54 | 0.30 | - | 1.42 | 0.28 |
| 135 | DU/097/980722 | - | 0.16 | 4.84 | 16.72 | 1.64 | - | 5.86 | 1.92 |
| 137 | DU/106/980723 | 0.21 | 0.17 | 3.66 | 11.41 | 1.34 | - | 5.14 | 1.33 |
| 139 | DU/498/980802 | - | 0.15 | 0.51 | 1.90 | 0.16 | - | 0.72 | - |
| 140 | DU/092/980814 | - | - | 0.18 | 0.52 | 0.15 | - | 0.25 | 0.16 |
| 143 | DU/497/980825 | - | 0.13 | 0.35 | 1.14 | 0.20 | - | 0.56 | 0.23 |
| 145 | DU/498/980826 | - | 0.13 | 0.20 | 0.61 | 0.15 | - | 0.29 | 0.15 |
| 148 | DU/104/980908 | - | 0.13 | 0.55 | 1.77 | 0.22 | - | 0.81 | 0.31 |
| 151 | DU/098/980919 | - | 0.14 | 0.33 | 1.03 | 0.18 | 0.21 | 0.44 | 0.23 |
| 153 | DU/093/981001 | - | 1.14 | 0.21 | 1.06 | 0.57 | - | 0.55 | 0.58 |
| 155 | DU/092/981014 | - | - | 0.43 | 1.89 | 0.62 | - | 0.86 | 0.66 |
| 158 | DU/099/981025 | - | 1.16 | 0.26 | 1.23 | 0.58 | - | 0.65 | 0.59 |
| 163 | DU/097/981106 | - | - | 0.30 | 1.46 | 0.58 | - | 0.67 | 0.59 |
| 166 | DU/091/981118 | - | - | 0.24 | 1.03 | - | - | 0.45 | 0.13 |
| 168 | DU/098/981130 | - | - | - | 0.14 | - | - | - | - |



“-“: concentration is below 0.1 ppb

# DUNCRAIG AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2,4-Trimethyl-benzene | 1,3-Dichloro-benzene | 1,4-Dichloro-benzene | 1,2-Dichloro-benzene | 1,2,4-Trichloro-benzene | Hexachloro--1,3-butadiene |
|---|---|---|---|---|---|---|---|
| 12 | DU/103/970320 | - | - | - | - | - | - |
| 16 | DU/096/970403 | - | - | - | - | 1.05 | - |
| 20 | DU/099/970409 | - | - | - | - | - | - |
| 24 | DU/105/970416 | - | - | - | - | - | - |
| 26 | DU/099/970522 | - | - | - | - | - | - |
| 28 | DU/103/970528 | - | - | - | - | - | - |
| 29 | DU/104/970618E | 1.23 | - | - | - | - | - |
| 31 | DU/096/970623E | 0.44 | - | - | - | - | - |
| 32 | DU/092/970626E | 0.55 | - | - | - | - | - |
| 33 | DU/093/970717E | 1.43 | - | - | - | - | - |
| 35 | DU/106/970731 | 0.30 | 0.15 | 0.17 | - | - | - |
| 37 | DU/103/970819 | 1.08 | 0.13 | 0.15 | - | - | - |
| 39 | DU/093/970912 | 0.87 | 1.66 | 1.64 | 1.26 | 1.19 | 1.18 |
| 40 | DU/105/970916E | 1.86 | 1.05 | 1.51 | 1.25 | - | - |
| 41 | DU/092/970917E | 1.85 | 0.26 | 0.30 | 0.22 | 0.28 | - |
| 43 | DU/106/970924 | 1.33 | 0.27 | 0.32 | 0.23 | 0.27 | - |
| 45 | DU/096/971006 | 0.86 | 0.25 | 0.27 | 0.21 | 0.23 | - |
| 47 | DU/099/971018 | 0.52 | 0.36 | 0.38 | 0.36 | 0.53 | 0.18 |
| 49 | DU/093/971030 | 0.31 | 0.21 | 0.17 | 0.38 | 0.16 | - |
| 52 | DU/096/971111 | 0.21 | 0.19 | 0.14 | 0.37 | 0.16 | - |
| 54 | DU/105/971123 | 0.99 | 0.93 | 0.89 | 0.94 | 1.61 | 0.68 |
| 57 | DU/716/971205 | - | - | - | - | - | - |
| 60 | DU/096/971217 | 0.50 | - | 0.20 | - | 0.23 | - |
| 64 | DU/106/971223 | 0.47 | 0.22 | 0.44 | 0.32 | 0.44 | - |
| 68 | DU/096/980110 | 0.32 | 0.40 | 0.34 | 0.38 | 0.31 | 0.11 |
| 72 | DU/105/980122 | - | 0.13 | - | 0.15 | 0.26 | - |
| 76 | DU/106/980126 | - | - | - | - | - | - |
| 81 | DU/743/980209 | - | - | - | - | - | - |
| 82 | DU/099/980219 | 0.22 | - | - | - | - | - |
| 93 | DU/092/980305 | 0.12 | - | - | - | - | - |
| 96 | DU/498/980325 | 0.17 | - | - | - | - | - |
| 106 | DU/104/980404 | - | - | - | - | - | - |
| 108 | DU/716/980422 | 0.58 | - | - | - | - | - |
| 112 | DU/092/980501 | 0.21 | - | - | - | - | - |
| 119 | DU/716/980519 | 0.49 | 0.26 | 0.36 | 0.34 | 0.18 | - |
| 123 | DU/099/980603 | 0.31 | 0.26 | 0.34 | 0.33 | 0.17 | - |
| 126 | DU/093/980615 | 0.38 | 0.20 | 0.25 | 0.24 | 0.12 | 0.10 |
| 127 | DU/103/980627 | 1.14 | - | 0.13 | - | - | - |
| 129 | DU/099/980628 | 1.87 | 1.06 | 1.34 | 1.23 | 1.52 | 0.46 |
| 132 | DU/092/980709 | 0.99 | - | - | - | - | - |
| 135 | DU/097/980722 | 5.02 | - | - | - | - | - |
| 137 | DU/106/980723 | 5.00 | - | - | - | - | - |
| 139 | DU/498/980802 | 0.35 | - | - | - | - | - |
| 140 | DU/092/980814 | 0.21 | 0.11 | 0.12 | 0.16 | - | - |
| 143 | DU/497/980825 | 0.48 | 0.11 | 0.13 | - | - | - |
| 145 | DU/498/980826 | 0.13 | 0.11 | 0.13 | - | - | - |
| 148 | DU/104/980908 | 0.16 | 0.11 | 0.15 | 0.17 | - | - |
| 151 | DU/098/980919 | 0.14 | 0.14 | 0.19 | 0.20 | - | - |
| 153 | DU/093/981001 | - | 0.96 | 1.11 | 0.94 | 0.78 | 0.31 |
| 155 | DU/092/981014 | - | 0.95 | 1.09 | - | - | - |
| 158 | DU/099/981025 | - | 0.97 | 1.12 | 0.94 | 0.77 | 0.29 |
| 163 | DU/097/981106 | - | 0.97 | 1.11 | - | 0.74 | - |
| 166 | DU/091/981118 | 0.27 | - | - | - | - | - |
| 168 | DU/098/981130 | - | - | - | - | - | - |



“-“: concentration is below 0.1 ppb

## Queen's Buildings (QB) Air Toxics Samples

| | | | | Start date | Start time | End date | End time | Flowrate | Scaling | |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Canister# | AVOCS# | (dd/mm/yy) | (hhmm) | (dd/mm/yy) | (hhmm) | (ml/min) | Factor | Quarter# |
| 10 | QB/104/970320 | 03104 | 409 | 20/03/97 | 0000 | 20/03/97 | 2400 | 8 | 1 | 2 |
| 14 | QB/092/970403 | 03092 | 409 | 03/04/97 | 0600 | 03/04/97 | 1800 | 16 | 0.5 | 2 |
| 18 | QB/094/970409 | 03094 | 409 | 09/04/97 | 1200 | 10/04/97 | 1200 | 8 | 1 | 2 |
| 22 | QB/098/970416 | 03098 | 409 | 16/04/97 | 0815 | 16/04/97 | 2015 | 16 | 0.5 | 2 |
| 25 | QB/094/970522 | 03094 | 409 | 22/05/97 | 1230 | 23/05/97 | 1230 | 8 | 1 | 2 |
| 27 | QB/095/970528 | 03095 | 409 | 28/05/97 | 1245 | 29/05/97 | 1245 | 8 | 1 | 2 |
| 30 | QB/098/970623E | 03098 | 409 | 23/06/97 | 1215 | 25/06/97 | 1410 | 20 | 0.3 | 3 |
| 34 | QB/095/970731 | 03095 | 409 | 31/07/97 | 1400 | 01/08/97 | 1400 | 8 | 1 | 3 |
| 36 | QB/097/970819 | 03097 | 409 | 19/08/97 | 1400 | 20/08/97 | 1400 | 8 | 1 | 3 |
| 38 | QB104/970912 | 03104 | 409 | 12/09/97 | 1400 | 13/09/97 | 1400 | 8 | 1 | 4 |
| 42 | QB/716/970924 | 22716 | 409 | 24/09/97 | 1400 | 25/09/97 | 1400 | 8 | 1 | 4 |
| 44 | QB/103/971006 | 03106 | 409 | 06/10/97 | 1615 | 07/10/97 | 1615 | 8 | 1 | 4 |
| 46 | QB/098/971018 | 03098 | 409 | 18/10/97 | 1400 | 19/10/97 | 1400 | 8 | 1 | 4 |
| 48 | QB/104/971030 | 03104 | 409 | 30/10/97 | 1400 | 31/10/97 | 1400 | 8 | 1 | 4 |
| 51 | QB/106/971111 | 03106 | 409 | 11/11/97 | 1400 | 12/11/97 | 1400 | 8 | 1 | 4 |
| 53 | QB/103/971123 | 03103 | 409 | 23/11/97 | 1400 | 24/11/97 | 1400 | 8 | 1 | 4 |
| 56 | QB/097/971205 | 03097 | 409 | 05/12/97 | 1400 | 06/12/97 | 1400 | 8 | 1 | 5 |
| 59 | QB/094/971217 | 03094 | 409 | 17/12/97 | 1400 | 18/12/97 | 1400 | 8 | 1 | 5 |
| 63 | QB/105/971223 | 03105 | 409 | 23/12/97 | 1140 | 24/12/97 | 1140 | 8 | 1 | 5 |
| 67 | QB/097/980110 | 03097 | 409 | 10/01/98 | 1400 | 11/01/98 | 1400 | 8 | 1 | 5 |
| 71 | QB/103/980122 | 03103 | 409 | 22/01/98 | 1400 | 23/01/98 | 1400 | 8 | 1 | 5 |
| 75 | QB/716/980126 | 22716 | 409 | 26/01/98 | 1200 | 27/01/98 | 1200 | 8 | 1 | 5 |
| 77 | QB/044/980207 | 24044 | 409 | 07/02/98 | 1200 | 08/02/98 | 1200 | 8 | 1 | 5 |
| 78 | QB/497/980208 | 24497 | 409 | 08/02/98 | 1400 | 09/02/98 | 1400 | 8 | 1 | 5 |
| 84 | QB/716/980219 | 22716 | 409 | 19/02/98 | 1400 | 20/02/98 | 1400 | 8 | 1 | 5 |
| 89 | QB/104/980228 | 03104 | 409 | 28/02/98 | 1200 | 01/03/98 | 1200 | 8 | 1 | 5 |
| 94 | QB/106/980305 | 03106 | 409 | 05/03/98 | 1200 | 06/03/98 | 1200 | 8 | 1 | 6 |
| 98 | QB/716/980325 | 22716 | 409 | 25/03/98 | 1200 | 26/03/98 | 1200 | 8 | 1 | 6 |
| 102 | QB/096/980403 | 03096 | 409 | 03/04/98 | 1200 | 04/04/98 | 1200 | 8 | 1 | 6 |
| 104 | QB/497/980404 | 24497 | 409 | 04/04/98 | 1400 | 05/04/98 | 1400 | 8 | 1 | 6 |
| 111 | QB/861/980424 | 22861 | 409 | 24/04/98 | 1400 | 25/04/98 | 1400 | 8 | 1 | 6 |
| 115 | QB/743/980501 | 24743 | 409 | 01/05/98 | 1200 | 02/05/98 | 1200 | 8 | 1 | 6 |
| 116 | QB/498/980502 | 24498 | 409 | 02/05/98 | 1400 | 03/05/98 | 1400 | 8 | 1 | 6 |
| 121 | QB/497/980519 | 24497 | 409 | 19/05/98 | 1415 | 20/05/98 | 1415 | 8 | 1 | 6 |
| 122 | QB/091/980603 | 03091 | 409 | 03/06/98 | 1230 | 04/06/98 | 1230 | 8 | 1 | 7 |
| 125 | QB/103/980615 | 03103 | 409 | 15/06/98 | 1400 | 16/06/98 | 1400 | 8 | 1 | 7 |
| 128 | QB/104/980627 | 03104 | 409 | 27/06/98 | 1200 | 28/06/98 | 1200 | 8 | 1 | 7 |
| 130 | QB/716/980628 | 22716 | 409 | 28/06/98 | 1200 | 29/06/98 | 1200 | 8 | 1 | 7 |
| 133 | QB/091/980709 | 03091 | 409 | 09/07/98 | 1200 | 10/07/98 | 1200 | 8 | 1 | 7 |
| 134 | QB/497/980722 | 24497 | 409 | 22/07/98 | 1200 | 23/07/98 | 1200 | 8 | 1 | 7 |
| 136 | QB/095/980723 | 03095 | 409 | 23/07/98 | 1200 | 24/07/98 | 1200 | 8 | 1 | 7 |
| 138 | QB/044/980802 | 24044 | 409 | 02/08/98 | 1200 | 03/08/98 | 1200 | 8 | 1 | 7 |
| 141 | QB/094/980814 | 03094 | 409 | 14/08/98 | 1200 | 15/08/98 | 1200 | 8 | 1 | 7 |
| 142 | QB/091/980825 | 03091 | 409 | 25/08/98 | 1200 | 26/08/98 | 1200 | 8 | 1 | 7 |
| 144 | QB/044/980826 | 24044 | 409 | 26/08/98 | 1200 | 27/08/98 | 1200 | 8 | 1 | 7 |
| 149 | QB/097/980908 | 03097 | 409 | 08/09/98 | 0000 | 09/09/98 | 0000 | 8 | 1 | 8 |
| 150 | QB/095/980919 | 03095 | 409 | 19/09/98 | 1200 | 20/09/98 | 1200 | 8 | 1 | 8 |
| 152 | QB/716/981001 | 22716 | 409 | 01/10/98 | 1200 | 02/10/98 | 1200 | 8 | 1 | 8 |
| 154 | QB/497/981014 | 24497 | 409 | 14/10/98 | 0000 | 15/10/98 | 0000 | 8 | 1 | 8 |
| 159 | QB/498/981025 | 24498 | 409 | 25/10/98 | 1200 | 26/10/98 | 1200 | 8 | 1 | 8 |
| 162 | QB/103/981103 | 03103 | 409 | 03/11/98 | 1115 | 04/11/98 | 1115 | 8 | 1 | 8 |
| 164 | QB/044/981106 | 24044 | 408 | 06/11/98 | 1200 | 07/11/98 | 1200 | 8 | 1 | 8 |
| 165 | QB/044/981118 | 24044 | 408 | 18/11/98 | 1400 | 19/11/98 | 1400 | 8 | 1 | 8 |
| 169 | QB/498/981130 | 24498 | 408 | 30/11/98 | 1200 | 01/12/98 | 1200 | 8 | 1 | 8 |



"-": concentration is below 0.1 ppb

## QUEEN'S BUILDINGS AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | | Methyl | | Vinyl | Methyl | Ethyl | | Vinylidene | Methylene |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Freon 12 | Chloride | Freon 114 | Chloride | Bromide | Chloride | Freon 11 | Chloride | Chloride |
| 10 | QB/104/970320 | - | - | - | | - | | - | | - |
| 14 | QB/092/970403 | - | - | - | | - | | - | | - |
| 18 | QB/094/970409 | - | - | - | | - | | - | | - |
| 22 | QB/098/970416 | - | - | - | | - | | - | | - |
| 25 | QB/094/970522 | - | - | - | | - | | 3.00 | | - |
| 27 | QB/095/970528 | - | - | - | | - | | 3.00 | | - |
| 30 | QB/098/970623E | 0.23 | - | - | | - | | - | | - |
| 34 | QB/095/970731 | 0.38 | - | - | | - | | - | | - |
| 36 | QB/097/970819 | - | - | - | | - | | - | | - |
| 38 | QB104/970912 | 0.78 | - | - | | - | | 0.39 | | - |
| 42 | QB/716/970924 | 0.76 | - | - | | - | | 0.32 | | - |
| 44 | QB/103/971006 | 0.64 | - | - | | - | | 0.35 | | - |
| 46 | QB/098/971018 | 0.68 | - | - | | - | | 0.43 | | - |
| 48 | QB/104/971030 | 1.35 | - | 0.78 | | 0.55 | | 0.73 | | - |
| 51 | QB/106/971111 | 1.33 | - | 0.78 | | - | | 0.59 | | - |
| 53 | QB/103/971123 | 1.34 | - | 0.77 | | - | | 0.60 | | - |
| 56 | QB/097/971205 | 0.62 | - | - | | - | | 0.12 | | - |
| 59 | QB/094/971217 | 0.77 | - | 0.38 | | - | | 0.77 | | - |
| 63 | QB/105/971223 | 0.87 | - | 0.39 | | - | | 0.84 | | - |
| 67 | QB/097/980110 | 0.90 | - | - | | - | | 0.25 | | - |
| 71 | QB/103/980122 | 0.61 | - | - | | - | | 0.19 | | - |
| 75 | QB/716/980126 | 11.68 | - | - | | - | | 0.21 | | - |
| 77 | QB/044/980207 | 0.77 | - | - | | - | | 0.17 | | - |
| 78 | QB/497/980208 | 1.63 | - | - | | - | | 0.20 | | - |
| 84 | QB/716/980219 | 0.72 | - | - | | 0.13 | | 0.33 | | - |
| 89 | QB/104/980228 | 0.47 | 0.40 | - | | - | | 0.26 | | - |
| 94 | QB/106/980305 | 0.47 | - | - | | - | | 0.29 | | - |
| 98 | QB/716/980325 | 0.82 | - | - | | - | | 0.27 | | 0.42 |
| 102 | QB/096/980403 | 0.61 | 0.72 | - | | - | | 0.33 | | 0.11 |
| 104 | QB/497/980404 | 0.55 | - | - | | - | | 0.27 | | - |
| 111 | QB/861/980424 | 0.56 | - | - | | - | | 0.32 | | 0.10 |
| 115 | QB/743/980501 | 0.56 | - | - | | - | | 0.33 | | 0.10 |
| 116 | QB/498/980502 | 0.62 | - | - | | - | | 0.28 | | - |
| 121 | QB/497/980519 | 0.90 | - | 0.16 | | - | | 0.62 | | - |
| 122 | QB/091/980603 | 0.94 | - | 0.17 | | 0.11 | | 0.42 | | - |
| 125 | QB/103/980615 | 0.98 | - | - | | - | | 0.44 | | 1.34 |
| 128 | QB/104/980627 | 3.54 | - | - | | - | | 1.15 | | 0.23 |
| 130 | QB/716/980628 | 1.30 | 0.90 | 0.20 | | - | | 0.40 | | 0.60 |
| 133 | QB/091/980709 | 3.19 | - | - | | - | | 1.22 | | 0.26 |
| 134 | QB/497/980722 | 3.79 | - | - | | - | | 1.49 | | 0.44 |
| 136 | QB/095/980723 | 3.75 | 5.60 | - | | - | | 2.23 | | 0.49 |
| 138 | QB/044/980802 | 3.21 | - | - | | - | | 1.26 | | 0.13 |
| 141 | QB/094/980814 | 0.88 | - | 0.52 | | - | | 0.85 | | 0.75 |
| 142 | QB/091/980825 | 0.83 | - | 0.52 | | - | | 0.40 | | 0.71 |
| 144 | QB/044/980826 | 0.79 | - | 0.53 | | - | | 0.47 | | 0.80 |
| 149 | QB/097/980908 | 0.80 | - | 0.52 | | - | | 0.64 | | 0.76 |
| 150 | QB/095/980919 | 0.80 | - | 0.52 | | - | | 0.45 | | - |
| 152 | QB/716/981001 | 1.37 | - | 0.24 | | - | | 1.20 | | - |
| 154 | QB/497/981014 | 1.47 | - | 0.24 | | - | | 1.23 | | - |
| 159 | QB/498/981025 | 1.35 | - | 0.24 | | - | | 1.15 | | - |
| 162 | QB/103/981103 | 1.40 | - | 0.25 | | - | | 1.24 | | - |
| 164 | QB/044/981106 | 1.46 | - | - | | - | | 1.17 | | - |
| 165 | QB/044/981118 | 0.92 | - | - | | - | | 1.51 | | 0.84 |
| 169 | QB/498/981130 | 0.69 | - | - | | - | | 2.18 | | 0.81 |



"-": concentration is below 0.1 ppb

# QUEEN'S BUILDINGS AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | | 1,1-Dichloro- | 1,2-Dichloro- | | 1,2-Dichloro- | Methyl | | Carbon |
|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Freon 113 | ethane | ethylene | Chloroform | ethane | Chloroform | Benzene | tetrachloride |
| 10 | QB/104/970320 | - | | - | - | | - | - | - |
| 14 | QB/092/970403 | - | | - | - | | - | - | - |
| 18 | QB/094/970409 | - | | - | - | | - | 2.70 | - |
| 22 | QB/098/970416 | - | | - | - | | - | 1.80 | - |
| 25 | QB/094/970522 | - | | - | - | | - | 2.20 | - |
| 27 | QB/095/970528 | - | | - | - | | - | 4.70 | - |
| 30 | QB/098/970623E | - | | - | 0.18 | | 0.18 | 0.75 | - |
| 34 | QB/095/970731 | - | | - | - | | 0.53 | 1.87 | - |
| 36 | QB/097/970819 | - | | - | - | | 0.53 | 1.27 | - |
| 38 | QB104/970912 | 0.20 | | - | - | | 0.14 | 1.18 | 0.24 |
| 42 | QB/716/970924 | 0.19 | | - | - | | 0.12 | 1.21 | 0.19 |
| 44 | QB/103/971006 | 0.17 | | - | - | | - | 1.24 | 0.19 |
| 46 | QB/098/971018 | 0.16 | | 0.23 | - | | 0.11 | 0.37 | 0.20 |
| 48 | QB/104/971030 | 0.82 | | - | - | | 0.82 | 1.92 | 0.67 |
| 51 | QB/106/971111 | 0.78 | | - | - | | 0.80 | 1.03 | 0.64 |
| 53 | QB/103/971123 | 0.77 | | - | - | | 0.79 | 2.26 | 0.65 |
| 56 | QB/097/971205 | - | | - | - | | - | 0.91 | - |
| 59 | QB/094/971217 | - | | - | - | | 0.26 | 1.46 | 0.32 |
| 63 | QB/105/971223 | 1.13 | | - | - | | 0.27 | 1.39 | 0.33 |
| 67 | QB/097/980110 | - | | - | - | | - | 2.10 | - |
| 71 | QB/103/980122 | - | | - | - | | - | 1.28 | - |
| 75 | QB/716/980126 | - | | - | - | | - | 1.26 | - |
| 77 | QB/044/980207 | - | | 1.18 | - | | - | 0.62 | - |
| 78 | QB/497/980208 | - | | - | - | | - | 1.37 | - |
| 84 | QB/716/980219 | - | | - | - | | 0.13 | 2.69 | 0.14 |
| 89 | QB/104/980228 | - | | - | 0.18 | | - | 1.49 | - |
| 94 | QB/106/980305 | - | | - | - | | - | 0.57 | - |
| 98 | QB/716/980325 | 0.23 | | - | - | | 0.22 | 1.95 | 0.13 |
| 102 | QB/096/980403 | - | | - | - | | 0.12 | 3.34 | - |
| 104 | QB/497/980404 | - | | - | - | | - | 1.30 | 0.10 |
| 111 | QB/861/980424 | 0.12 | | - | - | | 0.14 | 0.22 | 0.16 |
| 115 | QB/743/980501 | 0.11 | | - | - | | - | 0.76 | 0.13 |
| 116 | QB/498/980502 | 0.16 | | - | - | | - | 0.90 | 0.15 |
| 121 | QB/497/980519 | 0.24 | | - | 0.12 | | 0.21 | 2.84 | 0.15 |
| 122 | QB/091/980603 | 0.23 | | - | - | | 0.19 | 3.29 | 0.15 |
| 125 | QB/103/980615 | - | | - | - | | 0.16 | 2.45 | 0.22 |
| 128 | QB/104/980627 | 0.14 | | - | - | | 0.14 | 5.44 | 0.44 |
| 130 | QB/716/980628 | 0.20 | | - | - | | - | 1.90 | 0.30 |
| 133 | QB/091/980709 | 0.11 | | - | - | | 0.14 | 4.35 | 0.48 |
| 134 | QB/497/980722 | - | | - | - | | 0.15 | 11.20 | 0.45 |
| 136 | QB/095/980723 | 0.12 | | - | - | | - | 7.90 | 0.39 |
| 138 | QB/044/980802 | - | | - | - | | 0.12 | 6.75 | 0.41 |
| 141 | QB/094/980814 | 0.28 | | - | 0.38 | | 0.28 | 0.66 | 0.22 |
| 142 | QB/091/980825 | 0.26 | | - | - | | 0.33 | 0.95 | 0.24 |
| 144 | QB/044/980826 | 0.28 | | - | 0.37 | | 0.34 | 1.62 | 0.26 |
| 149 | QB/097/980908 | 0.27 | | - | 0.38 | | 0.32 | 2.23 | 0.24 |
| 150 | QB/095/980919 | 0.25 | | - | 0.37 | | 0.32 | 1.57 | 0.24 |
| 152 | QB/716/981001 | 0.70 | | - | - | | - | 2.30 | 1.04 |
| 154 | QB/497/981014 | 0.72 | | - | - | | - | 2.64 | 1.05 |
| 159 | QB/498/981025 | 0.70 | | - | - | | - | 1.45 | 1.04 |
| 162 | QB/103/981103 | 0.73 | | - | - | | 0.24 | 2.19 | 1.05 |
| 164 | QB/044/981106 | 0.70 | | - | - | | 0.12 | 2.25 | 1.06 |
| 165 | QB/044/981118 | - | | - | - | | - | 2.15 | - |
| 169 | QB/498/981130 | - | | - | - | | - | 2.57 | 0.11 |



"-": concentration is below 0.1 ppb

## QUEEN’S BUILDINGS AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2-Dichloro- propane | Trichloro- ethylene | cis-1,3-Dichloro- propylene | trans-1,3-Dichloro- propylene | 1,1,2-Trichloro- ethane | Toluene | 1,2-Dibromo- ethane (EDB) |
|---|---|---|---|---|---|---|---|---|
| 10 | QB/104/970320 | - | - | - | - | - | 3.10 | - |
| 14 | QB/092/970403 | - | - | - | - | - | 1.10 | - |
| 18 | QB/094/970409 | - | - | - | - | - | 4.00 | - |
| 22 | QB/098/970416 | - | - | - | - | - | 2.50 | - |
| 25 | QB/094/970522 | - | - | - | - | - | 2.80 | - |
| 27 | QB/095/970528 | - | - | - | - | - | 6.40 | - |
| 30 | QB/098/970623E | - | 0.12 | - | - | - | 1.78 | - |
| 34 | QB/095/970731 | - | 0.37 | - | - | - | 3.55 | - |
| 36 | QB/097/970819 | - | 0.37 | - | - | - | 4.03 | 0.48 |
| 38 | QB104/970912 | - | 0.23 | 0.12 | 0.65 | - | 2.57 | 0.36 |
| 42 | QB/716/970924 | - | 0.12 | - | 0.28 | 0.11 | 2.77 | 0.18 |
| 44 | QB/103/971006 | - | 0.11 | - | 0.26 | - | 3.46 | 0.17 |
| 46 | QB/098/971018 | - | - | - | 0.14 | 0.14 | 0.79 | 0.11 |
| 48 | QB/104/971030 | - | - | - | - | - | 4.52 | 0.93 |
| 51 | QB/106/971111 | - | - | - | - | - | 2.08 | - |
| 53 | QB/103/971123 | - | - | - | - | - | 4.77 | - |
| 56 | QB/097/971205 | - | - | - | - | - | 1.82 | - |
| 59 | QB/094/971217 | - | - | - | - | - | 2.54 | - |
| 63 | QB/105/971223 | - | - | - | - | - | 2.47 | - |
| 67 | QB/097/980110 | - | - | - | - | - | 4.19 | - |
| 71 | QB/103/980122 | - | - | - | - | - | 3.18 | - |
| 75 | QB/716/980126 | - | - | - | - | - | 3.08 | - |
| 77 | QB/044/980207 | - | - | - | - | - | 1.49 | - |
| 78 | QB/497/980208 | - | - | - | - | - | 2.48 | - |
| 84 | QB/716/980219 | - | - | - | - | - | 3.99 | - |
| 89 | QB/104/980228 | - | - | - | - | - | 3.22 | - |
| 94 | QB/106/980305 | - | - | - | - | - | 0.95 | - |
| 98 | QB/716/980325 | - | - | - | - | - | 3.00 | - |
| 102 | QB/096/980403 | - | - | - | - | - | 6.15 | - |
| 104 | QB/497/980404 | - | - | - | - | - | 2.20 | - |
| 111 | QB/861/980424 | - | - | - | - | - | 0.37 | - |
| 115 | QB/743/980501 | 0.13 | - | - | - | - | 1.05 | - |
| 116 | QB/498/980502 | - | - | - | - | - | 0.95 | - |
| 121 | QB/497/980519 | - | 0.13 | - | - | - | 5.02 | - |
| 122 | QB/091/980603 | - | 0.14 | - | - | - | 6.20 | - |
| 125 | QB/103/980615 | - | - | - | - | - | 4.99 | - |
| 128 | QB/104/980627 | - | - | - | - | - | 10.86 | - |
| 130 | QB/716/980628 | - | - | - | - | - | 4.00 | - |
| 133 | QB/091/980709 | - | - | - | - | - | 8.52 | - |
| 134 | QB/497/980722 | - | - | - | - | - | 19.86 | - |
| 136 | QB/095/980723 | - | - | - | - | - | 18.21 | - |
| 138 | QB/044/980802 | - | - | - | - | - | 12.83 | - |
| 141 | QB/094/980814 | - | - | - | - | - | 1.37 | - |
| 142 | QB/091/980825 | - | - | - | - | 0.70 | 1.86 | - |
| 144 | QB/044/980826 | - | - | - | - | - | 2.52 | - |
| 149 | QB/097/980908 | - | - | - | - | - | 3.54 | - |
| 150 | QB/095/980919 | - | - | - | - | 0.69 | 2.30 | - |
| 152 | QB/716/981001 | - | - | - | - | - | 4.32 | - |
| 154 | QB/497/981014 | - | - | - | - | 1.20 | 4.60 | - |
| 159 | QB/498/981025 | - | - | - | - | - | 2.52 | - |
| 162 | QB/103/981103 | - | - | - | - | - | 3.79 | - |
| 164 | QB/044/981106 | - | - | - | - | - | 3.59 | - |
| 165 | QB/044/981118 | - | - | - | - | - | 3.34 | - |
| 169 | QB/498/981130 | - | - | - | - | - | 4.02 | - |



“-“: concentration is below 0.1 ppb

## QUEEN'S BUILDINGS AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | Tetrachloro-ethylene | Chloro-benzene | Ethyl-benzene | (m+p)--Xylene | Styrene | Tetrachloro-ethane | o-Xylene | 1,3,5-Trimethyl-benzene |
|---|---|---|---|---|---|---|---|---|---|
| 10 | QB/104/970320 | - | - | - | - | - | - | - | - |
| 14 | QB/092/970403 | - | - | - | - | - | - | - | - |
| 18 | QB/094/970409 | - | - | - | - | - | - | - | - |
| 22 | QB/098/970416 | - | - | - | 2.00 | - | - | - | - |
| 25 | QB/094/970522 | - | - | - | - | 2.00 | - | - | - |
| 27 | QB/095/970528 | - | - | 2.90 | - | - | - | - | - |
| 30 | QB/098/970623E | 0.26 | 0.16 | 0.29 | 0.73 | - | - | 0.37 | 0.20 |
| 34 | QB/095/970731 | 0.77 | 0.53 | 0.69 | 1.10 | 0.11 | - | 0.56 | 0.51 |
| 36 | QB/097/970819 | 0.79 | 0.54 | 0.83 | 1.74 | 0.15 | - | 0.74 | - |
| 38 | QB104/970912 | 0.18 | 0.46 | 0.74 | 2.40 | 0.84 | - | 1.14 | 0.62 |
| 42 | QB/716/970924 | 0.15 | 0.25 | 0.61 | 2.16 | 0.38 | - | 1.00 | 0.41 |
| 44 | QB/103/971006 | 0.18 | 0.24 | 0.65 | 2.52 | 0.40 | - | 1.22 | 0.38 |
| 46 | QB/098/971018 | 0.11 | 0.21 | 0.27 | 0.76 | 0.14 | - | 0.32 | 0.16 |
| 48 | QB/104/971030 | 1.57 | 0.31 | 0.43 | 1.86 | 0.63 | - | 0.99 | 0.33 |
| 51 | QB/106/971111 | 1.56 | 0.31 | 0.26 | 1.22 | 0.59 | - | 0.71 | 0.25 |
| 53 | QB/103/971123 | 1.56 | 0.30 | 0.67 | 2.72 | 0.67 | - | 1.35 | 0.39 |
| 56 | QB/097/971205 | - | - | 0.30 | 1.08 | - | - | 0.50 | - |
| 59 | QB/094/971217 | - | - | 0.21 | 2.01 | 0.31 | - | 0.88 | 0.19 |
| 63 | QB/105/971223 | - | - | 0.23 | 1.90 | 0.36 | - | 0.89 | 0.31 |
| 67 | QB/097/980110 | - | - | 0.44 | 2.35 | - | - | 0.96 | 0.15 |
| 71 | QB/103/980122 | - | - | 0.20 | 1.39 | - | - | 0.55 | - |
| 75 | QB/716/980126 | - | - | 0.15 | 1.17 | - | - | 0.49 | - |
| 77 | QB/044/980207 | - | - | - | 0.43 | - | - | 0.17 | - |
| 78 | QB/497/980208 | - | - | 0.11 | 1.04 | - | - | 0.42 | 0.10 |
| 84 | QB/716/980219 | - | - | 0.42 | 1.80 | 0.13 | - | 0.72 | 0.15 |
| 89 | QB/104/980228 | - | - | 0.26 | 1.04 | - | - | 0.53 | - |
| 94 | QB/106/980305 | - | - | 0.15 | 0.51 | - | - | 0.24 | - |
| 98 | QB/716/980325 | 0.13 | - | 0.50 | 1.31 | 0.19 | - | 0.64 | 0.22 |
| 102 | QB/096/980403 | - | - | 0.74 | 3.09 | 0.22 | - | 1.23 | 0.41 |
| 104 | QB/497/980404 | - | - | 0.25 | 0.95 | - | - | 0.47 | 0.15 |
| 111 | QB/861/980424 | - | - | - | 0.22 | - | - | 0.11 | - |
| 115 | QB/743/980501 | - | - | 0.16 | 0.58 | - | - | 0.32 | - |
| 116 | QB/498/980502 | - | - | 0.14 | 0.54 | - | - | 0.29 | - |
| 121 | QB/497/980519 | 0.34 | 0.30 | 0.81 | 2.54 | 0.31 | 0.18 | 1.16 | 0.39 |
| 122 | QB/091/980603 | 0.37 | 0.30 | 0.81 | 2.88 | 0.33 | 0.17 | 1.14 | 0.36 |
| 125 | QB/103/980615 | 0.30 | 0.18 | 0.63 | 2.11 | 0.26 | - | 0.91 | 0.31 |
| 128 | QB/104/980627 | - | 0.27 | 2.01 | 7.66 | 0.56 | - | 2.56 | 0.76 |
| 130 | QB/716/980628 | - | - | 0.60 | 2.40 | 0.30 | - | 1.00 | 0.30 |
| 133 | QB/091/980709 | - | 0.16 | 1.34 | 5.56 | 0.44 | - | 2.13 | 0.48 |
| 134 | QB/497/980722 | 0.27 | 0.16 | 3.76 | 13.27 | 1.01 | - | 4.76 | 1.63 |
| 136 | QB/095/980723 | 0.21 | 0.17 | 2.68 | 9.74 | 0.88 | - | 3.60 | 0.99 |
| 138 | QB/044/980802 | - | 0.16 | 1.86 | 7.73 | 0.59 | - | 2.97 | 0.89 |
| 141 | QB/094/980814 | - | - | 0.29 | 0.89 | 0.17 | - | 0.40 | 0.20 |
| 142 | QB/091/980825 | 0.11 | 0.13 | 0.35 | 1.14 | 0.19 | - | 0.51 | 0.24 |
| 144 | QB/044/980826 | 0.14 | 0.14 | 0.53 | 1.72 | 0.23 | - | 0.76 | 0.31 |
| 149 | QB/097/980908 | 0.12 | 0.13 | 0.68 | 2.28 | 0.26 | - | 0.94 | 0.34 |
| 150 | QB/095/980919 | - | 0.13 | 0.47 | 1.45 | 0.24 | - | 0.71 | 0.28 |
| 152 | QB/716/981001 | 1.46 | - | 0.73 | 3.45 | 0.71 | 0.45 | 1.48 | 0.83 |
| 154 | QB/497/981014 | 1.42 | - | 0.86 | 3.63 | 0.73 | - | 1.53 | 0.86 |
| 159 | QB/498/981025 | 1.42 | 1.14 | 0.41 | 1.92 | 0.63 | - | 0.90 | 0.65 |
| 162 | QB/103/981103 | 1.52 | - | 0.64 | 2.96 | 0.71 | - | 1.16 | 0.76 |
| 164 | QB/044/981106 | - | 1.16 | 0.65 | 2.66 | 0.66 | - | 1.12 | 0.77 |
| 165 | QB/044/981118 | - | - | 0.46 | 1.82 | 0.21 | - | 0.77 | 0.21 |
| 169 | QB/498/981130 | - | - | 0.51 | 2.04 | 0.19 | - | 0.91 | 0.25 |



"-": concentration is below 0.1 ppb

## QUEEN'S BUILDINGS AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2,4-Trimethyl-benzene | 1,3-Dichloro-benzene | 1,4-Dichloro-benzene | 1,2-Dichloro-benzene | 1,2,4-Trichloro-benzene | Hexachloro--1,3-butadiene |
|---|---|---|---|---|---|---|---|
| 10 | QB/104/970320 | 2.00 | - | - | - | 2.00 | - |
| 14 | QB/092/970403 | - | - | - | - | - | - |
| 18 | QB/094/970409 | 2.00 | - | - | - | - | - |
| 22 | QB/098/970416 | 1.00 | - | - | - | - | - |
| 25 | QB/094/970522 | - | - | - | - | - | - |
| 27 | QB/095/970528 | 2.50 | - | - | - | - | - |
| 30 | QB/098/970623E | 0.27 | - | - | - | - | - |
| 34 | QB/095/970731 | 0.70 | 0.13 | 0.15 | - | - | - |
| 36 | QB/097/970819 | 0.93 | 0.13 | 0.18 | - | - | - |
| 38 | QB104/970912 | 2.08 | 0.96 | 1.25 | 0.92 | - | - |
| 42 | QB/716/970924 | 1.50 | 0.27 | 0.31 | 0.22 | 0.24 | - |
| 44 | QB/103/971006 | 1.45 | 0.24 | 0.29 | 0.20 | 0.21 | - |
| 46 | QB/098/971018 | 0.48 | 0.19 | 0.22 | 0.16 | 0.25 | - |
| 48 | QB/104/971030 | 0.62 | 0.23 | 0.17 | 0.37 | 0.15 | - |
| 51 | QB/106/971111 | 0.36 | 0.25 | 0.19 | - | 0.15 | - |
| 53 | QB/103/971123 | 0.94 | 0.26 | 0.20 | - | 0.14 | - |
| 56 | QB/097/971205 | 0.46 | - | - | - | - | - |
| 59 | QB/094/971217 | 1.22 | - | 0.22 | - | 0.22 | - |
| 63 | QB/105/971223 | 1.29 | 0.33 | 0.64 | 0.46 | 1.06 | 0.28 |
| 67 | QB/097/980110 | 0.66 | 0.14 | - | 0.12 | - | - |
| 71 | QB/103/980122 | 0.41 | - | - | - | - | - |
| 75 | QB/716/980126 | 0.31 | - | - | - | - | - |
| 77 | QB/044/980207 | 0.17 | - | - | - | - | - |
| 78 | QB/497/980208 | 0.40 | - | - | 0.10 | - | - |
| 84 | QB/716/980219 | 0.61 | - | - | - | - | - |
| 89 | QB/104/980228 | 0.36 | - | - | - | - | - |
| 94 | QB/106/980305 | 0.15 | - | - | - | - | - |
| 98 | QB/716/980325 | 0.30 | - | - | - | - | - |
| 102 | QB/096/980403 | 1.10 | 0.15 | 0.15 | - | - | - |
| 104 | QB/497/980404 | 0.37 | - | - | - | - | - |
| 111 | QB/861/980424 | 0.14 | - | - | - | - | - |
| 115 | QB/743/980501 | 0.32 | - | - | - | - | - |
| 116 | QB/498/980502 | 0.29 | - | - | - | - | - |
| 121 | QB/497/980519 | 0.99 | 0.30 | 0.34 | - | - | - |
| 122 | QB/091/980603 | 0.81 | 0.26 | 0.36 | 0.33 | 0.17 | - |
| 125 | QB/103/980615 | 0.73 | 0.20 | 0.27 | 0.23 | - | - |
| 128 | QB/104/980627 | 1.97 | - | 0.30 | - | - | - |
| 130 | QB/716/980628 | 0.90 | - | - | - | - | - |
| 133 | QB/091/980709 | 1.57 | - | - | - | - | - |
| 134 | QB/497/980722 | 4.84 | - | 0.26 | - | - | - |
| 136 | QB/095/980723 | 4.31 | - | - | - | - | - |
| 138 | QB/044/980802 | 2.97 | - | - | - | - | - |
| 141 | QB/094/980814 | 0.37 | 0.11 | 0.14 | 0.16 | - | - |
| 142 | QB/091/980825 | 0.46 | 0.11 | 0.16 | 0.16 | - | - |
| 144 | QB/044/980826 | 0.71 | 0.12 | 0.15 | 0.17 | - | - |
| 149 | QB/097/980908 | 1.00 | 0.11 | 0.16 | 0.17 | - | - |
| 150 | QB/095/980919 | 0.62 | 0.12 | 0.17 | 0.17 | - | - |
| 152 | QB/716/981001 | 1.98 | 0.97 | 1.11 | - | 0.76 | - |
| 154 | QB/497/981014 | 1.99 | 0.97 | 1.11 | 0.91 | 0.75 | - |
| 159 | QB/498/981025 | - | 0.95 | 1.12 | 0.93 | 0.76 | - |
| 162 | QB/103/981103 | 1.76 | 0.96 | 1.13 | 0.94 | 0.77 | - |
| 164 | QB/044/981106 | - | 0.96 | 1.10 | - | - | - |
| 165 | QB/044/981118 | 0.47 | - | - | - | - | - |
| 169 | QB/498/981130 | 0.63 | - | - | - | - | - |



"-": concentration is below 0.1 ppb

**Hope Valley (HV) & Swanbourne (SW) Air Toxics Samples**

**North Fremantle (HF) & Gooseberry Hill (GH) Air Toxics Samples**

| | | | | Start date | Start time | End date | End time | Flowrate | Scaling | |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Canister# | AVOCS# | (dd/mm/yy) | (hhmm) | (dd/mm/yy) | (hhmm) | (ml/min) | Factor | Quarter# |
| 11 | HV/093/970320 | 03093 | 413 | 20/03/97 | 0000 | 20/03/97 | 2400 | 8 | 1 | 2 |
| 15 | HV/091/970403 | 03091 | 413 | 03/04/97 | 0600 | 03/04/97 | 1800 | 16 | 0.5 | 2 |
| 19 | HV/103/970409 | 03103 | 413 | 09/04/97 | 1200 | 10/04/97 | 2400 | 16 | 0.5 | 2 |
| 23 | HV/091/970416 | 03091 | 413 | 16/04/97 | 1200 | 16/04/97 | 2200 | 20 | 0.4 | 2 |
| 50 | HV/092/971107E | 03092 | 412 | 07/11/97 | 1600 | 11/11/97 | 1600 | 8 | 1 | 4 |
| 58 | HV/104/971210 | 03104 | 413 | 10/12/97 | 1200 | 11/12/97 | 1200 | 8 | 1 | 5 |
| 62 | HV/091/971217 | 03091 | 413 | 17/12/97 | 1400 | 18/12/97 | 1400 | 8 | 1 | 5 |
| 66 | HV/092/971223 | 03092 | 413 | 23/12/97 | 1230 | 24/12/97 | 1230 | 8 | 1 | 5 |
| 70 | HV/104/980110 | 03104 | 413 | 10/01/98 | 1400 | 11/01/98 | 1400 | 8 | 1 | 5 |
| 74 | HV/092/980122 | 03092 | 413 | 22/01/98 | 1400 | 23/01/98 | 1400 | 8 | 1 | 5 |
| 80 | HV/045/980208 | 24045 | 413 | 08/02/98 | 1400 | 09/02/98 | 1400 | 8 | 1 | 5 |
| 83 | HV/498/980219 | 24498 | 413 | 19/02/98 | 1400 | 20/02/98 | 1400 | 8 | 1 | 5 |
| 88 | HV/097/980228 | 03097 | 413 | 28/02/98 | 1200 | 01/03/98 | 1200 | 8 | 1 | 5 |
| 97 | HV/743/980325 | 24743 | 413 | 25/03/98 | 1200 | 26/03/98 | 1200 | 8 | 1 | 6 |
| 103 | HV/097/980403 | 03097 | 413 | 03/04/98 | 1200 | 04/04/98 | 1200 | 8 | 1 | 6 |
| 105 | HV/045/980404 | 24045 | 413 | 04/04/98 | 1400 | 05/04/98 | 1400 | 8 | 1 | 6 |
| 109 | HV/094/980422 | 03094 | 413 | 22/04/98 | 1200 | 23/04/98 | 1200 | 8 | 1 | 6 |
| 113 | HV/091/980501 | 03091 | 413 | 01/05/98 | 1200 | 02/05/98 | 1200 | 8 | 1 | 6 |
| 114 | HV/095/980502 | 03095 | 413 | 02/05/98 | 1400 | 03/05/98 | 1400 | 8 | 1 | 6 |
| 120 | HV/106/980519 | 03106 | 413 | 19/05/98 | 1400 | 20/05/98 | 1400 | 8 | 1 | 6 |
| 157 | HV/091/981014 | 03091 | 413 | 14/10/98 | 0000 | 15/10/98 | 0000 | 8 | 1 | 8 |
| 160 | HV/098/981025 | 03098 | 413 | 25/10/98 | 1200 | 26/10/98 | 1200 | 8 | 1 | 8 |
| 170 | HV/095/981130 | 03095 | 413 | 30/11/98 | 1200 | 01/12/98 | 1200 | 8 | 1 | 8 |
| 9 | SW/105/970320 | 03105 | 408 | 20/03/97 | 0000 | 20/03/97 | 2400 | 8 | 1 | 2 |
| 13 | SW/097/940403 | 03097 | 408 | 03/04/97 | 0600 | 03/04/97 | 1800 | 16 | 0.5 | 2 |
| 17 | SW/095/970409 | 03095 | 408 | 09/04/97 | 0600 | 10/04/97 | 1100 | 16 | 0.5 | 2 |
| 21 | SW/097/970416 | 03097 | 408 | 16/04/97 | 1600 | 17/04/97 | 1000 | 20 | 0.4 | 2 |
| 61 | SW/093/971217 | 03093 | 408 | 17/12/97 | 1400 | 18/12/97 | 1400 | 8 | 1 | 5 |
| 65 | SW/103/971223 | 03103 | 408 | 23/12/97 | 1000 | 24/12/97 | 1000 | 8 | 1 | 5 |
| 69 | SW/094/980110 | 03094 | 408 | 10/01/98 | 1400 | 11/01/98 | 1400 | 8 | 1 | 5 |
| 73 | SW/091/980122 | 03091 | 408 | 22/01/98 | 1400 | 23/01/98 | 1400 | 8 | 1 | 5 |
| 79 | SW/498/980208 | 24498 | 408 | 08/02/98 | 1400 | 09/02/98 | 1400 | 8 | 1 | 5 |
| 85 | SW/091/980219 | 03091 | 408 | 19/02/98 | 1400 | 20/02/98 | 1400 | 8 | 1 | 5 |
| 99 | SW/091/980325 | 03091 | 408 | 25/03/98 | 1200 | 26/03/98 | 1200 | 8 | 1 | 6 |
| 107 | SW/092/980404 | 03092 | 408 | 04/04/98 | 1400 | 05/04/98 | 1400 | 8 | 1 | 6 |
| 110 | SW/106/980422 | 03106 | 408 | 22/04/98 | 1200 | 23/04/98 | 1200 | 8 | 1 | 6 |
| 117 | SW/097/980501 | 03097 | 408 | 01/05/98 | 1245 | 02/05/98 | 1245 | 8 | 1 | 6 |
| 124 | SW/104/980605 | 03104 | 408 | 05/06/98 | 1200 | 06/06/98 | 1200 | 8 | 1 | 7 |
| 156 | SW/094/981014 | 03094 | 408 | 14/10/98 | 0000 | 15/10/98 | 0000 | 8 | 1 | 8 |
| 161 | SW/095/981025 | 03095 | 408 | 25/10/98 | 1200 | 26/10/98 | 1200 | 8 | 1 | 8 |
| 167 | SW/094/981120 | 03094 | 411 | 20/11/98 | 0000 | 21/11/98 | 0000 | 8 | 1 | 8 |
| 86 | NF/096/980223 | 03096 | 411 | 23/02/98 | 1130 | 24/02/98 | 1130 | 8 | 1 | 5 |
| 87 | NF/743/980224 | 24743 | 411 | 24/02/98 | 1200 | 25/02/98 | 1200 | 8 | 1 | 5 |
| 90 | NF/045/980228 | 24045 | 411 | 28/02/98 | 1200 | 01/03/98 | 1200 | 8 | 1 | 5 |
| 91 | NF/094/980301 | 03094 | 411 | 01/03/98 | 1200 | 02/03/98 | 1200 | 8 | 1 | 6 |
| 92 | GH/044/980304 | 24044 | 411 | 04/03/98 | 1200 | 05/03/98 | 1200 | 8 | 1 | 6 |
| 95 | GH/497/980305 | 24497 | 411 | 05/03/98 | 1200 | 06/03/98 | 1200 | 8 | 1 | 6 |
| 100 | GH/095/980327 | 03095 | 411 | 27/03/98 | 1200 | 28/03/98 | 1200 | 8 | 1 | 6 |
| 101 | GH/099/980328 | 03099 | 411 | 28/03/98 | 1200 | 29/03/98 | 1200 | 8 | 1 | 6 |



"-": concentration is below 0.1 ppb

## HV, SW, NF & GH AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| | | | Methyl | | Vinyl | Methyl | Ethyl | | Vinylidene | Methylene |
|---|---|---|---|---|---|---|---|---|---|---|
| RUN# | SAMPLE NAME | Freon 12 | Chloride | Freon 114 | Chloride | Bromide | Chloride | Freon 11 | Chloride | Chloride |
| 11 | HV/093/970320 | - | - | - | | - | | - | | - |
| 15 | HV/091/970403 | - | - | - | | - | | - | | - |
| 19 | HV/103/970409 | - | - | - | | - | | - | | - |
| 23 | HV/091/970416 | - | - | - | | - | | - | | - |
| 50 | HV/092/971107E | 1.26 | - | 0.77 | | 0.53 | | 0.60 | | - |
| 58 | HV/104/971210 | 0.75 | - | 0.39 | | - | | 0.78 | | - |
| 62 | HV/091/971217 | 0.48 | - | 0.15 | | - | | 0.66 | | - |
| 66 | HV/092/971223 | 0.69 | - | 0.38 | | - | | 0.73 | | - |
| 70 | HV/104/980110 | 0.76 | 0.79 | - | | - | | 0.24 | | - |
| 74 | HV/092/980122 | 0.63 | - | - | | - | | 0.21 | | - |
| 80 | HV/045/980208 | 0.46 | - | - | | - | | 0.17 | | - |
| 83 | HV/498/980219 | 0.63 | - | - | | - | | 0.37 | | - |
| 88 | HV/097/980228 | 0.48 | 0.41 | - | | - | | 0.23 | | - |
| 97 | HV/743/980325 | 0.66 | - | - | | - | | 0.20 | | 0.36 |
| 103 | HV/097/980403 | 0.51 | 0.48 | - | | - | | 0.24 | | - |
| 105 | HV/045/980404 | 2.36 | - | - | | - | | 0.24 | | - |
| 109 | HV/094/980422 | 0.53 | - | - | | - | | 0.28 | | 0.16 |
| 113 | HV/091/980501 | 0.48 | - | - | | - | | 0.25 | | - |
| 114 | HV/095/980502 | 0.54 | - | - | | - | | 0.28 | | - |
| 120 | HV/106/980519 | 0.99 | - | 0.16 | | 0.12 | | 0.39 | | - |
| 157 | HV/091/981014 | 1.24 | - | - | | - | | 1.10 | | - |
| 160 | HV/098/981025 | 1.41 | - | 0.24 | | - | | 1.16 | | - |
| 170 | HV/095/981130 | 0.71 | - | - | | - | | 1.27 | | 0.78 |
| 9 | SW/105/970320 | - | | - | | - | | - | | - |
| 13 | SW/097/940403 | - | | - | | - | | - | | - |
| 17 | SW/095/970409 | - | | - | | - | | - | | - |
| 21 | SW/097/970416 | - | | - | | - | | - | | - |
| 61 | SW/093/971217 | 0.74 | | 0.39 | | - | | 0.77 | | - |
| 65 | SW/103/971223 | 0.64 | | - | | - | | 0.11 | | - |
| 69 | SW/094/980110 | 0.61 | | - | | - | | 0.21 | | - |
| 73 | SW/091/980122 | 0.69 | | - | | - | | 0.18 | | - |
| 79 | SW/498/980208 | 0.65 | | - | | - | | 0.19 | | - |
| 85 | SW/091/980219 | 0.88 | | - | | - | | 0.53 | | 0.29 |
| 99 | SW/091/980325 | 0.63 | | - | | - | | 0.22 | | 0.33 |
| 107 | SW/092/980404 | 0.40 | | - | | - | | 0.24 | | - |
| 110 | SW/106/980422 | 0.61 | | - | | - | | 0.35 | | 0.12 |
| 117 | SW/097/980501 | 0.52 | | - | | - | | 0.27 | | - |
| 124 | SW/104/980605 | 0.88 | | 0.17 | | 0.12 | | 0.35 | | - |
| 156 | SW/094/981014 | 1.36 | | 0.24 | | - | | 1.15 | | - |
| 161 | SW/095/981025 | 1.34 | | 0.24 | | - | | 1.16 | | - |
| 167 | SW/094/981120 | 0.75 | | - | | - | | - | | 0.83 |
| 86 | NF/096/980223 | 0.69 | - | | | | | 0.36 | | - |
| 87 | NF/743/980224 | 0.68 | - | | | | | 0.38 | | 0.15 |
| 90 | NF/045/980228 | 0.52 | 0.31 | | | | | 0.25 | | - |
| 91 | NF/094/980301 | 0.60 | - | | | | | 0.31 | | - |
| 92 | GH/044/980304 | 0.50 | | | | | | 0.27 | | - |
| 95 | GH/497/980305 | 0.40 | | | | | | 0.25 | | - |
| 100 | GH/095/980327 | 0.62 | | | | | | 0.20 | | 0.29 |
| 101 | GH/099/980328 | 0.59 | | | | | | 0.21 | | 0.28 |



"-": concentration is below 0.1 ppb

## HV, SW, NF & GH AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | Freon 113 | 1,1-Dichloro-ethane | 1,2-Dichloro-ethylene | Chloroform | 1,2-Dichloro-ethane | Methyl Chloroform | Benzene | Carbon tetrachloride |
|---|---|---|---|---|---|---|---|---|---|
| 11 | HV/093/970320 | - | | - | - | | - | - | - |
| 15 | HV/091/970403 | - | | - | - | | - | - | - |
| 19 | HV/103/970409 | - | | - | - | | - | - | - |
| 23 | HV/091/970416 | - | | - | - | | - | - | - |
| 50 | HV/092/971107E | 0.84 | | - | - | | 0.80 | 1.05 | 0.68 |
| 58 | HV/104/971210 | 1.10 | | - | - | | 0.21 | 0.21 | 0.31 |
| 62 | HV/091/971217 | 1.11 | | - | - | | - | - | 0.14 |
| 66 | HV/092/971223 | 1.11 | | - | - | | 0.22 | 0.16 | 0.31 |
| 70 | HV/104/980110 | - | | 1.46 | - | | - | 0.54 | - |
| 74 | HV/092/980122 | - | | 0.66 | - | | - | - | - |
| 80 | HV/045/980208 | - | | - | - | | - | - | - |
| 83 | HV/498/980219 | - | | - | - | | 0.11 | 0.57 | 0.15 |
| 88 | HV/097/980228 | - | | - | - | | - | 0.32 | - |
| 97 | HV/743/980325 | 0.23 | | - | - | | 0.24 | 0.38 | 0.12 |
| 103 | HV/097/980403 | - | | - | - | | - | 0.55 | - |
| 105 | HV/045/980404 | - | | - | - | | - | 0.21 | 0.10 |
| 109 | HV/094/980422 | - | | 2.06 | 0.25 | | - | 0.24 | 0.16 |
| 113 | HV/091/980501 | - | | - | - | | - | 0.11 | 0.15 |
| 114 | HV/095/980502 | 0.11 | | 1.77 | - | | - | 0.13 | 0.15 |
| 120 | HV/106/980519 | 0.23 | | - | - | | 0.20 | 0.49 | 0.15 |
| 157 | HV/091/981014 | 0.68 | | - | - | | - | 0.87 | 1.03 |
| 160 | HV/098/981025 | 0.71 | | - | - | | - | 0.90 | 1.05 |
| 170 | HV/095/981130 | - | | - | - | | - | 0.16 | - |
| 9 | SW/105/970320 | - | | - | | - | - | - | - |
| 13 | SW/097/940403 | - | | - | | - | - | - | - |
| 17 | SW/095/970409 | - | | - | | - | - | - | - |
| 21 | SW/097/970416 | - | | - | | - | - | - | - |
| 61 | SW/093/971217 | 1.13 | | - | | - | 0.30 | 0.12 | 0.31 |
| 65 | SW/103/971223 | - | | - | | - | - | - | - |
| 69 | SW/094/980110 | - | | - | | - | - | - | - |
| 73 | SW/091/980122 | - | | - | | - | - | - | - |
| 79 | SW/498/980208 | 0.11 | | - | | - | - | - | - |
| 85 | SW/091/980219 | 0.14 | | - | | 0.29 | 0.24 | 0.57 | 0.22 |
| 99 | SW/091/980325 | 0.21 | | - | | 0.22 | 0.30 | 0.60 | 0.11 |
| 107 | SW/092/980404 | - | | 1.14 | | - | 0.10 | 0.19 | - |
| 110 | SW/106/980422 | 0.16 | | - | | - | - | 0.73 | 0.17 |
| 117 | SW/097/980501 | 0.11 | | - | | - | 0.12 | 0.23 | 0.17 |
| 124 | SW/104/980605 | 0.24 | | - | | - | 0.17 | 0.81 | 0.16 |
| 156 | SW/094/981014 | 0.75 | | - | | - | 0.24 | 0.86 | 1.03 |
| 161 | SW/095/981025 | 0.72 | | - | | - | 0.13 | 0.90 | 1.04 |
| 167 | SW/094/981120 | - | | - | | - | - | 0.35 | 0.12 |
| 86 | NF/096/980223 | | | | | | 0.13 | 0.24 | 0.12 |
| 87 | NF/743/980224 | | | | | | 0.10 | 0.31 | 0.15 |
| 90 | NF/045/980228 | | | | | | - | 0.54 | - |
| 91 | NF/094/980301 | | | | | | - | 0.40 | 0.12 |
| 92 | GH/044/980304 | - | | | | | - | - | - |
| 95 | GH/497/980305 | - | | | | | - | - | 0.10 |
| 100 | GH/095/980327 | 0.20 | | | | | 0.22 | 0.21 | - |
| 101 | GH/099/980328 | 0.19 | | | | | 0.20 | 0.20 | 0.10 |



"-": concentration is below 0.1 ppb

## HV, SW, NF & GH AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2-Dichloro-propane | Trichloro-ethylene | cis-1,3-Dichloro-propylene | trans-1,3-Dichloro-propylene | 1,1,2-Trichloro-ethane | Toluene | 1,2-Dibromo-ethane (EDB) |
|---|---|---|---|---|---|---|---|---|
| 11 | HV/093/970320 | - | - | | | | - | |
| 15 | HV/091/970403 | - | - | | | | - | |
| 19 | HV/103/970409 | - | - | | | | 1.55 | |
| 23 | HV/091/970416 | - | - | | | | - | |
| 50 | HV/092/971107E | 0.62 | 0.88 | | | | 1.65 | |
| 58 | HV/104/971210 | - | - | | | | - | |
| 62 | HV/091/971217 | - | - | | | | 0.21 | |
| 66 | HV/092/971223 | - | - | | | | - | |
| 70 | HV/104/980110 | - | - | | | | 1.18 | |
| 74 | HV/092/980122 | - | - | | | | - | |
| 80 | HV/045/980208 | - | - | | | | - | |
| 83 | HV/498/980219 | - | - | | | | 0.91 | |
| 88 | HV/097/980228 | - | - | | | | 0.48 | |
| 97 | HV/743/980325 | - | - | | | | 0.54 | |
| 103 | HV/097/980403 | - | - | | | | 0.96 | |
| 105 | HV/045/980404 | - | - | | | | 0.28 | |
| 109 | HV/094/980422 | - | - | | | | 0.36 | |
| 113 | HV/091/980501 | 0.12 | - | | | | - | |
| 114 | HV/095/980502 | 0.22 | - | | | | - | |
| 120 | HV/106/980519 | - | - | | | | 1.01 | |
| 157 | HV/091/981014 | - | - | | | | 1.21 | |
| 160 | HV/098/981025 | - | - | | | | 1.18 | |
| 170 | HV/095/981130 | - | - | | | | 0.29 | |
| 9 | SW/105/970320 | | | | | - | - | |
| 13 | SW/097/940403 | | | | | - | - | |
| 17 | SW/095/970409 | | | | | - | - | |
| 21 | SW/097/970416 | | | | | - | - | |
| 61 | SW/093/971217 | | | | | - | - | |
| 65 | SW/103/971223 | | | | | 0.11 | 0.19 | |
| 69 | SW/094/980110 | | | | | - | - | |
| 73 | SW/091/980122 | | | | | - | - | |
| 79 | SW/498/980208 | | | | | - | 0.30 | |
| 85 | SW/091/980219 | | | | | - | 0.99 | |
| 99 | SW/091/980325 | | | | | - | 0.94 | |
| 107 | SW/092/980404 | | | | | - | 0.27 | |
| 110 | SW/106/980422 | | | | | - | 1.01 | |
| 117 | SW/097/980501 | | | | | - | 0.28 | |
| 124 | SW/104/980605 | | | | | - | 1.28 | |
| 156 | SW/094/981014 | | | | | - | 1.16 | |
| 161 | SW/095/981025 | | | | | - | 1.19 | |
| 167 | SW/094/981120 | | | | | - | 0.51 | |
| 86 | NF/096/980223 | | | | | | 0.42 | |
| 87 | NF/743/980224 | | | | | | 0.62 | |
| 90 | NF/045/980228 | | | | | | 1.08 | |
| 91 | NF/094/980301 | | | | | | 0.53 | |
| 92 | GH/044/980304 | | | | | | - | |
| 95 | GH/497/980305 | | | | | | 0.11 | |
| 100 | GH/095/980327 | | | | | | 0.31 | |
| 101 | GH/099/980328 | | | | | | 0.28 | |



“-“: concentration is below 0.1 ppb

HV, SW, NF & GH AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | Tetrachloro-ethylene | Chloro-benzene | Ethyl-benzene | (m+p)--Xylene | Styrene | Tetrachloro-ethane | o-Xylene | 1,3,5-Trimethyl-benzene |
|---|---|---|---|---|---|---|---|---|---|
| 11 | HV/093/970320 | - | - | - | - | - | - | - | - |
| 15 | HV/091/970403 | - | - | - | - | - | - | - | - |
| 19 | HV/103/970409 | - | - | - | 1.40 | - | - | - | - |
| 23 | HV/091/970416 | - | - | - | - | - | - | - | - |
| 50 | HV/092/971107E | - | 0.31 | 0.19 | 0.86 | 0.54 | - | 0.55 | 0.19 |
| 58 | HV/104/971210 | - | - | - | - | 0.20 | - | - | - |
| 62 | HV/091/971217 | - | 0.23 | - | 0.10 | - | - | - | - |
| 66 | HV/092/971223 | - | - | - | - | - | - | - | - |
| 70 | HV/104/980110 | - | - | - | - | - | - | - | - |
| 74 | HV/092/980122 | - | - | - | - | - | - | - | - |
| 80 | HV/045/980208 | - | - | - | - | - | - | - | - |
| 83 | HV/498/980219 | - | - | 0.12 | 0.48 | - | - | 0.16 | - |
| 88 | HV/097/980228 | - | - | - | 0.24 | - | - | - | - |
| 97 | HV/743/980325 | - | - | 0.20 | 0.51 | 0.11 | - | 0.16 | - |
| 103 | HV/097/980403 | - | - | - | 0.45 | - | - | 0.19 | - |
| 105 | HV/045/980404 | - | - | - | 0.26 | - | - | 0.12 | - |
| 109 | HV/094/980422 | - | - | - | 0.26 | - | - | 0.11 | - |
| 113 | HV/091/980501 | - | - | - | - | - | - | - | - |
| 114 | HV/095/980502 | - | - | - | - | - | - | - | - |
| 120 | HV/106/980519 | 0.28 | 0.30 | 0.32 | 0.85 | 0.28 | - | 0.25 | 0.15 |
| 157 | HV/091/981014 | - | - | 0.21 | 1.06 | - | - | 0.54 | 0.56 |
| 160 | HV/098/981025 | - | 1.15 | 0.21 | 1.04 | 0.57 | 0.45 | 0.54 | 0.57 |
| 170 | HV/095/981130 | - | - | - | 0.14 | - | - | - | - |
| 9 | SW/105/970320 | - | - | - | - | - | - | - | - |
| 13 | SW/097/940403 | - | - | - | - | - | - | - | - |
| 17 | SW/095/970409 | - | - | - | - | - | - | - | - |
| 21 | SW/097/970416 | - | - | - | - | - | - | - | - |
| 61 | SW/093/971217 | - | - | - | - | - | - | - | - |
| 65 | SW/103/971223 | - | - | - | - | - | - | - | - |
| 69 | SW/094/980110 | - | - | - | - | - | - | - | - |
| 73 | SW/091/980122 | - | - | - | - | - | - | - | - |
| 79 | SW/498/980208 | - | - | - | - | - | - | - | - |
| 85 | SW/091/980219 | - | - | 0.15 | 0.45 | 0.12 | - | 0.20 | 0.13 |
| 99 | SW/091/980325 | 0.12 | 0.10 | 0.24 | 0.63 | 0.12 | - | 0.24 | - |
| 107 | SW/092/980404 | - | - | - | 0.14 | - | - | - | - |
| 110 | SW/106/980422 | - | - | 0.17 | 0.70 | - | - | 0.33 | - |
| 117 | SW/097/980501 | - | - | - | 0.21 | - | 0.22 | 0.10 | - |
| 124 | SW/104/980605 | 0.29 | 0.31 | 0.37 | 1.09 | 0.22 | - | 0.35 | 0.17 |
| 156 | SW/094/981014 | - | 1.14 | 0.32 | 1.07 | - | - | 0.57 | 0.59 |
| 161 | SW/095/981025 | - | 1.16 | 0.21 | 1.06 | 0.57 | - | 0.55 | 0.57 |
| 167 | SW/094/981120 | - | - | - | 0.29 | - | - | 0.15 | - |
| 86 | NF/096/980223 | | | 0.11 | 0.41 | | | 0.18 | |
| 87 | NF/743/980224 | | | 0.12 | 0.40 | | | 0.20 | |
| 90 | NF/045/980228 | | | 0.15 | 0.51 | | | 0.25 | |
| 91 | NF/094/980301 | | | - | 0.33 | | | 0.14 | |
| 92 | GH/044/980304 | | - | - | - | - | | - | |
| 95 | GH/497/980305 | | - | - | - | - | | - | |
| 100 | GH/095/980327 | | 0.10 | 0.16 | 0.43 | 0.11 | | 0.11 | |
| 101 | GH/099/980328 | | - | 0.15 | 0.38 | - | | - | |



“-“: concentration is below 0.1 ppb

## HV, SW, NF & GH AIR TOXICS (CONCENTRATIONS ARE IN PPB)

| RUN# | SAMPLE NAME | 1,2,4-Trimethyl-benzene | 1,3-Dichloro-benzene | 1,4-Dichloro-benzene | 1,2-Dichloro-benzene | 1,2,4-Trichloro-benzene | Hexachloro--1,3-butadiene |
|---|---|---|---|---|---|---|---|
| 11 | HV/093/970320 | - | - | - | - | - | |
| 15 | HV/091/970403 | - | - | - | - | 1.00 | |
| 19 | HV/103/970409 | - | - | - | - | - | |
| 23 | HV/091/970416 | - | - | - | - | - | |
| 50 | HV/092/971107E | 0.40 | 0.19 | 0.13 | - | - | |
| 58 | HV/104/971210 | 0.45 | - | 0.19 | 0.13 | 0.22 | |
| 62 | HV/091/971217 | 1.32 | - | 0.35 | - | 0.61 | |
| 66 | HV/092/971223 | 0.43 | - | 0.19 | - | 0.22 | |
| 70 | HV/104/980110 | - | - | - | - | - | |
| 74 | HV/092/980122 | - | - | - | - | - | |
| 80 | HV/045/980208 | - | - | - | - | - | |
| 83 | HV/498/980219 | - | - | - | - | - | |
| 88 | HV/097/980228 | - | - | - | - | - | |
| 97 | HV/743/980325 | - | - | - | - | - | |
| 103 | HV/097/980403 | - | - | - | - | - | |
| 105 | HV/045/980404 | - | - | - | - | - | |
| 109 | HV/094/980422 | 0.13 | - | - | - | - | |
| 113 | HV/091/980501 | - | - | - | - | - | |
| 114 | HV/095/980502 | - | - | - | - | - | |
| 120 | HV/106/980519 | 0.28 | 0.26 | 0.35 | 0.34 | 0.18 | |
| 157 | HV/091/981014 | - | - | - | - | - | |
| 160 | HV/098/981025 | - | 0.97 | 1.12 | 0.94 | 0.79 | |
| 170 | HV/095/981130 | - | - | - | - | - | |
| 9 | SW/105/970320 | 2.00 | - | - | - | - | |
| 13 | SW/097/940403 | - | - | - | - | 2.10 | |
| 17 | SW/095/970409 | - | - | - | - | - | |
| 21 | SW/097/970416 | - | - | - | - | - | |
| 61 | SW/093/971217 | 0.50 | - | 0.19 | - | 0.22 | |
| 65 | SW/103/971223 | - | - | - | - | - | |
| 69 | SW/094/980110 | - | - | - | - | - | |
| 73 | SW/091/980122 | - | - | - | - | - | |
| 79 | SW/498/980208 | - | - | - | - | - | |
| 85 | SW/091/980219 | - | - | - | - | - | |
| 99 | SW/091/980325 | - | - | - | - | - | |
| 107 | SW/092/980404 | - | - | - | - | - | |
| 110 | SW/106/980422 | 0.33 | - | - | - | - | |
| 117 | SW/097/980501 | 0.11 | - | - | - | - | |
| 124 | SW/104/980605 | 0.31 | 0.26 | 0.34 | 0.33 | 0.17 | |
| 156 | SW/094/981014 | - | 0.96 | 1.10 | 0.91 | - | |
| 161 | SW/095/981025 | - | 0.95 | 1.10 | 0.92 | 0.76 | |
| 167 | SW/094/981120 | - | - | - | - | - | |
| 86 | NF/096/980223 | 0.16 | | | | | |
| 87 | NF/743/980224 | 0.15 | | | | | |
| 90 | NF/045/980228 | 0.14 | | | | | |
| 91 | NF/094/980301 | - | | | | | |
| 92 | GH/044/980304 | | | | | | |
| 95 | GH/497/980305 | | | | | | |
| 100 | GH/095/980327 | | | | | | |
| 101 | GH/099/980328 | | | | | | |



“-“: concentration is below 0.1 ppb