Government of Western Australia
Department of Environment Regulation

REPORT

Kwinana Background Air Quality Study

Phase 4 – 2013 to 2014

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Executive summary

The Background Air Quality Study (BAQS) was initiated in 2004, by the then Department of Environment (DoE), to assess ambient concentrations of a class of pollutants known as 'air toxics' in the Perth metropolitan and selected regional areas. DoE conducted phase 1 of the study from 2005 to 2006.

Phases 2 and 3 of the study were conducted from 2007 to 2008 and 2009 to 2010, respectively, by the then Department of Environment and Conservation (DEC). .

The Department of Environment Regulation (DER) conducted phase 4 of the study from 2013 to 2014.

Air toxics monitored included volatile organic compounds (VOCs), heavy metals, polycyclic aromatic hydrocarbons (PAHs), carbonyl compounds, nitrogen dioxide (NO_2), ammonia (NH_3) and fine particles ($PM_{2.5}$). Sampling was conducted over periods of twenty-four hours or longer using canisters and passive samplers. The standardised methodology, used in the previous studies, while useful to determine VOCs at levels of concern, were unable to identify short-term peaks of air toxics that may have occurred over several minutes and that may have contributed to complaints.

In this current and final phase of the study, an Open-Path Fourier Transform Infrared (OP-FTIR) spectrometer was used due to its capability to provide short-term data and for a range of compounds simultaneously. Air toxics monitored in phase 4 of the study included ammonia and targeted VOCs: acetaldehyde; acetone; benzene; carbon disulfide; ethylbenzene; formaldehyde; xylene; toluene; and a measure of the total VOCs.

The air toxics monitored were selected in consultation with the community through the Kwinana Airshed Study Advisory Group (KASAG) and in consideration of NPI data. KASAG comprises representatives from State and Local Government, industry and the community.

The sampling sites were also selected in consultation with the community. Ten sites were selected in the area surrounding the Kwinana Industrial Area (KIA), encompassing the Cities of Kwinana, Cockburn and Rockingham. Most sites were located within Area C (residential area) of the *Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999* (Kwinana EPP). Some were located in Area B (buffer area) and one site within the industrial area (Area A).

The study was conducted from April 2013 to October 2014, with a total of 69 sampling days. Sampling was generally conducted continuously between 9am and 3pm and downwind of the KIA on each sampling day. Concentration levels were averaged over one-hour and compared to air quality criteria.

The Department of Health (DoH) advised that the measurements of the air toxics monitored in phase 4 are well below the air quality criteria, but advise that even though measurements may be below the air quality criteria and odour thresholds, impact on local amenities are likely. This is evidenced by the observation of odours during monitoring.

It is difficult to compare to the results of the previous phases of the BAQS because the OP-FTIR monitors over a path length, rather than at a point as is the case with other monitoring techniques used in the previous phases of the study.

The table below shows a summary of the results for the study.

Summary of results (maximum one-hour average concentrations in parts per billion)

Site/compound (max)		Ammonia	Acetone	Benzene	Carbon disulfide	Ethylbenzene	Xylene	Toluene	Aldehyde
Beeliar Oval*		<LOD	43	<LOD	1.1	31	72	11	<LOD
Bertram Oval*		<LOD	31	<LOD	1.2	21	42	<LOD	<LOD
Calista Oval		20	<LOD	<LOD	<LOD	29	24	10	<LOD
Department of Agriculture		10	<LOD	<LOD	<LOD	47	52	45	47
Dixon Road Reserve *		160	260	<LOD	<LOD	33	37	13	<LOD
Medina Oval*		4.0	48	<LOD	3.3	45	22	14	<LOD
Sloan's Reserve		20	58	<LOD	<LOD	38	14	6.4	<LOD
Thomas Oval*		59	<LOD	<LOD	4.4	29	78	9.9	<LOD
Wattleup*		7.2	150	<LOD	<LOD	20	16	<LOD	<LOD
Wells Park		170	90	<LOD	4.2	32	21	6.8	<LOD
Air Quality Criteria	**(1hr, ppb)**	**480**	**9300**	**9.0**	**27**	**1800**	**-**	**-**	**-**
	(24hr, ppb)	-	-	-	8	-	250	1000	-
LOD		1.5	24	2.2	1.0	10	7.0	6.0	29

*Odours observed
Note: The FTIR was unable to quantify total VOCs

Short-term air toxics peaks were identified and back trajectories conducted to identify likely industrial sources and causes. In only one case was a direct link between a peak and industry established. Although odours were observed during some of the sampling days, there was no correlation with the peaks identified.

In addition to the six-hour sampling sessions conducted, continuous monitoring for a one-month period was also conducted during the study, to assess diurnal variations in air toxics monitored. The continuous monitoring was conducted at a site within the industrial area as a suitable site within the residential area could not be located due to the inability to meet security concerns and OP-FTIR siting requirements. The continuous monitoring showed that the measured ammonia increased from early evening to the early hours of the morning, but were still below the air quality criteria of 480ppb (1 hour). The maximum one-hour average ammonia concentration recorded at the Cogeneration Plant during continuous monitoring was 120ppb, which is lower than highest ammonia levels recorded at Wells Park (170ppb) and Dixon Road Reserve (160ppb).

The FTIR was unable to quantify total VOCs (TVOCs), therefore, polar plots were used to present TVOCs results, which are useful in identifying potential sources.

DoH advised that the levels of air toxics recorded during phases 1 to 3 of the study were similar to those found elsewhere in the Perth metropolitan region, but was unable to provide similar comments for phase 4 as the levels measured were averaged over one-hour rather than the usual 24 hours or annual averaging periods.

Contents

Purpose

The Department of Environment Regulation (DER) commenced Phase 4 of the Kwinana Background Air Quality Study (BAQS) in 2013, herein referred to as the study, which was a twelve-month study to obtain short-term averaged data for ammonia and targeted volatile organic compounds (VOCs) at selected sites within the region surrounding the Kwinana Industrial Area (KIA) and bounded by the Cities of Cockburn, Kwinana and Rockingham. Previous phases of the study provided measurements over longer timeframes. An OP-FTIR spectrometer was used in this phase as it is capable of providing short-term measurements and for a range of compounds simultaneously.

Key messages

- Air quality impacts on health and amenity from industry in the KIA is of concern to residents in the surrounding area. DER has received occasional complaints from residents pertaining to odours and concerns over possible health impacts.
- In consultation with the community, the Department has been conducting monitoring in the residential area surrounding the KIA since 2005, to understand the possible reasons for these concerns. It has been found that levels of air pollutants remain below air quality health criteria. On occasion, however, Departmental officers observed odours during field monitoring.
- The OP-FTIR spectrometer has proven to be a significant advancement in monitoring technology, allowing short-term events to be monitored and assessed in detail. DER continues to use new monitoring techniques and scientific studies that can provide improved data acquisition enabling better interpretation and assessment of air quality.

1.0 Introduction

This phase of the BAQS study was designed in consultation with the community, local government, industry and State Government departments to measure ammonia and targeted VOCs of acetaldehyde; acetone; benzene; carbon disulfide; ethylbenzene; formaldehyde; xylene; total VOCs; and toluene. The study was undertaken in the region surrounding the Kwinana Industrial Area (KIA), encompassing the Cities of Kwinana, Cockburn and Rockingham, from April 2013 to October 2014, using an OP-FTIR.

The aims of phase 4 of the study were to:

- sample ammonia and targeted VOCs in the Kwinana region for at least twelve months using an OP-FTIR;
- provide targeted short-term averaged data for different sites within the Kwinana region;
- capture real-time worst-case ammonia and VOC levels by sampling down-wind from sources;
- obtain up-wind measurements at the same sites for comparison;

- compare the measured levels of ammonia and the targeted VOCs with established air quality criteria;
- conduct back trajectory analysis for ammonia and VOC peaks to identify potential sources; and
- conduct continuous monitoring over a few weeks to assess diurnal variations of ammonia and VOCs.

Major sources of ammonia and VOCs in the KIA include: Alcoa Alumina Refinery; Australian Gold Reagents; BASF; BP Refinery; CSBP; Kwinana Nickel Refinery (Nickel West); and Woodman Point Wastewater Treatment Plant (WWTP).

2.0 Study design

2.1 Previous studies

The BAQS was initiated in 2004, by the then DoE, to assess ambient concentrations of a class of pollutants known as 'air toxics' in the Perth metropolitan and selected regional areas. DoE conducted phase 1 of the study from 2005 to 2006.

Phases 2 and 3 of the study were conducted from 2007 to 2008 and 2009 to 2010, respectively, by the then DEC.

Air toxics monitored included VOCs, heavy metals, polycyclic aromatic hydrocarbons (PAHs), carbonyl compounds, nitrogen dioxide (NO_2), ammonia (NH_3) and fine particles ($PM_{2.5}$). Table 1 outlines the previous phases of the BAQS. A detailed report, "*Background air quality monitoring in Kwinana 2005-10*", is available on DER's website at www.der.wa.gov.au.

DoH advised that the levels of air toxics recorded during the first three phases of the study were similar to those found elsewhere in the Perth metropolitan region and the levels of air toxics were not sufficiently increased to cause a health concern for the majority of people.

Despite the low levels measured, limitations with existing monitoring techniques at the time made it difficult to determine the root cause of many of the community complaints, which most likely resulted from short-term peaks and/or odour events. In previous studies, samples were collected over 24-hour or six-day sampling periods using canisters or passive samplers.

Table 1. Kwinana region air toxics sampling: 2005 to 2010

Phase	Date	Substances	Sampling Location
Phase 1: 2005–06	Jan 05–Jul 06	VOCs Carbonyls Heavy metals PAHs	Hope Valley
	May 05–Jul 06	VOCs NO_2 Ammonia	Munster Wattleup Medina Calista Challenger North Rockingham Kwinana Beach
	Sep 05–Sep 06	$PM_{2.5}$ particles	Kwinana Rockingham
Phase 2: 2007–08	Jul 07–Aug 08	VOCs Carbonyls Ammonia	Benjamin Way Governor Road Kwinana Beach Thomas/Mason Road Hope Valley Henderson James Point Kwinana Container Terminal Wellard Road Orelia Oval Kwinana Freeway Mandogalup Road Thomas Oval Kwinana Golf Course
Phase 3: 2009–10	May 09–June 10	$PM_{2.5}$ particles NO_2 Heavy metals	Calista Hillman

2.2 Monitoring device

An OP-FTIR was chosen for the Kwinana Phase 4 study because of its capability to simultaneously measure multiple compounds over a short timeframe.

The OP-FTIR is a real-time monitoring technique for detection and quantification of multiple compounds simultaneously in ambient air. A beam of infrared radiation (IR) is passed through a specified portion of air (plume) and measures the path integrated pollutant concentration along the entire length of the infrared path. After passing through the plume, the IR beam is subjected to spectral analysis to determine the infrared absorbance of the individual compounds passing through the beam.

During this study, the OP-FTIR (Midac model M4416-F) was operated using a high sensitivity closed cycle cooled photoconductive mercury cadmium telluride (MCT) detector. The detector covered the infrared range of 650cm^{-1} to 4500cm^{-1}, to enable detection of ammonia and VOCs in the air samples, and recorded an average of 64

scans over the chosen path length every 37 seconds. The path length was set to 80 metres (m) and spectral resolution was 1.0cm^{-1}. At the beginning and the end of each sampling session, two background spectra were obtained over two minutes (256 scans).

The concentration of the target gases are analysed and reported, in real-time. FTIR analysis is done using calibrated infrared spectra contained in a standards library stored on the hard drive of the instrument computer. Every measurement is individually measured against these standards during analysis. The cooling system, detector, instrument electronics and spectrometer mechanical parts are enclosed in a light metal case. The device and IR light source are powered by a 12v DC power supply and controlled by a computer. A list of specifications of the OP-FTIR is presented in Table 2. A typical OP-FTIR field setup is presented in Figure 1.

The OP-FTIR method has been used in various studies overseas and has shown good agreement with standard ambient air quality monitoring methods (NMED Report, 2004). The U.S. Department of Agriculture Forest Service Fire Sciences Combustion Facility studies showed good OP-FTIR VOC agreement with proton transfer reaction mass spectrometry (PTR-MS) and canister samples analysed by gas chromatography (GC) with mass spectrometry (MS), flame ionisation detection (FID), and electron capture detection (ECD) (Christian et al, 2004). DER also used the OP-FTIR in the Midland Background Air Quality Study (2011-2012) to measure levels of acid gases (hydrogen chloride and hydrogen fluoride) in the ambient air in the Midland area. This report, "*2011-2012 Midland Background Air Quality Study*", is available on DER's website at www.der.wa.gov.au.

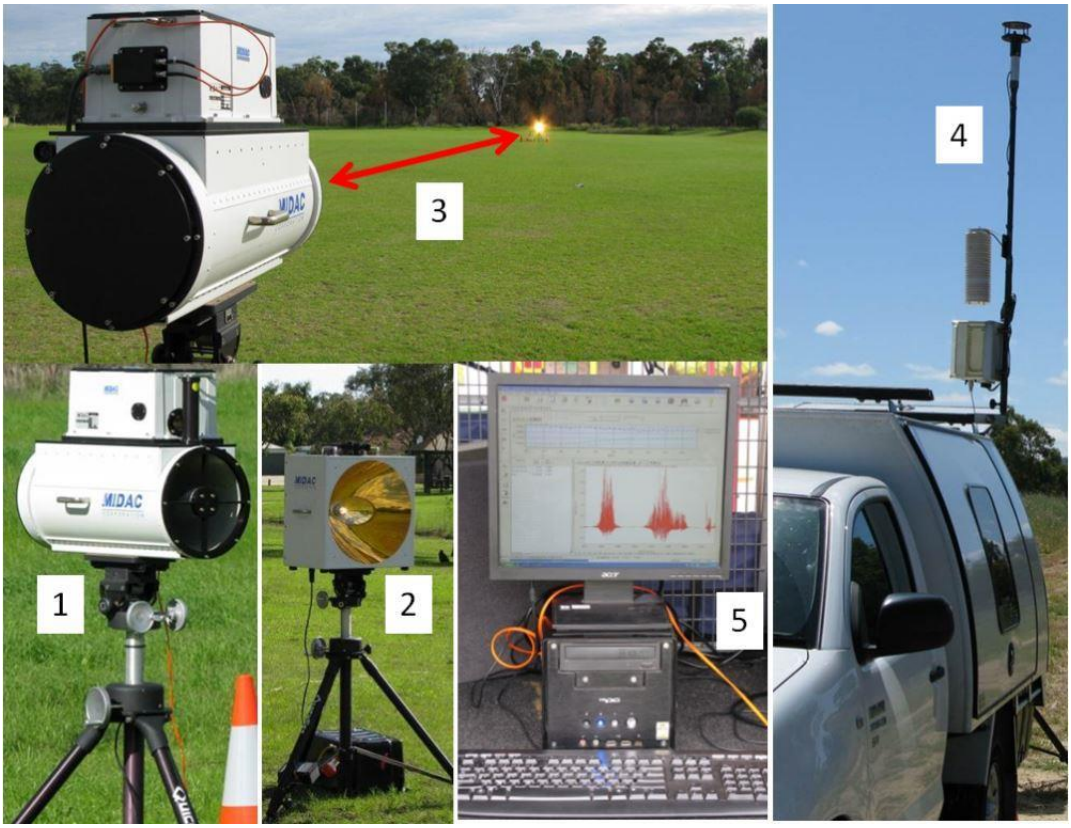


Figure 1. Typical OP-FTIR monitoring set-up: (1) OP-FTIR detector, (2) OP-FTIR light source, (3) 80-metre path between the detector and light source, (4) meteorological sensors on mast and (5) computer logging measurements

Table 2. Specifications of OP-FTIR deployed in the Background Air Quality Study Phase 4

	Specifications
Instrument type	Bi-Static Open-Path Fourier Transform Infrared spectrometer
IR Source	20" IR Source, Gold Plated, Collimating Mirror
Spectral range (cm^{-1})	Mid IR: 650–4500
Co-added scans	2-256
Spectral resolution (cm^{-1}):	0.5-8
Detector type	Mercury Cadmium Telluride (MCT) with10" Telescope
Limits of Detection (LOD)	Vary by compound from ppb to ppm
Typical path-length	Approximately 80 metres
Power	12v DC for both IR source and Detector

It should be noted that the FTIR data is collected over a path rather than a point, as is the case with standard air quality monitoring techniques. Consequently, while the data may be used to evaluate short-term peaks occurring over several minutes, the data cannot be used for direct comparison with air quality criteria, as these are derived from point sampling.

2.3 Selection of air toxics to be monitored

This study focused on the measurement of ammonia and targeted VOCs: acetaldehyde; acetone; benzene; carbon disulfide; ethylbenzene; formaldehyde; xylene; total VOCs; and toluene, in consultation with the Kwinana Airshed Study Advisory Group (KASAG) consisting of members from community, local government, industry and State Government departments.

Major industrial sources of ammonia and the targeted VOCs in the KIA are shown in Table 3. Some monitoring sites were located close to the Kwinana Freeway and therefore vehicle emissions may have contributed to the levels of air toxics measured.

Table 3. Air toxics monitored in the study and emission sources

Air toxics assessed	Major sources in the Kwinana region
Ammonia	Nickel West
	BP Refinery
	Woodman Point WWTP
	Doral Fused Materials
	Alcoa Alumina Refinery
	CSBP
	Australian Gold Reagents
Acetone	Alcoa Alumina Refinery
Aldehyde	Alcoa Alumina Refinery
	BP Refinery
Benzene	Nickel West
	BP Refinery
	Coogee Chemicals
Carbon disulfide	BP Refinery
	Coogee Chemicals
Ethylbenzene	Nickel West
	BP Refinery
	Coogee Chemicals
Xylene	BP Refinery
	Coogee Chemicals
Total VOCs	Nickel West
	BP Refinery
	Alcoa Alumina Refinery
	CSBP
	BASF
	Coogee Chemicals
Toluene	Nickel West
	BP Refinery
	Coogee Chemicals

2.4 Site selection

Sites for air quality monitoring were selected on the basis of consultation undertaken in July 2012 with key stakeholders: KASAG; the local government authorities and communities of Kwinana, Rockingham and Cockburn; Communities and Industries Forum (CIF), Kwinana Industries Council (KIC); industry in the KIA; the then DEC (now DER); and DoH.

Twenty sites were scoped by DEC in consultation with the Kwinana community. These were presented to KASAG and ten highly desirable sites were selected for monitoring. The ten selected monitoring sites are presented in Figure 2.

Key considerations in scoping of the sites included a range of physical requirements relating to set-up and operation of the OP-FTIR: access to power; a clear path length of at least 80 metres; ability to direct the light source away from housing and roads; and vehicular access to the site.

The selected sites provided a range of locations in residential areas likely to be impacted by potential sources of VOCs and ammonia in the KIA.

The community consultation process included an online survey and two community open days held in Kwinana and Rockingham (as shown in Appendix A).

Feedback in the form of a report on the community consultation was provided to participating stakeholders.

The survey, promotional flyer and consultation report are shown in Appendix A.

The selected sites also met the requirements of the relevant guidance. The US EPA Guidance (USEPA TO-16, 1999) recommends that the OP-FTIR should be placed sufficiently away from the edge of the road, major transportation routes, buildings, fences and the drip line of trees. The Guidance recommends that (i) 90% of the path must be at least 20m from the drip line of trees (ii) 90% of path must have unrestricted air flow and if the path has to be near an obstruction then must be upwind of any obstruction. In addition, the sampling path needs to be downwind of industrial sites and almost perpendicular to the prevailing wind direction. Concurrent wind speed and wind direction measurements were undertaken.

Figure 2. Sampling sites - The green shaded area represents the Kwinana Industrial Area (Area A) while the red shaded area represents the Kwinana Buffer Area (Area B) and the area outside Area B is the residential area (Area C)

2.5 Sampling design

The aim was to conduct the study over a twelve-month period, with two sampling sessions per week on average, totaling between 50 to 100 sampling sessions. However, the study was extended to 18 months, with a total of 69 sampling sessions conducted.

2.5.1 Daily sampling and equipment setup

The sampling was conducted continuously for approximately six hours during the day, generally between 9am and 3pm, and downwind of the KIA to capture real time, worst case air toxics levels.

The path-integrated concentration in the pollutant plume was measured by the OP-FTIR at 1.5m above ground-level and along a path which was approximately 80m in length.

Days for specific monitoring sessions were selected throughout the period of the study based on suitability of forecast weather conditions a few days prior to sampling. The sampling could not be conducted on rainy days due to potential for equipment damage and impacts on quality of data.

Sampling sites were selected based on wind direction, downwind of the KIA to sample worst case scenario conditions.

The deployment form, which included FTIR setup requirements, was prepared several days prior to sampling events. An example field deployment request form is presented in Appendix B. Wind roses for the study region are presented in Appendix C to provide information on general wind trends.

Several checks were performed on the OP-FTIR instrumentation prior to and during deployment in the field. The FTIR field checklist form used during the sampling is at Appendix D. During the OP-FTIR measurements, some meteorological parameters such as: wind speed, wind direction, ambient temperature, atmospheric pressure and relative humidity were recorded. A wind sensor (Gill WindSonic) was used to measure wind speed and wind direction. Air temperature and relative humidity were measured using a Rotronic MP-100 sensor. These sensors were mounted on a mast within 10 metres of the OP-FTIR sampling path.

2.5.2 Continuous monitoring

The OP-FTIR was also deployed for one-month continuous monitoring of air toxics at the Kwinana Cogeneration Plant to provide insight into diurnal variations of air toxics levels. A site within the residential area would have been preferred for the continuous monitoring, however, due to security concerns and the inability to meet all OP-FTIR siting requirements, the Kwinana Cogeneration Plant was selected.

Details of sampling conducted at each site are presented in Table 4.

Table 4. FTIR monitoring sites and sampling periods

Site name	Sampling dates	Sampling sessions	Total sampling (hours)
Beeliar Oval	21 August 2013; 2 October 2013; 6 November 2013; 13 November 2013; 25 November 2013; 3 December 2013; 18 September 2014	7	42
Calista Oval	30 October 2013; 30 January 2014; 4 February 2014; 4 April 2014; 14 May 2014; 6 August 2014; 23 September 2014	7	42
Department of Agriculture	6 February 2014; 7 February 2014; 14 February 2014; 16 April 2014; 6 May 2014; 17 September 2014; 15 October 2014	7	40
Dixon Road Reserve	14 May 2013; 7 June 2013; 20 June 2013; 28 June 2013; 29 April 2014; 24 June 2014; 1 August 2014	7	42
Medina Oval	9 August 2013; 28 November 2013; 15 January 2014; 8 April 2014; 30 April 2014; 27 August 2014; 14 October 2014	7	41
Sloan's Reserve	11 June 2013; 1 August 2013; 5 September 2013; 3 April 2014; 15 April 2014; 4 June 2014; 25 September 2014; 7 October 2014	8	48
Thomas Oval	11 November 2013;16 December 2013; 31 January 2014; 9 April 2014; 11 April 2014; 29 May 2014; 11 September 2014	7	39
Wattleup	21 May 2013; 31 May 2013; 31 October 2013; 12 December 2013; 18 December 2013; 7 January 2014; 14 January 2014	7	42
Wells Park	24 May 2013; 21 November 2013; 5 December 2013; 10 December 2013; 11 February 2014; 5 August 2014; 4 September 2014	7	42
Background sampling			
Bertram Oval	30 April 2013; 2 January 2014; 21 January 2014; 1 October 2014; 2 October 2014	5	27
Continuous sampling			
Kwinana Cogeneration Plant	25 February to 27 March 2014	30 days	701
Project duration	May 2013 to October 2014		1106

2.5.3 Recordkeeping

The field technicians kept a log of events that occurred during the period of the sampling on an OP-FTIR Field Record Data Sheet as shown in Appendix E. These logs became a part of the data interpretation and analysis. Typically, these logs recorded any conditions which may have impacted the sampling site including, but not limited to odours, train movements, heavy vehicle movements, public activity in the area, lawn mowing activities, weather conditions and equipment issues.
General observations relating to the site conditions, weather conditions and any odour events were recorded by the operators on a regular basis during sampling.

2.6 Data analysis and interpretation

Data analysis and interpretation were conducted soon after each sampling event to identify significant VOC and ammonia peaks. A significant peak was considered as the average of a collection of data points for a specific pollutant extending over any five-minute period (approximately 10 readings) which exceeds by a factor of ten the mean concentration of the pollutant for that day's monitoring.

2.6.1 Wind back trajectory analysis

Wind back trajectories were created in an attempt to identify potential sources. Industry and KIC were consulted to establish if plant operating conditions may have been a factor. The flowchart in Figure 3 represents the process used for data analysis and identifying possible sources.

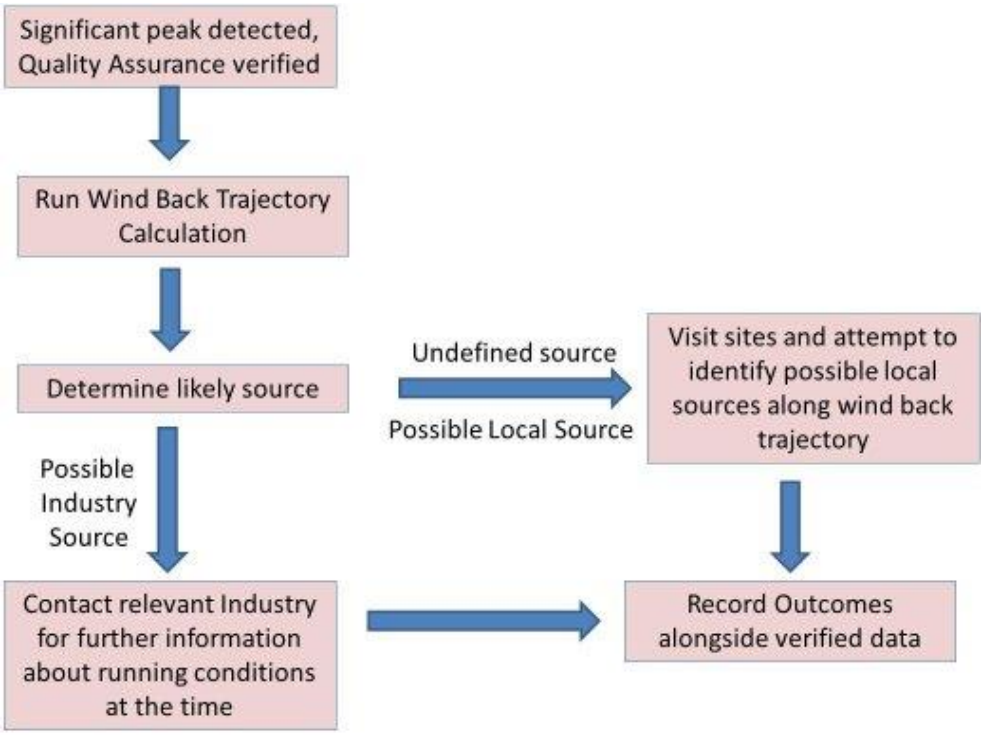


Figure 3: The process used for data analysis and interpretation to identify possible sources

2.6.2 Reported concentration levels

Reference spectra used in this study are sourced from laboratory measurements of gases from infrared absorption databases, such as those produced by USEPA and MIDAC.

Concentrations are calculated based upon the spectral area(s) chosen from each reference spectra. The reported concentrations of VOCs and ammonia in this study have a confidence of greater than 99.7%. The data analysis was conducted in accordance with USEPA TO-16 method.

The results of the study were averaged over one-hour timeframes for comparison with one-hour criteria recommended by DoH in consultation with DER. The criteria are provided in Table 5.

2.6.3 Limit of detection (LOD)

The limit of detection is the smallest concentrations which can be measured with reasonable confidence and was calculated according to the procedures in the USEPA method TO-16.

2.7 Quality Assurance

A number of quality assurance procedures need to be performed on the OP-FTIR field measurement data to obtain reliable results. The standardisation documents for the OP-FTIR technique were used for quality assurance purposes: Compendium Method TO-16 (USEPA TO-16, 1999); OP-FTIR Monitoring Guidance (Open-Path Monitoring Guidance, 1999); USEPA Quality Assurance Handbook (USEPA QA Handbook, 1994); and NATA Technical Note 17 (NATA Technical Report, 2013). All OP-FTIR field measurements were evaluated by checking on the equipment signal strength, water vapour variations, baseline noise variations, wave number shifts and the LOD variation. In addition, the long-time signal stability of the OP-FTIR system was monitored during the project.

3 Results and discussion

3.1 Results of nominated sites

The monitoring results (one-hour maximum, second highest, sixth highest and mean concentrations) for ammonia and VOCs at each sampling site are presented in this section. The concentration axis for these graphs is presented in a logarithmic scale to better display all the concentrations.

Ambient air quality criteria against which the monitoring results are compared are presented in Table 5. As indicated in Section 2.1, the FTIR data are collected over a path rather than a point, as is the case with standard air quality monitoring techniques.

Therefore, while the data may be used to evaluate short-term peaks occurring over several minutes, the data cannot be used for direct comparison with air quality criteria. Air quality criteria are provided here to provide some comparison.

Odour events observed during monitoring are also discussed. A summary of odour events is presented in Appendix F.

Ammonia and VOC peaks observed and likely sources are also discussed in this section. Wind back trajectories for highest peaks observed are presented in this section and back trajectories of all observed peaks are provided in Appendices G (VOCs) and H (ammonia). Consultation with industry, to establish plant operating conditions that may have contributed to peaks, is also discussed.

Table 5. Air quality criteria

Substance	Averaging period	Maximum ambient concentration (ppb)
Ammonia	1 hour	480
Benzene	1 hour	9
Toluene	24 hours	1000
Acetone	1 hour	9300
Ethylbenzene	1 hour	1800
Carbon disulfide	1 hour	27
	24 hours	8
Xylenes (total of all isomers)	24 hours	250
Aldehyde	-	N/A
Total VOC	-	N/A
* Converted from µg/m^3 to ppb at 25°C		

3.1.1 Beeliar Oval

Beeliar Oval is located within the Kwinana EPP residential area (Area C) at the corner of The Grange and Bluebush Avenue in Beeliar, in the city of Cockburn. This site is situated close to Woodman Point WWTP, Alcoa Alumina Refinery and the Munster Cement and Lime Operations.

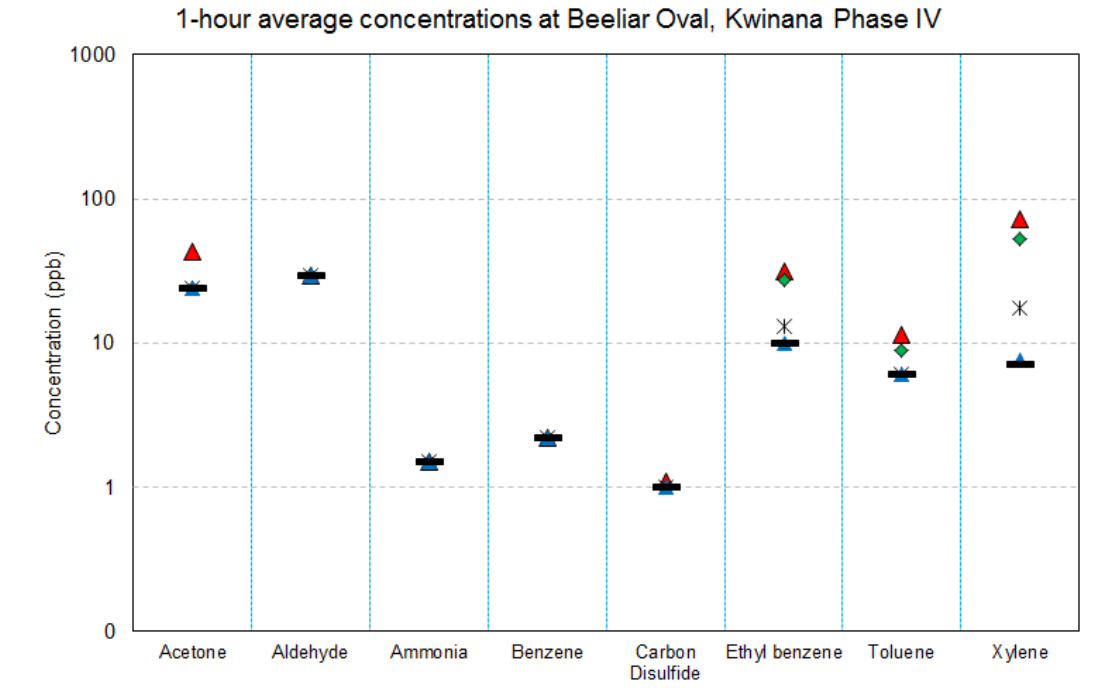
As shown in Figure 4, VOC species such as acetone, carbon disulfide, ethylbenzene, toluene and xylene were detected at the Beeliar Oval with concentration levels of 43ppb, 1.1ppb, 31ppb, 11ppb and 72ppb, respectively.

No ammonia was detected at this site during monitoring.

VOC peaks were observed on 2 October 2013 (xylene and ethylbenzene) and 3 December 2013 (acetone). Wind back trajectories (Figure 5 and Appendix G) show that the likely source of xylene was the KIA; the likely source of acetone was near sources; and the likely source of ethylbenzene was either nearby sources or on-road vehicles from the Kwinana Freeway. All the significant xylene peaks at this site occurred on 2 October 2013.

All concentrations were well below the one-hour air quality criteria. Toluene and xylene maximum concentrations measured were lower than the 24-hour air quality criteria (Table 5), and therefore should meet relevant one-hour criteria.

Odour events were observed on sixteen of the sixty-nine monitoring days (Appendix F). Odour strength varied from distinct to very strong. Wet cement odour and strong sulfur-like odours were experienced by DER staff at Beeliar Oval during monitoring. Odour events were transient and lasted from several seconds up to five minutes. Some odours described as “wet cement/brickworks” like odours were observed on 25 November 2013. Potential odour sources could be industries in the KIA or local sources to the southeast.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
MAX	43	<LOD	<LOD	<LOD	1.1	31	11	72
2nd Highest	<LOD	<LOD	<LOD	<LOD	<LOD	27	8.9	53
6th highest	<LOD	<LOD	<LOD	<LOD	<LOD	13	<LOD	18
Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	8
LOD	24	29	1.5	2.2	1.0	10.0	6.0	7.0

Figure 4. One-hour average concentrations of ammonia and VOCs at Beeliar Oval

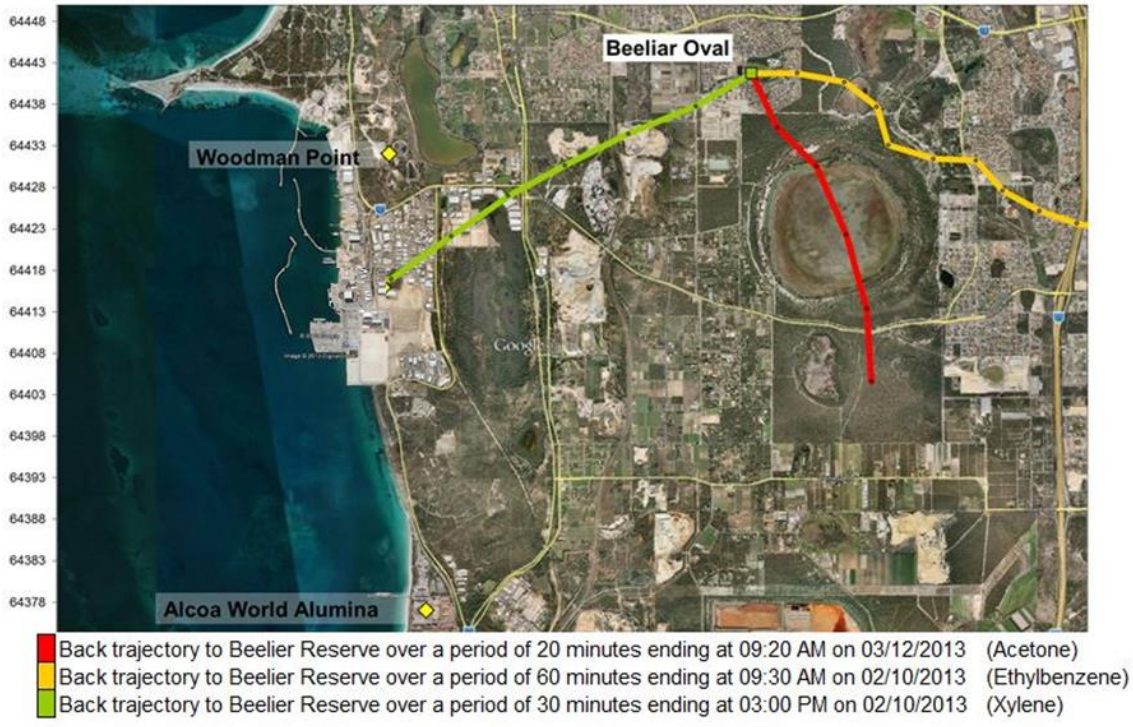


Figure 5. Back trajectory for the maximum recorded concentrations of acetone, ethylbenzene and xylene at Beeliar Oval

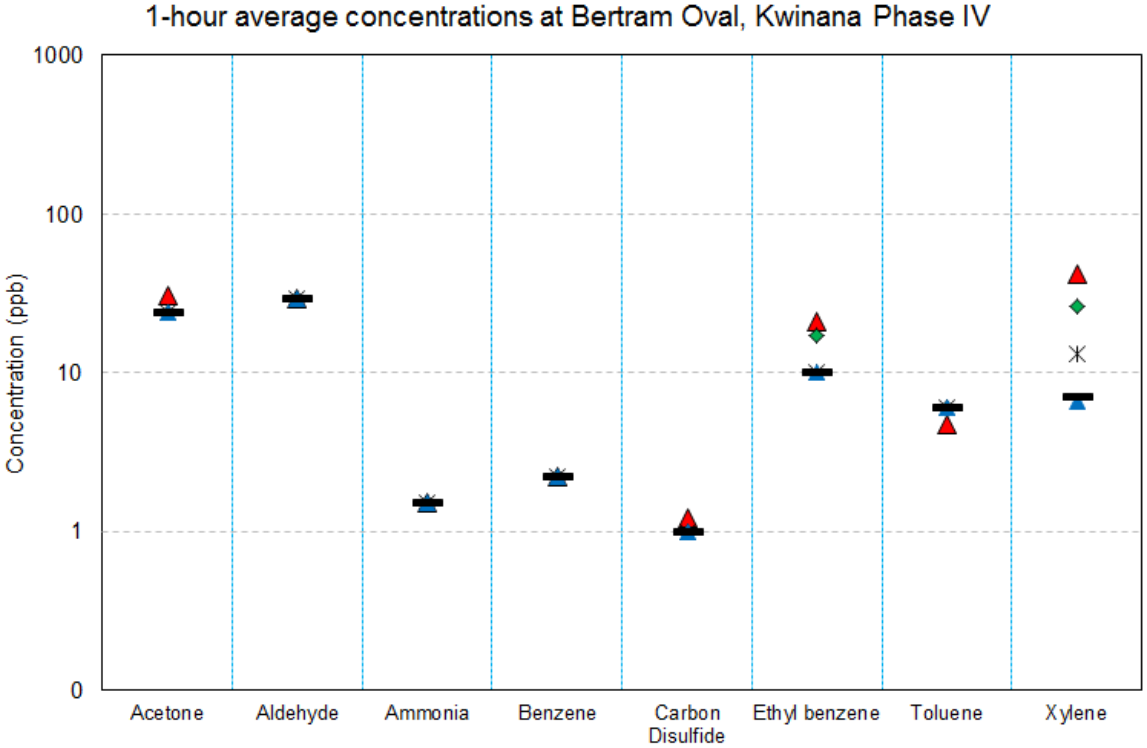
3.1.2 Bertram Oval

Bertram Oval is located in the Kwinana EPP Area C (residential area) at the corner of Mangart Road and Champion Drive, Bertram in the City of Kwinana. As Bertram Oval is a school oval, sampling was only carried out during school holidays when the oval was not being used by the school. Bertram Oval was the furthest site from the KIA and therefore this site was used as a background site for quality assurance purposes to compare with concentrations recorded at the sampling sites close to the KIA (Figure 1). This site is located close to a major roadway, the Kwinana Freeway, and therefore likely to be impacted by vehicle emissions.

No ammonia peaks were detected at Bertram Oval.

As shown in Figure 6, VOC peaks for ethylbenzene and xylene occurred on the same day on 30 April 2013. Wind back trajectories (Figure 7 and Appendix G) show that winds did not originate from the KIA. It is probable that these VOCs are nearby sources or the Kwinana Freeway. These concentrations were well below the air quality criteria.

Odours were observed by DER staff at Bertram Oval on one day of sampling (Appendix F). A few distinct to strong wet cement odours were observed. The odours were transient and lasted several seconds. Likely sources of the odours are local sources to the southeast of the site.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
MAX	31	<LOD	<LOD	<LOD	1.2	21	<LOD	42
2nd Highest	<LOD	<LOD	<LOD	<LOD	<LOD	17	<LOD	26
6th highest	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	13
Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 6. One-hour average concentrations of ammonia and VOCs at Bertram Oval

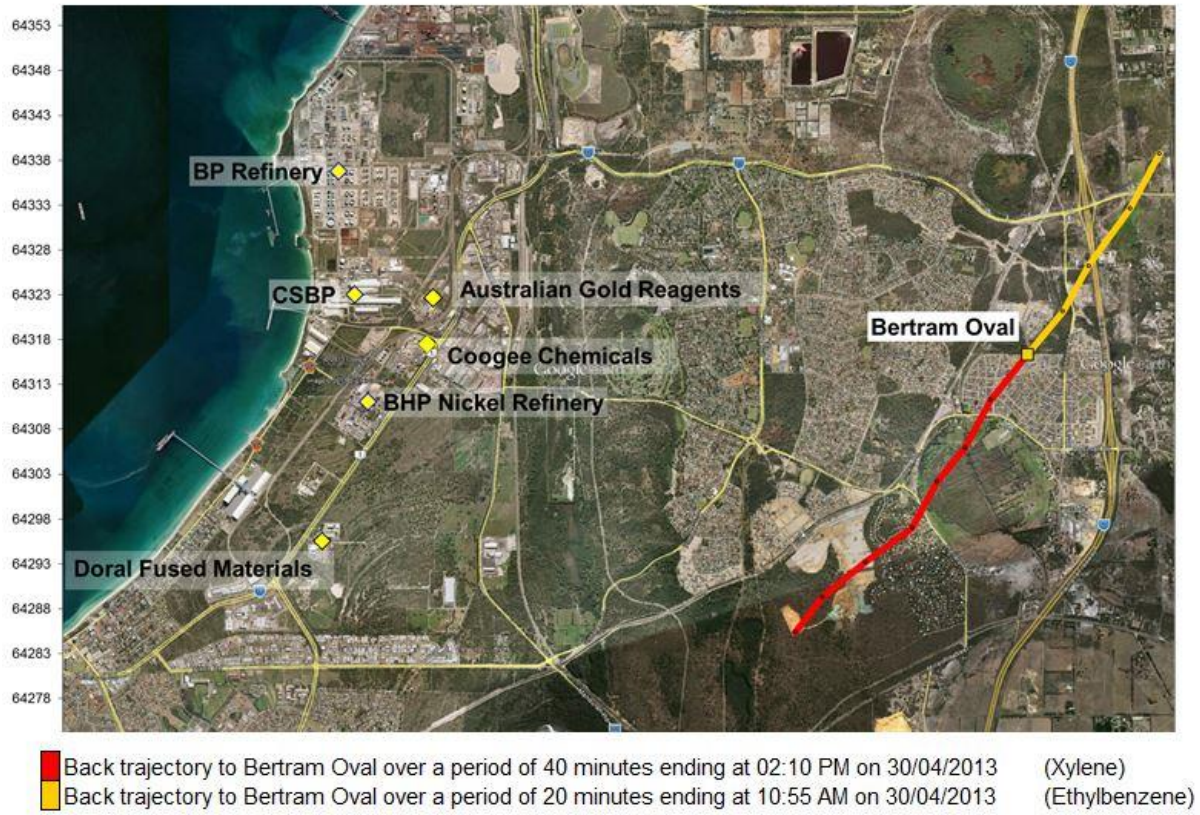


Figure 7. Back trajectory for the maximum recorded concentration of xylene and ethylbenzene at Bertram Oval

3.1.3 Calista Oval

Calista Oval is located at the corner of Walgreen Crescent and Harlow Road, close to the Kwinana Town Centre and Gilmore Avenue and east of the KIA. This site is located in the Kwinana EPP Area C (residential area).

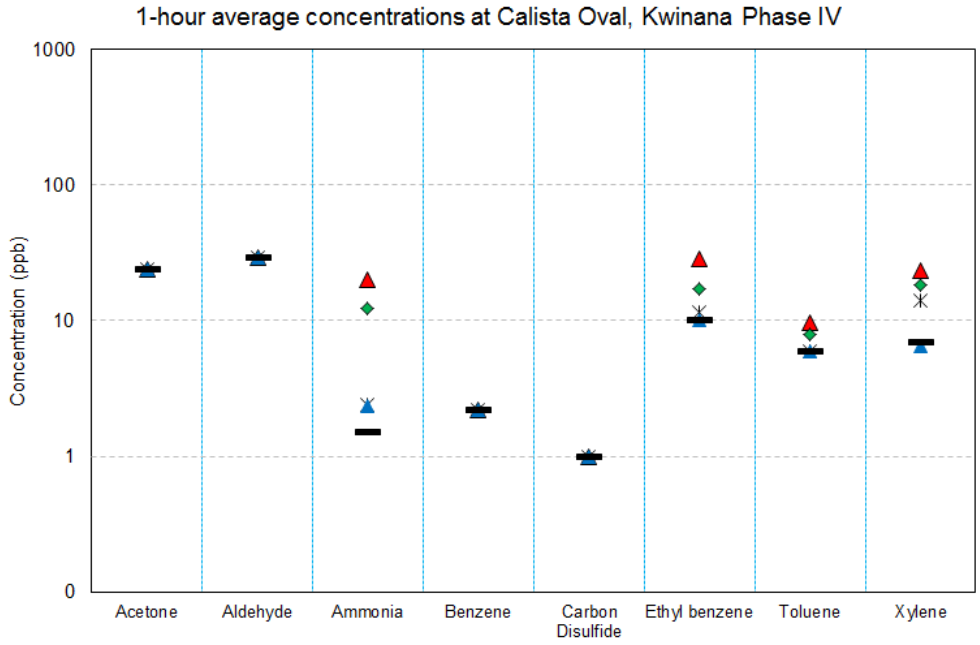
As shown in Figure 8, low levels of ammonia and VOCs (ethylbenzene, toluene and xylene) were detected at Calista Oval.

An ammonia peak was measured at Calista Oval on 30 October 2013 (Figure 9 and Appendix H). Likely sources, based on back trajectory analysis, are the main ammonia sources in the KIA. Smaller ammonia peaks were also observed on 4 February 2014 and 4 April 2014 (Appendix H).

VOC peaks were observed on 30 January 2014 (xylene) and 23 September 2014 (ethylbenzene) (Figure 9). Back trajectory analysis indicates that nearby emission sources and/or on-road vehicles from Kwinana Freeway are probable sources for both peaks.

The concentration levels of all detected air toxics at this site were significantly lower than relevant standards.

No odours were observed during monitoring at Calista Oval.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
▲MAX	<LOD	<LOD	20	<LOD	<LOD	29	10	24
◆2nd Highest	<LOD	<LOD	12	<LOD	<LOD	17	8.0	19
✳ 6th highest	<LOD	<LOD	2.4	<LOD	<LOD	12	<LOD	14
▲Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
– LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 8. One-hour average concentrations of ammonia and VOCs at Calista Oval

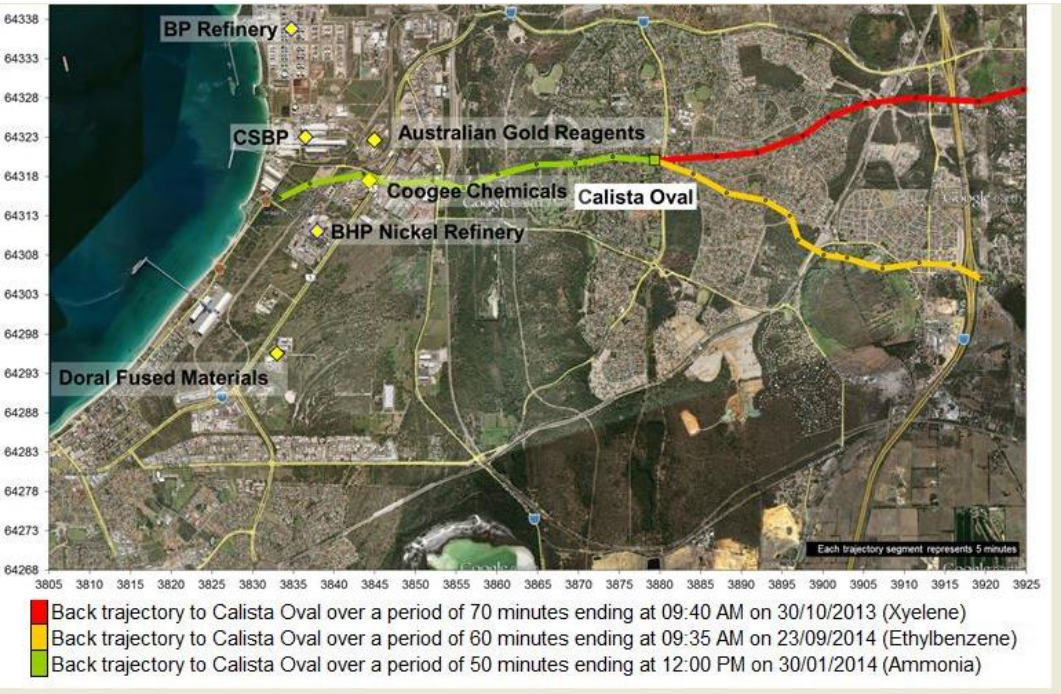


Figure 9. Back trajectory for the maximum recorded concentration of xylene, ethylbenzene and ammonia at Calista Oval

3.1.4 Department of Agriculture Medina Research Station

The Department of Agriculture site is located at Abercrombie Road next to the Medina agriculture research station, in the City of Kwinana, within the Kwinana residential area. The site is situated close to several quarries, the Alcoa tailings ponds and the Kwinana Wastewater Treatment Plant. The site is also surrounded by four major roads: Thomas Road, Anketell Road, Rockingham Road and the Kwinana Freeway.

A number of VOC and ammonia peaks were detected at the Department of Agriculture site (Figure 10).

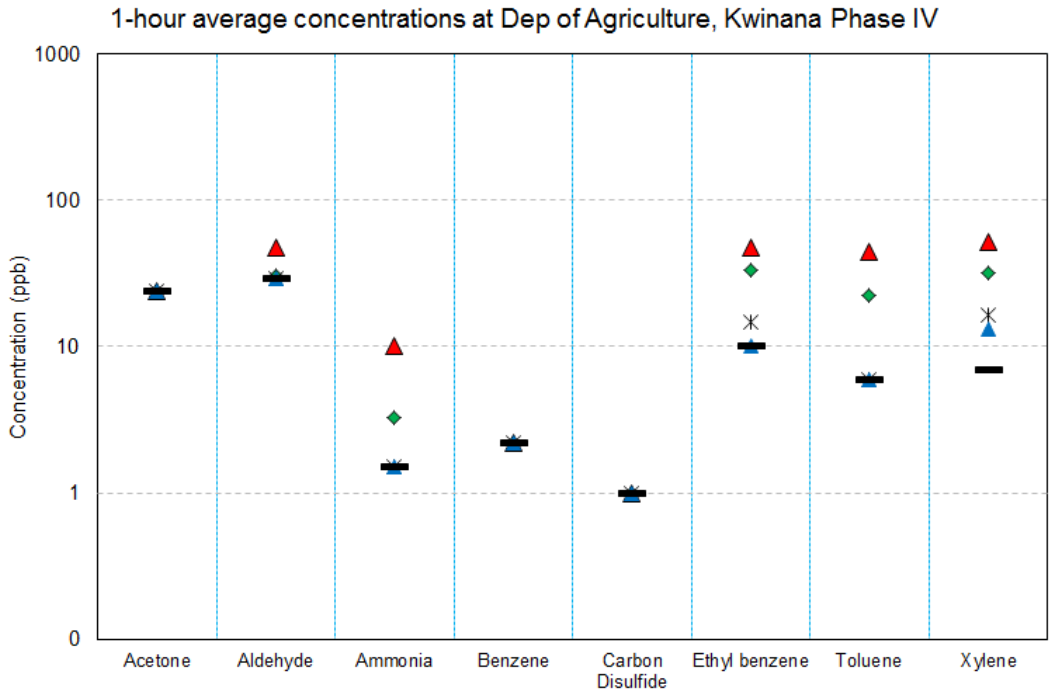
As indicated in Figure 11 and Appendix G, the maximum concentration of ethylbenzene and toluene occurred on the same day, on 6 February 2014, and the back trajectory analysis shows that winds originated from the direction of the KIA during this period.

The wind back trajectories illustrated in Figure 11 and Appendix G show that nearby emission sources and/or onroad vehicles from Kwinana Freeway could be the major sources for xylene and aldehyde measured at the Department of Agriculture site.

Some small ammonia peaks occurred on 14 February 2014 (Figure 11 and Appendix H) which appear to come from major ammonia sources in KIA.

These concentration values are still well below the air quality criteria.

No odours were observed at the Department of Agriculture during monitoring.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
▲MAX	<LOD	47	10	<LOD	<LOD	47	45	52
◆2nd Highest	<LOD	31	3.3	<LOD	<LOD	33	23	32
✳ 6th highest	<LOD	<LOD	<LOD	<LOD	<LOD	15	<LOD	17
▲Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	13
– LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 10. One-hour average concentrations of ammonia and VOCs at Department of Agriculture

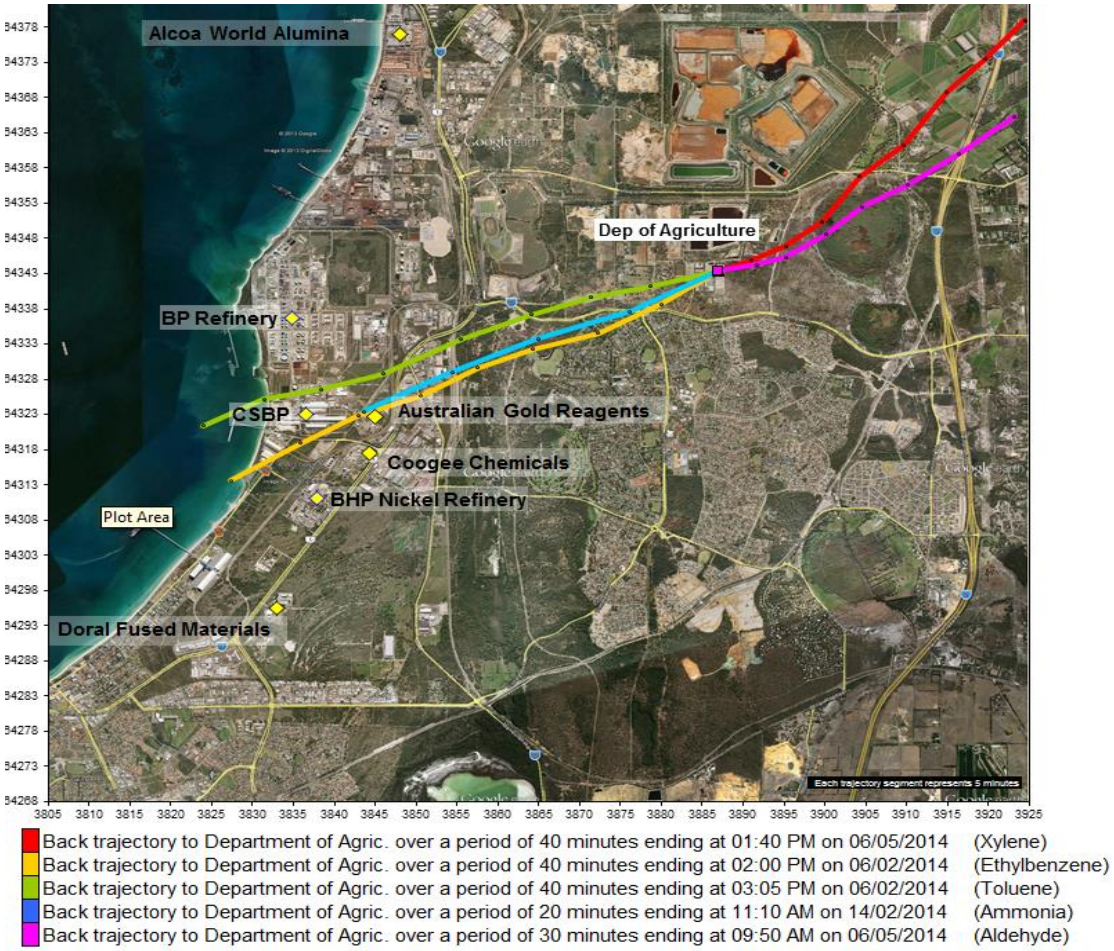


Figure 11. Back trajectory for the maximum recorded concentration of xylene, ethylbenzene, toluene, ammonia and aldehyde at the Department of Agriculture

3.1.5 Dixon Road Reserve

Dixon Road Reserve is located in Rockingham and south of the KIA. This site is very close to the Kwinana EPP buffer zone (Area B). Levels of air toxics at Dixon Road Reserve (and Wells Park) were higher than at other sites.

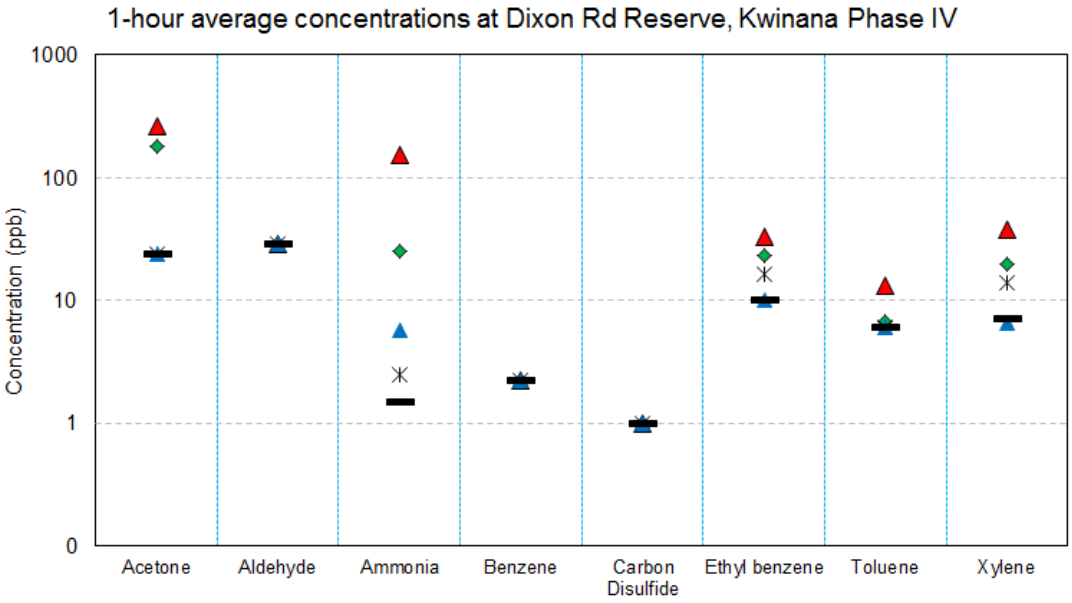
The maximum and second highest one-hour acetone concentration levels in the study were recorded at Dixon Road Reserve on 20 June 2013 and 28 June 2013 with concentrations of 260ppb and 180ppb, respectively (Figure 12). The wind back trajectory indicates that the main acetone source at this site could be either the KIA or nearby sources (Figure 13).

The highest one-hour ammonia concentration recorded at this site was 160ppb (on 28 June 2013) which likely originated from the KIA and was lower than the air quality criteria of 480ppb (Figure 13 and Appendix H). Doral Fused Materials confirmed the use of ammonia on the day. Several short-term ammonia peaks were observed on 20 June 2013, 28 June 2013, 29 April 2014 and 24 June 2014 (Appendix H). All these ammonia peaks likely originated from the KIA and are below the air quality criteria of 480ppb.

Xylene and ethylbenzene peaks were recorded on 20 June 2013 and 1 August 2014, respectively (Figure 13 and Appendix G) that possibly originated from nearby sources such as panelbeaters and painting workshops.

Low levels of toluene also were detected at this site.

Distinct to strong roasted coffee odours were experienced by DER staff at Dixon Road Reserve on three sampling days. The likely source of odours is a nearby coffee roaster or the KIA.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
MAX	260	<LOD	160	<LOD	<LOD	33	13	37
2nd Highest	180	<LOD	25	<LOD	<LOD	23	6.7	20
6th highest	<LOD	<LOD	2.5	<LOD	<LOD	16	<LOD	14
Average	<LOD	<LOD	5.7	<LOD	<LOD	<LOD	<LOD	<LOD
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 12. One-hour average concentrations of ammonia and VOCs at Dixon Road Reserve

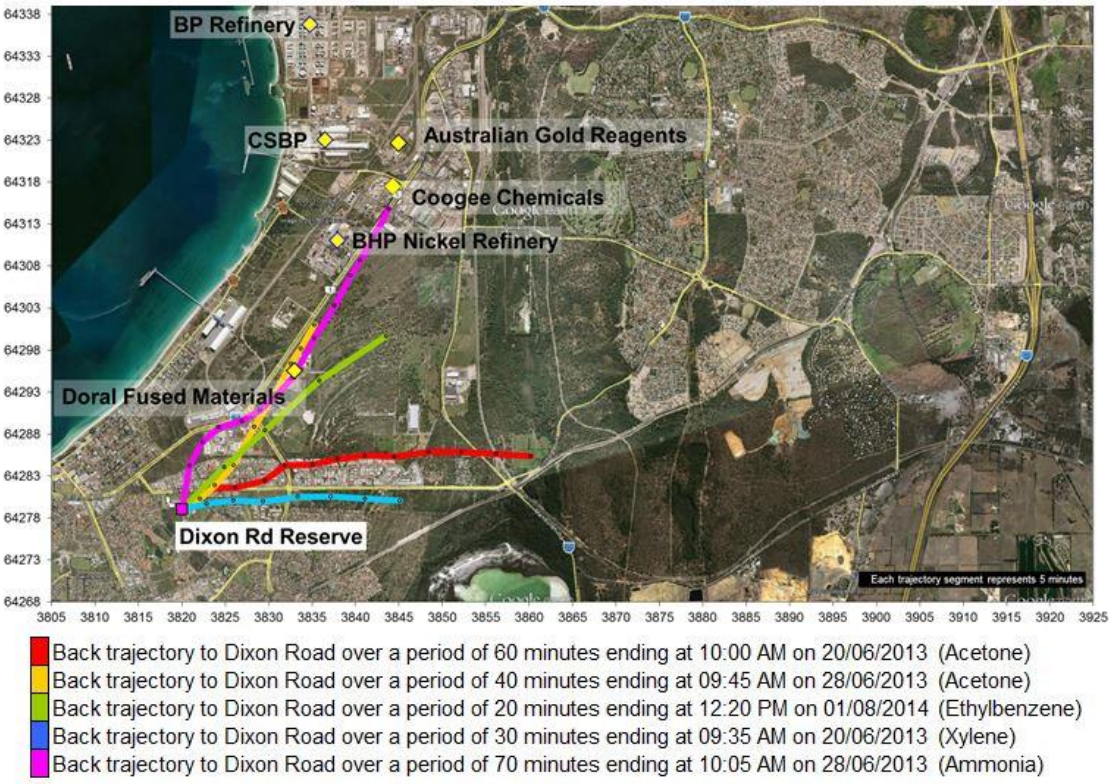


Figure 13. Back trajectory for the maximum recorded concentration of acetone, ethylbenzene, xylene and ammonia at Dixon Road Reserve

3.1.6 Medina Oval

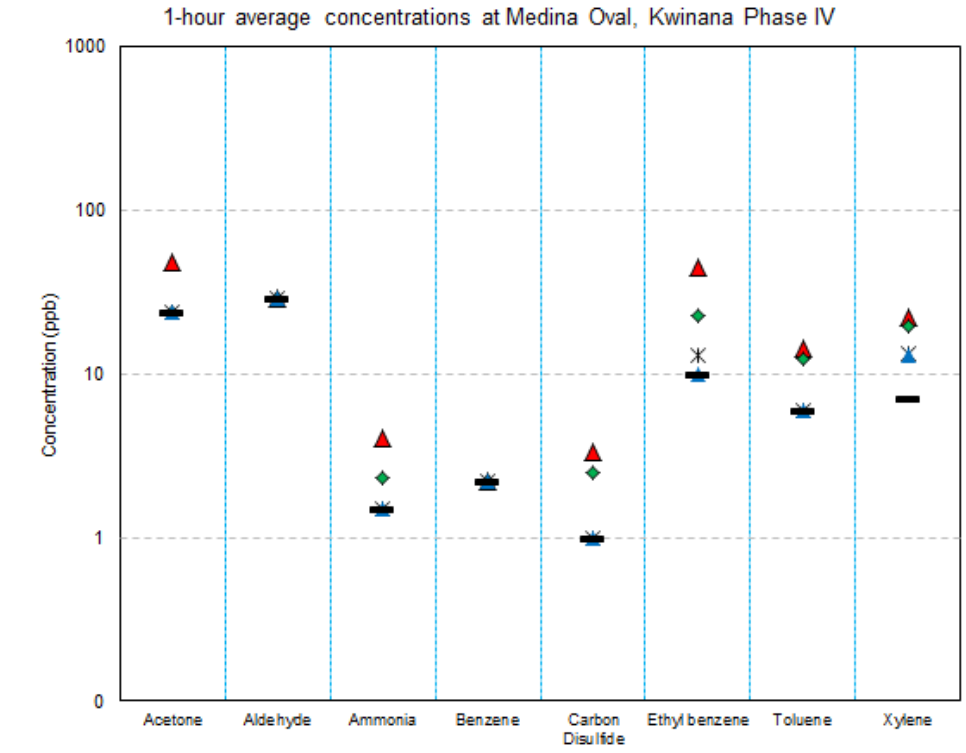
Medina Oval is situated at Brownell Crescent in Medina in the City of Kwinana and within the Kwinana EPP residential area. It is Kwinana's local football ground. Medina Oval is close to the sources of VOCs and ammonia in the KIA.

As shown in Figure 14, Medina was one of the two sites where most of the nominated VOCs for this study were detected (six of the eight), albeit at low levels, the other being Wells Park. However, levels were lower when compared to other sites like Wells Park and Dixon Road Reserve where high levels were recorded compared to other sites.

Acetone and ethylbenzene peaks occurred at Medina Oval on the same day, on 9 August 2013. The back trajectory analysis shows that winds originated from the direction of the KIA during this period (Figure 15). Levels were below air quality criteria.

The concentration levels of ammonia, carbon disulfide and toluene were also well below the air quality criteria.

Distinct odours were observed by DER staff at Medina Oval on 15 January 2014. The odour was transient and likened to burning rubber. No verified source of the odour was identified. Cars doing 'burnouts' were observed later, which could be the likely source of the burnt rubber smell observed earlier.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethylbenzene	Toluene	Xylene
MAX	48	<LOD	4.0	<LOD	3.3	45	14	22
2nd Highest	<LOD	<LOD	2.3	<LOD	2.5	23	13	20
6th highest	<LOD	<LOD	<LOD	<LOD	<LOD	13	<LOD	13
Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	13
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 14. One-hour average concentrations of ammonia and VOCs at Medina Oval

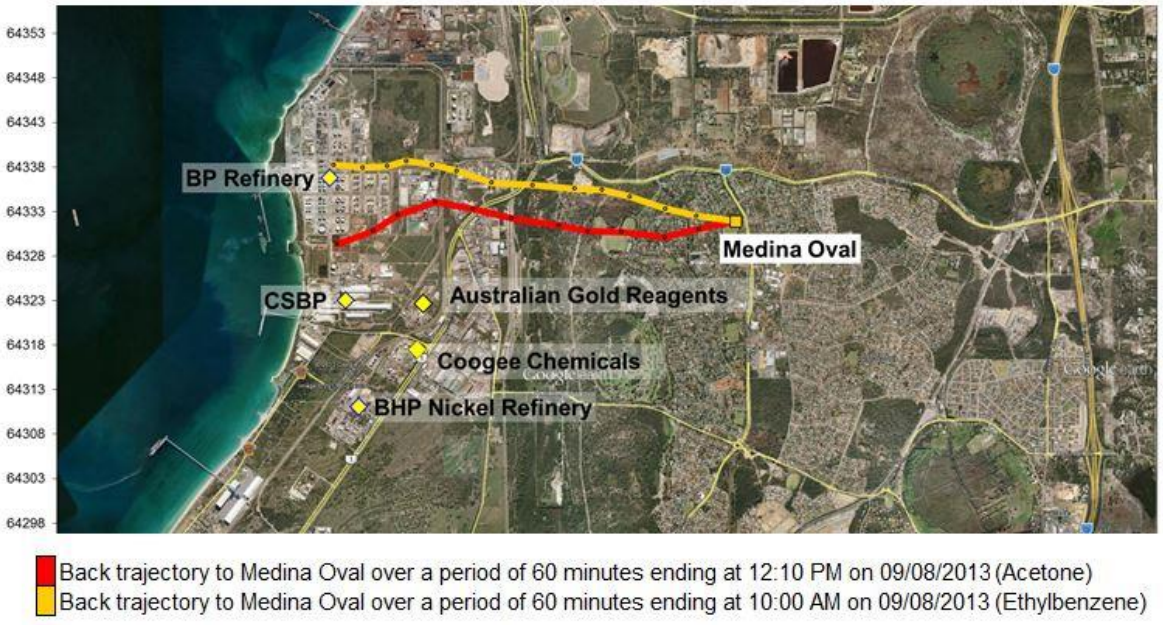


Figure 15. Back trajectory for the maximum recorded concentration of ethylbenzene and acetone at Medina Oval

3.1.7 Sloan's Reserve

Sloan's Reserve is located in the Kwinana EPP residential area, at the corner of Sloan's Drive and Harman Street in Leda. Sloan's Reserve joins onto Wally's Walk Trail which connects up to the Kwinana Loop Trail. This site is close to the Kwinana EPP buffer area.

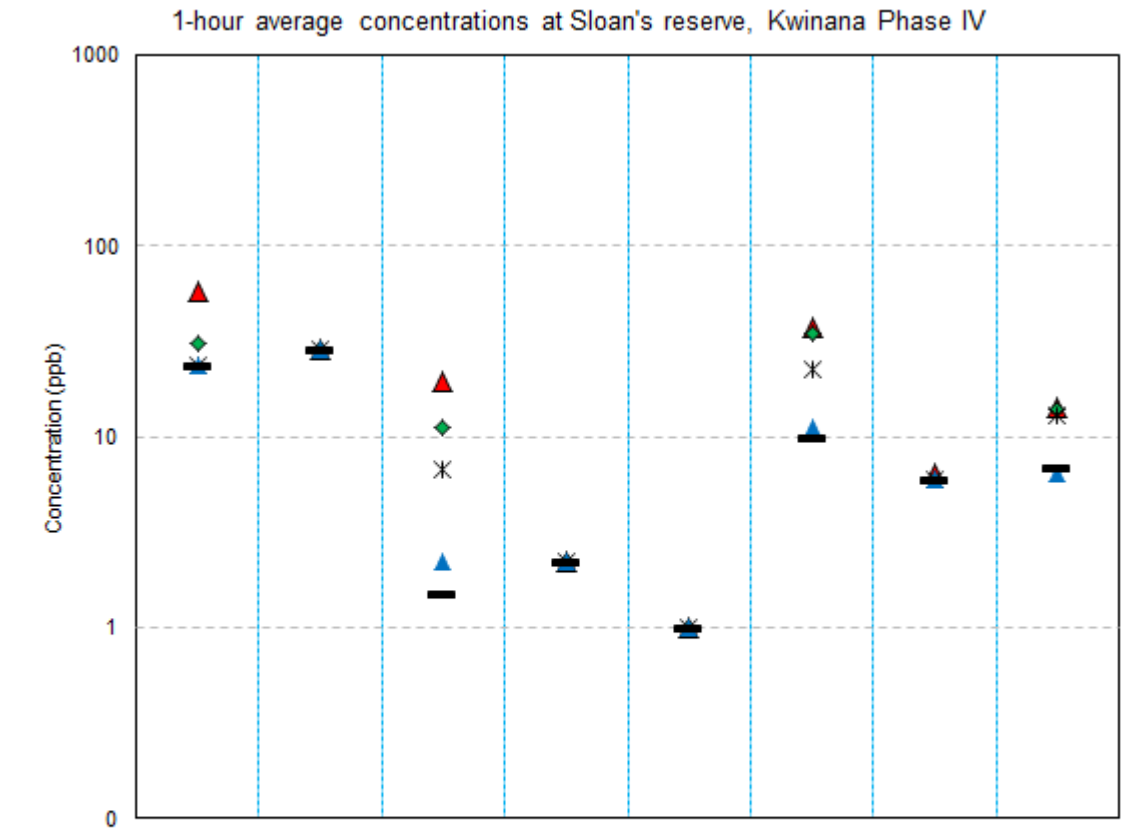
As shown in Figure 16, some air toxics with low concentration levels were recorded at Sloan's Reserve.

A number of short-term acetone and ethylbenzene peaks were recorded on 11 June 2013 and 25 September 2014, respectively, which were not from the KIA and possibly from nearby emission sources (Figure 17 and Appendix G).

Figure 17 also illustrates a wind back trajectory of low ammonia levels on 7 October 2014 that likely originated from the KIA.

All recorded concentration values for ammonia and VOCs were well below the air quality criteria.

No odour was observed at this site during the monitoring.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethylbenzene	Toluene	Xylene
MAX	58	<LOD	20	<LOD	<LOD	38	6.4	14
2nd Highest	31	<LOD	11	<LOD	<LOD	35	<LOD	14
6th highest	<LOD	<LOD	6.7	<LOD	<LOD	23	<LOD	13
Average	<LOD	<LOD	<LOD	<LOD	<LOD	11	<LOD	<LOD
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 16. One-hour average concentrations of ammonia and VOCs at Sloan's Reserve

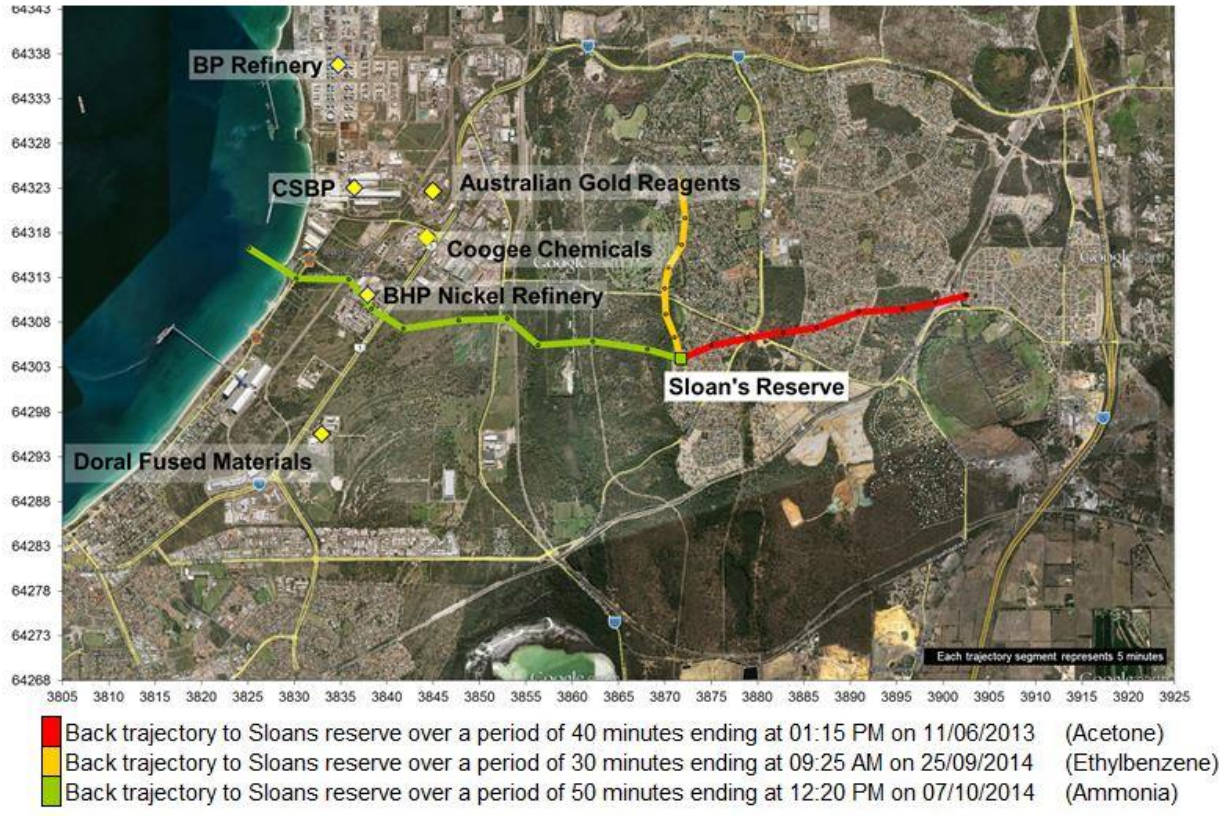


Figure 17. Back trajectory for the maximum recorded concentration of acetone, ethylbenzene and ammonia at Sloan's Reserve

3.1.8 Thomas Oval

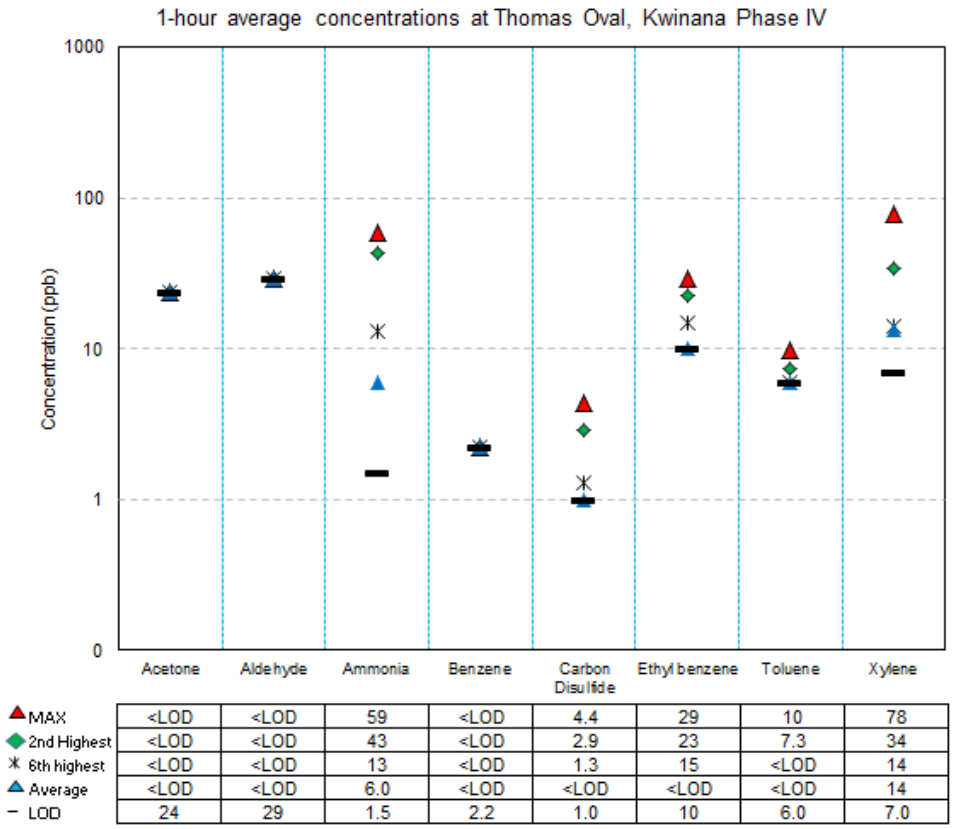
Thomas Oval is located at Tucker Street in Medina, to the east of the KIA and situated on the border of the Kwinana EPP buffer. Thomas Oval is made up of six large ovals used for sports such as soccer, rugby, softball, tee ball and archery.

The highest concentration values for ethylbenzene (29ppb) and xylene (78ppb) were recorded on 11 November 2013 and 11 April 2014 respectively, and the back trajectory analysis shows that winds originated from the direction of the KIA (Figure 19 and Appendix G). Some low levels of carbon disulfide and toluene were detected at this site (Figure 18).

Ammonia peaks were detected more frequently at Thomas Oval than at the other sampling sites. A number of short-term ammonia peaks with noticeable levels were observed on 11 November 2013, 16 December 2013 and 31 January 2014. Wind back trajectories indicated that these peaks may originate from main ammonia sources in the KIA (Figure 19 and Appendix H).

All air toxics levels recorded at Thomas Oval were well below the air quality criteria.

Distinct wet cement odours were observed by DER staff at Thomas Oval on 9 April 2014. The odours were generally transient and lasted from several seconds to five minutes, during the event. These odours likely originated from the KIA.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
MAX	<LOD	<LOD	59	<LOD	4.4	29	10	78
2nd Highest	<LOD	<LOD	43	<LOD	2.9	23	7.3	34
6th highest	<LOD	<LOD	13	<LOD	1.3	15	<LOD	14
Average	<LOD	<LOD	6.0	<LOD	<LOD	<LOD	<LOD	14
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 18. One-hour average concentrations of ammonia and VOCs at Thomas Oval

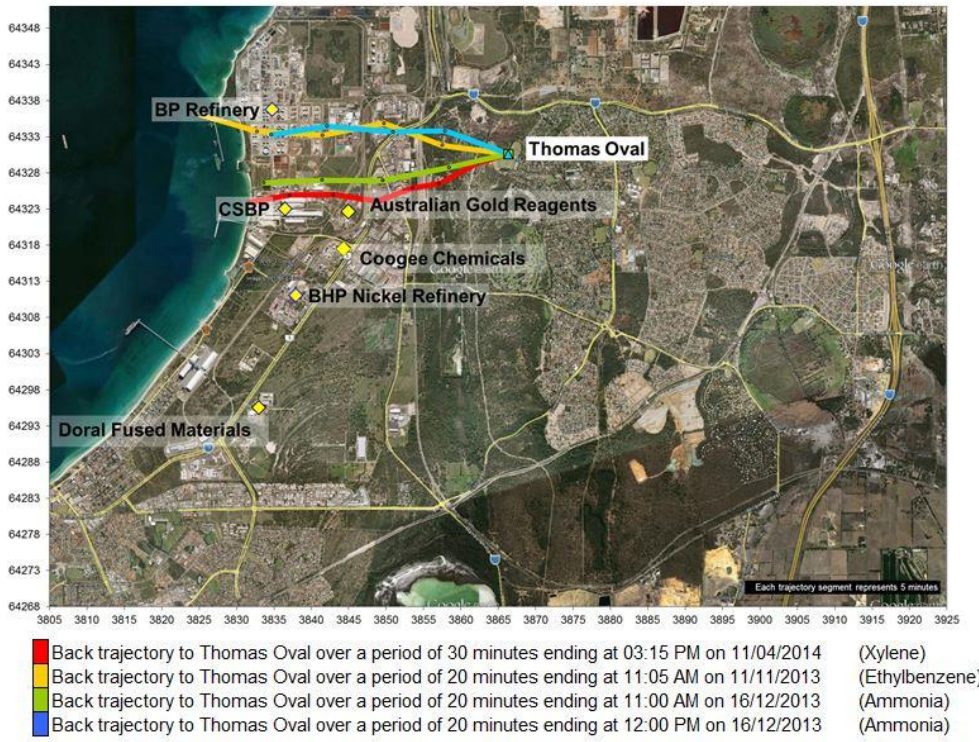


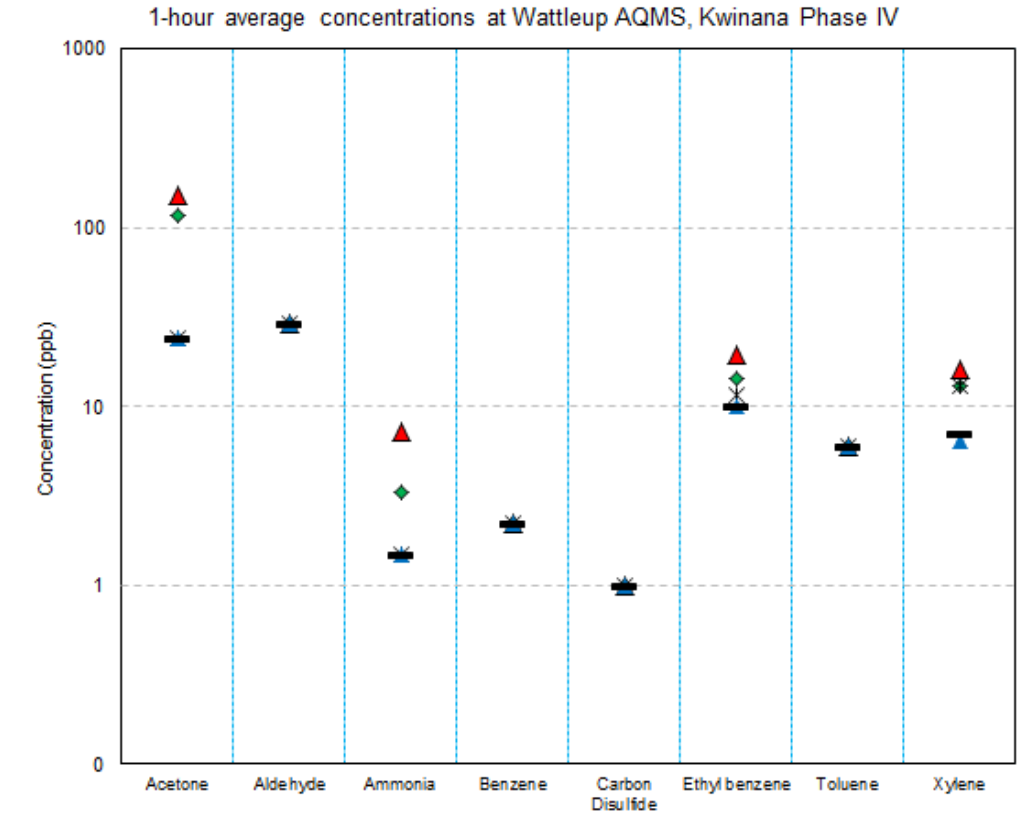
Figure 19. Back trajectories for the maximum recorded concentration of xylene, ethylbenzene, and ammonia at Thomas Oval

3.1.9 Wattleup

The Wattleup monitoring site is situated at the corner of Wattleup Road and Tomislav Place in Wattleup, close to the KIA and within the Kwinana EPP buffer area.

The maximum and the second highest concentration levels of acetone were much higher at 150ppb and 120ppb compared to other sampling sites (with the exception of Dixon Road Reserve where the highest acetone values were recorded) but well below the one-hour criteria of 9300ppb (Figure 20). The back trajectory analysis indicates that winds likely originated from the direction of the KIA on 18 December 2013 (Figure 21 and Appendix G). The concentration levels of ammonia, ethylbenzene and xylene were very low compared to the air quality criteria.

Odours were observed at Wattleup on five sampling days. Distinct to strong odours were observed by DER staff at the Wattleup site on two sampling days. Strong dry and wet cement odours were observed on 31 October 2013. The odours were generally transient (lasting several seconds to five minutes) on this day. Distinct and strong transient wet cement odour was recorded on 12 December 2013 but odours became continuous in the afternoon and lasted more than 60 minutes. The likely source was the KIA.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethyl benzene	Toluene	Xylene
MAX	150	<LOD	7.2	<LOD	<LOD	20	<LOD	16
2nd Highest	120	<LOD	3.3	<LOD	<LOD	14	<LOD	13
6th highest	<LOD	<LOD	<LOD	<LOD	<LOD	12	<LOD	13
Average	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 20. One-hour average concentrations of ammonia and VOCs at Wattleup

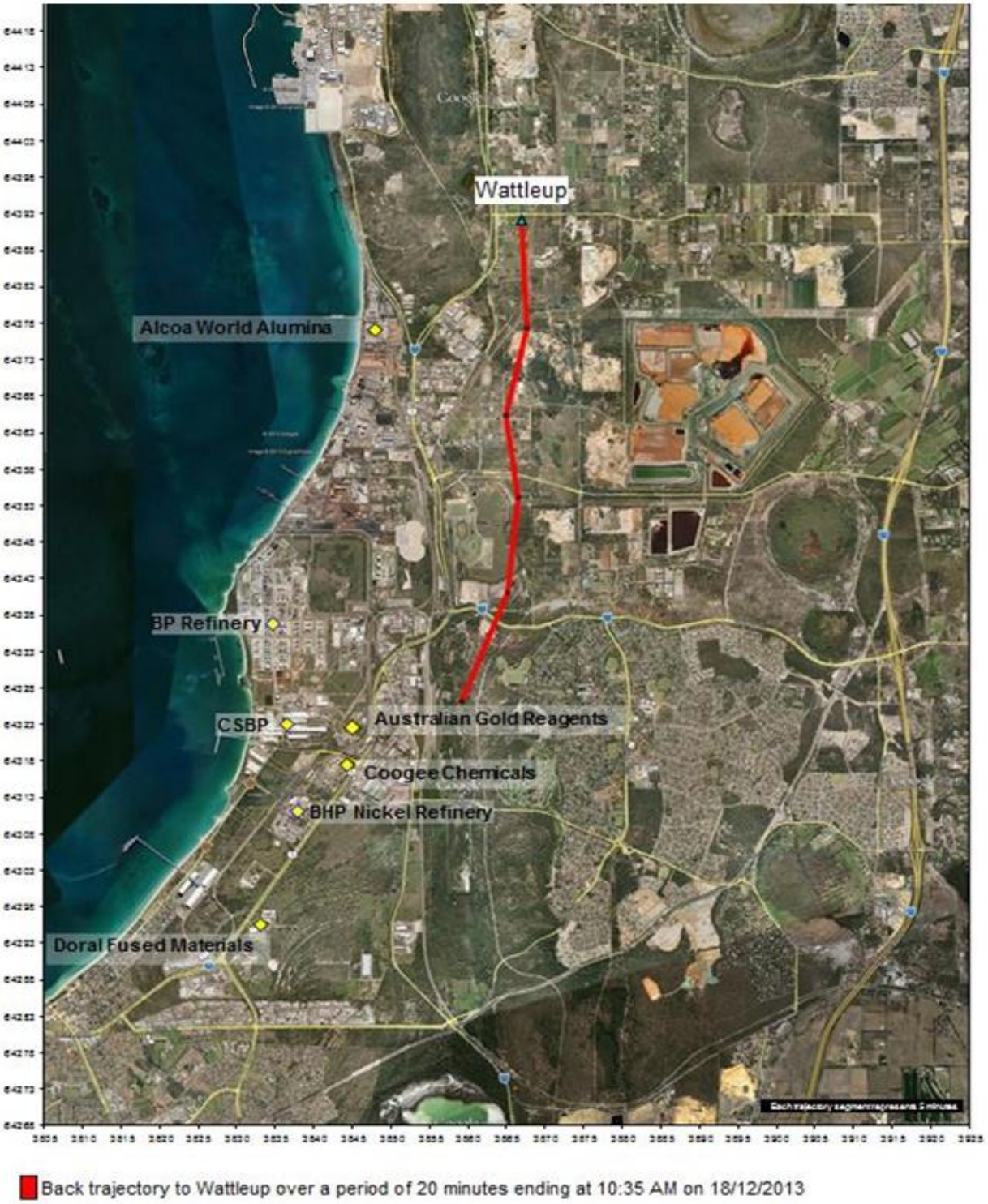


Figure 21. Back trajectory for the maximum recorded concentration of acetone at Wattleup Oval

3.1.10 Wells Park

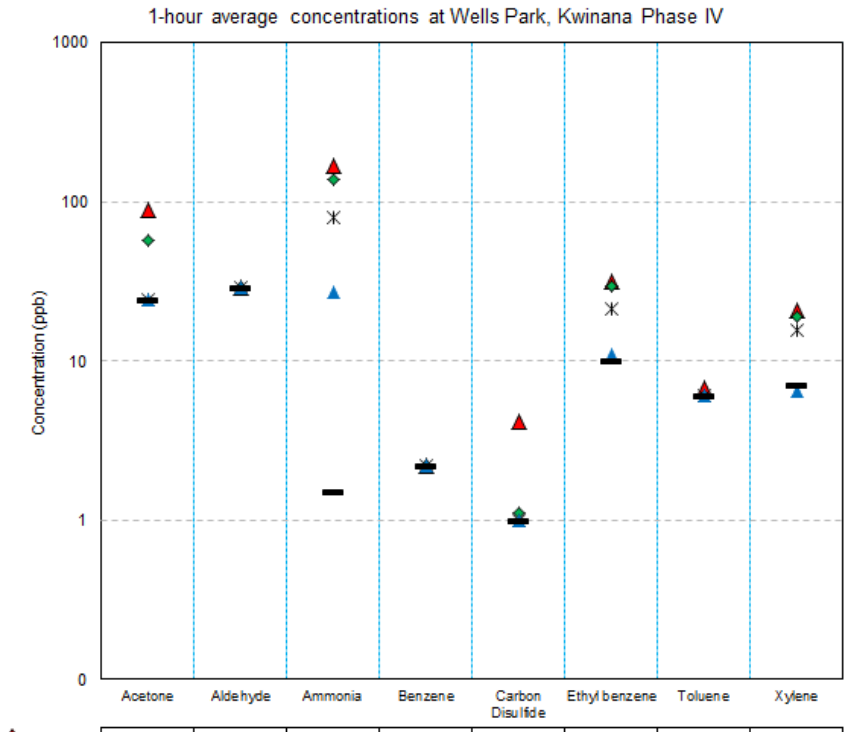
Wells Park is situated along Kwinana Beach Road, immediately south of the KIA, and a short distance from major industrial sources of VOCs and ammonia in the KIA such as CSBP, Australian Gold Reagents, Coogee Chemicals and BHP Nickel Refinery. Wells Park is the only sampling site which is located within the industrial zone of the Kwinana EPP Area (Area A).

As shown in Figure 22, Wells Park is one of the two sites where most of the nominated air toxics for this study were detected (six of the eight), the other being Medina Oval. Levels of air toxics at Wells Park (and Dixon Road Reserve) were high compared to other sites.

Some short-term acetone and ethylbenzene peaks were detected on 24 May 2013 and 4 September 2014 respectively, which likely originated from the KIA (Figure 23 and Appendix G). Low levels of carbon disulfide and xylene were also detected at Wells Park.

The highest one-hour ammonia concentration level (170ppb) in the study was recorded at Wells Park on 11 February 2014, as well as the third and fourth highest ammonia concentration levels. Short and long-term ammonia peaks were also detected on 10 December 2013, 11 February 2014, 5 August 2014 and 4 September 2014 (Figure 23 and Appendix H). All these ammonia peaks originated from the KIA and are lower than the air quality criteria of 480ppb.

No odour was observed at this site during the monitoring.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon Disulfide	Ethylbenzene	Toluene	Xylene
MAX	90	<LOD	170	<LOD	4.2	32	6.8	21
2nd Highest	58	<LOD	140	<LOD	1.1	30	<LOD	19
6th highest	<LOD	<LOD	80	<LOD	<LOD	21	<LOD	16
Average	<LOD	<LOD	27	<LOD	<LOD	11	<LOD	<LOD
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 22. One-hour average concentrations of ammonia and VOCs at Wells Park

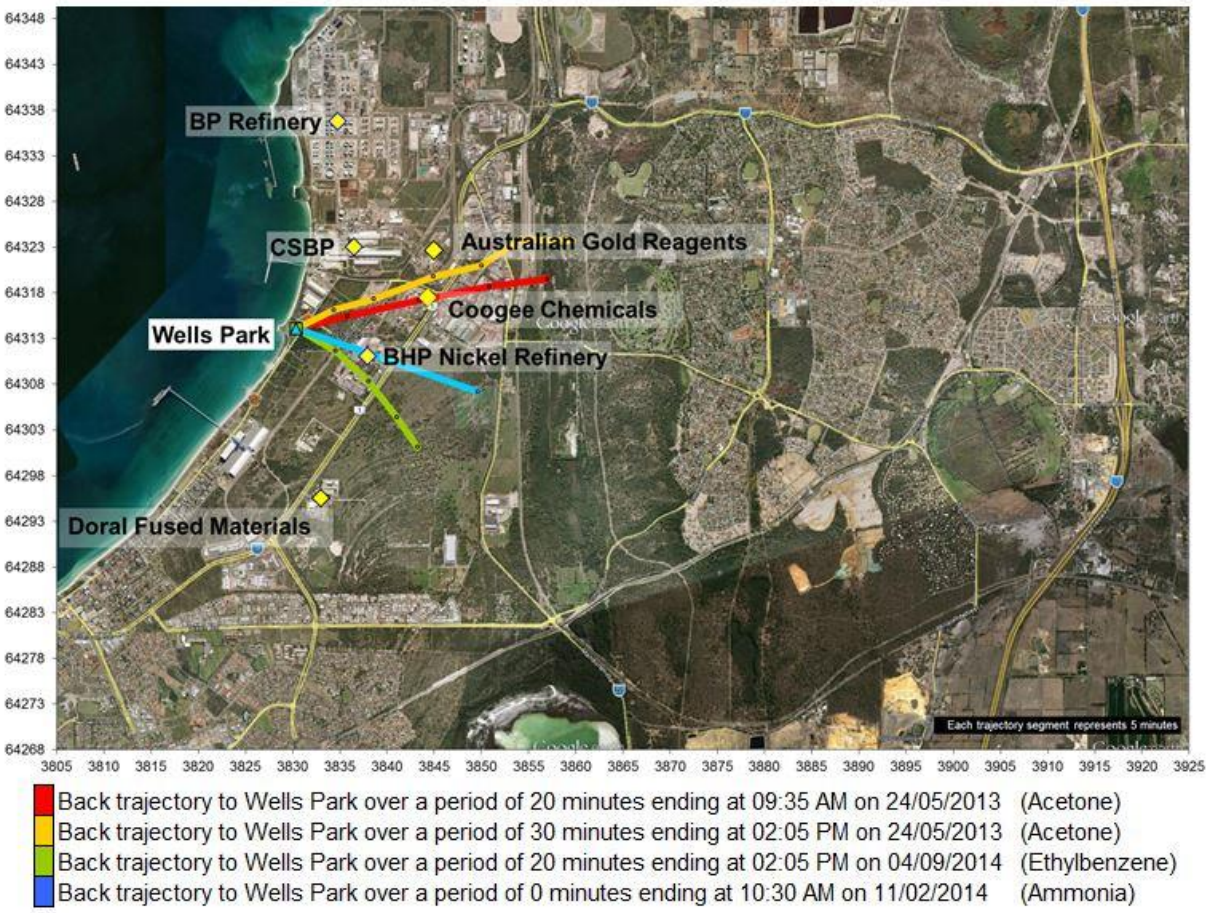


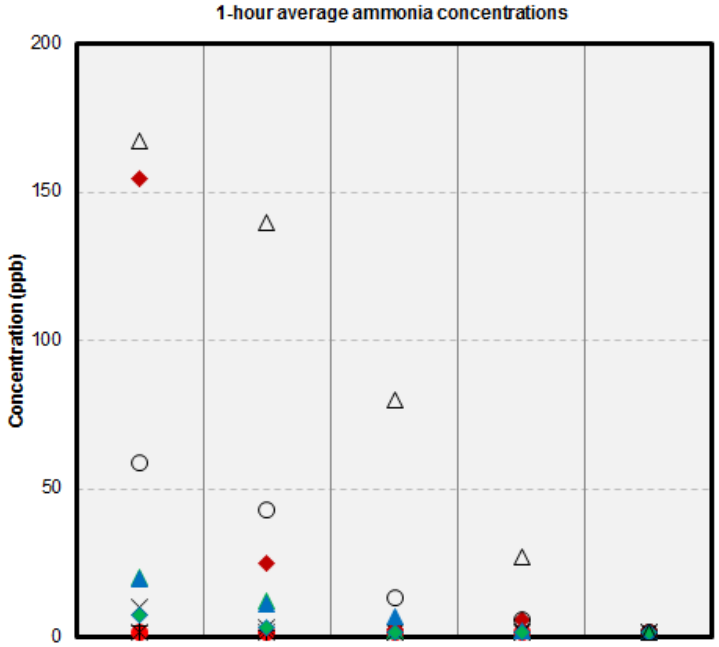
Figure 23. Back trajectory for the maximum concentrations of acetone, ethylbenzene and ammonia at Wells Park

3.2 Results for compounds monitored

3.2.1 Ammonia

Ammonia (NH_3) is a volatile and colourless gas that has a very distinct odour. It is widely used in household and industrial cleaners, bleaching agents and disinfectants. It is also used in the preparation of synthetic fibres (e.g. nylons), plastics and explosives, resins, human and veterinary medicines, fertilisers, chemical compounds, fuel cells, rocket fuel, dyes, metal treating operations, refrigeration, and in the petroleum industry. Ammonia is commonly used in the KIA in various industrial processes.

Figure 25 shows that the highest one-hour ammonia concentration during the study was recorded on 11 February 2014 at Wells Park with 170ppb. The wind back trajectory for this event shows that the likely ammonia source was the KIA (Appendix H). In addition, the third, fourth and sixth highest ammonia concentrations recorded in this study occurred at Wells Park. Wells Park is the only sampling site which is located within industrial zone of the Kwinana EPP and close to major ammonia sources in the KIA. The second highest ammonia level was recorded on 28 June 2013 at Dixon Road Reserve with one-hour concentration of 160ppb. The wind back trajectories indicate that KIA is the likely source of these events (Appendix H).



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	<LOD	<LOD	<LOD	<LOD	1.5
Bertram Oval	<LOD	<LOD	<LOD	<LOD	1.5
Calista Oval	20	12	2.4	2.3	1.5
Dep of Agriculture	10	3.3	<LOD	<LOD	1.5
Dixon Rd Reserve	160	25	2.5	5.7	1.5
Medina Oval	4.0	2.3	<LOD	<LOD	1.5
Sloan's Reserve	20	11	6.7	2.2	1.5
Thomas Oval	59	43	13	6.0	1.5
Wattelup AQMS	7.2	3.3	<LOD	<LOD	1.5
Wells Park	170	140	80	27	1.5

Figure 24. One-hour average ammonia concentrations

3.2.2 Aldehyde

Acetaldehyde is one of the most important aldehyde, occurring widely in nature and being produced on a large scale in industry. Acetaldehyde is colourless with a fruity odour and occurs naturally in coffee, bread, and ripe fruit, and is produced by plants. Acetaldehyde is primarily used as an intermediate in the manufacture of a range of chemicals, perfumes, explosives, plastics, synthetic rubber, drugs and in some fuel compounds. It is also used as a synthetic flavouring substance, food preservative and as a fragrance. Acetaldehyde is toxic when applied externally for prolonged periods and is an irritant.

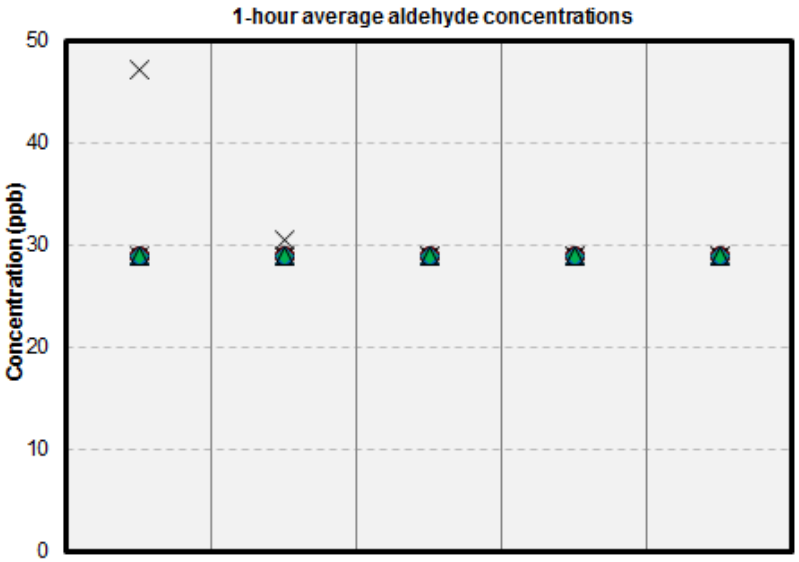
Formaldehyde is a colourless and highly flammable liquid or gas with a pungent odour. Formaldehyde is used in the manufacture of formaldehyde-based resins and plastics used in many industries, but mostly in the wood-products industry. Formaldehyde is also used in a number of industries including agriculture, the building industry (to water- and grease-proof concrete and plaster), medicine-based industries (forensics, hospitals and pathology laboratories), embalming fluid in funeral homes and crematoria, film processing, textile treatments, leather tanning and a wide range of personal care and consumer products.

Formaldehyde and acetaldehyde have common spectral absorption regions and due to these overlapping features, it can be difficult to distinguish between them. Therefore, a combined concentration level was defined for formaldehyde, acetaldehyde and other aldehydes in the analytical method used by OP-FTIR,referred to in this report, as “aldehyde”.. The maximum and second highest aldehyde concentrations (47ppb and 31ppb, respectively) were recorded on 6 May 2014 at the Department of Agriculture site. Back trajectory analysis indicates that winds did not originate from the direction of the KIA. Nearby sources or vehicle emissions from the Kwinana Freeway are the likely source (Appendix G).

3.2.3 Acetone

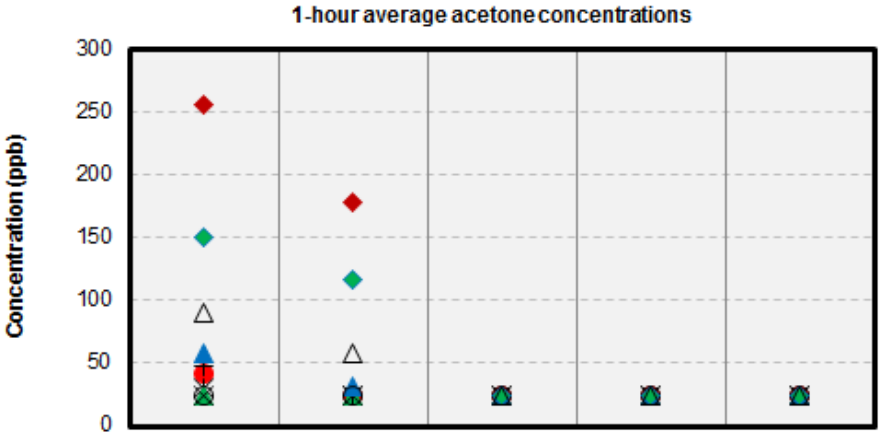
Acetone is a colourless and flammable compound with a distinct odour. It is used to make many chemical compounds, rayon, photographic films, plastics, fibres, drugs and other chemicals, for storing acetylene gas, and is present in paint and varnish removers, purifying paraffin and for hardening and dehydrating tissues. Acetone is also used as a solvent for fats, oils, waxes, resins, rubber, plastics, lacquers, varnishes. Acetone reacts with iron and steel in the presence of moisture.

The one-hour maximum, second highest, sixth highest and mean acetone concentrations measured across all monitoring sites in the Kwinana Study are shown in Figure 26. The first and second highest acetone concentrations of 260ppb and 180ppb were recorded at Dixon Road Reserve on 20 June 2013 and 28 June 2013, respectively. Back trajectory analysis indicates that winds possibly originated from nearby sources such as panel beaters and paint workshops (Appendix G). The third and fourth highest acetone concentrations were recorded at Wattleup site and likely from the KIA. All the recorded acetone concentrations were well below the one-hour criteria of 4900ppb.



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	<LOD	<LOD	<LOD	<LOD	29
Bertram Oval	<LOD	<LOD	<LOD	<LOD	29
Calista Oval	<LOD	<LOD	<LOD	<LOD	29
Dep of Agriculture	47	31	<LOD	<LOD	29
Dixon Rd Reserve	<LOD	<LOD	<LOD	<LOD	29
Medina Oval	<LOD	<LOD	<LOD	<LOD	29
Sloan's Reserve	<LOD	<LOD	<LOD	<LOD	29
Thomas Oval	<LOD	<LOD	<LOD	<LOD	29
Wattelup AQMS	<LOD	<LOD	<LOD	<LOD	29
Wells Park	<LOD	<LOD	<LOD	<LOD	29

Figure 25. One-hour average aldehyde concentrations



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	43	<LOD	<LOD	<LOD	24
Bertram Oval	31	<LOD	<LOD	<LOD	24
Calista Oval	<LOD	<LOD	<LOD	<LOD	24
Dept of Agriculture	<LOD	<LOD	<LOD	<LOD	24
Dixon Rd Reserve	260	180	<LOD	<LOD	24
Medina Oval	48	<LOD	<LOD	<LOD	24
Sloan's Reserve	58	31	<LOD	<LOD	24
Thomas Oval	<LOD	<LOD	<LOD	<LOD	24
Wattelup AQMS	150	117	<LOD	<LOD	24
Wells Park	90	58	<LOD	<LOD	24

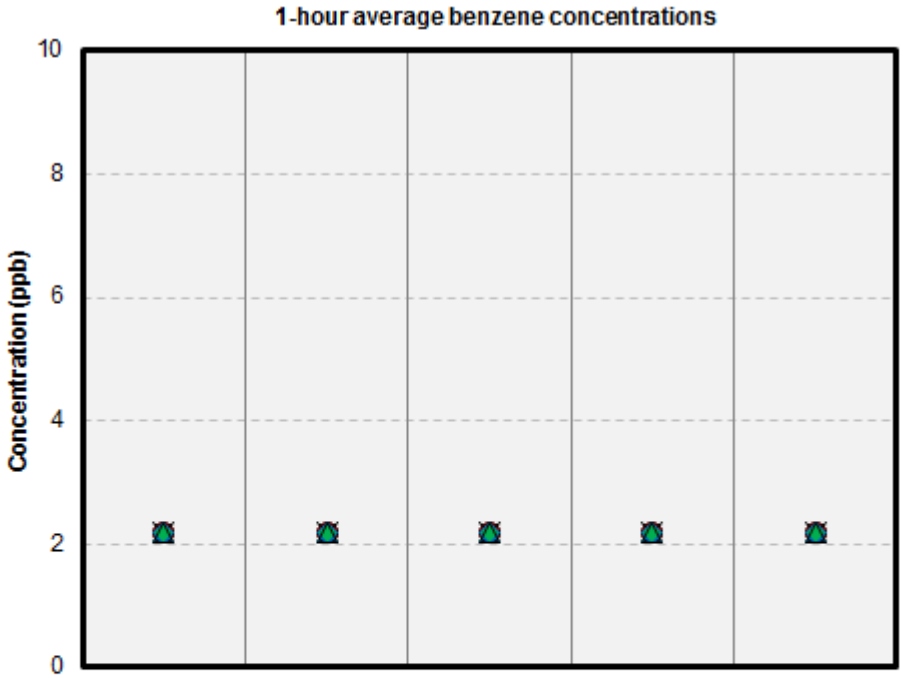
Figure 26. One-hour average acetone concentrations

3.2.4 Benzene

Benzene is a volatile, flammable and colourless compound that has a sweet odour. Industry is the main source of benzene in the environment. Emissions from burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gasoline service stations can cause benzene levels in the air to increase. Two natural sources of benzene are volcanoes and forest fires. Benzene is used in the manufacture of a large number of chemicals that contribute to the production of plastics (such as polystyrene) synthetic fibres, detergents, pharmaceuticals, and pesticides. It is used as a solvent for fats, oils, inks, paints, plastics, and rubbers, and as a degreasing agent.

Successful sampling of benzene by OP-FTIR is a challenging task as water vapour, carbon dioxide and ozone all interfere with the benzene absorption spectra. The one-hour average benzene concentrations all fell below the LOD of 2.2ppb.

As shown in Figure 27, the maximum, second and sixth highest and mean benzene concentrations at all sampling sites were equal to or below the LOD.



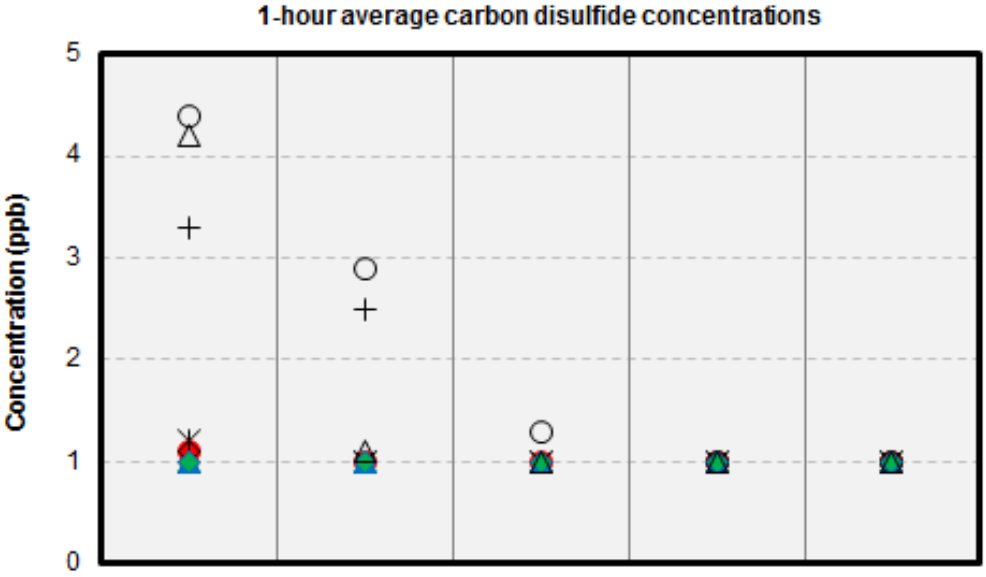
	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	<LOD	<LOD	<LOD	<LOD	2.2
Bertram Oval	<LOD	<LOD	<LOD	<LOD	2.2
Calista Oval	<LOD	<LOD	<LOD	<LOD	2.2
Dep of Agriculture	<LOD	<LOD	<LOD	<LOD	2.2
Dixon Rd Reserve	<LOD	<LOD	<LOD	<LOD	2.2
Medina Oval	<LOD	<LOD	<LOD	<LOD	2.2
Sloan's Reserve	<LOD	<LOD	<LOD	<LOD	2.2
Thomas Oval	<LOD	<LOD	<LOD	<LOD	2.2
Wattelup AQMS	<LOD	<LOD	<LOD	<LOD	2.2
Wells Park	<LOD	<LOD	<LOD	<LOD	2.2

Figure 27. One-hour average benzene concentrations

3.2.5 Carbon Disulfide

Carbon disulfide has been an important industrial chemical since the 1800s and is made for commercial use by combining carbon and sulfur at very high temperatures. Pure carbon disulfide is a colourless liquid with a pleasant odour that is like the smell of chloroform. The impure carbon disulfide that is usually used in most laboratory and industry processes is a colourless to faintly yellow liquid with a strong, disagreeable cabbage-like odour. It is highly refractive. Carbon disulfide easily forms explosive mixtures with air and catches fire very easily. In agriculture, carbon disulfide has been widely used as a fumigant to control insects in stored grain.

The one-hour maximum, second highest, sixth highest and mean carbon disulfide concentrations measured across all monitoring sites in the Kwinana Study are shown in Figure 28. The first, fourth and sixth highest carbon disulfide concentrations were recorded on the same day (31 January 2014) at Thomas Oval. Wind analysis shows that winds direction was constantly from KIA throughout the day. The second highest concentrations for carbon disulfide was recorded at Wells Park on 24 May 2013. The trajectory analysis indicates that winds originated from the direction of the KIA during this day also (Appendix G). Although carbon disulfide was detected at several of the sampling sites, all the recorded concentration levels were well below the one-hour criteria of 27ppb.



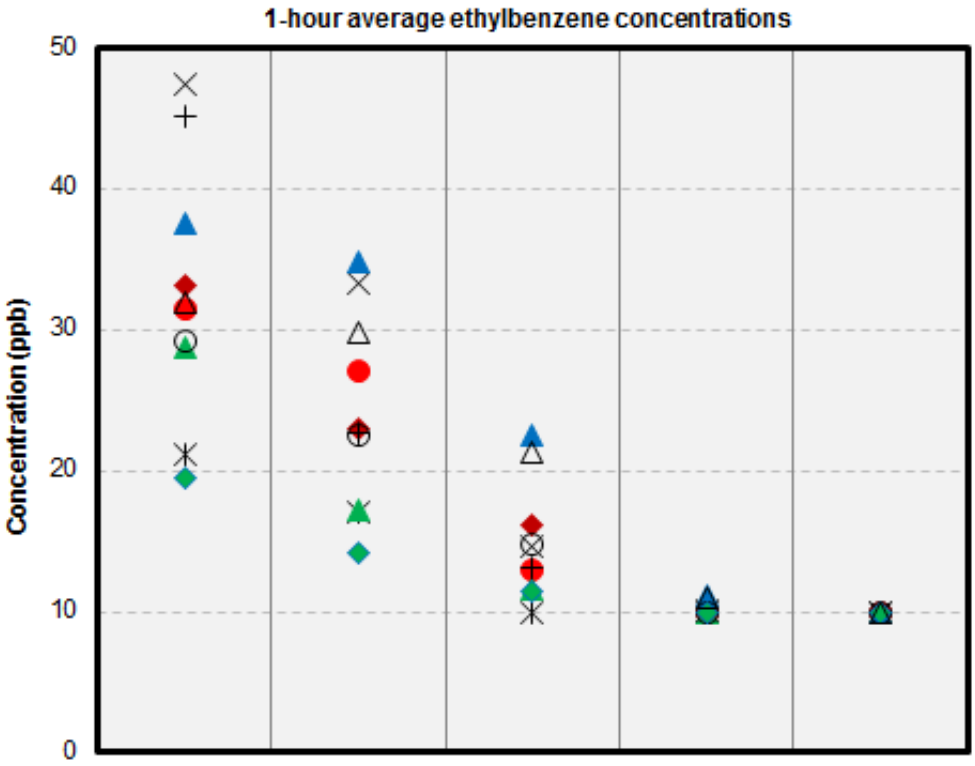
	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	1.1	<LOD	<LOD	<LOD	1.0
Bertram Oval	1.2	<LOD	<LOD	<LOD	1.0
Calista Oval	<LOD	<LOD	<LOD	<LOD	1.0
Dep of Agriculture	<LOD	<LOD	<LOD	<LOD	1.0
Dixon Rd Reserve	<LOD	<LOD	<LOD	<LOD	1.0
Medina Oval	3.3	2.5	<LOD	<LOD	1.0
Sloan's Reserve	<LOD	<LOD	<LOD	<LOD	1.0
Thomas Oval	4.4	2.9	1.3	<LOD	1.0
Wattelup AQMS	<LOD	<LOD	<LOD	<LOD	1.0
Wells Park	4.2	1.1	<LOD	<LOD	1.0

Figure 28. One-hour average carbon disulfide concentrations

3.2.6 Ethylbenzene

Ethylbenzene is a colorless, flammable compound and is released into the environment from burning oil, gas, and coal. It is also found in manufactured products such as inks, insecticides, and paints. Ethylbenzene can be found in gasoline, as a solvent in pesticides, carpet glues, varnishes and paints, and in tobacco.

As shown in Figure 29, the maximum one-hour ethylbenzene concentration of 47ppb was recorded on 6 February 2014 at the Department of Agriculture site. The second highest one-hour ethylbenzene concentration of 45ppb was recorded at Medina Oval. The back trajectory analysis indicates that winds originated from the direction of the KIA for both events (Appendix G). Although ethylbenzene was detected in most of the sampling sites, all the recorded concentration levels were very low compared to the one-hour criteria of 1800ppb.



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	31	27	13	<LOD	10
Bertram Oval	21	17	<LOD	<LOD	10
Calista Oval	29	17	12	<LOD	10
Dep of Agriculture	47	33	15	10	10
Dixon Rd Reserve	33	23	16	<LOD	10
Medina Oval	45	23	13	<LOD	10
Sloan's Reserve	38	35	23	11	10
Thomas Oval	29	23	15	<LOD	10
Wattelup AQMS	20	14	12	<LOD	10
Wells Park	32	30	21	11	10

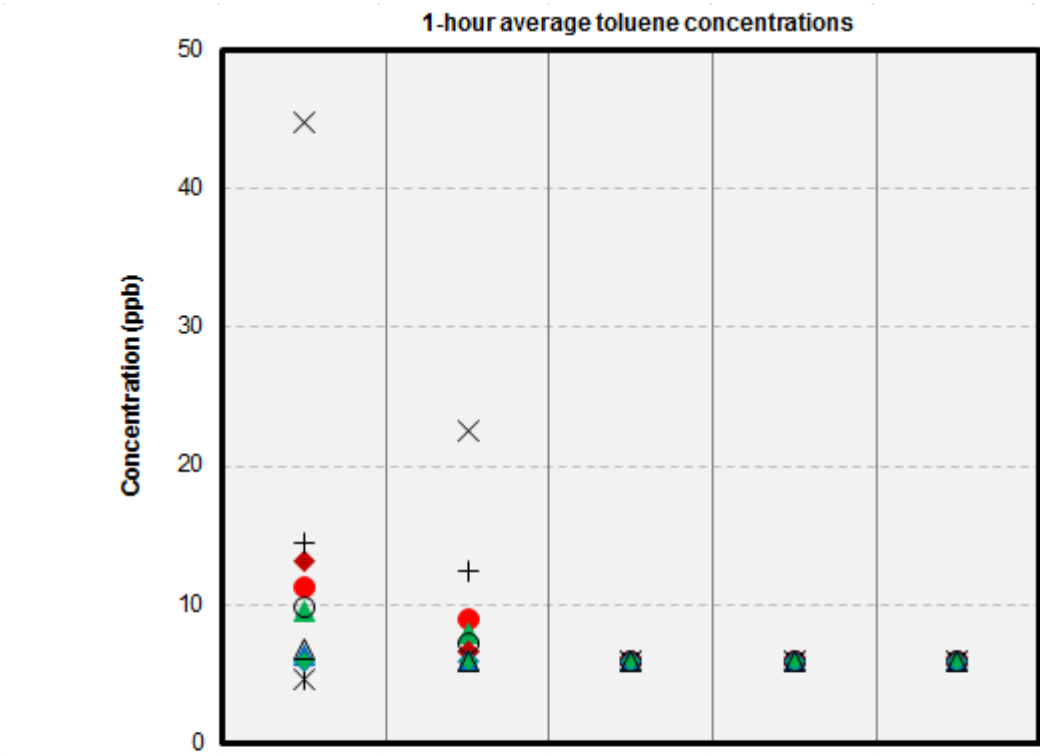
Figure 29. One-hour average ethylbenzene concentrations

3.2.7 Toluene

Toluene is a colorless gas with a distinctive smell. Toluene occurs naturally in crude oil and is emitted during the refining of crude oil to produce petrol, coal coking and it is a by-product of styrene manufacture. It is also used in the manufacture of paint and paint thinners, nail polish, lacquers, adhesives and rubber.

The highest and second highest toluene concentrations were recorded on same day at the Department of Agriculture site (6 February 2014) with concentration of 45ppb and 23ppb, respectively (Figure 30). The back trajectory analysis indicates that winds originated from the direction of the KIA.

There is no one-hour standard for toluene to compare the results with, but this concentration level was well below the 24-hour average air quality criteria of 1000ppb and as a result, these concentration levels also meet the one-hour criteria.



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	11	8.9	<LOD	<LOD	6.0
Bertram Oval	<LOD	<LOD	<LOD	<LOD	6.0
Calista Oval	10	8.0	<LOD	<LOD	6.0
Dep of Agriculture	45	23	<LOD	<LOD	6.0
Dixon Rd Reserve	13	6.7	<LOD	<LOD	6.0
Medina Oval	14	13	<LOD	<LOD	6.0
Sloan's Reserve	6.4	<LOD	<LOD	<LOD	6.0
Thomas Oval	10	7.3	<LOD	<LOD	6.0
Wattelup AQMS	<LOD	<LOD	<LOD	<LOD	6.0
Wells Park	6.8	<LOD	<LOD	<LOD	6.0

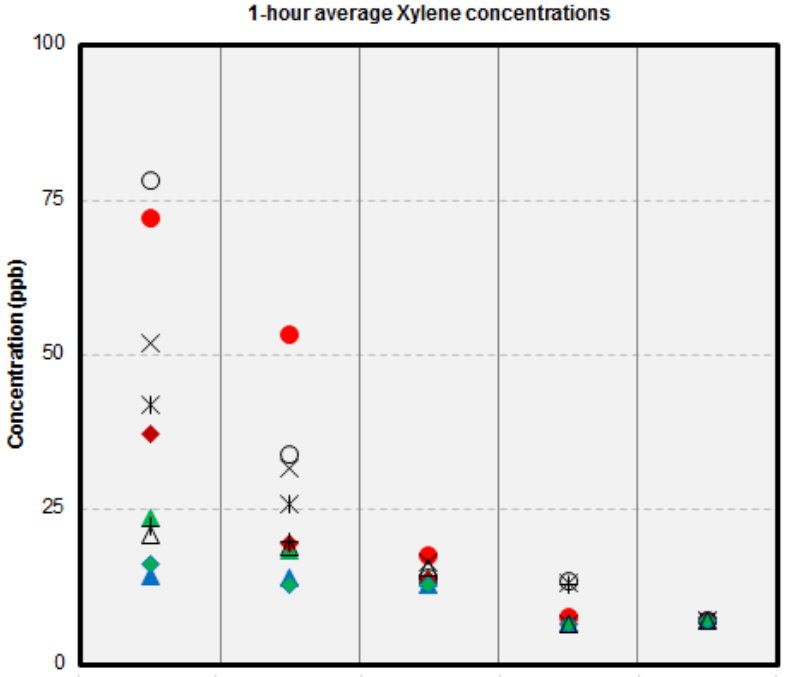
Figure 30. One-hour average toluene concentrations

3.2.8 Xylene

Xylene is a colourless liquid at room temperature with an aromatic odour. The term "total xylenes" refers to all three types of xylene (meta-, ortho-, and para-xylene). Xylene is mostly a man-made chemical. Chemical industries produce xylene from petroleum. Xylene is primarily released from industrial sources, in automobile exhaust, and during its use as a solvent. It quickly evaporates into the air from surface soil and water.

The reported xylene in this report refers to "total xylenes". As shown in Figure 31, the highest one-hour xylene concentration of 78ppb was recorded on 11 April 2014 at Thomas Oval.

The back trajectory analysis indicates that winds originated from the direction of the KIA (Appendix G). The second and third highest one-hour xylene concentrations of 72ppb and 52ppb respectively, were recorded at Beeliar Oval. The wind back trajectory indicates that KIA could be the xylene source for these events. The xylene peaks at the Department of Agriculture and Bertram Oval sites were most likely from nearby sources or on-road vehicles on the Kwinana Freeway. There is no one-hour standard for xylene to compare the results with, but all the recorded concentrations were well below 24-hour criteria, and so below the one-hour criteria.



	MAX	2nd Highest	6th Highest	Average	LOD
Beeliar Oval	72	53	18	7.6	7.0
Bertram Oval	42	26	13	<LOD	7.0
Calista Oval	24	19	14	<LOD	7.0
Dep of Agriculture	52	32	17	13	7.0
Dixon Rd Reserve	37	20	14	<LOD	7.0
Medina Oval	22	20	13	13	7.0
Sloan's Reserve	14	14	13	<LOD	7.0
Thomas Oval	78	34	14	14	7.0
Wattelup AQMS	16	13	13	<LOD	7.0
Wells Park	21	19	16	<LOD	7.0

Figure 31. One-hour average xylene concentrations

3.2.9 Total VOCs

Total volatile organic compounds (TVOCs) are a grouping of a wide range of organic chemical compounds to simplify reporting when these are present in ambient air or emissions. The chemical properties of TVOCs vary widely and many substances (i.e. natural gas) could be classified as VOCs. VOCs generally refer to vapours of gases given off by compounds rather than the liquid phase (NPI Report, 2013).

There is no air quality criteria available at present outlining target and action units for TVOCs. However, the World Health Organization (WHO) definition of VOCs refers to the behaviour of the compounds in traditional analytical procedures and not to their possibility, through environmental exposures, to cause discomfort and health effects. Also, some organic compounds outside the VOC range as defined by WHO may contribute to the relevant sensory effects.

3.2.9.1 Monitoring Method

Identification and quantification of all individual VOCs occurring in ambient air is difficult if not impossible, as a large number of samples have to be analysed for a large number of VOCs. The measurements of TVOCs are performed for various purposes using different definitions and techniques which yield different results. The TVOCs assessment can be performed with a simple integrating detector that generally reference one compound for calibration purposes and all compounds detected are then assumed to have the same response factor as the calibration compound.

An empirical method was designed for the OP-FTIR and used for qualitative assessments of TVOCs levels. This analytical method uses several IR bands between 2800cm^{-1} and 3000cm^{-1}, where most of VOC species indicate strong absorption within this spectral region. The spectral region of 2800-3000 cm^{-1} has been commonly used in other studies for qualitative assessment of TVOCs (Pasadakis et al. 2013). Peaks heights corresponding to VOC absorptions were used to calculate TVOC levels. These TVOC levels were considered as an indicator of the TVOC levels in the ambient air, rather than absolute concentration values.

3.2.9.2 Results for TVOCs

Polar plots were used to present TVOCs levels measured by OP-FTIR showing concentration by wind speed and direction. Wind speed, wind direction and concentration data are partitioned into wind speed-direction “bins” (for example a bin can be partitioned into 2-4m/s and 10-20 degrees bin) and the mean concentration were calculated for each bin and depending on the mean concentration, each bin was colour-coded. The colour scale at the bottom of graphs shows the TVOC levels. The TVOC level lies between the LOD and the highest detected level (HDL) recorded in the BAQS Phase 4. The LOD is the smallest concentration that can be measured with OP-FTIR (see section 2.4.5). All plots use five minute average data. The radial scale indicates the wind speed (e.g. 0-2 m/s, 2-4 m/s etc.), which increases from the centre of the plot radially outwards. A polar plot is a simple but effective technique to provide directional and dispersion information for emission sources (the technique has been made available through the Openair R package at www.openair-project.org).

Unshaded areas represent bins that contain no data, that is, there were no periods when the wind speed and direction corresponded to any sampling that took place.

The polar plots presented in this section indicate TVOCs levels recorded at all selected sites in the study. As shown in following graphs, the TVOCs levels were very low (close to FTIR's LOD) for most of the sites such as: Beeliar Oval (Figure 32), Bertram Oval (Figure 33), Calista Oval (Figure 34), Department of Agriculture (Figure 35), Sloan's Reserve (Figure 38), Thomas Oval (Figure 39) and Wattleup (Figure 40).

The highest TVOC levels recorded in the BAQS Phase 4 was seen at Dixon Road Reserve site (Figure 36). The most evident feature of Figure 36 is a noticeable level of TVOCs to the northeast of the site at low wind speeds (around 2 m/s). These higher concentrations might result from stable atmospheric conditions and reduced advection that exist under low wind speed conditions. The main VOCs source for this direction is expected to originate from commercial activities (i.e. panelbeaters and painting workshops). There are also indications of elevated TVOCs levels to the south-east and north-west.

As shown in Figure 41, an evident VOCs source was observed to the northwest of Wells Park, which may be from ships and loading/unloading activities at Kwinana Bulk Jetty. Another potential source for TVOCs to the southeast was observed that could originate from within the KIA. Wells Park is the only monitoring site which is located within the industrial zone of the Kwinana EPP Area A.

A VOC source is evident to the south of Medina Oval (Figure 37). While there are no industrial sources or major roads to the south of Medina Oval, the dominant source type affecting this monitoring site may be attributed to fugitive VOCs concentrations from nearby sources (residential or commercial).

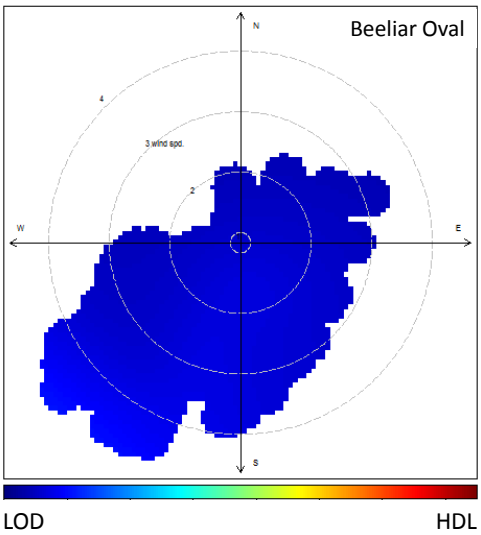


Figure 32: Polar plot for TVOC levels at Beeliar Oval.

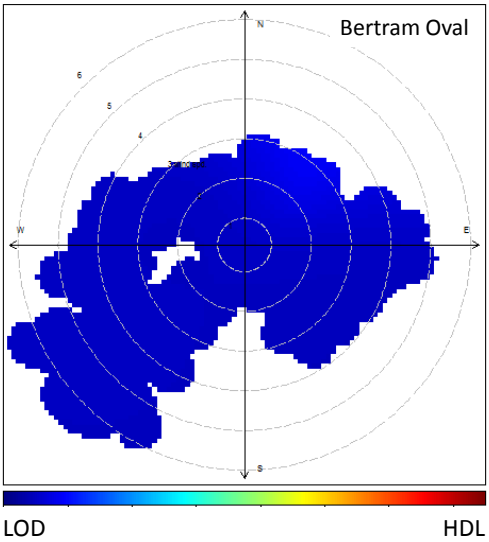


Figure 33: Polar plot for TVOC levels at Bertram Oval

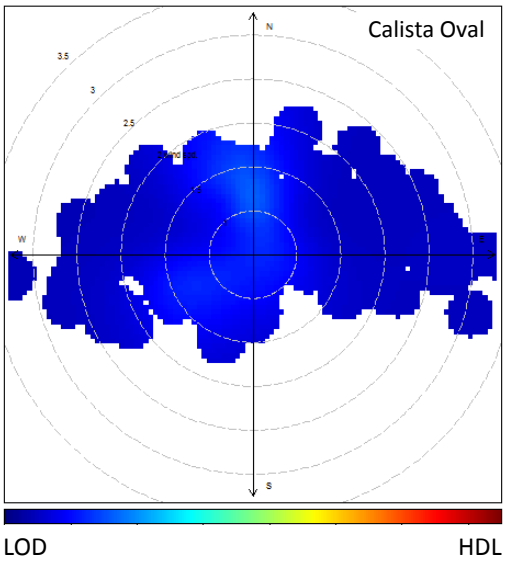


Figure 34: Polar plot for TVOC Levels at Calista Oval

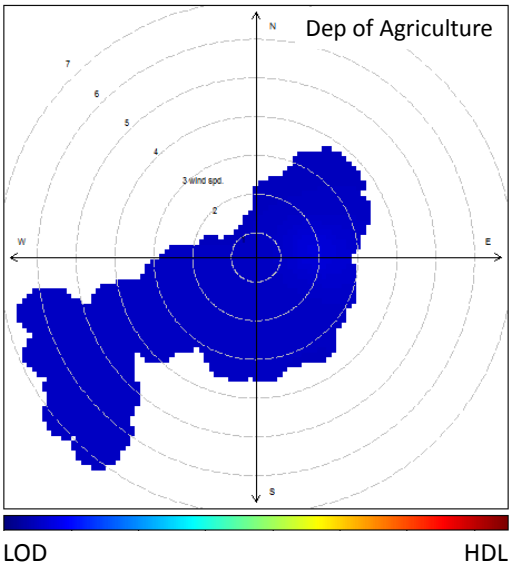


Figure 35: Polar plot for TVOC levels at the Department of Agriculture

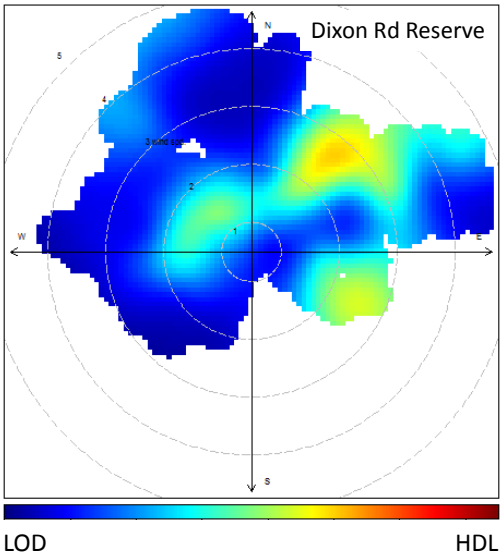


Figure 36: Polar plot for TVOC levels at Dixon Road Reserve

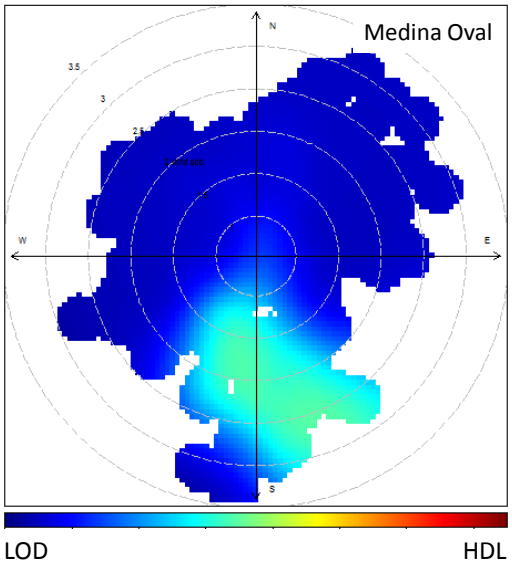


Figure 37: Polar plot for TVOC levels at Medina Oval

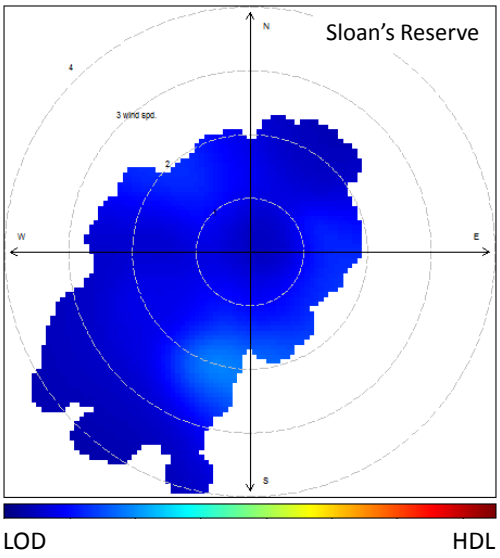


Figure 38: Polar plot for TVOC levels at Sloan's Reserve

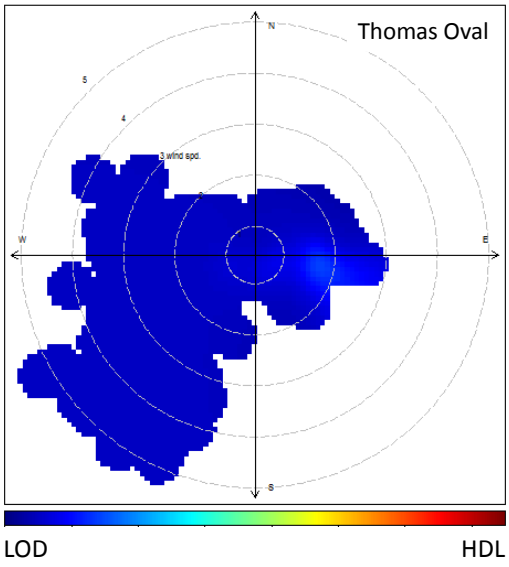


Figure 39: Polar plot for TVOC levels at Thomas Oval

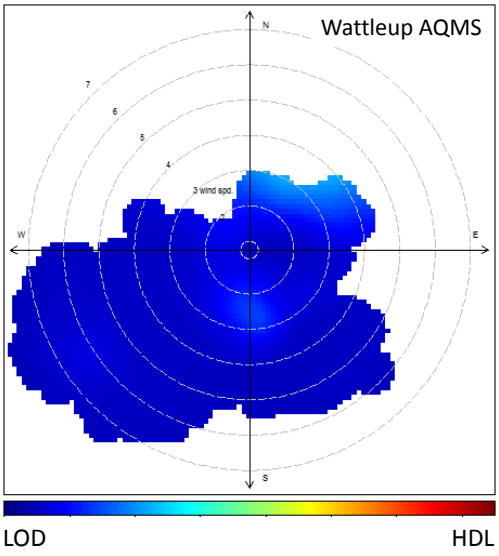


Figure 40: Polar plot for TVOC levels at Wattleup

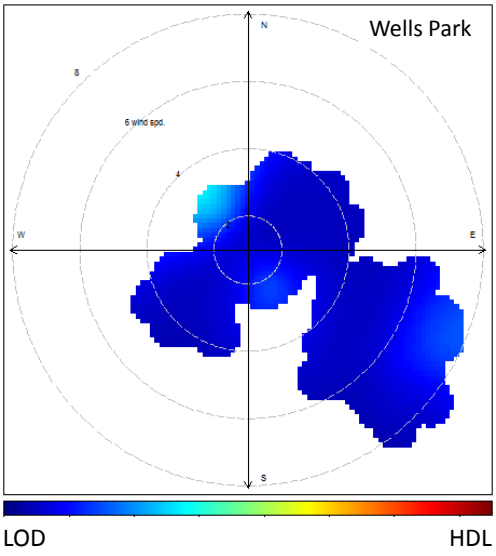


Figure 41: Polar plot for TVOC levels at Wells Park

3.3 Results of continuous monitoring

A suitable site for continuous monitoring of air toxics within the residential area was not found due to the inability to meet both equipment security concerns and FTIR siting requirements. Therefore, the OP-FTIR was deployed for one month at the Kwinana Cogeneration Plant from 25 February to 27 March 2014. The Kwinana Cogeneration Plant is located at James Court, Kwinana Beach, in a relatively central location to industries in the KIA (Figure 42). The aim of this continuous monitoring was to assess diurnal (day and night) variations in measured air toxics. The instrument and its infrared source were housed in separate sheds, for protection from rain and strong winds, at a separation distance of 80m. Due to the open-path nature of the OP-FTIR, the source and detector require a direct line of sight and so the shed doors remained open throughout the duration of the study.

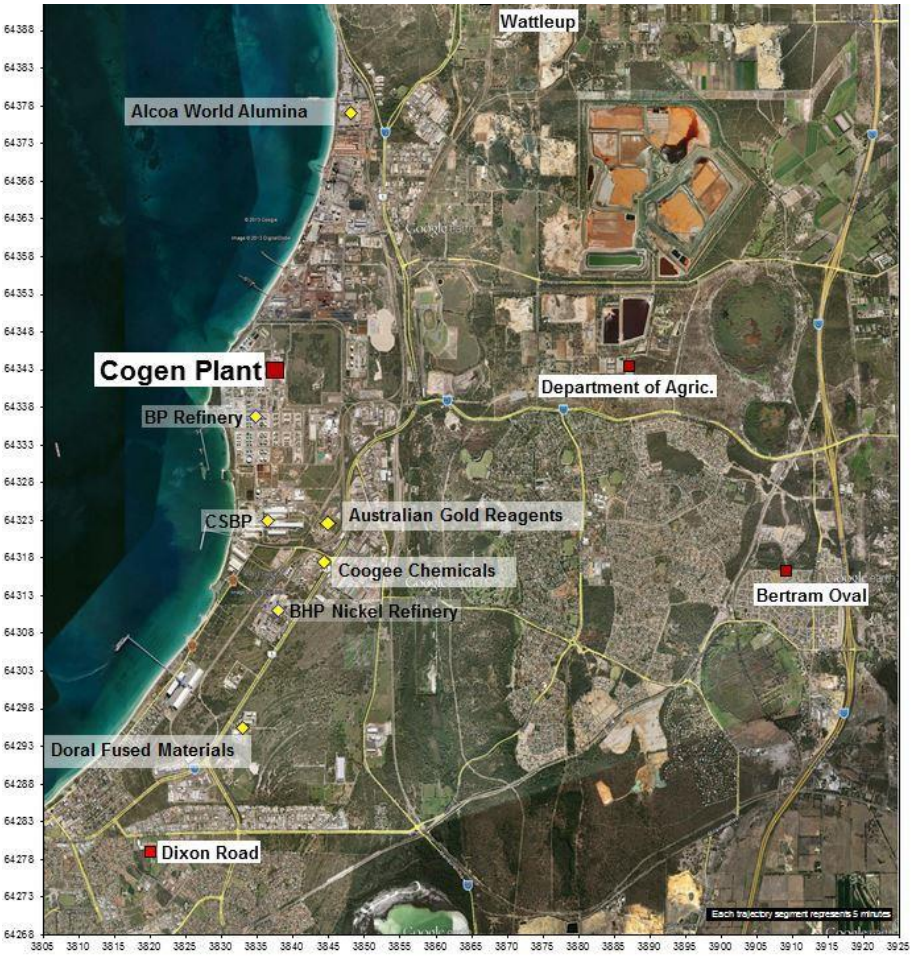
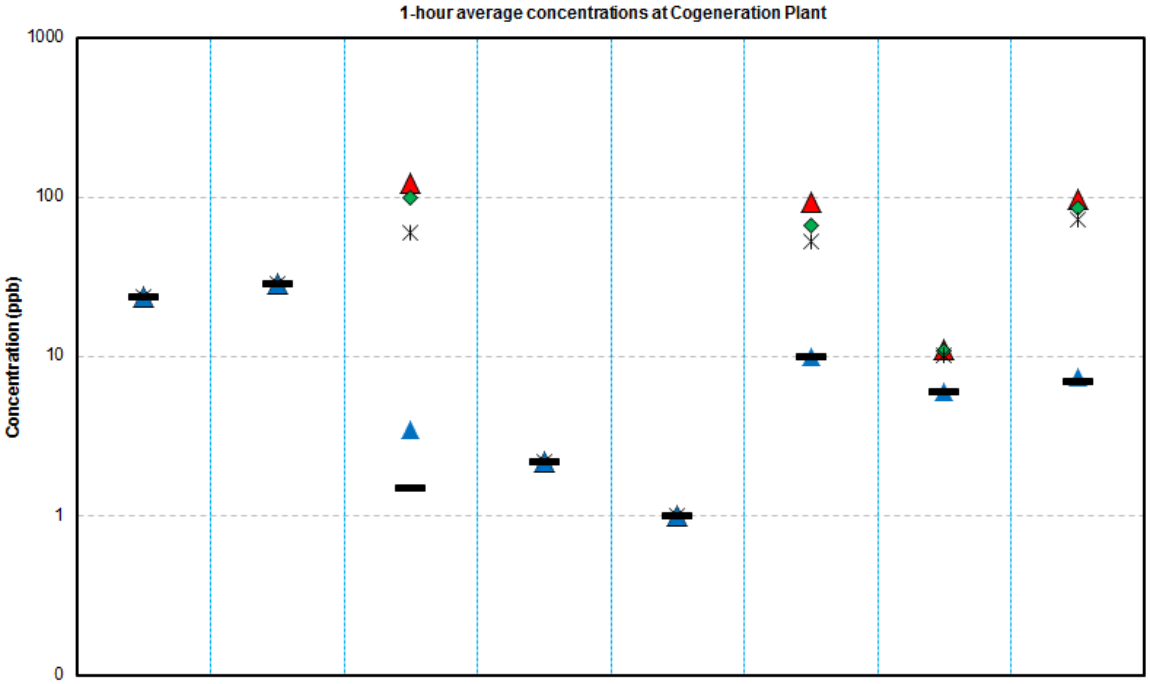


Figure 42. Location of Kwinana Cogeneration Plant

The maximum one-hour average concentrations of ammonia and VOCs at Kwinana Cogeneration Plant are shown in Figure 43. The graph concentration axis is presented in a logarithmic scale to better display all the concentrations. Of the VOCs and ammonia monitored in the study, only ammonia, ethylbenzene, toluene and xylene were detected at the Cogeneration Plant, despite being in close proximity to all the industrial sites in Kwinana (possibly due to the direction of the prevailing winds

and also because the other sites were impacted by local nearby sources), but concentrations were elevated compared to other sites (except for Wells Park and Dixon Road Reserve), as expected.



	Acetone	Aldehyde	Ammonia	Benzene	Carbon disulphide	Ethyl benzene	Toluene	Xylene
MAX	<LOD	<LOD	120	<LOD	<LOD	94	11	98
2nd Highest	<LOD	<LOD	100	<LOD	<LOD	67	11	87
6th highest	<LOD	<LOD	60	<LOD	<LOD	53	10	72
Average	<LOD	<LOD	3.5	<LOD	<LOD	<LOD	<LOD	7.4
LOD	24	29	1.5	2.2	1.0	10	6.0	7.0

Figure 43. The maximum one-hour average ammonia concentrations

Low levels of toluene were detected at this site which is well below relevant standards.

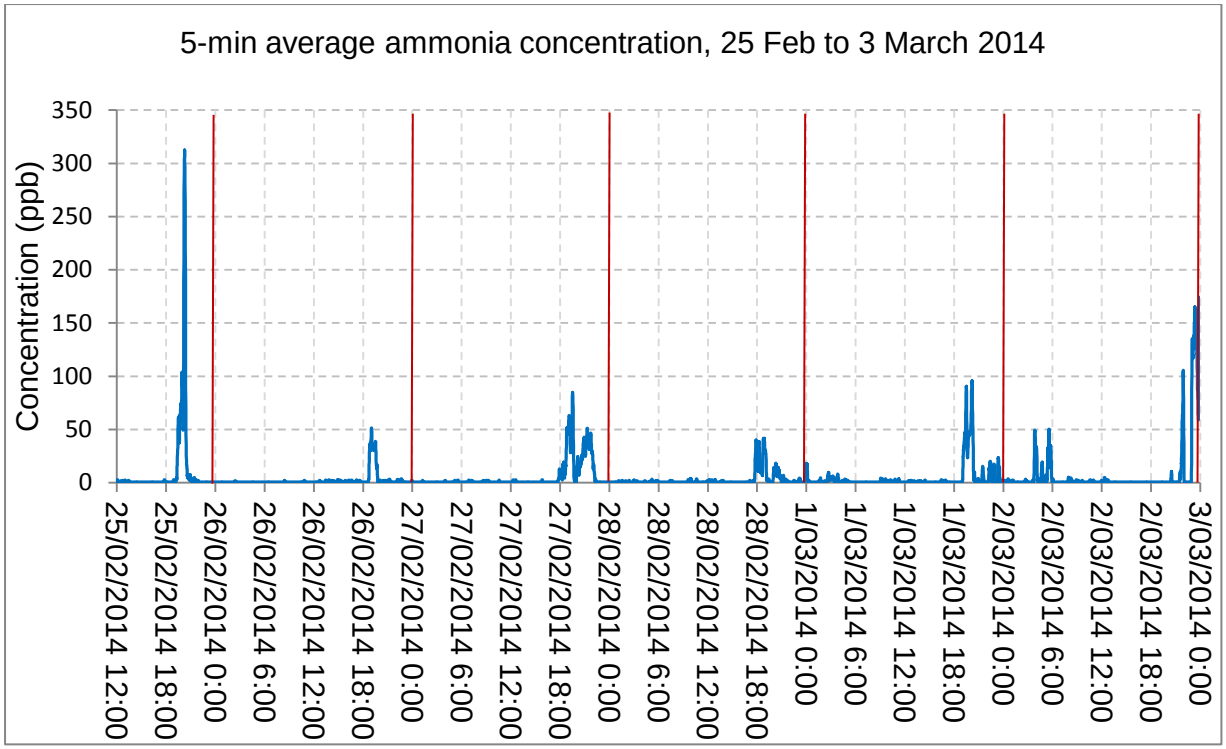
The highest one-hour ammonia level recorded at the Cogeneration Plant is 120ppb, which is lower than highest ammonia levels recorded at Wells Park (170ppb) and Dixon Road Reserve (160ppb). Large numbers of short and long-term ammonia peaks were observed at this site during this period.

The five-minute moving average of ammonia concentrations with corresponding wind data, which were monitored between 25 February and 27 March 2014, are presented in Figures 44, 47, 50, 53, 56 and 58. The wind speed and direction information presented in the graphs were obtained from DER's Wattleup Air Quality Monitoring Station (AQMS) monitoring site, which is the nearest meteorological monitoring site to the Cogeneration Plant. The average five-minute ammonia concentration was extracted from short-term OP-FTIR data (for each five-day intervals) to be compared with five-minute wind data. The vertical axis, in the wind graphs, indicates wind speed (in metres per second) and wind direction is indicated by the arrow direction. The arrow point shows the direction in which the wind is blowing. The blue arrows represent the wind directions at the time of peaks and grey arrows are for other wind directions.

As shown in the graphs, the majority of elevated ammonia levels occurred during night time (between early evening and the early hours of the morning). However, the difference in concentration between day and night times does not necessarily mean that the industrial emissions are higher during night time. As shown in the wind graphs, the predominant winds during night time were from south-east to south-west, which is in line with major ammonia sources in the KIA.

In addition, some local sources to the east to north east of the Kwinana Cogeneration Plant also contribute to elevated ammonia levels on occasion. Back trajectory analysis presented in following graphs clearly confirms that the KIA is a likely source of detectable ammonia levels. The recorded ammonia levels were well below the one-hour standard of 480ppb. The back trajectory results for all significant ammonia peaks between 25 February and 27 March 2014 are presented in Figures 45, 46, 48, 49, 51, 52, 54, 55, 57 and 59.

As shown in the polar plot (Figure 60), the maximum TVOC levels recorded at the Kwinana Cogeneration Plant were from a source to the south. Other sources are to the south-south-west, south-east, east and north-north-east.



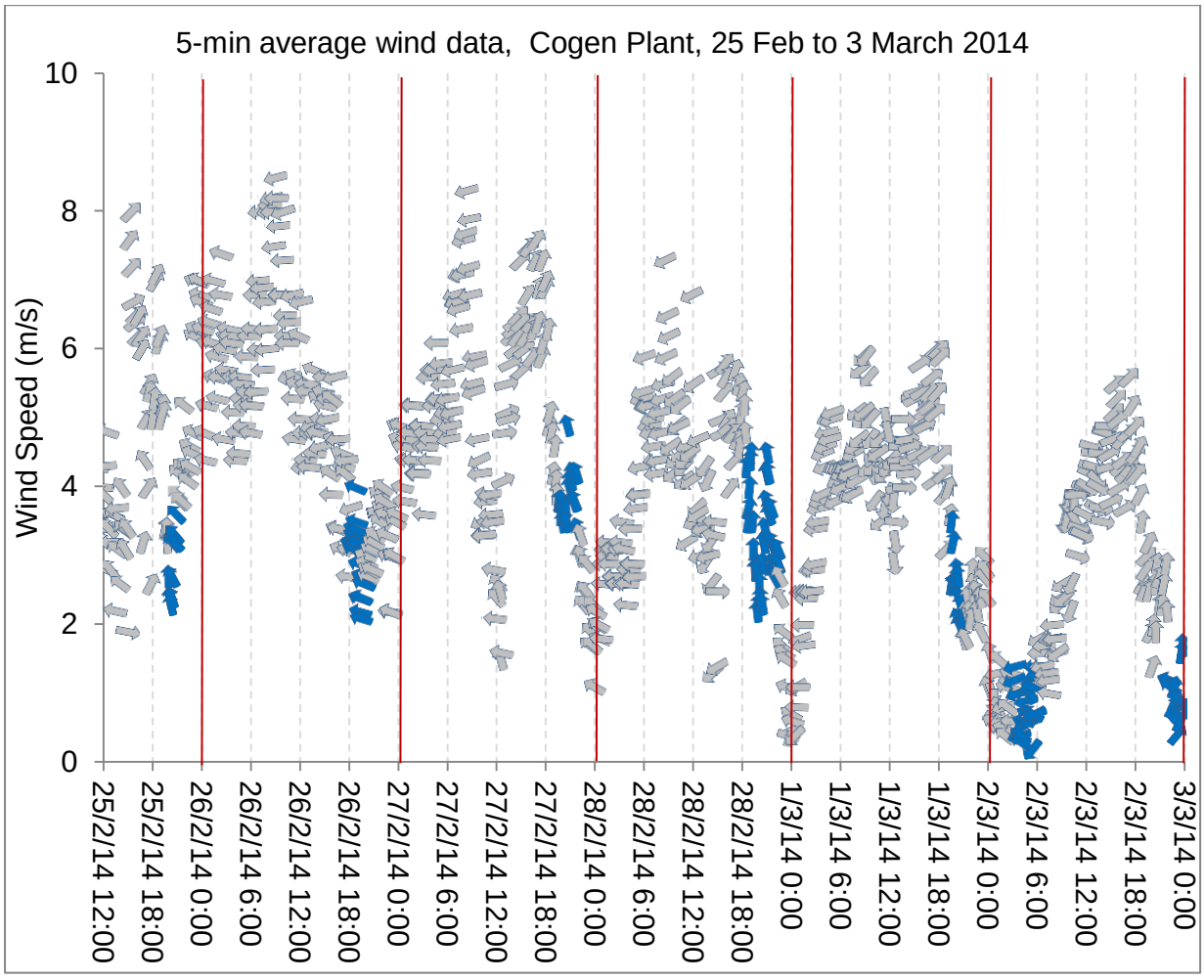


Figure 44. 5-min average wind data and ammonia concentrations for 26 February to 3 March 2014 at the Kwinana Cogeneration Plant

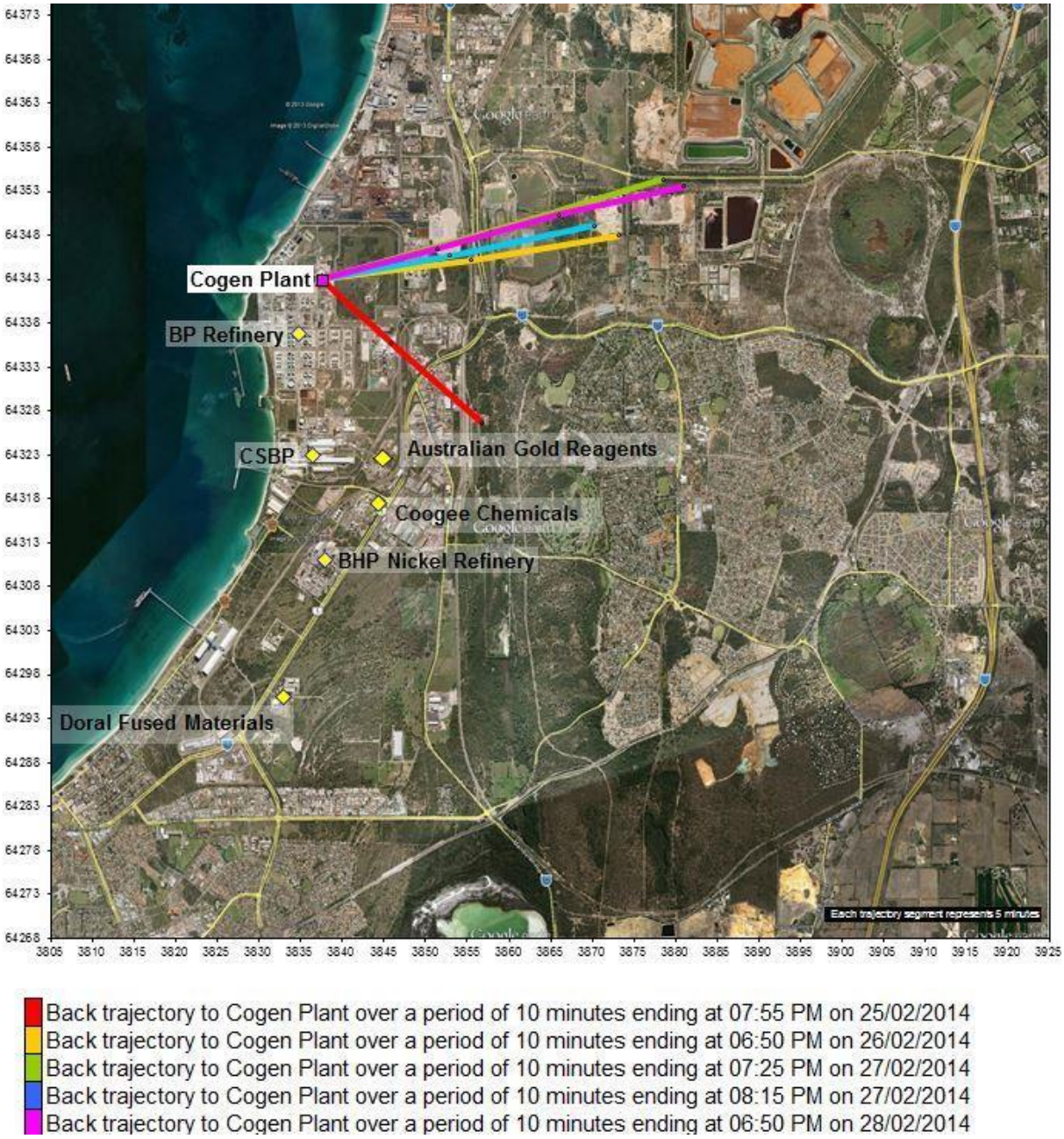


Figure 45. Back trajectories for ammonia peaks at Cogeneration Plant, 25 February to 28 February 2014

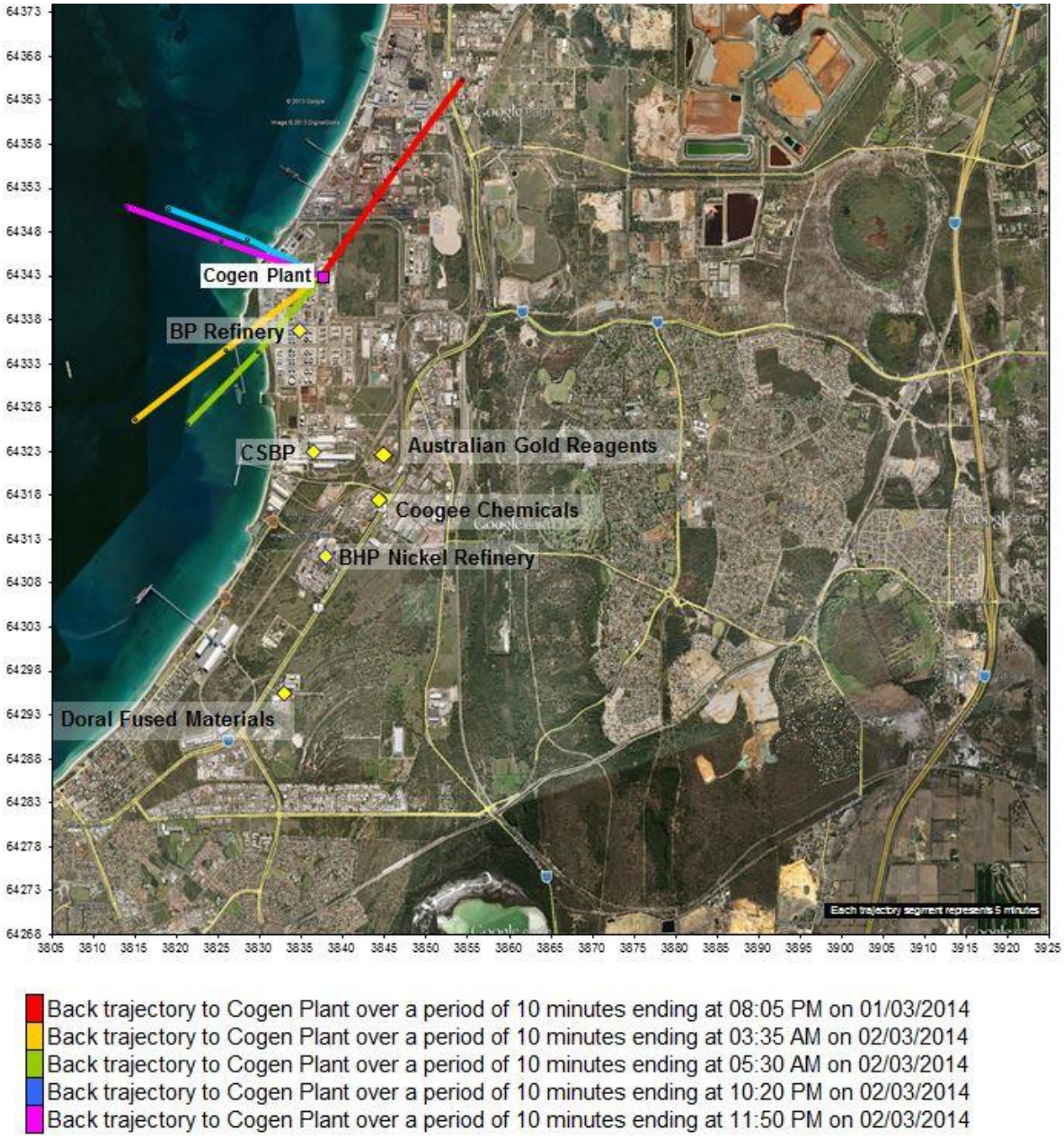
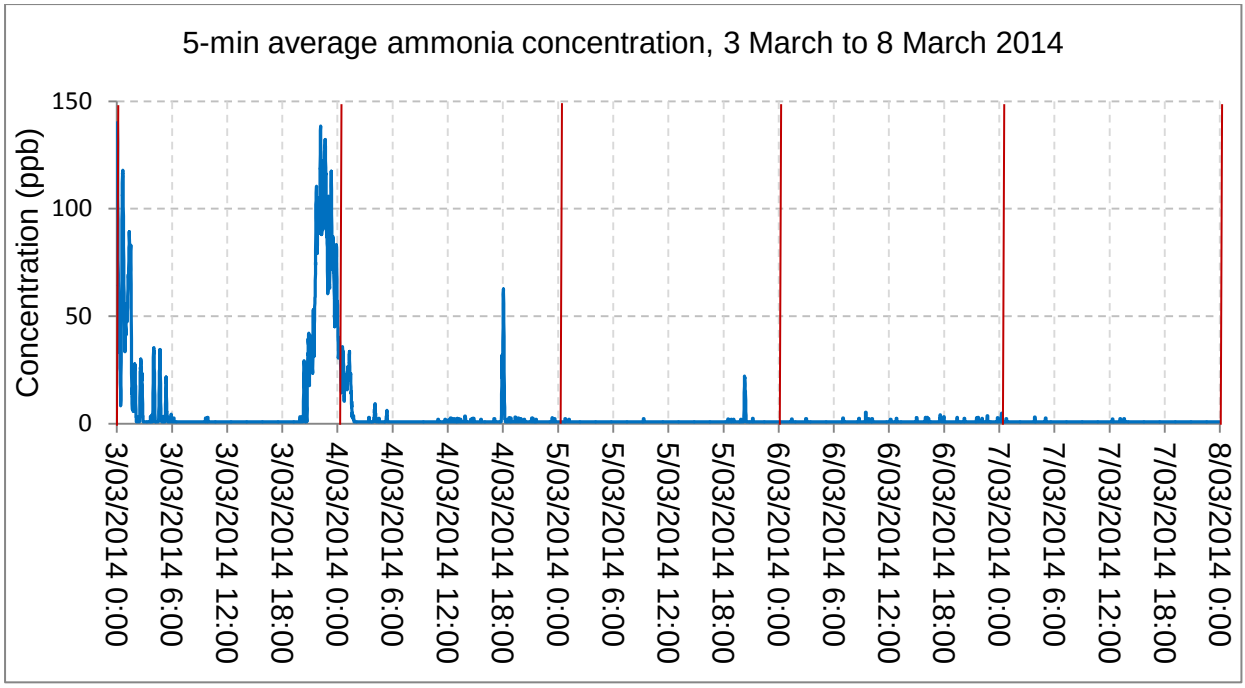


Figure 46. Back trajectories for ammonia peaks at Cogeneration Plant, 1 March to 2 March 2014



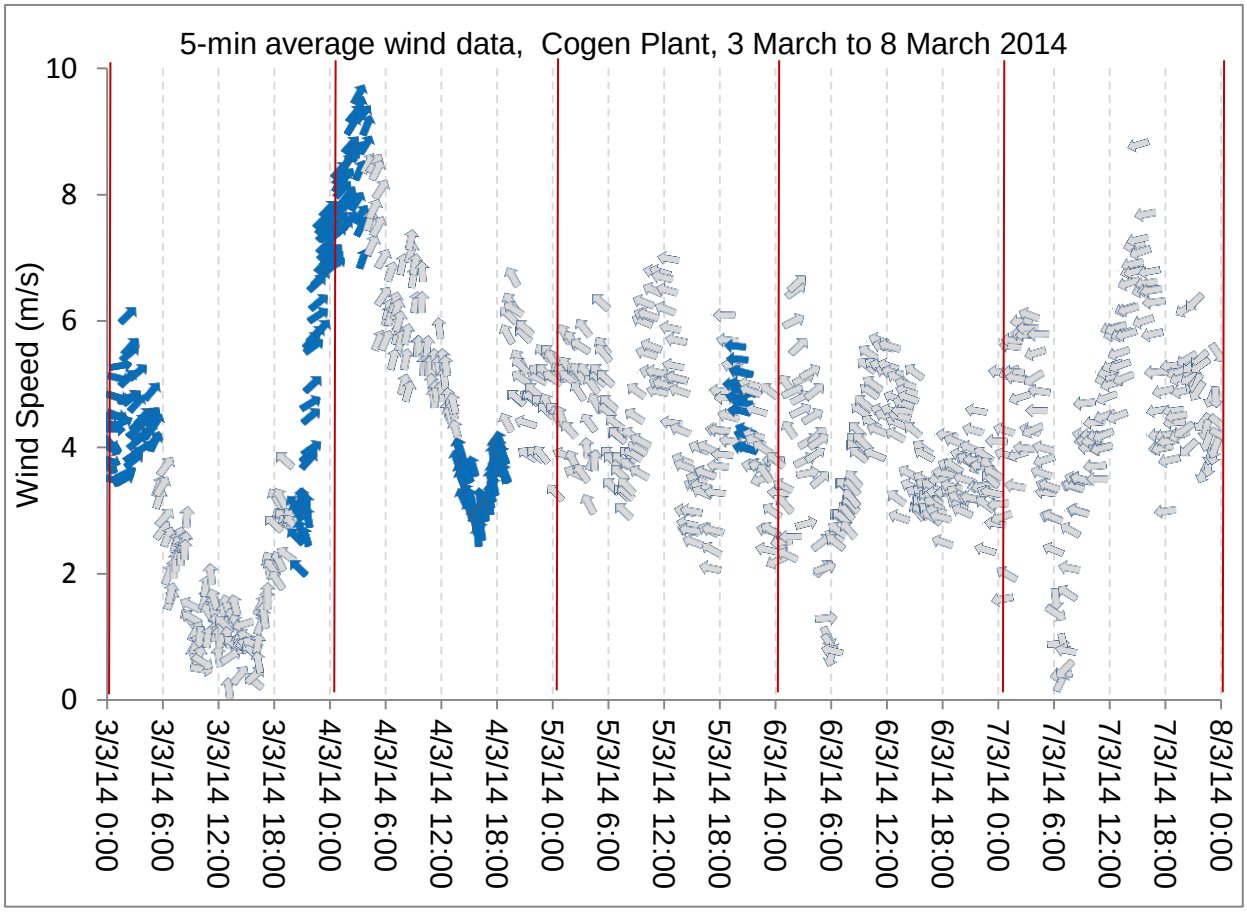


Figure 47. 5-min average wind data and ammonia concentrations for 3 March to 8 March 2014 at the Kwinana Cogeneration Plant

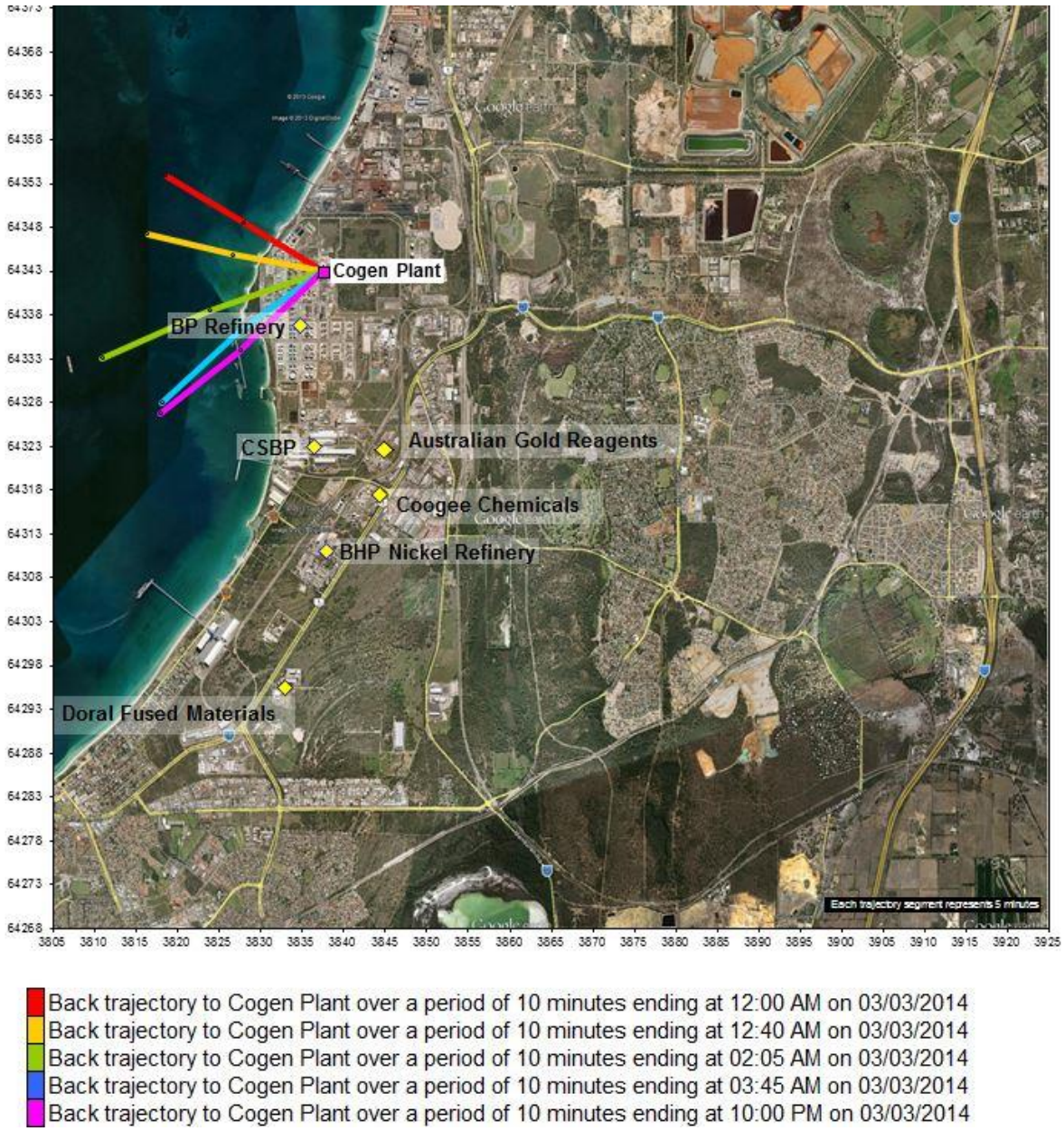


Figure 48. Back trajectories for ammonia peaks on 3 March 2014

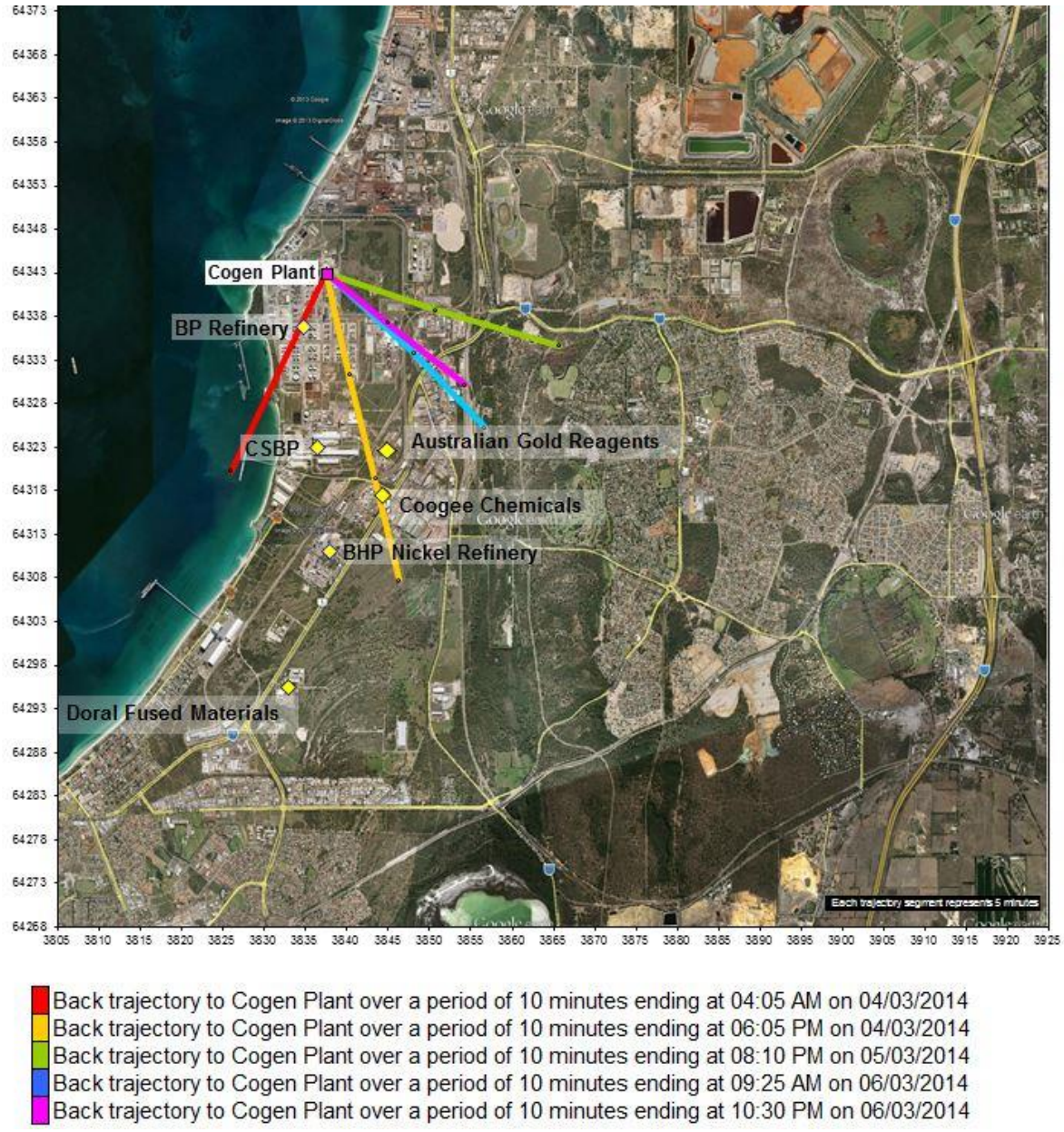


Figure 49. Back trajectories for ammonia peaks at Cogeneration Plant, 4 March to 6 March 2014

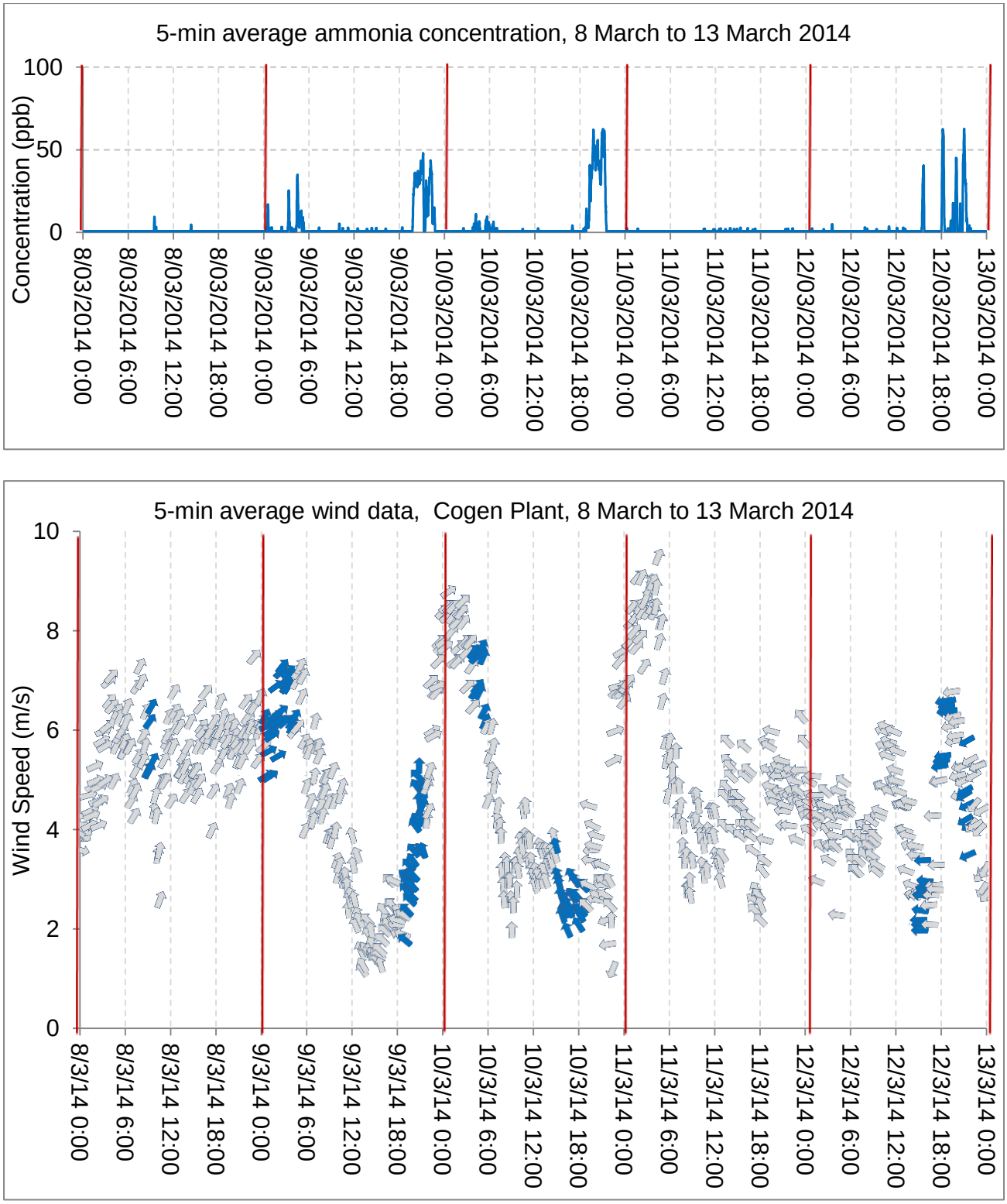


Figure 50. 5-min average for wind and ammonia concentrations between 8 March and 13 March 2014 at Cogeneration Plant

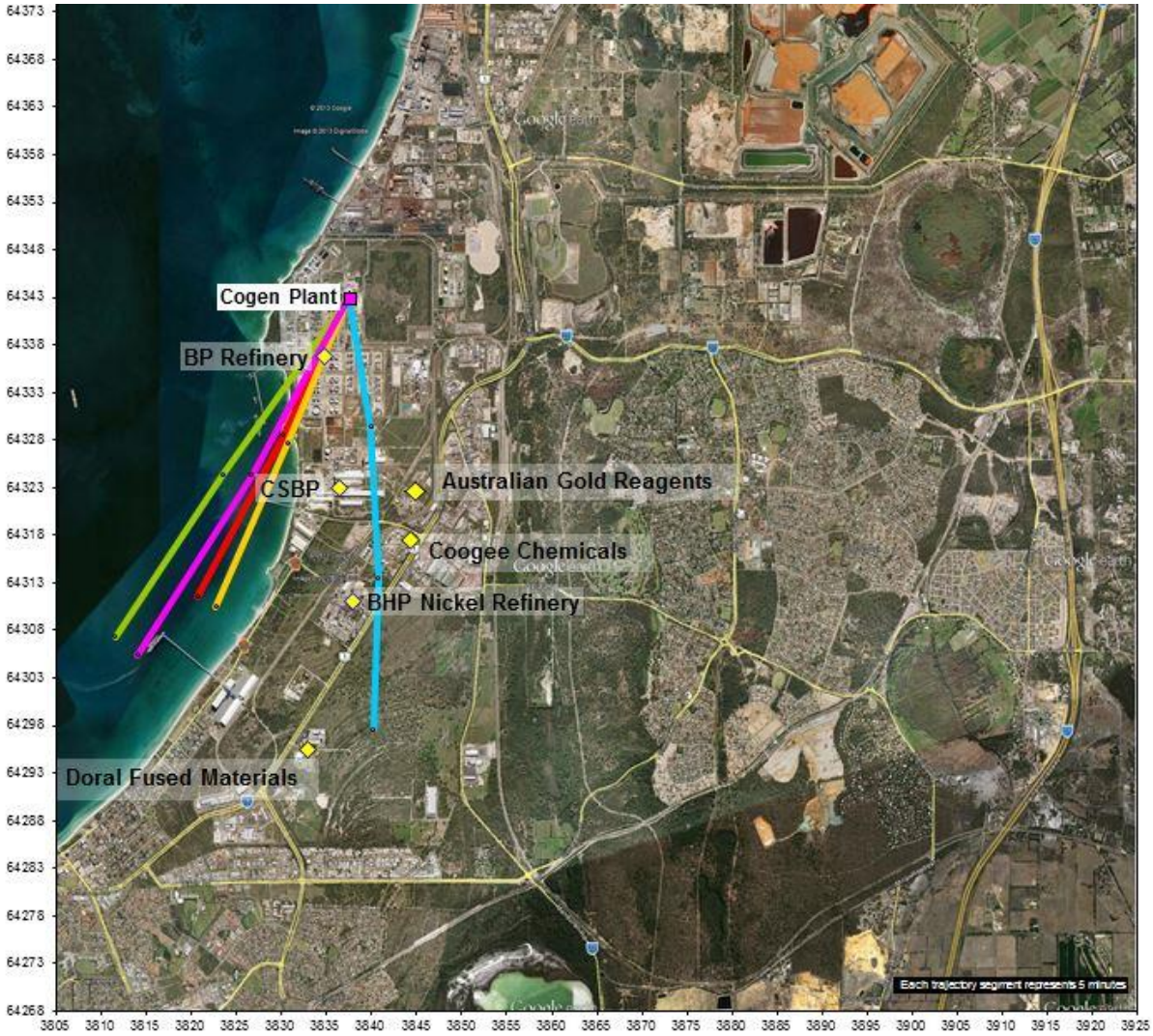


Figure 51. Back trajectories for ammonia peaks at Cogeneration Plant, 8 March to 10 March 2014

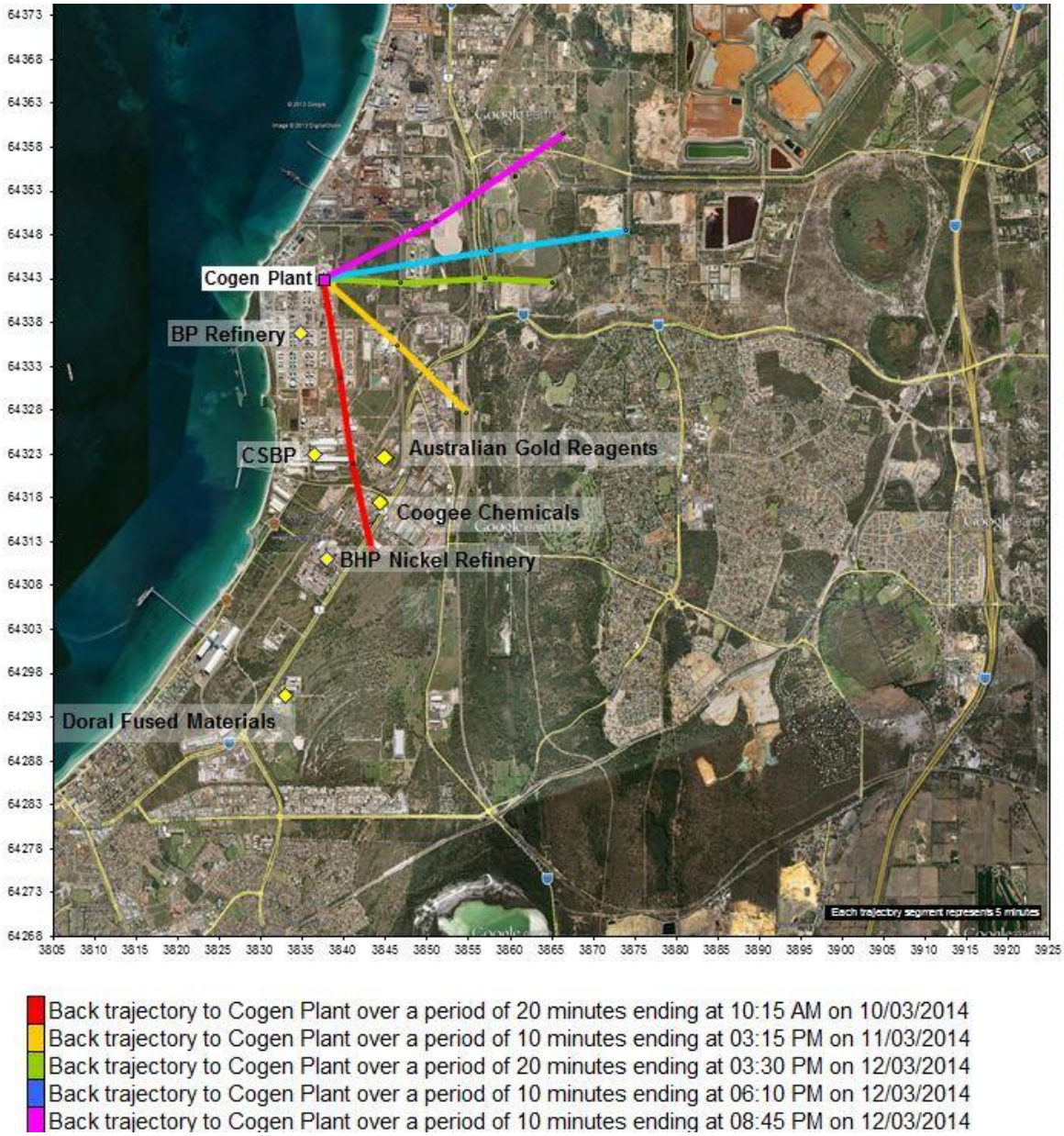
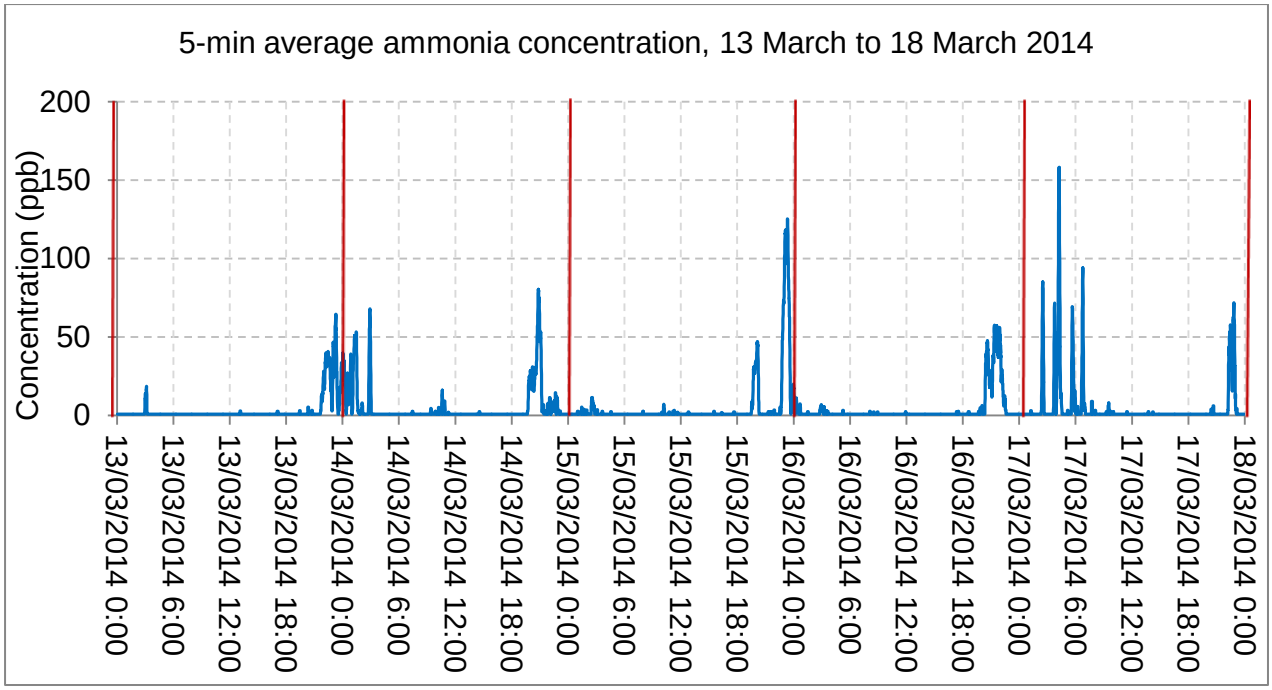


Figure 52. Back trajectories for ammonia peaks at Cogeneration Plant, 10 March to 12 March 2014



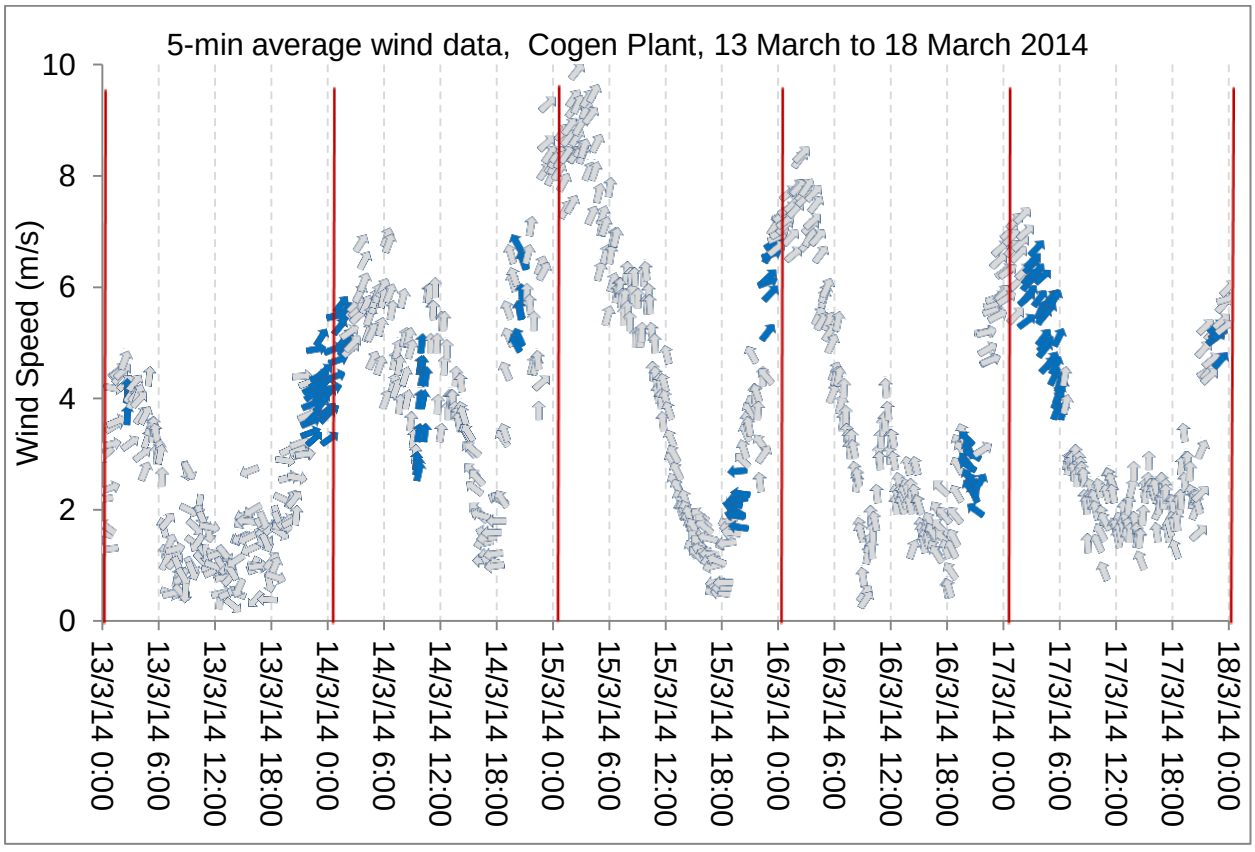


Figure 53. 5-min average for wind and ammonia concentrations between 13 March and 18 March 2014 at Cogeneration Plant

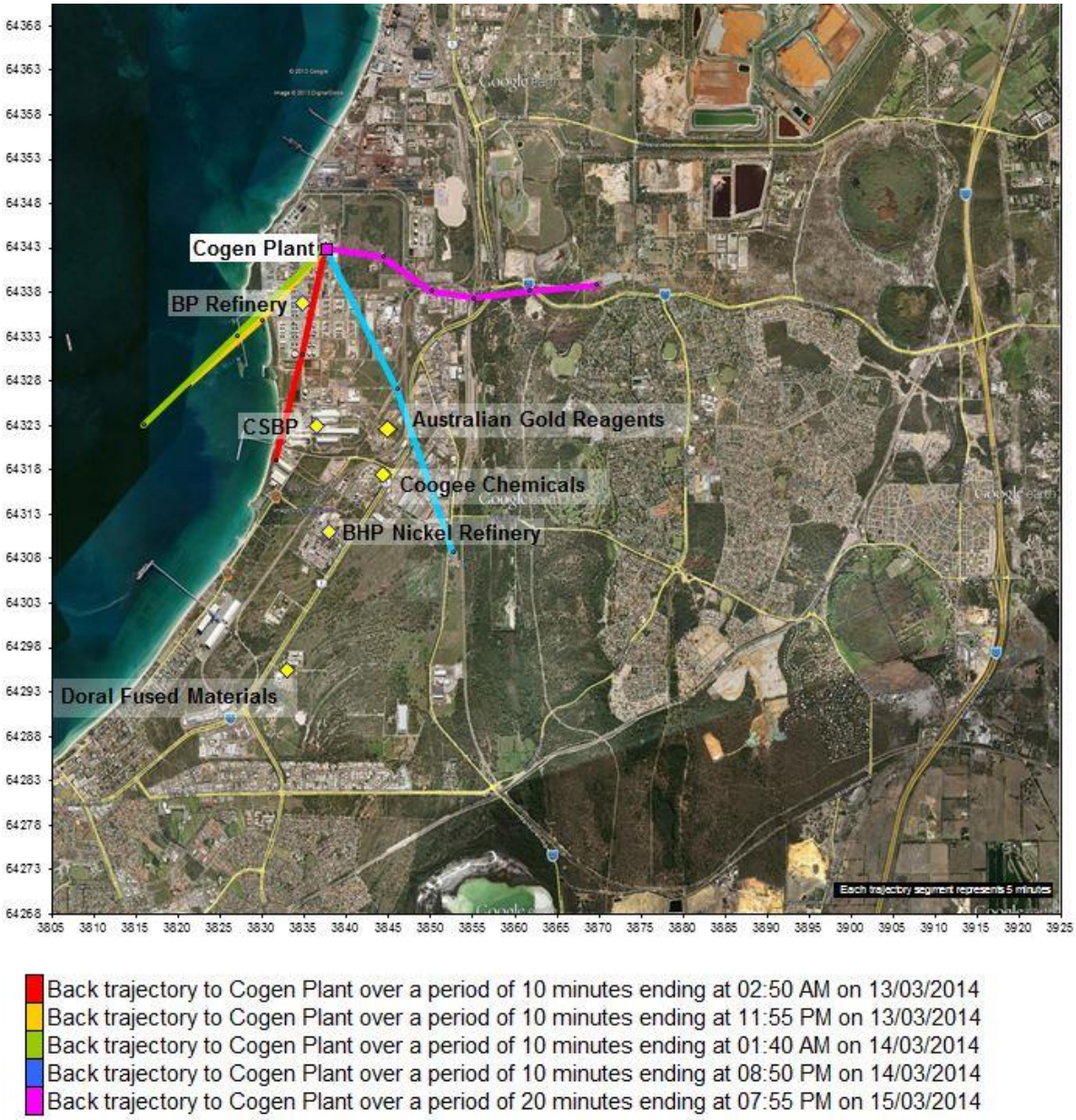


Figure 54. Back trajectories for ammonia peaks at Cogeneration Plant, 13 March to 15 March 2014

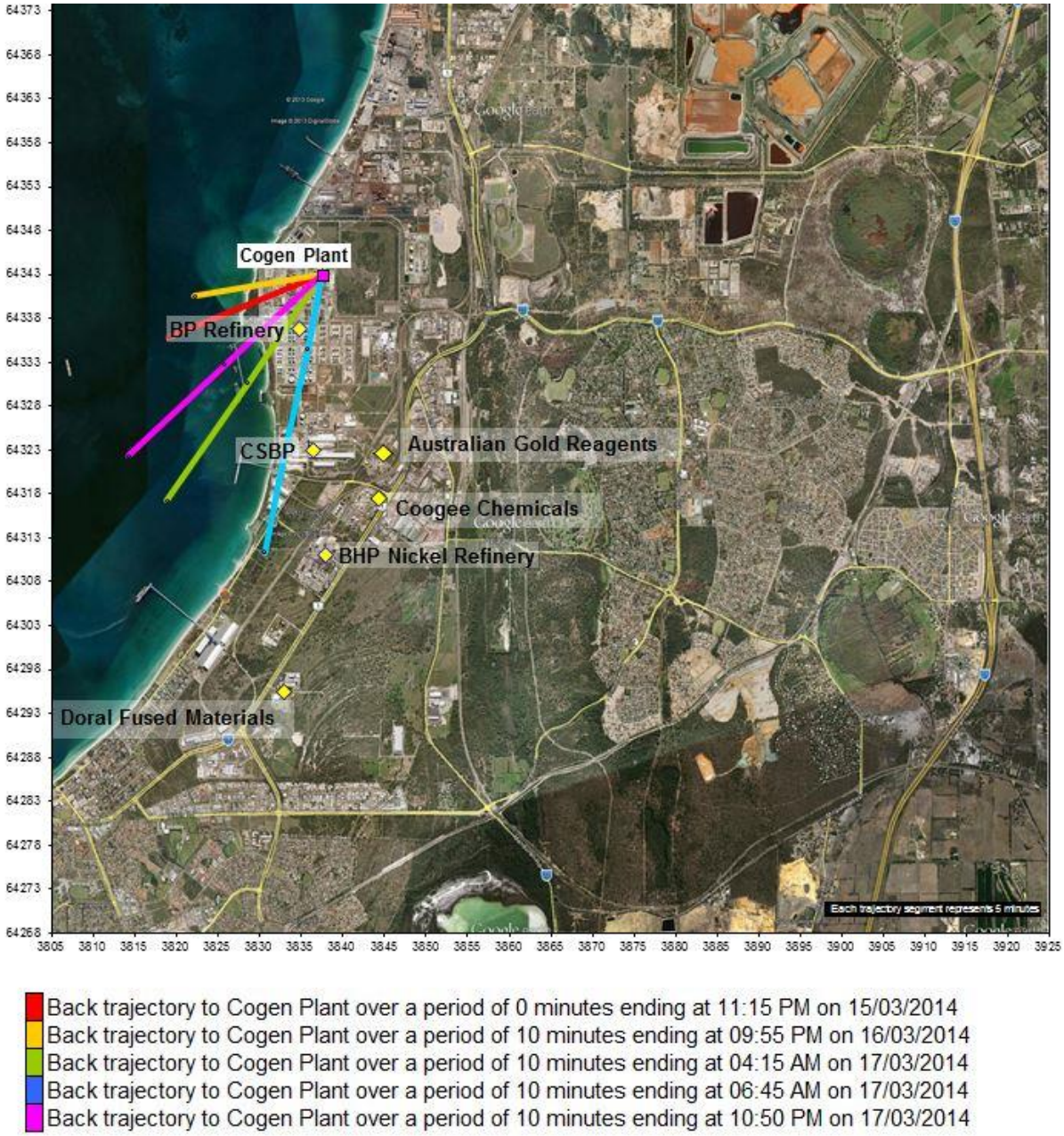
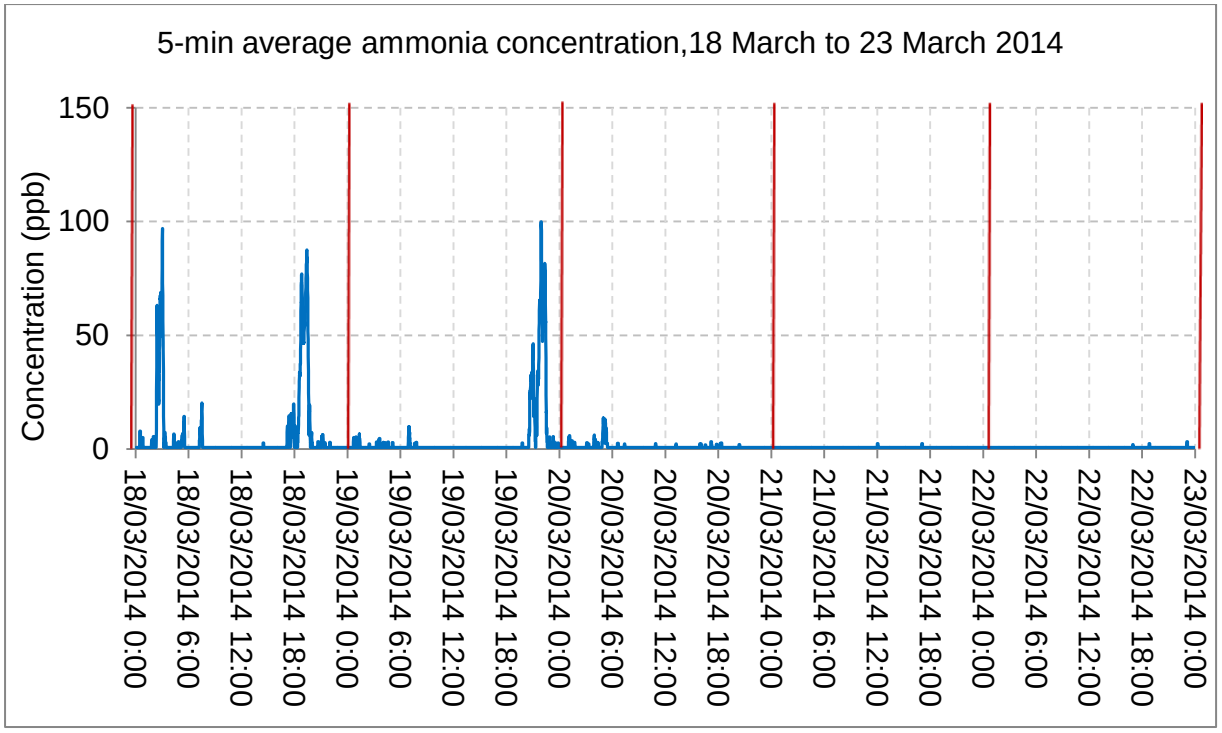


Figure 55. Back trajectories for ammonia peaks at Cogeneration Plant, 15 March to 17 March 2014



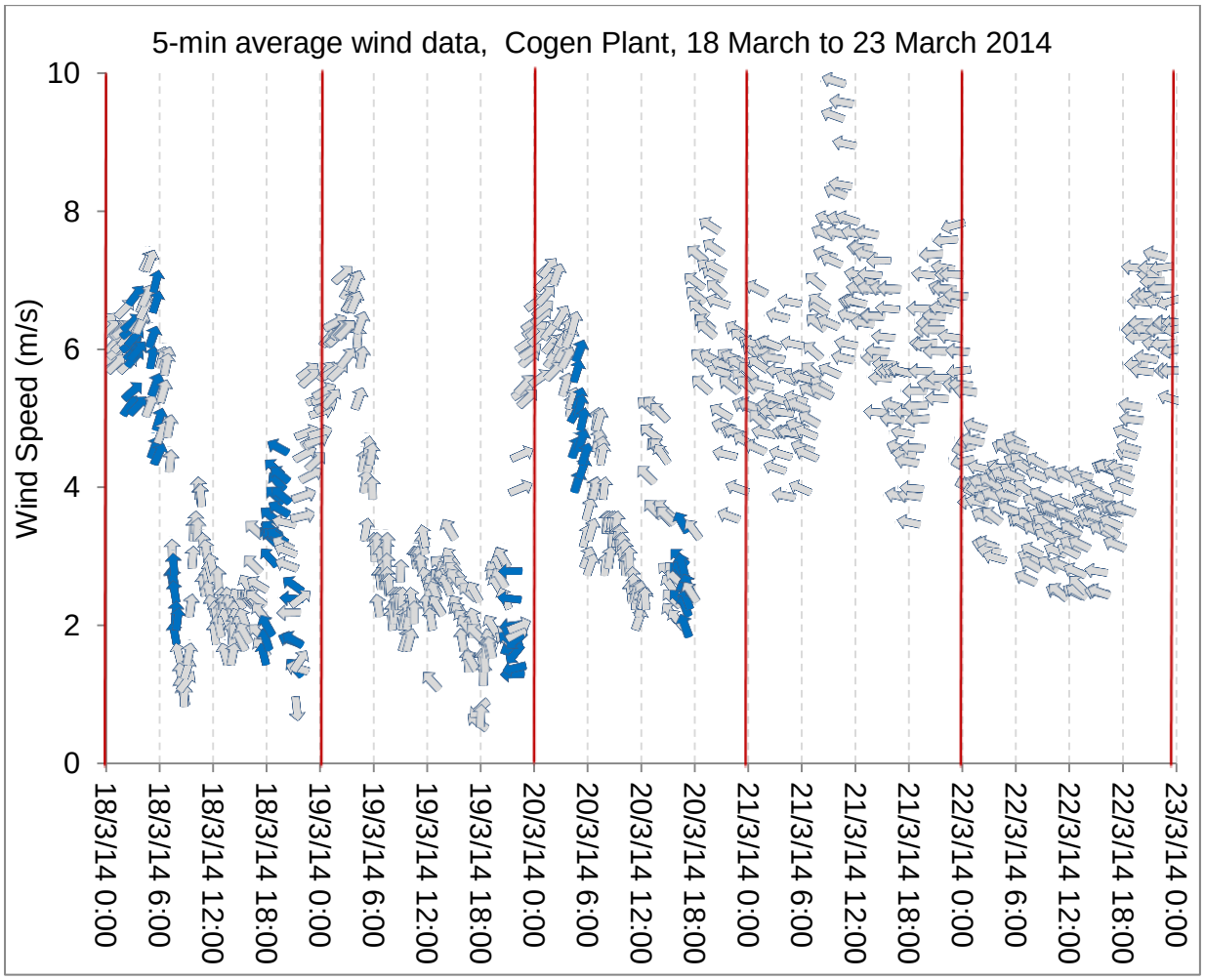


Figure 56. 5-min average for wind and ammonia concentrations between 18 March and 23 March 2014 at Cogeneration Plant

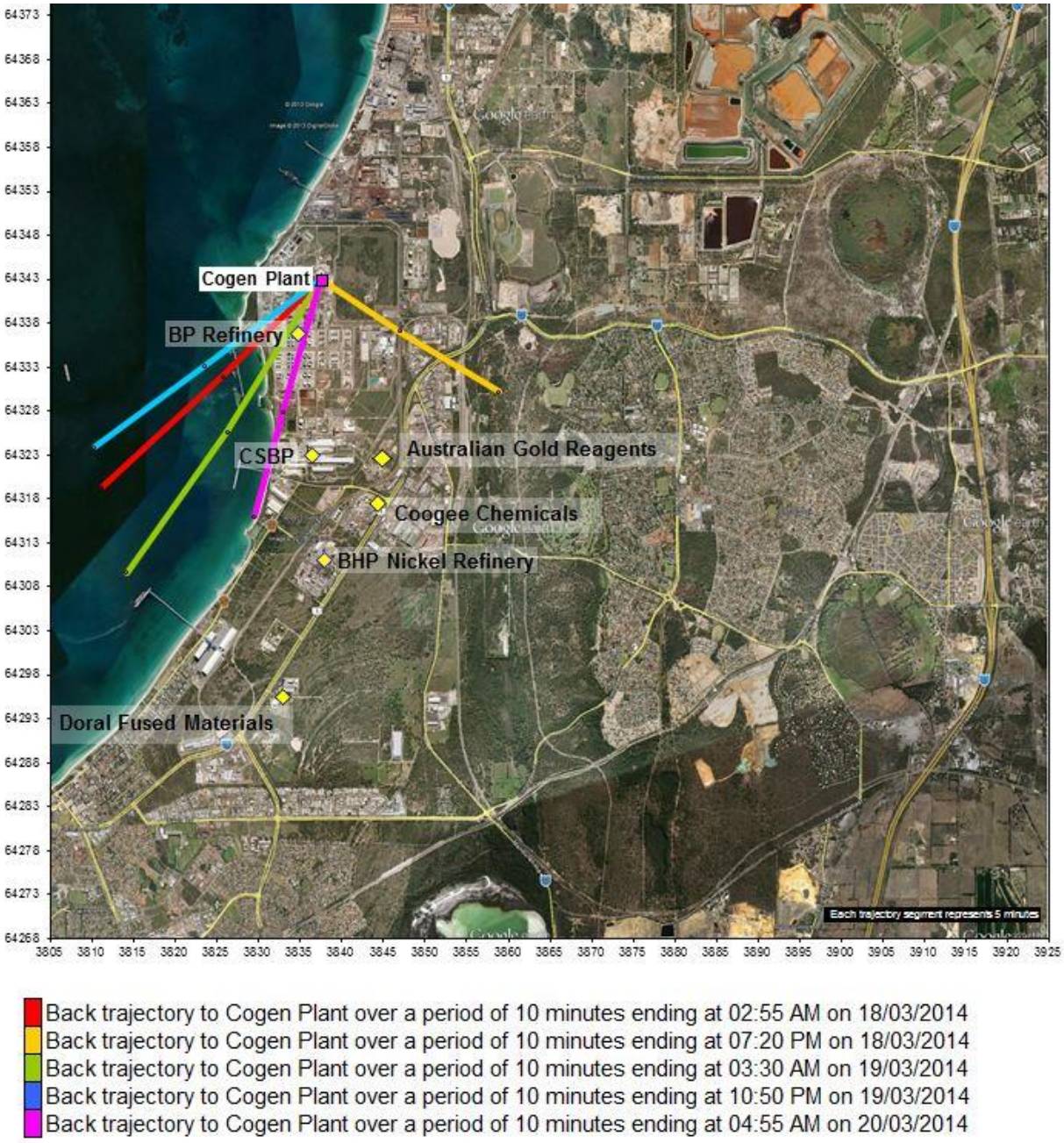
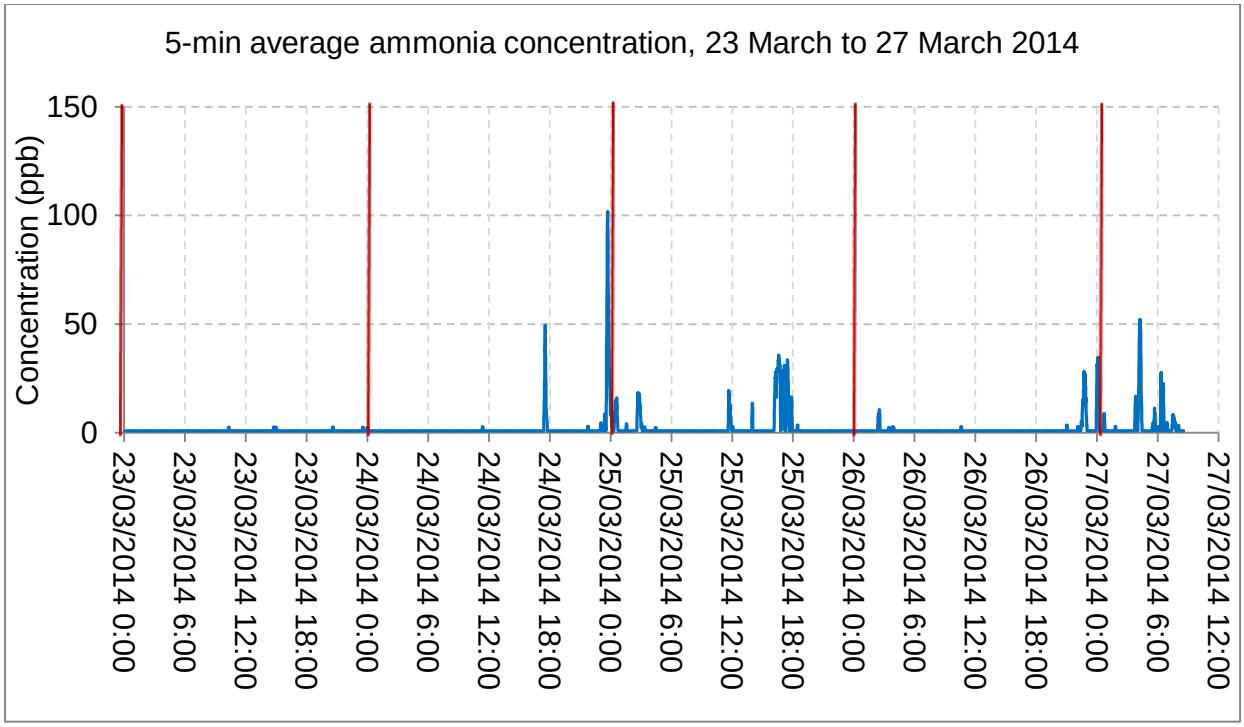


Figure 57. Back trajectories for ammonia peaks at Cogeneration Plant, 18 March to 20 March 2014



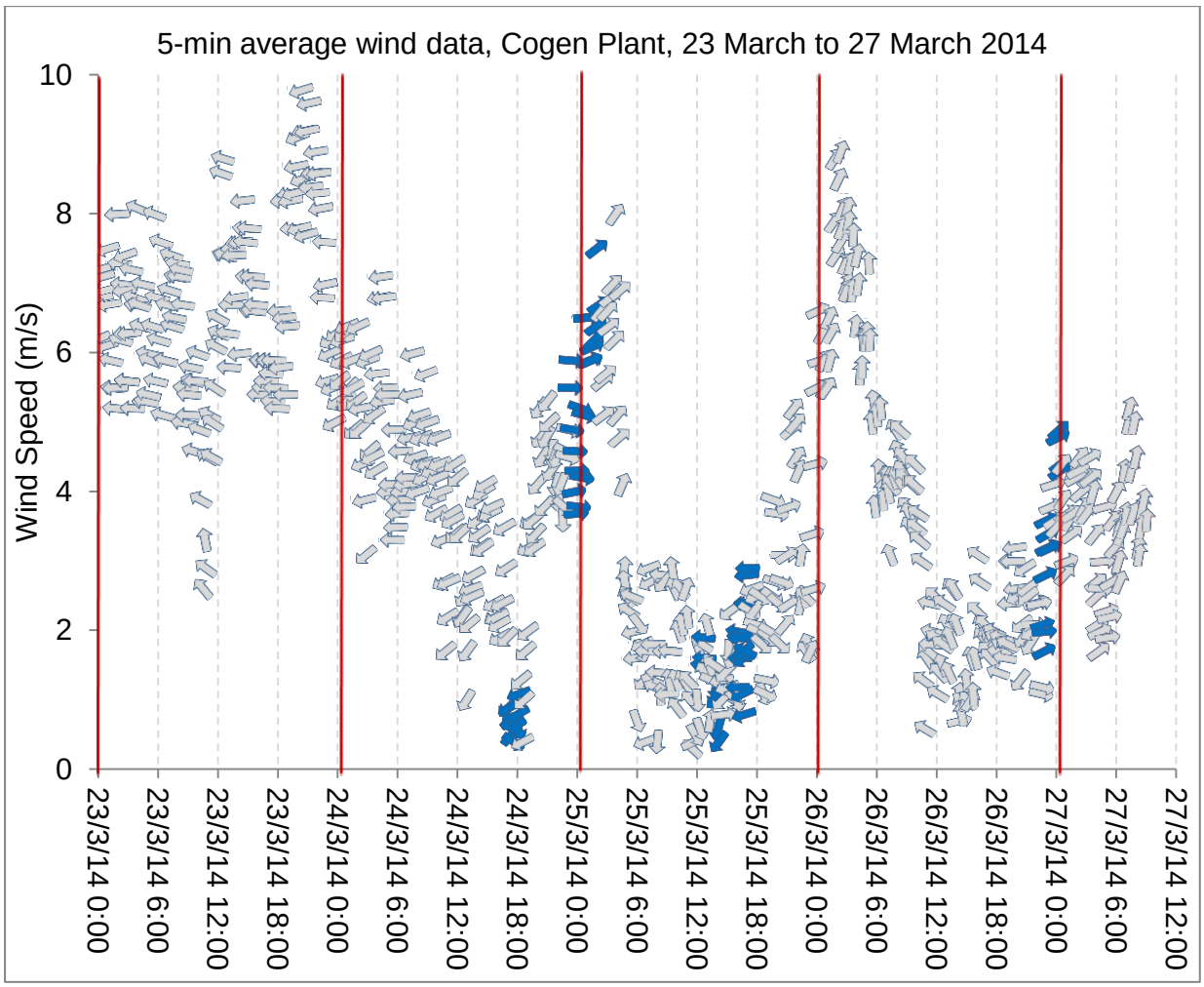


Figure 58. 5-min average for wind and ammonia concentrations between 23 March and 27 March 2014 at Cogeneration Plant

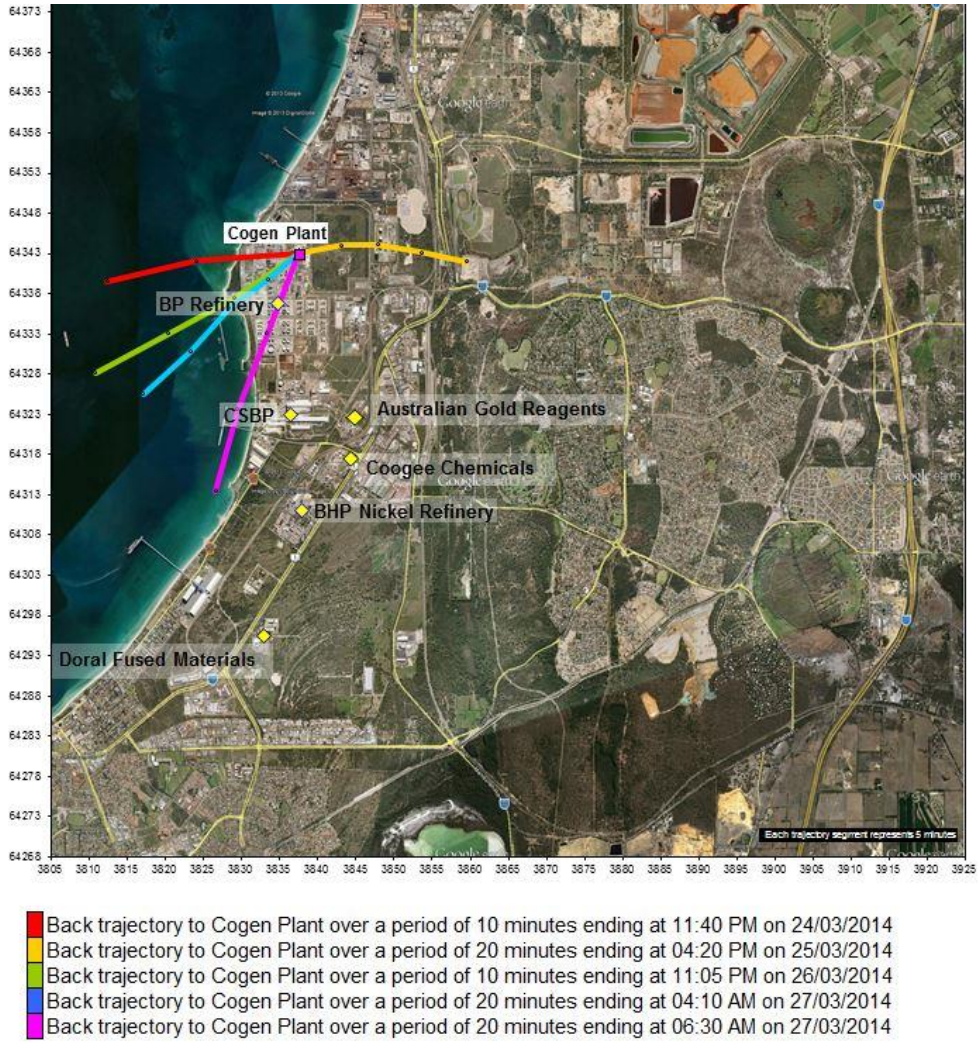


Figure 59. Back trajectories for ammonia peaks at Cogeneration Plant, 24 March to 27 March 2014

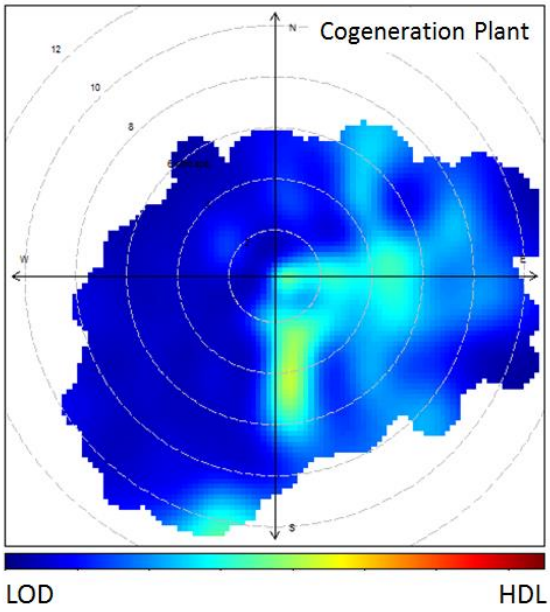


Figure 60: Polar plot for TVOCs levels at Kwinana Cogeneration Plant

4.0 Study conclusions

The OP-FTIR has proved to be an invaluable tool in detecting short-term and intermittent peaks of VOCs and ammonia at the selected ten sites in the Kwinana area. The OP-FTIR ability to take continuous sampling allowed correlation with odours and meteorological conditions with short-term readings from the instrument and consequently the capacity to derive back trajectory information for even low levels.

As shown in Table 6, a review of the data for the majority of monitoring sites located in a residential area (Area C) does not show any significant VOC or ammonia levels, with all levels below the air quality criteria. The one-month continuous monitoring also showed that while levels of ammonia and VOCs tended to increase from early evening to the early hours of the morning, they were still below the air quality criteria, with a maximum ammonia concentration of 120ppb, which is lower than levels recorded at Wells Park (170ppb) and Dixon Road Reserve (160ppb). The OP-FTIR was unable to determine total VOCs therefore polar plots were used to present TVOCs results, which are useful in identifying potential sources.

Odours were detected at six of the ten sites, with Wattleup and Beeliar Oval recording the most odour events during monitoring.

This study confirms that the major source of many of the target compounds and odours detected in the study area were from commercial and industrial activities in the KIA. Contributions from vehicle emissions at sites located close to the Kwinana Freeway were observed. This study also confirmed the results from the previous Kwinana BAQSs (phases 1 to 3) that found the levels of detected target pollutants to be low and below the air quality criteria.

Table 6. Summary of results (maximum one-hour average concentrations)

Site/compound (max)		Ammonia	Acetone	Benzene	Carbon disulfide	Ethylbenzene	Xylene	Toluene	Aldehyde
Beeliar Oval*		<LOD	43	<LOD	1.1	31	72	11	<LOD
Bertram Oval*		<LOD	31	<LOD	1.2	21	42	<LOD	<LOD
Calista Oval		20	<LOD	<LOD	<LOD	29	24	10	<LOD
Department of Agriculture		10	<LOD	<LOD	<LOD	47	52	45	47
Dixon Road Reserve *		160	260	<LOD	<LOD	33	37	13	<LOD
Medina Oval*		4.0	48	<LOD	3.3	45	22	14	<LOD
Sloan's Reserve		20	58	<LOD	<LOD	38	14	6.4	<LOD
Thomas Oval*		59	<LOD	<LOD	4.4	29	78	9.9	<LOD
Wattleup*		7.2	150	<LOD	<LOD	20	16	<LOD	<LOD
Wells Park		170	90	<LOD	4.2	32	21	6.8	<LOD
Air Quality Criteria	(1hr, ppb)	480	9300	9.0	27	1800	-	-	-
	(24hr, ppb)	-	-	-	8	-	250	1000	-
LOD		1.5	24	2.2	1.0	10	7.0	6.0	29

***Odours observed**

5.0 Glossary

AQMS	Air Quality Monitoring Station
Back trajectory	A trajectory is the path a parcel of air takes as it responds to changes in winds at different locations and times. A back trajectory indicates the recent history of a parcel of air before a given time
BAQS	Perth Background Air Quality Study
CIF	Communities and Industries Forum
Clock average	Clock hour averages are calculated by averaging data that finished at the end of each clock hour. Ten-minute clock averages are calculated by averaging data that finishes at the end of each ten-minute period
DER	Western Australian Department of Environment Regulation
DoH	Western Australian Department of Health
Heavy metals	Heavy metals are elements and therefore cannot be destroyed, nor can their properties be easily altered
KASAG	Kwinana Airshed Study Advisory Group
KIA	Kwinana Industrial Area
KIC	Kwinana Industry Council
LOD	Limit of detection – lowest concentration that can be detected but not necessarily quantified
MCT detector	Mercury Cadmium Telluride; Measurements in Kwinana phase 4 were performed by using a high sensitivity photoconductive MCT detector
Microgram (µg)	10^{-6} gram
Moving average	Moving average (rolling average or running average) is an average of time series data from several consecutive periods
NEPM	National Environment Protection Measure
NH_3	Ammonia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen - includes both NO and NO_2
NPI	The National Pollutant Inventory
OP-FTIR	Open-Path Fourier Transform Infrared Spectrometer (OP-FTIR) is an infrared-based monitoring technique for detection and quantification of multiple compounds simultaneously in industrial environments
$PM_{2.5}$	Particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres or less
PM_{10}	Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less
ppb	Parts per billion by volume (equivalent to 0.001ppm)
ppm	Parts per million by volume (equivalent to 1,000ppb)
Sigma (σ)	Standard deviation
TO-16	USEPA Compendium Method TO-16 Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric Gases
VOC	Volatile organic compounds (VOCs) include a very large group of compounds that readily evaporate and remain in the air as gases at normal ambient temperatures.

Wind rose	The wind rose correlates wind direction data with wind speed. The length of the line corresponds to the frequency of readings in that direction, while the line thickness corresponds to the magnitude of the speed value

6.0 References

Christian T. J., Kleiss B., Yokelson R. J., Holzinger R., Crutzen P. J., Hao W. M., Shirai T., and Blake D. R., 2004 "*Comprehensive laboratory measurements of biomass-burning emissions: 2. First intercomparison of open-path FTIR, PTR-MS, and GC-MS//FID//ECD*" Journal Of Geophysical Research, VOL. 109, D02311, doi:10.1029/2003JD003874, 2004

Department of Environment Regulation, 2015, "2011-12 *Midland background air quality study*", March 2015.

Department of Environment and Conservation, 2011, "*Background air quality monitoring in Kwinana – 2005-10*", December 2011.

NMED Report, 2004 "*Corrales Environmental Health Evaluation Community Process Summary Report*", the New Mexico Environment Department (NMED), June 2004

NATA Technical Report, 2013, "*Guidelines for the validation and verification of quantitative and qualitative test methods*" NATA Technical Note 17, October 2013

Open-Path Monitoring Guidance, Third Edition, 1999, TR-4423-99-03, June 1999

Pasadakis N, Livanos G, Zervakis M, *"Deconvolving the absorbance of methyl and methylene groups in the FT-IR 3000-2800 cm^{-1} band of petroleum fractions"*, Trends in Applied Spectroscopy, Vol.10 25-35, 2013.

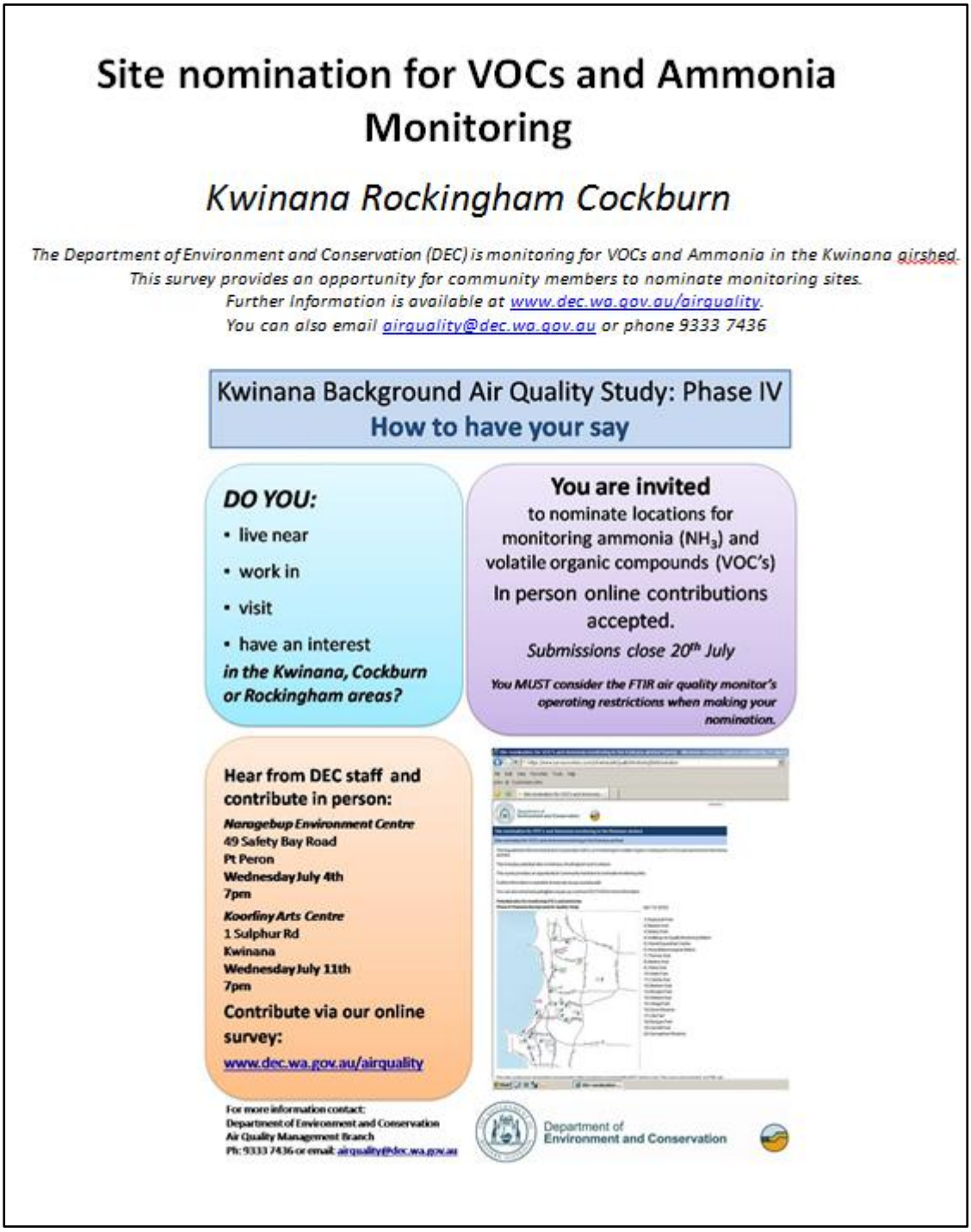
US-EPA TO-16 Report, 1999, *"Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric Gases"*, Compendium Method TO-16, Second Edition, EPA/625/R-96/010b

USEPA QA Handbook, 1994, *Quality Assurance Handbook for Air Pollution Measurement Systems*, U. S. Environmental Protection Agency, USEPA-600/R-94-038b, May 1994.

7.0 Appendices

Appendix A: Kwinana BAQS Phase 4 site selection documents

Survey



Site nomination for VOCs and Ammonia Monitoring

Kwinana Rockingham Cockburn

The Department of Environment and Conservation (DEC) is monitoring for VOCs and Ammonia in the Kwinana airshed. This survey provides an opportunity for community members to nominate monitoring sites. Further Information is available at www.dec.wa.gov.au/airquality. You can also email airquality@dec.wa.gov.au or phone 9333 7436

Kwinana Background Air Quality Study: Phase IV
How to have your say

DO YOU:

- live near
- work in
- visit
- have an interest

in the Kwinana, Cockburn or Rockingham areas?

You are invited
to nominate locations for monitoring ammonia (NH_3) and volatile organic compounds (VOC's)
In person online contributions accepted.
Submissions close 20th July
You MUST consider the FTIR air quality monitor's operating restrictions when making your nomination.

Hear from DEC staff and contribute in person:

Naragebup Environment Centre
49 Safety Bay Road
Pt Peron
Wednesday July 4th
7pm

Koorliny Arts Centre
1 Sulphur Rd
Kwinana
Wednesday July 11th
7pm

Contribute via our online survey:
www.dec.wa.gov.au/airquality

For more information contact:
Department of Environment and Conservation
Air Quality Management Branch
Ph: 9333 7436 or email: airquality@dec.wa.gov.au

Department of Environment and Conservation

The sites on the map all meet the requirements for the monitoring equipment that DEC will be using.

This piece of equipment, an FTIR, will detect short term fluctuations in VOCs and ammonia levels, such as those that could create odours.

Use the grid on the following page to nominate your top five (5) sites for VOCs and ammonia monitoring

1. Rank your top five (5) preferred sites for VOCs and ammonia monitoring.
Refer to the map on page 2 for the location of each potential site.

Monitoring Site	1st preference	2nd preference	3rd preference	4th preference	5th preference
1) Radonich Park	☐	☐	☐	☐	☐
2) Beeliar Oval	☐	☐	☐	☐	☐
3) Botany Park	☐	☐	☐	☐	☐
4) Wattleup Air Quality Monitoring Station	☐	☐	☐	☐	☐
5) Wandi Equestrian Centre	☐	☐	☐	☐	☐
6) Alcoa Meteorological Station	☐	☐	☐	☐	☐
7) Thomas Oval	☐	☐	☐	☐	☐
8) Medina Oval	☐	☐	☐	☐	☐
9) Orelia Oval	☐	☐	☐	☐	☐
10) Wells Park	☐	☐	☐	☐	☐
11) Calista Oval	☐	☐	☐	☐	☐
12) Bertram Oval	☐	☐	☐	☐	☐
13) Rhodes Park	☐	☐	☐	☐	☐
14) Wellard Oval	☐	☐	☐	☐	☐
15) Village Park	☐	☐	☐	☐	☐
16) Dixon Reserve	☐	☐	☐	☐	☐
17) City Park	☐	☐	☐	☐	☐
18) Bungary Park	☐	☐	☐	☐	☐
19) Garnett Oval	☐	☐	☐	☐	☐
20) Georgetown Reserve	☐	☐	☐	☐	☐

2. Would you like to nominate an additional site for monitoring? *Yes* ☐ *No* ☐

3. Name your nominated site and provide site contact details if relevant.

Site Name:

Site Address:

Site Contact:

4. Which of the following criteria does your site meet?

- ☐ Access to 240V power
- ☐ A clear open path of 60 – 100m
- ☐ Vehicular access available from 7.30am
- ☐ Proximity to Kwinana Industrial Area
- ☐ Catches prevailing winds from Kwinana Industrial Area
- ☐ FTIR light source can be directed away from housing and roads to minimise safety risk

5. Is this site located on private property *Yes* ☐ *No* ☐

6. Can permission to use this site be gained? *Yes* ☐ *No* ☐ *I don't know* ☐

The Department of Environment and Conservation (DEC) would like to keep community members who have nominated sites up to date on air quality monitoring in the Kwinana Region

7. Please provide contact details if you would like to receive updates.

Name:

Email:

Postal address:

Promotional flyer (brochure)

Community consultation

All community members are invited.

Hear about the study from Department of Environment and Conservation staff.

Community members can then nominate sites for monitoring ammonia and VOCs.

Please RSVP for catering purposes

WEDNESDAY 4 JULY
7PM
Naragebup Environment Centre

or

WEDNESDAY 11 JULY
7PM
Koorliny Arts Centre

Can't make it?

Nominate sites using our online survey.
airquality@dec.wa.gov.au
Submission close 20 July 2012

Department of Environment and Conservation

To RSVP for community meetings or find out more please contact
airquality@dec.wa.gov.au
phone 9333 7436

To nominate sites using our online survey go to:
www.dec.wa.gov.au/airquality
Submissions close 20 July 2012

DO YOU **have an interest in air quality *in the Kwinana, Cockburn and Rockingham area?***

You are invited to nominate locations for air quality monitoring, in person or online.

Kwinana Background Air Quality Study Phase IV

Department of Environment and Conservation

Phase IV monitoring will identify short term trends of:

- ammonia (NH_3)
- selected volatile organic compounds (VOCs)

Ammonia was monitored during
2005 – 06 (6 day averages).
2007 – 08 (7 day averages).

VOCs were monitored during
2005- 06 (24hr and 6 day averages).
2007- 08 (7 day averages).

Kwinana Background Air Quality Study

Phase IV monitoring will be undertaken:

- at 10 community nominated sites *(see map, left)*
- up to 100 days over 12 months
- weekly, dependent on weather conditions.

Phase IV monitoring will use:

- Open-Path Fourier Transform Infra-Red (FTIR)
- 30-second averaging periods
- over a distance of 60 to 100 metres.

FTIR air quality monitor

Some ideas to consider when nominating sites

- Close to a place where you have noticed smells
- Away from major roads
- Close to where people live or recreate
- Downwind from a potential pollution source
- Meets operating criteria of the FTIR

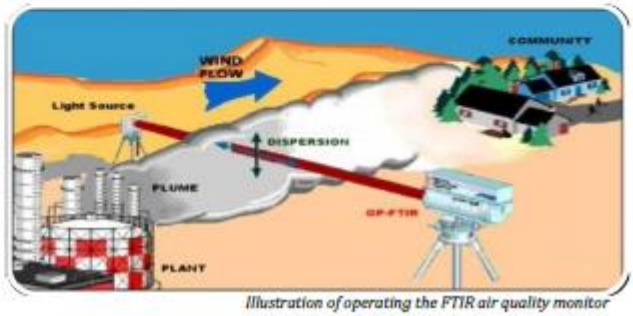


Illustration of operating the FTIR air quality monitor

Poster

Monitoring air quality with Fourier Transform Infra Red Spectroscopy

What is an FTIR?

The FTIR has 2 parts, the light source and the detector.

These parts are set up hundreds of meters apart (pathway)and concentrations of pollutants are averaged along the light beam.

The concentration of a pollutant is determined using a mathematical calculation (fourier transformation).

How does it work?

The FTIR collects continuous data over a pathway (rather than a single point).

Virtually all chemicals absorb infrared energy. The FTIR light source produces infrared energy which moves through the pathway.
Gases that are present absorb the infrared energy and are measured by the detector.

The detector sends this information to a computer where it is plotted on a graph.

Benefit: The FTIR averages air quality readings over 30 second intervals. Other monitoring equipment which averages over longer periods, such as 7 days, are not as useful at detecting short periods poor air quality.

Interpreting data

Information on the absorption of infrared energy by all substances in the air is collected by the detector.

A highly skilled professional is needed to interpret how much of a particular substance absorbed the infrared energy.

For more information contact:
Department of Environment and Conservation
Air Quality Management Branch
Ph: 93337436 or Email: airquality@dec.wa.gov.au

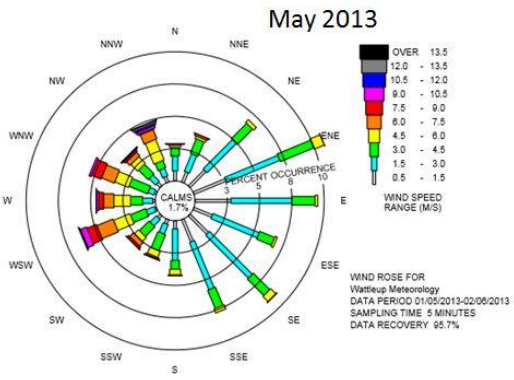
Department of
Environment and Conservation

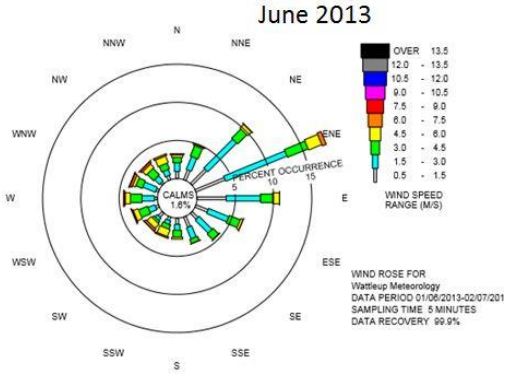
Appendix B: OP-FTIR field deployment request form

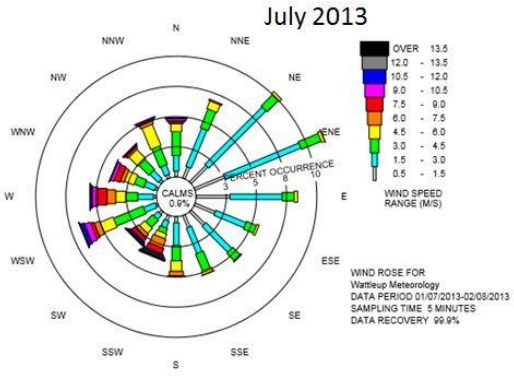
FTIR monitoring for Tuesday, 14 October 2014	
Recommended Sites	
Main Monitoring Site	Medina Oval
Backup Monitoring Site	Department of Agriculture
Purpose of Deployment	Sampling
Forecast	
Weather Forecast	Sunny
Wind Direction	NE in the morning and SW the afternoon
Wind Speed	Light wind
Chance of Rain	0%
Information Source	http //www.willyweather.com.au/wa/perth/kwinana.html http://www.wunderground.com/global/stations/94610.html?MR=1
FTIR Set Up	
Path Length (m)	80m or closest possible
Path Orientation	Around N-S
Warm-up Duration	At least 30 min
Parameters for FTIR Software	
Temperature (°C)	27
Pressure (atm)	1.025
Peak-to-peak (counts)	The highest possible
Spectral Resolution (cm^{-1})	1
Number of scans	64
Gain	1
Spectral Region (cm^{-1})	600-4500
Number of Background Sample	One before and one after monitoring
Background Resolution (cm^{-1})	1 (this should be always identical to *"Spectral Resolution"*)
Calibration Parameters	
Spike Gases	carbon monoxide, nitrogen oxides and sulfur dioxide
Gas Outlet Pressure	10 psi
Gas release duration	5 min
Canisters	
DoH Canisters	6 X one-hour canisters
DEC Canisters	instant cracking at any odour events with intensity of 4+
Location of Canister Sampling	DoH canisters: preferably in the middle of the path DEC canisters: any part of the path but as quick as possible
Additional Sampling Device	
ppbRAE	Not available
DNPH Tubes	Will be used every hours + one blank
Attending Staff	

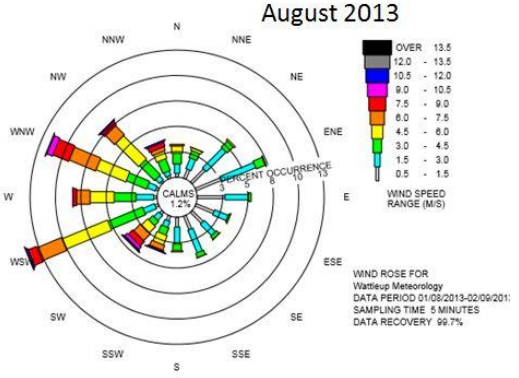
Appendix C: Windroses for the BAQS Phase 4

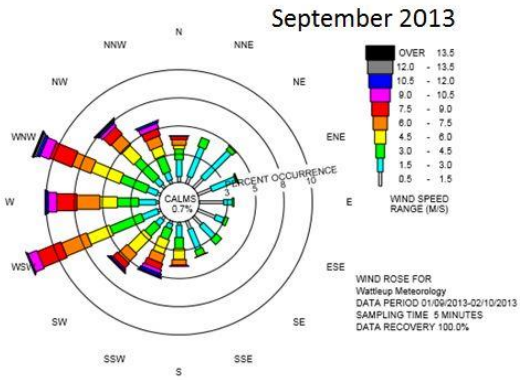
The length of the line corresponds to the frequency of readings in that direction, while the line thickness corresponds to the magnitude of the speed value.

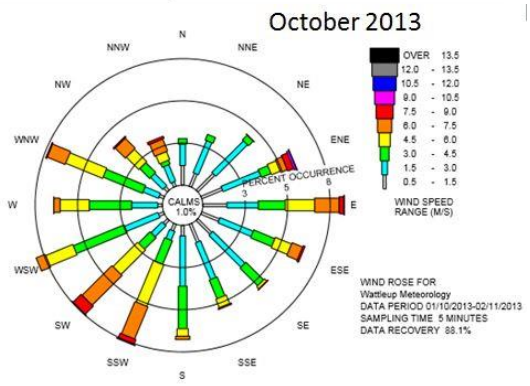


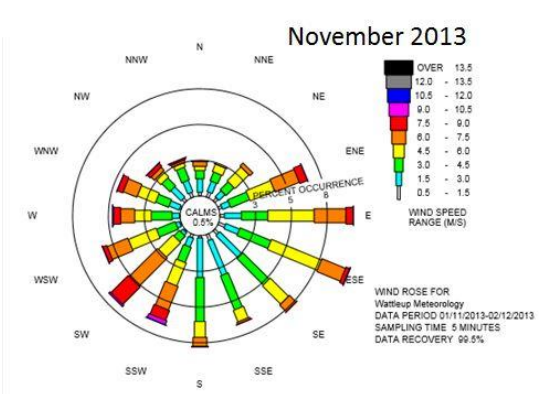


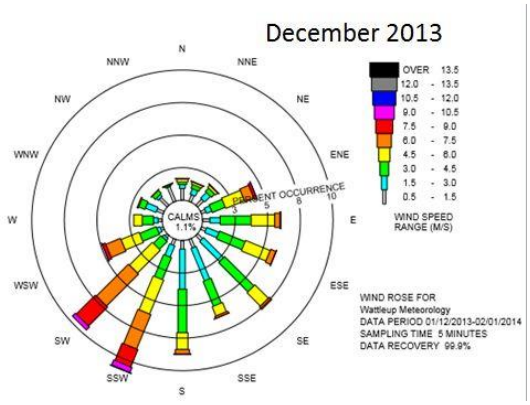


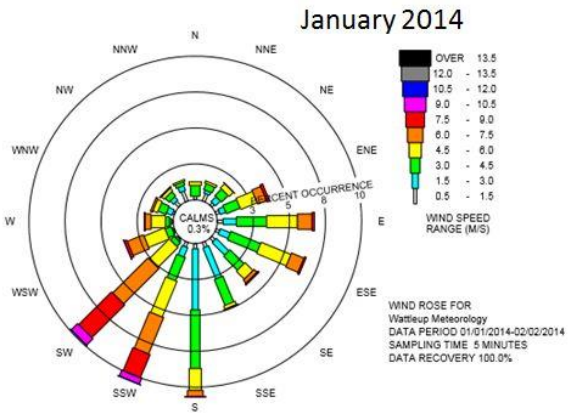


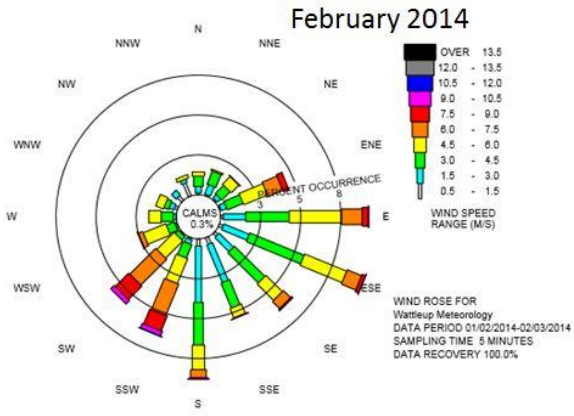


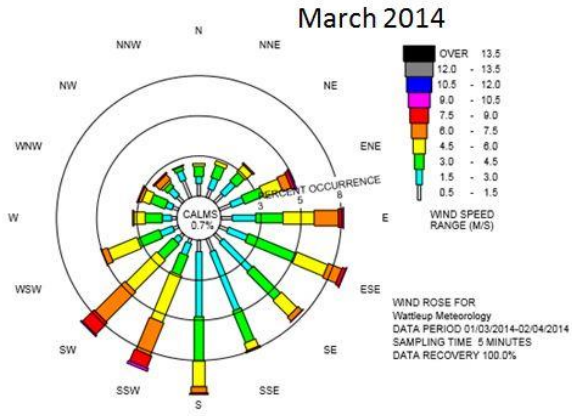


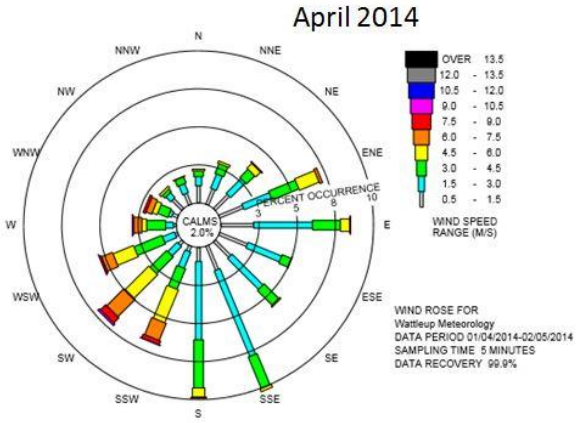


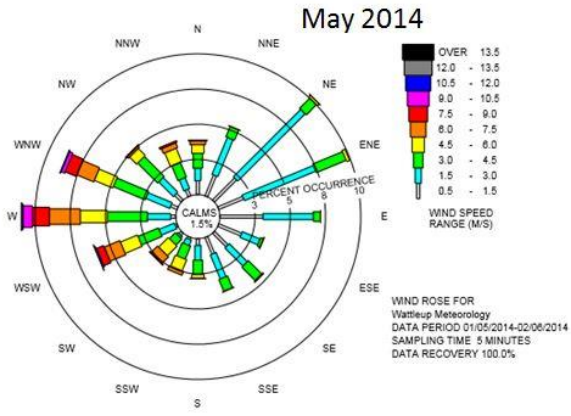


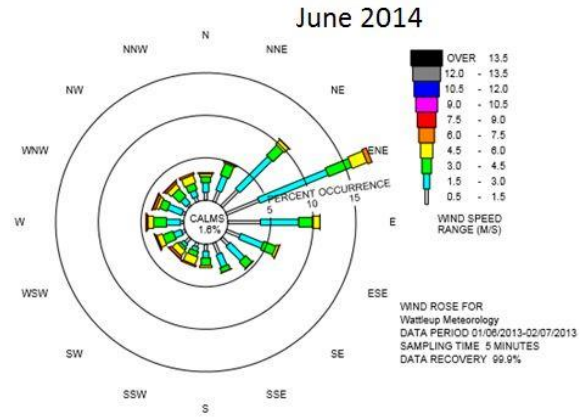

January 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
0.3%
PERCENT OCCURRENCE
3
5
8
10
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/01/2014-02/02/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%

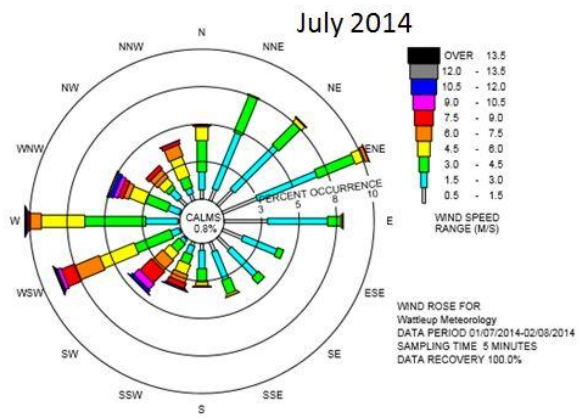

February 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
0.3%
PERCENT OCCURRENCE
3
5
8
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/02/2014-02/03/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%

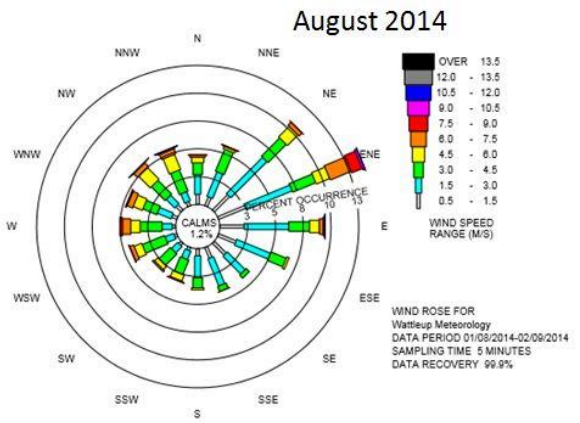

March 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
0.7%
PERCENT OCCURRENCE
3
5
8
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/03/2014-02/04/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%

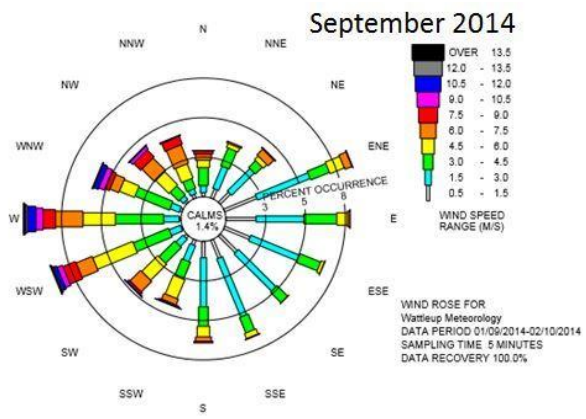

April 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
2.0%
PERCENT OCCURRENCE
3
5
8
10
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/04/2014-02/05/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 99.9%

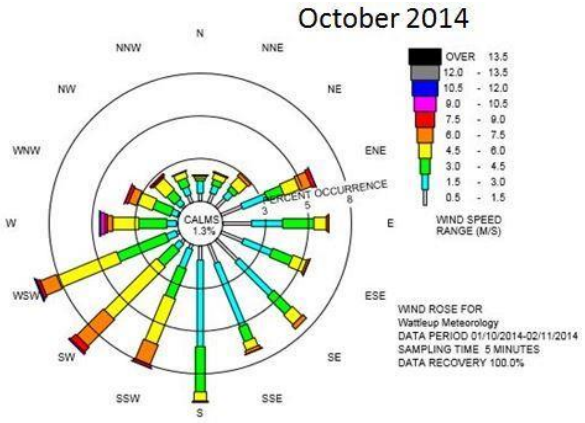

May 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
1.5%
PERCENT OCCURRENCE
3
5
8
10
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/05/2014-02/06/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%


June 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
1.6%
PERCENT OCCURRENCE
5
10
15
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/06/2013-02/07/2013
SAMPLING TIME 5 MINUTES
DATA RECOVERY 99.9%


July 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
0.8%
PERCENT OCCURRENCE
3
5
8
10
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/07/2014-02/08/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%


August 2014
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
CALMS
1.2%
PERCENT OCCURRENCE
3
5
8
10
13
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/08/2014-02/09/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 99.9%


September 2014
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
PERCENT OCCURRENCE
3
5
8
CALMS
1.4%
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/09/2014-02/10/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%


October 2014
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
PERCENT OCCURRENCE
3
5
8
CALMS
1.3%
OVER 13.5
12.0 - 13.5
10.5 - 12.0
9.0 - 10.5
7.5 - 9.0
6.0 - 7.5
4.5 - 6.0
3.0 - 4.5
1.5 - 3.0
0.5 - 1.5
WIND SPEED
RANGE (M/S)
WIND ROSE FOR
Wattleup Meteorology
DATA PERIOD 01/10/2014-02/11/2014
SAMPLING TIME 5 MINUTES
DATA RECOVERY 100.0%

Appendix D: OP-FTIR field deployment checklist

Checklist for FTIR Deployment in the Field

This form should be completed on site for the duration of field FTIR monitoring and attached to any supplementary forms

Site Name and Location:
Completed by: **Date:**

Remarks	CONTROLS (tick as appropriate)	INITIAL
Before Deployment	❑ Appropriate safety gears are used and correct manual handling techniques are performed when moving equipment ❑ Power is connected and all trailing cords are isolated with cones ❑ Weather station is installed correctly and it is operating ❑ All parameters checked within software package ❑ Scanning (Resolution is $1cm^{-1}$, scanning number 64 for sampling and 256 for background ❑ Method (Open-Path is selected) ❑ Cells (enter the values for path-length, pressure and temperature) ❑ Highest peak-to-peak value is achieved ❑ Background sampling is performed ❑ Spike gas calibration is undertaken ❑ FTIR is operating well (no additional noise, no unusual occurrence on PC display such as noisy spectral, high negative or positive values and etc. ❑ All parallel samplers are in place and start sampling with FTIR	
During Sampling	❑ FTIR field record sheet is field out carefully ❑ W-S, W-D, P, T, R/H and cloudiness are updated hourly ❑ Canisters, DNPH tubes and other sampling are performed promptly ❑ All observations are recorded (anybody crosses the path, vehicles parked nearby, fire, any activity and etc.) ❑ All odour incidences are recorded with exact time, type of odour and odour intensities	
End of Sampling	❑ Spike gas calibration is undertaken ❑ Background sampling is performed ❑ Ensure all data are saved and placed in the right folder	

Appendix E: OP-FTIR field record data sheet

FTIR Field Record Data Sheets

Detector Coordinate:	Date:
Source Coordinate:	Arrival time:
Site Description and Remarks:	

FTIR deployment

Purpose of deployment:	Spectral Region (cm⁻¹):
Path Length (m):	No of Scans:
Path Orientation:	Temperature :(°C)
Warm-up Duration:	Pressure (atm):
Peak-to-Peak Start: End:	Gain:

Background Sample			**Weather**	
Pre	Start	End	☐ Calm	☐
Post (b)	Start	End	☐ Breeze	☐

Spike Calibration Spike Gas:	P_{out} (psi):		**Sky**	
Pre	Start	End	☐ Clear Sky	☐ Overcast
Post (b)	Start	End	☐ Partly Cloudy	☐ Hazy

Parallel Sampling

Canisters

	Canister Serial #	Canister Pressure Start ("Hg)	Canister Pressure End ("Hg)	Start Time	End Time
DOH - 1st hour					
DOH - 2nd hour					
DOH - 3rd hour					
DOH - 4th hour					
DOH - 5th hour					
DOH - 6th hour					
DEC Can 1					
DEC Can 2					
DEC Can 3					
DEC Can 4					
DEC Can 3					
DEC Can 4					

Location of Canisters: ☐ Detector Side ☐ Middle of Path ☐ IR Source Side

ppbRAE

Start Time End Time

Location of ppbRAE: ☐ Detector Side ☐ Middle of Path ☐ IR Source Side ☐ Outside of Path

Remarks:

Additional Sampling Device

Device Name: Start Time End Time

Location of Device: ☐ Detector Side ☐ Middle of Path ☐ IR Source Side ☐ Outside of Path

Remarks:

Observations at the sampling point:

	Odour Events (#) denotes intensity	W-D	W-S	T	P	RH	Cloud (%)
Start							
1st hour							
2nd hour							
3rd hour							
4th hour							
5th hour							
6th hour							

Officer Name **Signature** **Date**

Appendix F: Odour events observed during the BAQS Phase 4

Site	Date: Time	Odour intensity	Odour type	Possible source
Beeliar Oval	2 Oct 2013: 12:48 13:00 13:20 14:00 14:40	Distinct Strong Strong Weak-Strong Strong	Transient cement	KIA
	6 Nov 2013: 11:57 12:00	Strong Strong	Cement	KIA
	25 Nov 2013: 12:01 12:03 12:44 13:25 14:41	Very Strong Strong Strong Distinct Strong	Cement/brickworks	KIA
	3 Dec 2013: 11:34 12:03 12:20 14:46	Distinct-Strong Strong Very Strong Weak-Distinct	Cement	KIA
	18 Sep 2014: 10:41 11:01 11:19	Distinct Distinct Distinct	Cement	KIA
Medina Oval	15 Jan 2014: 11:41	Distinct	Continuous burning rubber	KIA/Local
Thomas Oval	9 April 2014: 11:59 14:04	Distinct Strong	Wet Cement	KIA
Bertram Oval	2 Oct 2014: 11:59 14:04	Distinct Strong	Cement	KIA
Dixon Road Reserve	20 June 2013: 09:19 10:55	Distinct Distinct	Coffee	Local (Coffee Roasters)
	29 April 2014: 09:18 09:40	Distinct Distinct	Coffee	Local (Coffee Roasters)
	24 June 2014: 09:00	Distinct-Strong	Coffee	Local (Coffee Roasters)

Site	Date: Time	Odour intensity	Odour type	Possible source
Wattleup	31 Oct 2013: 12:07	Weak-Distinct	Cement	KIA
	12:16	Strong		
	12:39	Strong		
	13:33	Strong		
	12 Dec 2013: 11:53	Distinct	Cement	KIA
	12:09	Distinct		
	12:15	Strong		
	12:18	Distinct-Strong		
	12:24	Strong		
	12:35	Strong		
	12:55	Strong		
	13:00-15:00	Transient		
	18 Dec 2013: 12:42	Strong	Wet cement	KIA
	12:50	Strong		
	12:59	Distinct-Strong		
	13:03	Very strong		
	13:54	Strong		
	14:00-15:00	Weak, transient		
	7 Jan 2014: 9:00-9:30	Weak, transient	Cement	KIA
	9:30	Very strong		
	9:59	Very strong		
	10:00-11:30	Weak, transient		
	11:30	Strong		
	12:00-15:00	Weak, transient		
	12:27	Very strong		
	14:35	Very strong		
	14 Jan 2014: 10:05	Distinct-Strong	Wet cement	KIA
	10:21	Strong		
	10:34	Very strong		
	10:54	Distinct-Strong		
	11:00-12:00	Weak, transient		
	12:13	Very strong		
	12:17	Very strong		
	12:29	Strong		
	12:54	Strong		
	13:32	Strong		
	13:32-14:12	Weak, transient		
	14:12	Strong		
	14:34	Strong		

Appendix G: Short-term VOCs peaks and potential sources

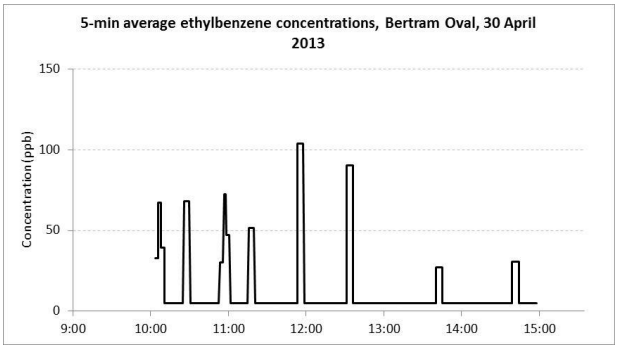
Introduction

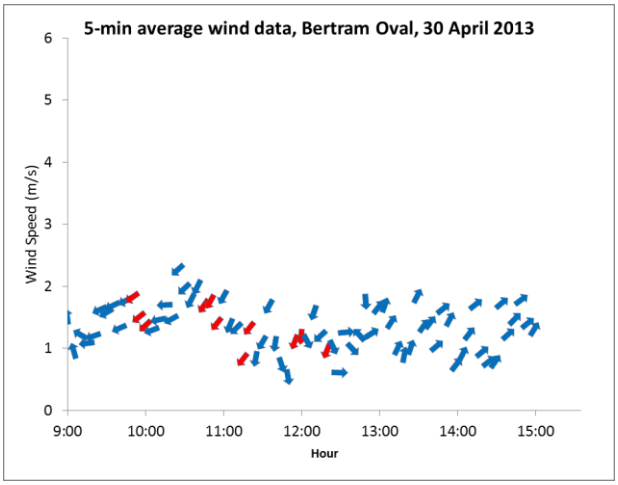
The following pages contain information specific to short-term VOCs peaks measured by the OP-FTIR during the project. Each analysis is provided in date order and includes a back trajectory, concentration and wind plots together with information on the highest concentrations reached and possible sources.

Each days back trajectory is specific to one event and shows a possible path that a parcel of air may have taken through space to have arrived at a particular location at a certain time. It does no more than use the wind speed and direction information recorded at the particular monitoring site to track a simple path backwards to a possible origin site. Some major assumptions made in the calculation of these back trajectories, such as the meteorological conditions remain the same over the entire region and no air dispersion throughout the path, create large uncertainties in the predicted path and must be acknowledged. Notwithstanding, the back trajectories as calculated provide a reasonable first approximation for the possible path taken by an air parcel in arriving at its destination.

Plots of concentrations in parts per billion have been provided as five minute averages. These smoothed plots, compiled from the OP-FTIR 37 second scans, are indicative of concentrations throughout the day's operation. An additional graph shows the wind speed and direction over the course of the day. Wind speed is shown on the y-axis and time on the x-axis. Wind directions are displayed as arrows on the graph and red arrows represent those winds coming from the direction of emission sources during concentration peaks. Different sites will have different directions specific to the KIA.

30 April 2013





Pollutant

Ethylbenzene

Monitoring Site

Bertram Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	105
1 hour	21

Guideline

Time average	Concentration (ppb)
1 hour	1800

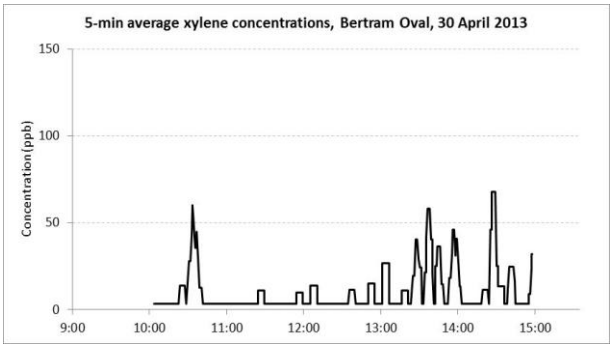
Description of Event

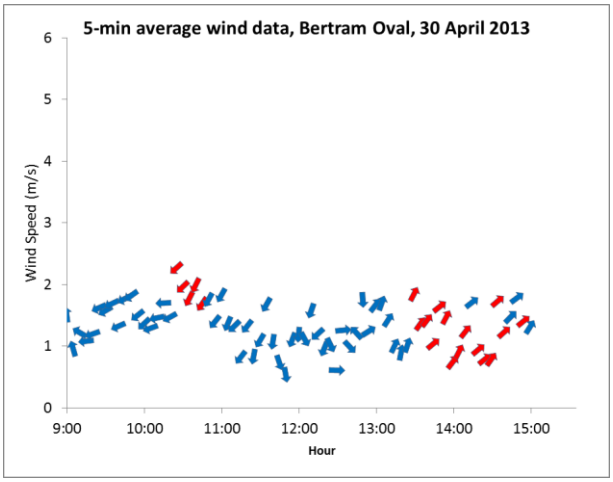
Winds were from the northeast during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

30 April 2013

Back trajectory to Bertram Oval over a period of 20 minutes ending at 02:10 PM on 30/04/2013





Pollutant

Xylene

Monitoring Site

Bertram Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	71
1 hour	29

Guideline

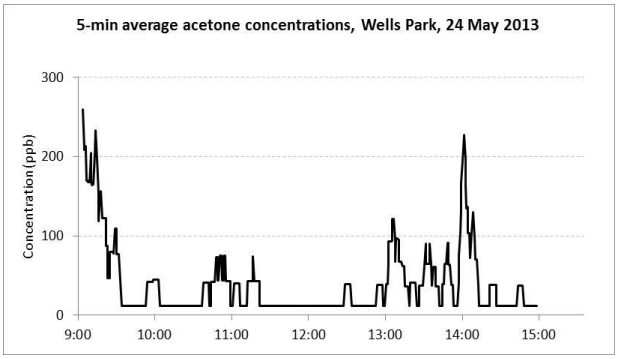
Time average	Concentration (ppb)
1 hour	-
24 hour	250

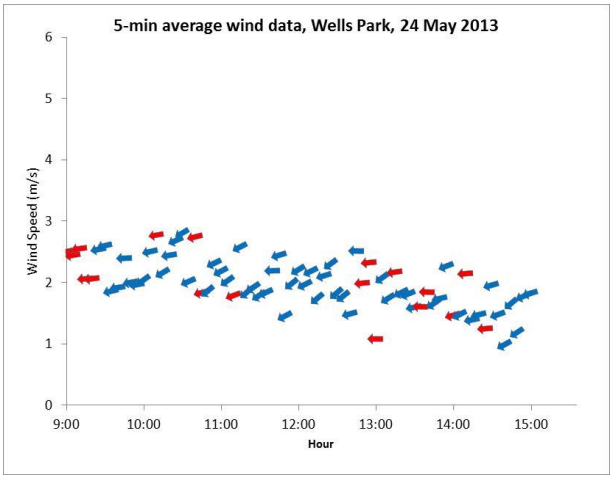
Description of Event

Winds were from the south west during the peak 5 minute averaged measurements at 2:10pm.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

24 May 2013





Pollutant

Acetone

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	260
1 hour	90

Guideline

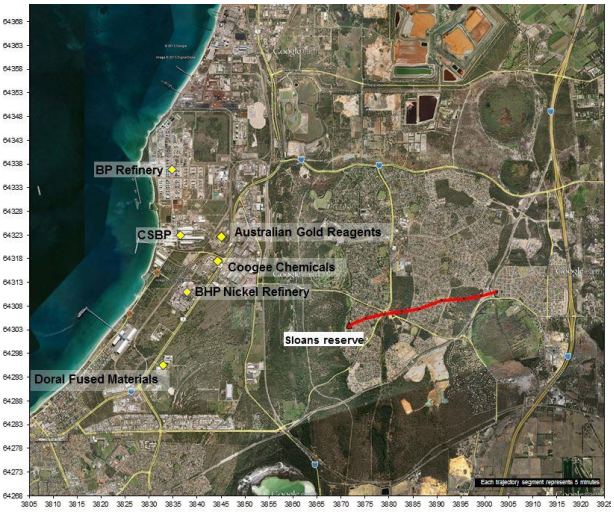
Time average	Concentration (ppb)
1 hour	9300

Description of Event

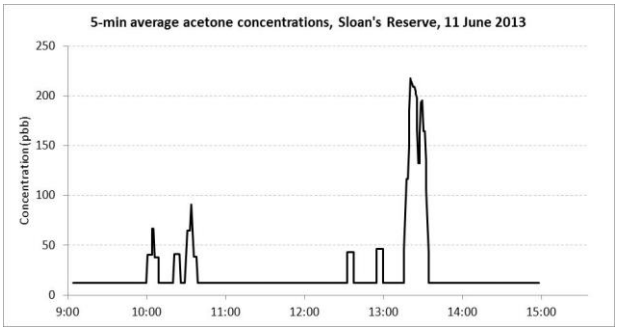
Winds were from the east northeast during the peak 5 minute averaged measurements at 9:05am.

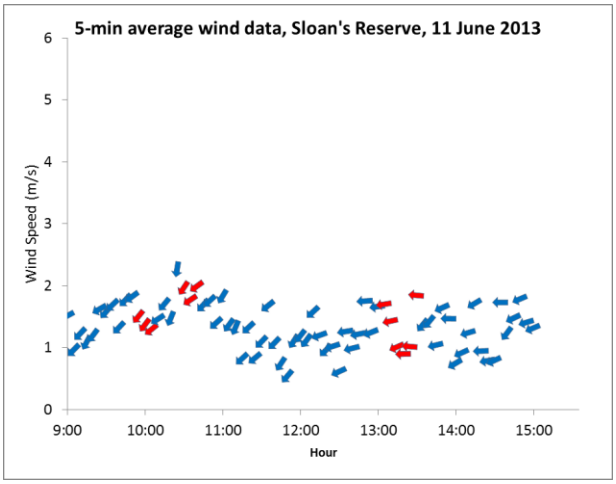
Back trajectory analysis indicates that winds originated from the direction of the KIA.

11 June 2013



Back trajectory to Sloans reserve over a period of 40 minutes ending at 01:15 PM on 11/06/2013





Pollutant

Acetone

Monitoring Site

Sloans Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	220
1 hour	57

Guideline

Time average	Concentration (ppb)
1 hour	9300

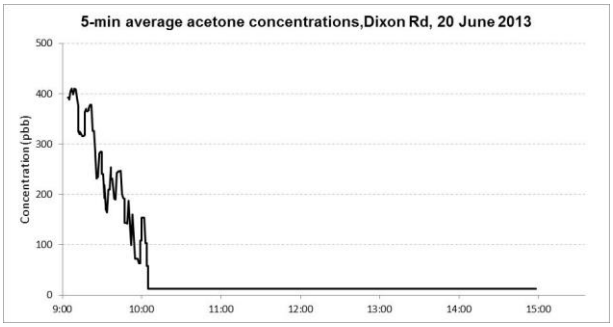
Description of Event

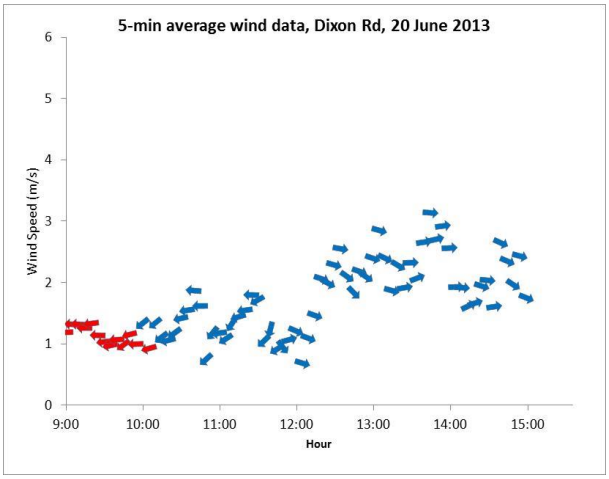
Winds were from the east during the peak 5 minute averaged measurements at 1.15pm.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

20 June 2013

Back trajectory to Dixon Road over a period of 60 minutes ending at 10:00 AM on 20/06/2013





Pollutant

Acetone

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	410
1 hour	260

Guideline

Time average	Concentration (ppb)
1 hour	9300

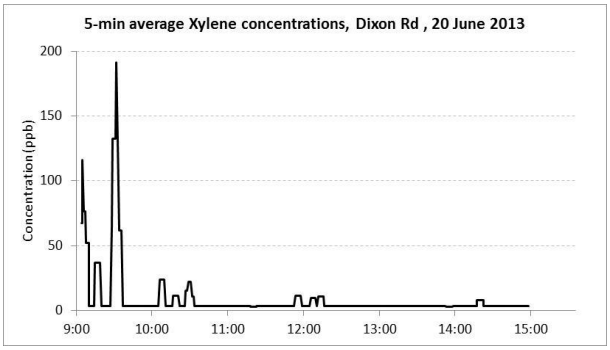
Description of Event

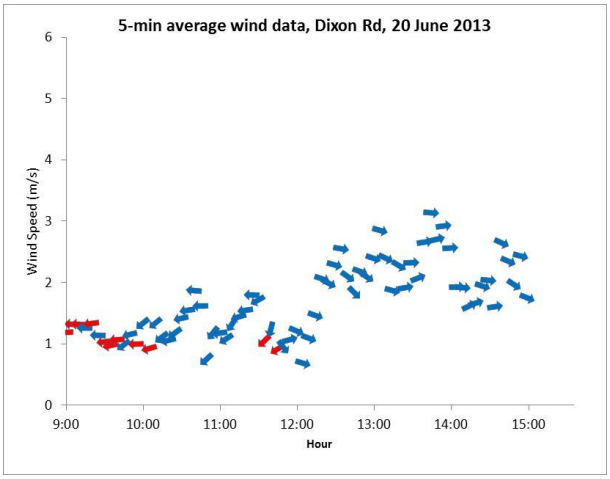
Winds were from the east during the peak 5 minute averaged measurements at 9:10am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

20 June 2013

Back trajectory to Dixon Road over a period of 30 minutes ending at 09:35 AM on 20/06/2013





Pollutant

Xylene

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	190
1 hour	31

Guideline

Time average	Concentration (ppb)
1 hour	-
24 hour	250

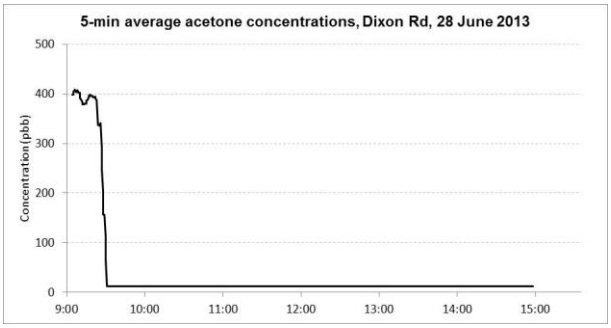
Description of Event

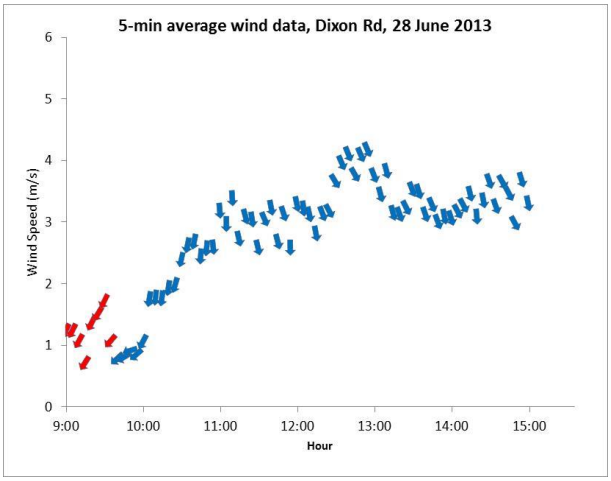
Winds were from the east during the peak 5 minute averaged measurements at 9:35am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

28 June 2013

Back trajectory to Dixon Road over a period of 40 minutes ending at 09:40 AM on 28/06/2013





Pollutant

Acetone

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	410
1 hour	180

Guideline

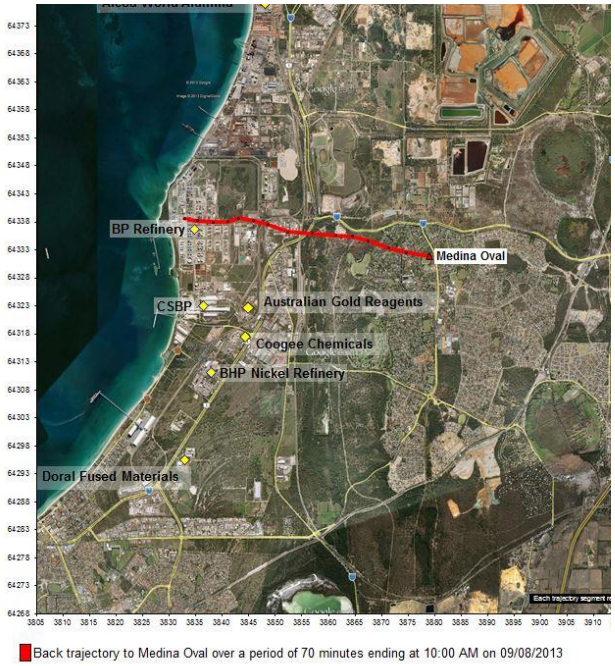
Time average	Concentration (ppb)
1 hour	9300

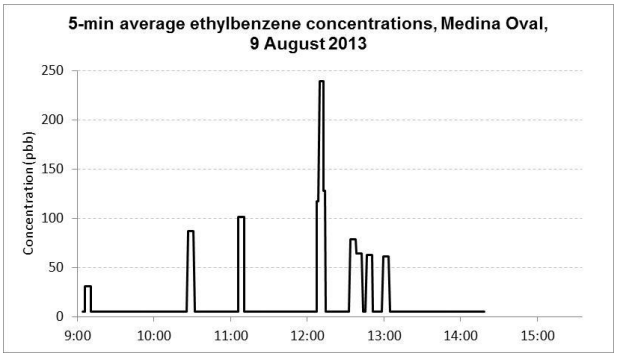
Description of Event

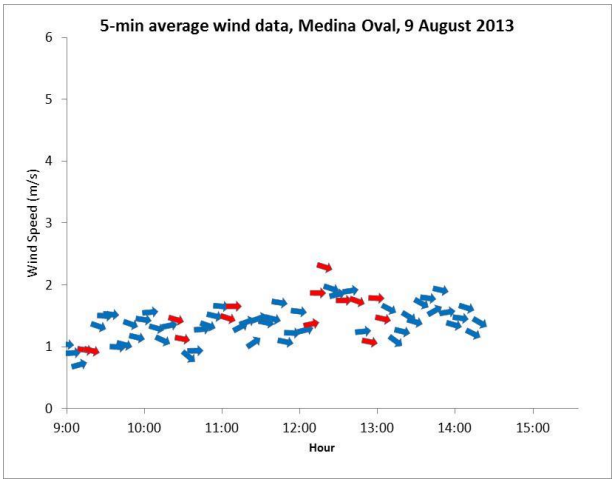
Winds were from the northeast during the peak 5 minute averaged measurements at 9:40am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

9 August 2013







Pollutant

Ethylbenzene

Monitoring Site

Medina Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	240
1 hour	45

Guideline

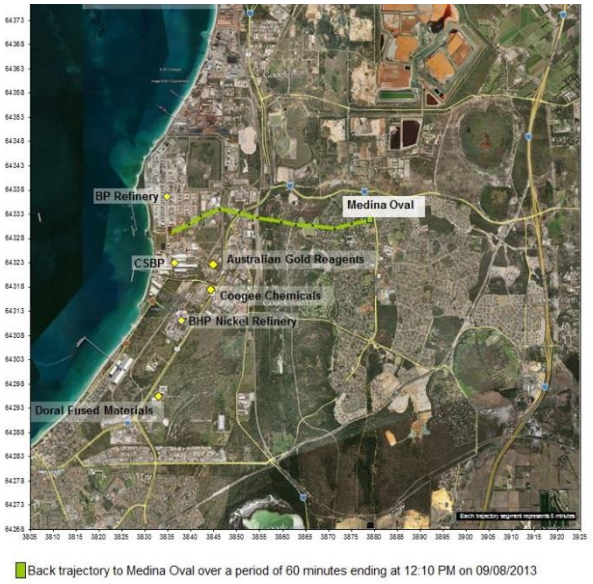
Time average	Concentration (ppb)
1 hour	1800

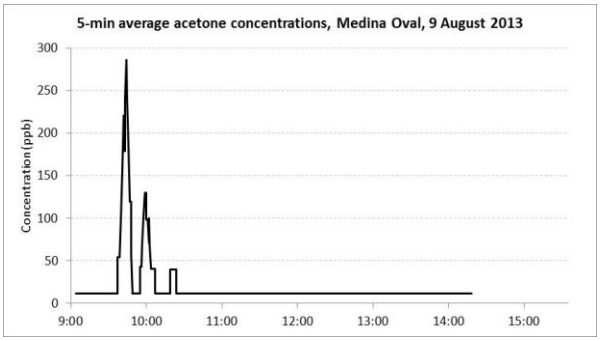
Description of Event

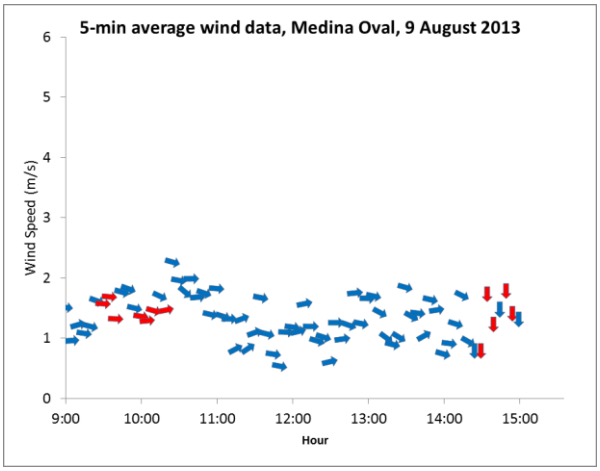
Winds were from the west during the peak 5 minute averaged measurements at 12:10pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

9 August 2013







Pollutant

Acetone

Monitoring Site

Medina Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	290
1 hour	48

Guideline

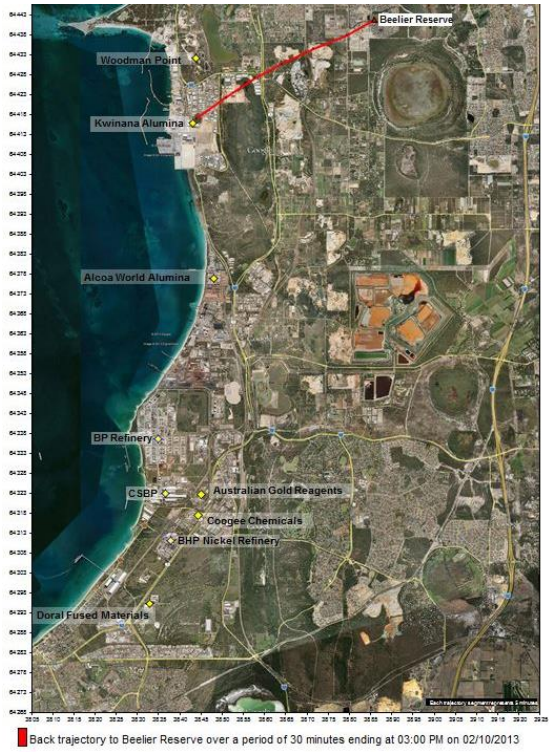
Time average	Concentration (ppb)
1 hour	9300

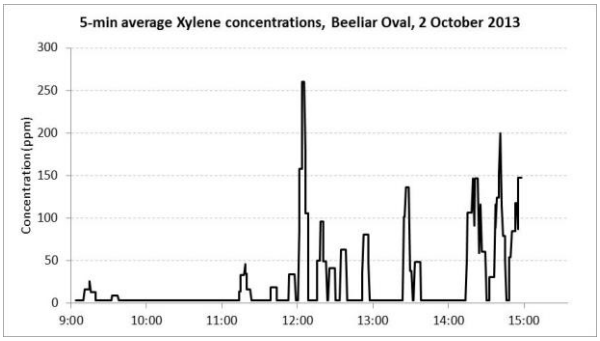
Description of Event

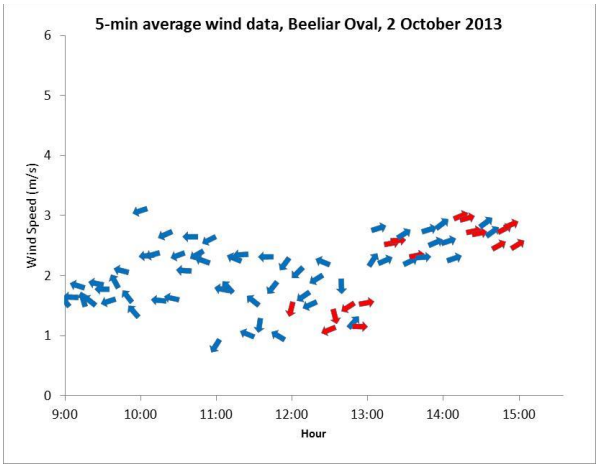
Winds were from the west during the peak 5 minute averaged measurements at 10am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

2 October 2013







Pollutant

Xylene

Monitoring Site

Beeliar Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	270
1 hour	66

Guideline

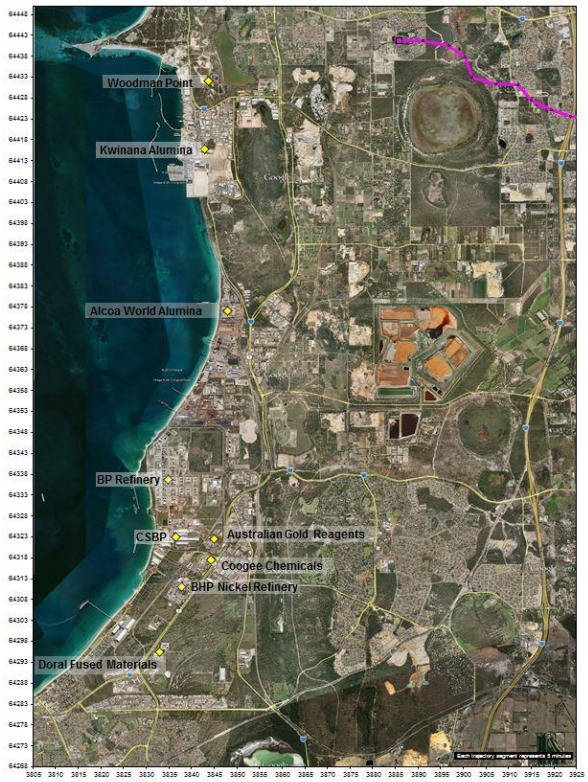
Time average	Concentration (ppb)
1 hour	-
24 hour	250

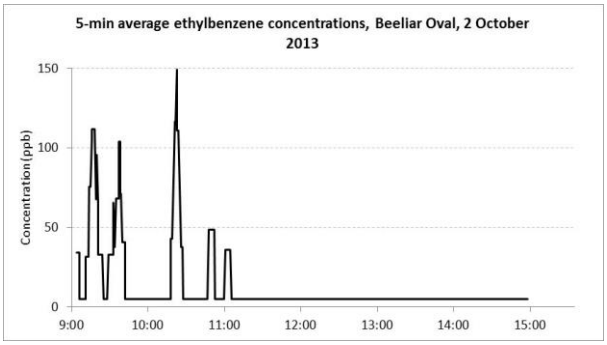
Description of Event

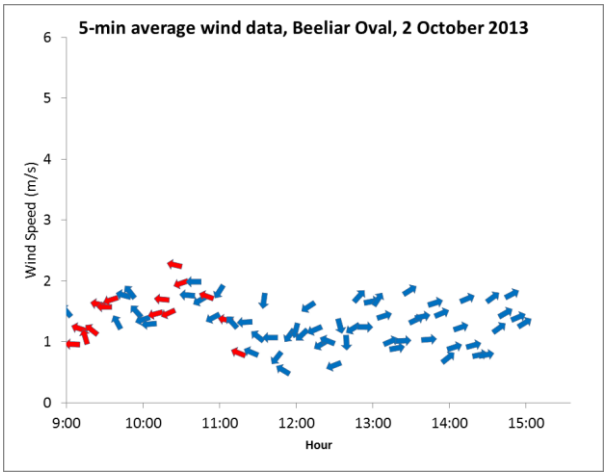
Winds were from the northeast during the highest 5 minute averaged measurement at 12:10pm. Winds were from the west to southwest during other peaks after 2.30pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA for the peaks observed after 2.30pm.

2 October 2013







Pollutant

Ethylbenzene

Monitoring Site

Beeliar Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	150
1 hour	31

Guideline

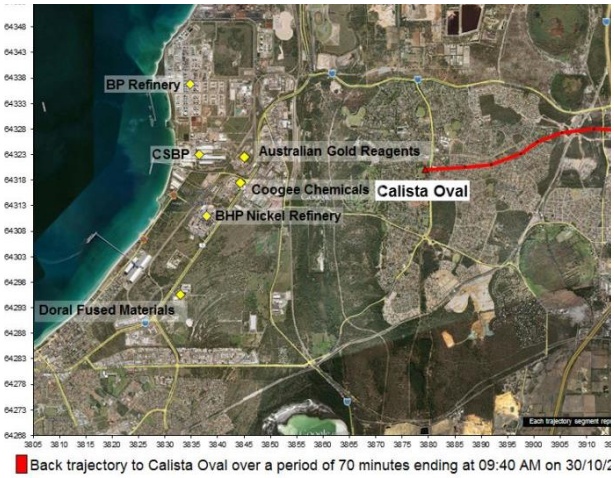
Time average	Concentration (ppb)
1 hour	1800

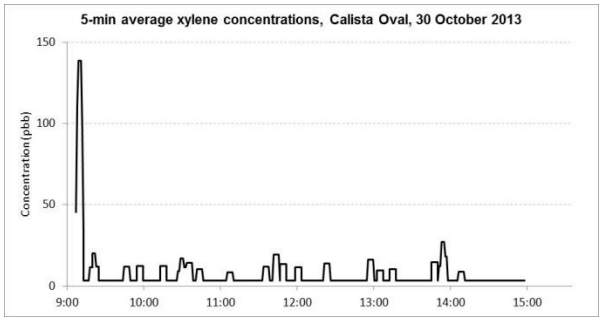
Description of Event

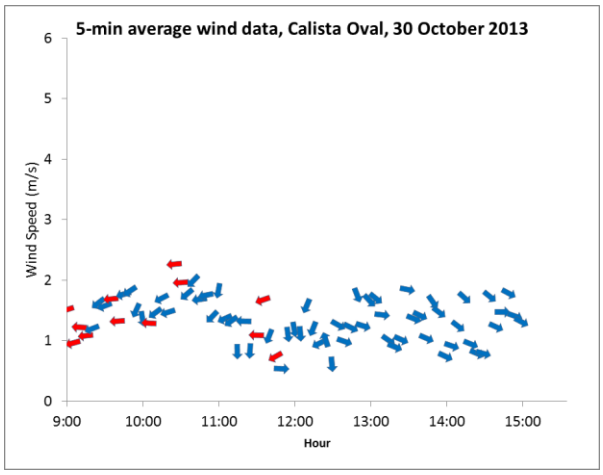
Winds were from the west during the highest 5 minute averaged measurement at 10.20am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA. A possible source is the Kwinana Freeway or nearby local sources.

30 January 2014







Pollutant

Xylene

Monitoring Site

Calista Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	140
1 hour	18

Guideline

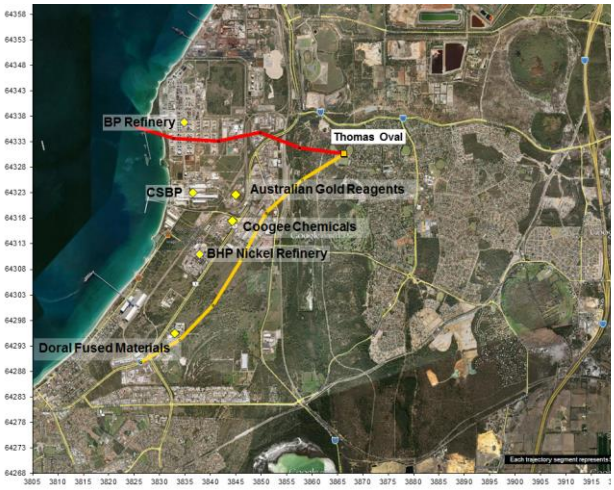
Time average	Concentration (ppb)
1 hour	-
24 hour	250

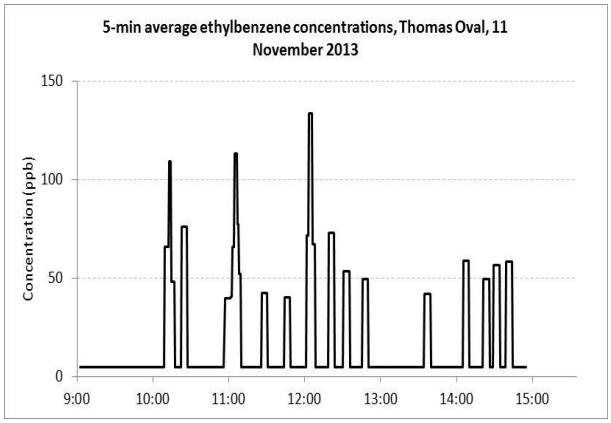
Description of Event

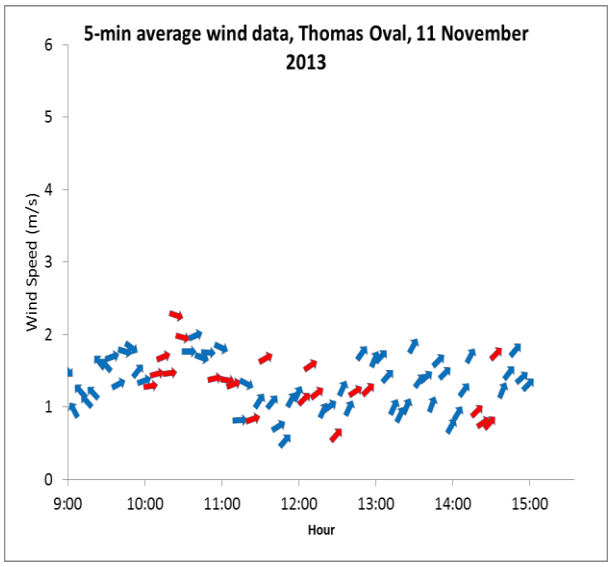
Winds were from the east during the peak 5 minute averaged measurements at 9:10am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA, but possibly from nearby sources or the Kwinana Freeway.

11 November 2013







Pollutant

Ethylbenzene

Monitoring Site

Thomas Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	130
1 hour	29

Guideline

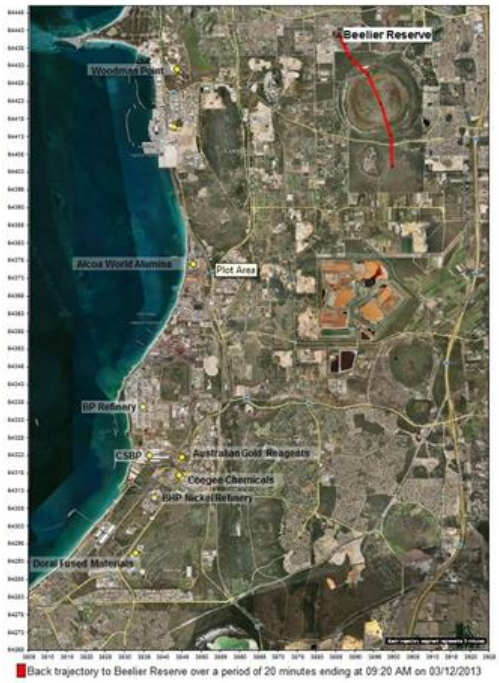
Time average	Concentration (ppb)
1 hour	1800

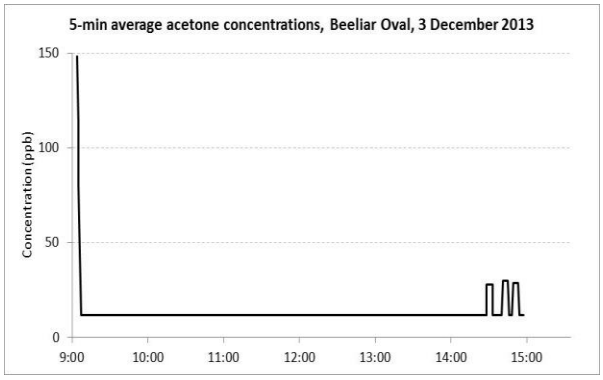
Description of Event

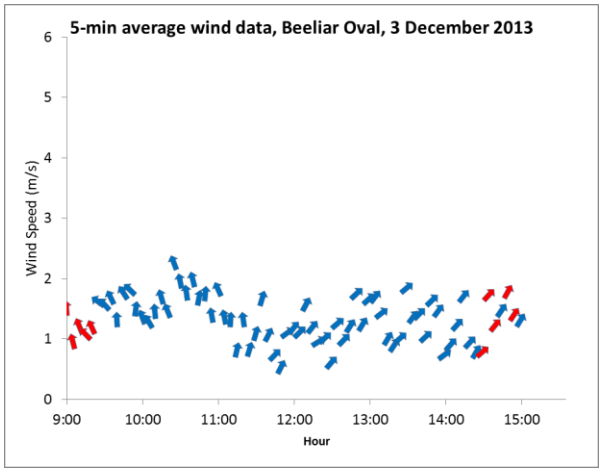
Winds were from the west and west-southwest during the peak 5 minute averaged measurements at 11:05am and 12:10pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

3 December 2013







Pollutant

Acetone

Monitoring Site

Beeliar Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	150
1 hour	23

Guideline

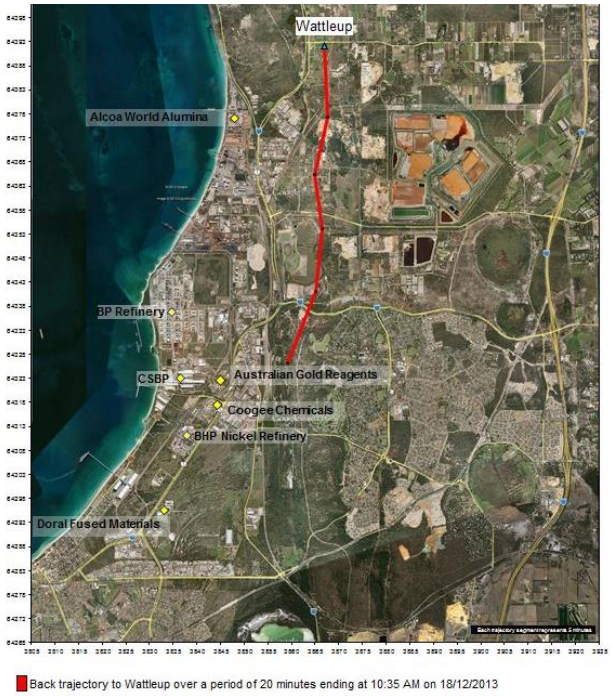
Time average	Concentration (ppb)
1 hour	9300

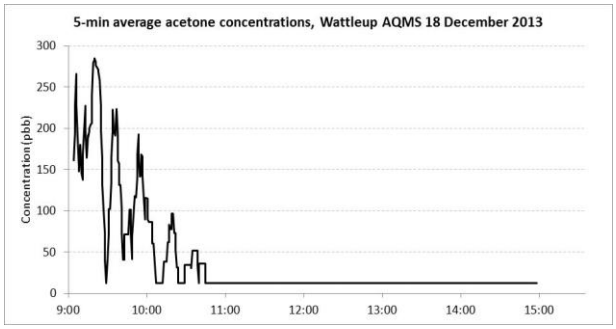
Description of Event

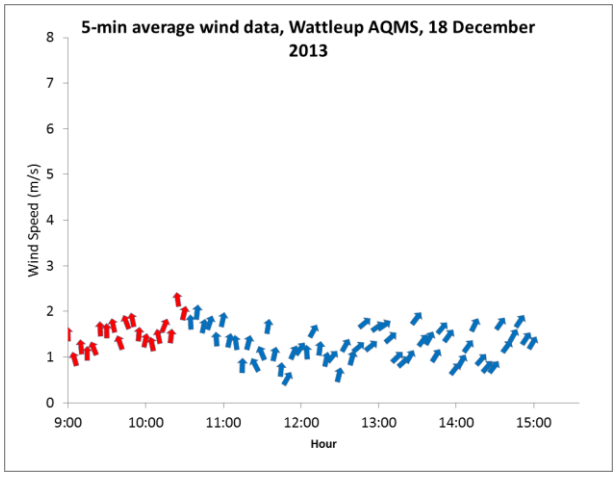
Winds were from the southeast during the peak 5 minute averaged measurements at 9:05am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

18 December 2013







Pollutant

Acetone

Monitoring Site

Wattleup

Highest Concentration

Time average	Concentration (ppb)
5 minute	280
1 hour	150

Guideline

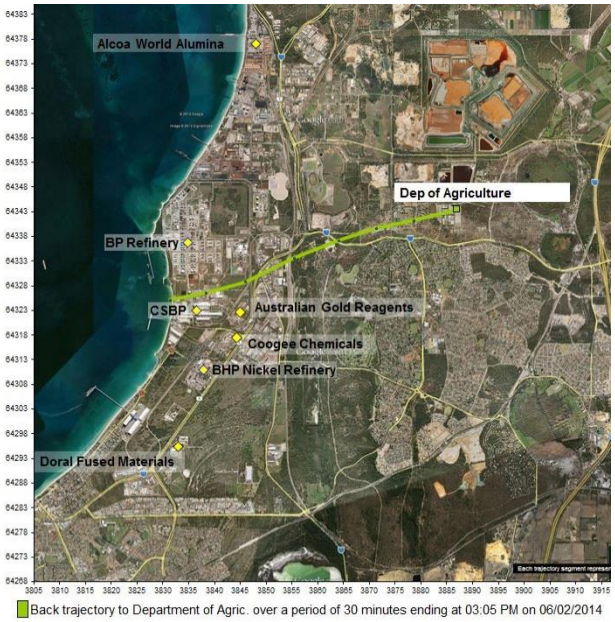
Time average	Concentration (ppb)
1 hour	9300

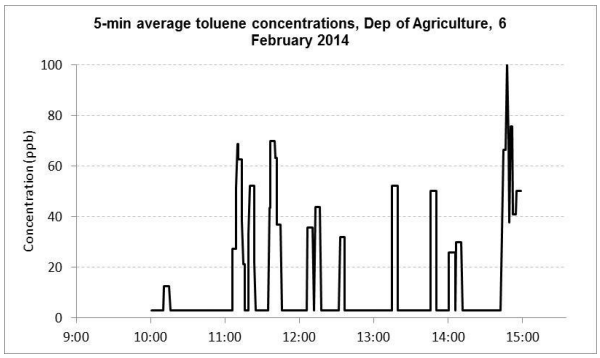
Description of Event

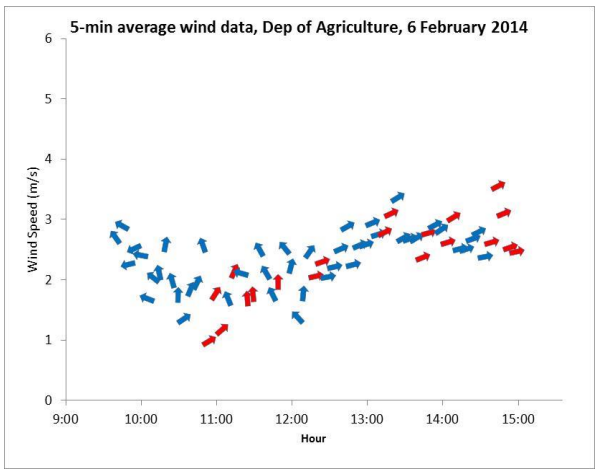
Winds were from the south to south-southwest during the peak 5 minute averaged measurements between 9am and 10.35am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

6 February 2014







Pollutant

Toluene

Monitoring Site

Department of Agriculture

Highest Concentration

Time average	Concentration (ppb)
5 minute	100
1 hour	45

Guideline

Time average	Concentration (ppb)
1 hour	-
24 hour	1000

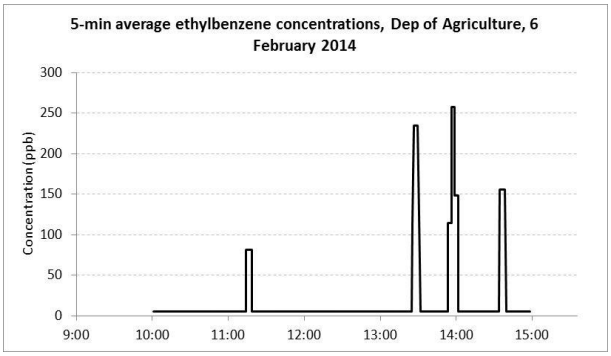
Description of Event

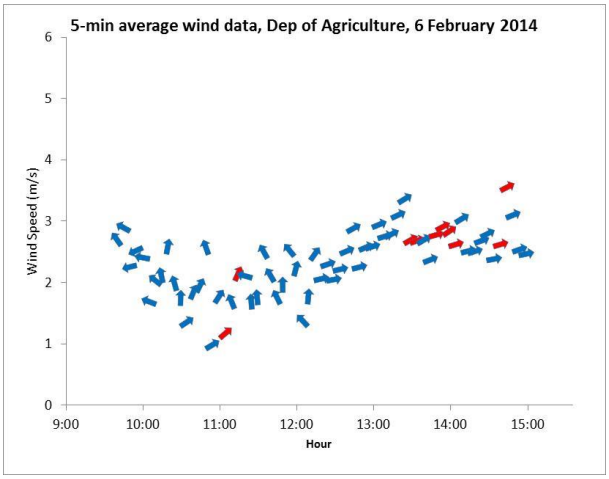
Winds were from the southwest during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

6 February 2014

Back trajectory to Department of Agric. over a period of 40 minutes ending at 02:00 PM on 06/02/2014





Pollutant

Ethylbenzene

Monitoring Site

Department of Agriculture

Highest Concentration

Time average	Concentration (ppb)
5 minute	250
1 hour	47

Guideline

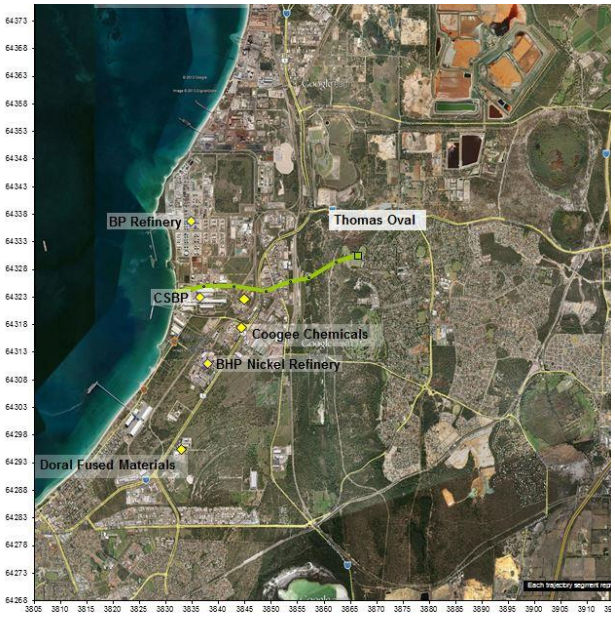
Time average	Concentration (ppb)
1 hour	1800

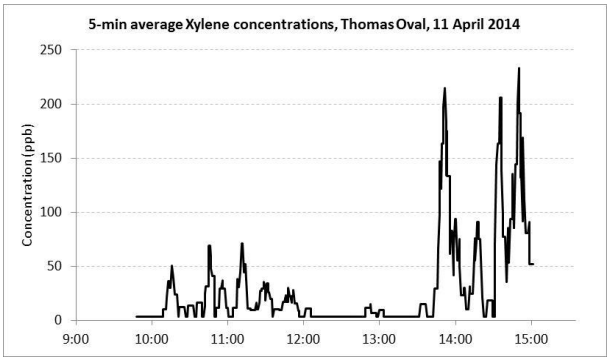
Description of Event

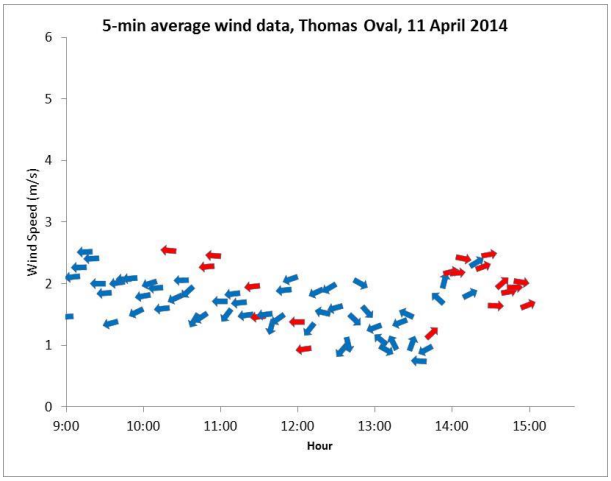
Winds were from the west-southwest during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

11 April 2014







Pollutant

Xylene

Monitoring Site

Thomas Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	240
1 hour	72

Guideline

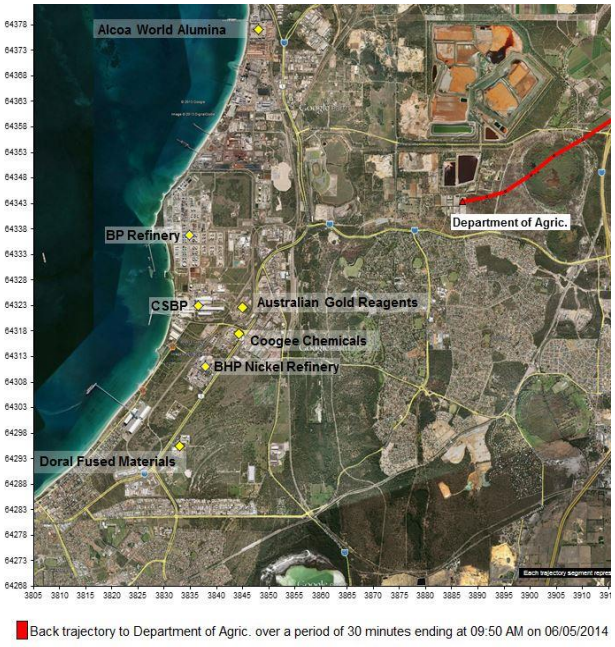
Time average	Concentration (ppb)
1 hour	-
24 hour	250

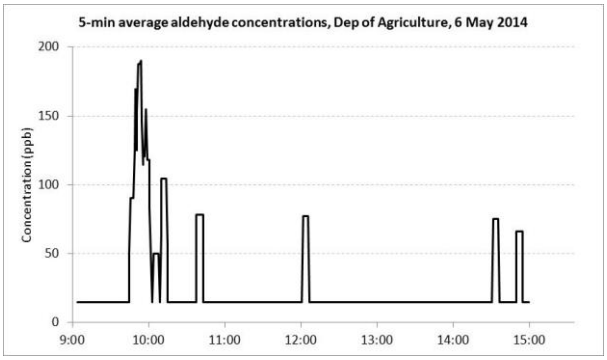
Description of Event

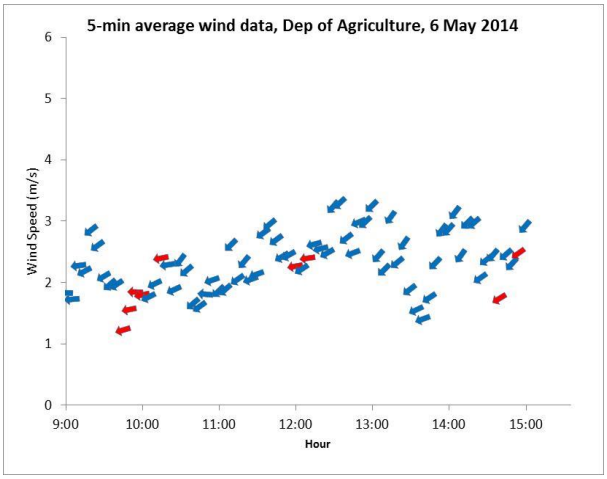
Winds were from the west during the highest 5 minute averaged measurement after 1:50 pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA

6 May 2014







Pollutant

Aldehyde

Monitoring Site

Department of Agriculture

Highest Concentration

Time average	Concentration (ppb)
5 minute	190
1 hour	47

Guideline

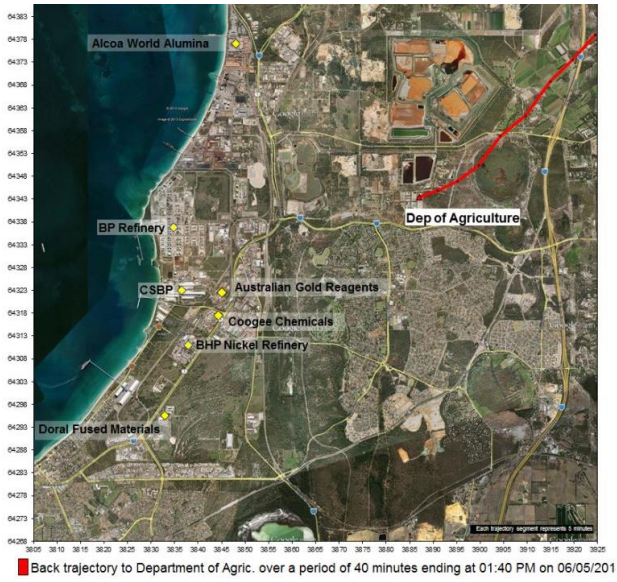
Time average	Concentration (ppb)
1 hour	-
24 hour	1000

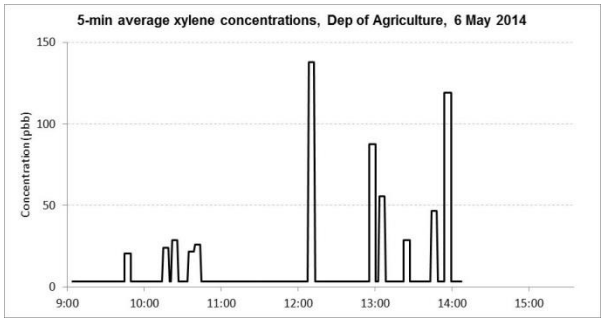
Description of Event

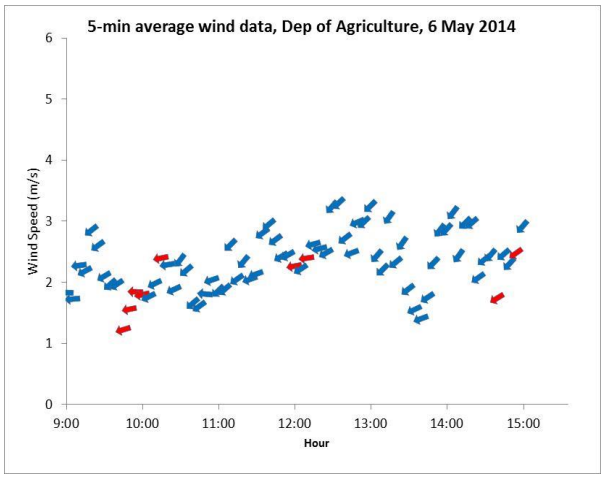
Winds were from the east to east-southeast during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds possibly did not originate from the direction of the KIA but possibly from a nearby source or the Kwinana Freeway.

6 May 2014







Pollutant

Xylene

Monitoring Site

Department of Agriculture

Highest Concentration

Time average	Concentration (ppb)
5 minute	140
1 hour	46

Guideline

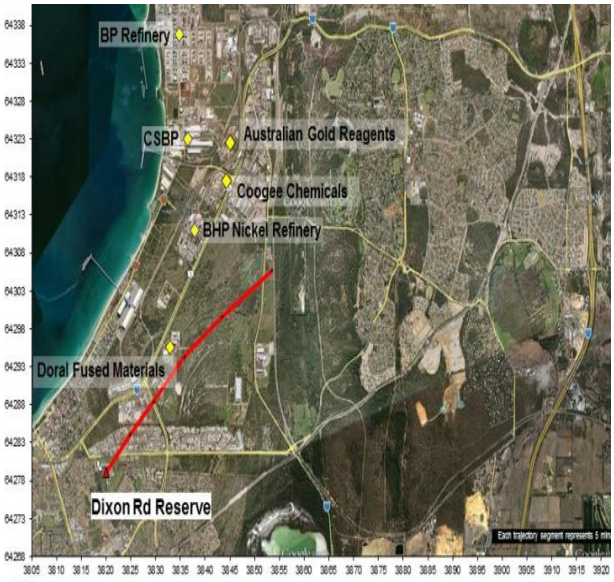
Time average	Concentration (ppb)
1 hour	-
24 hour	250

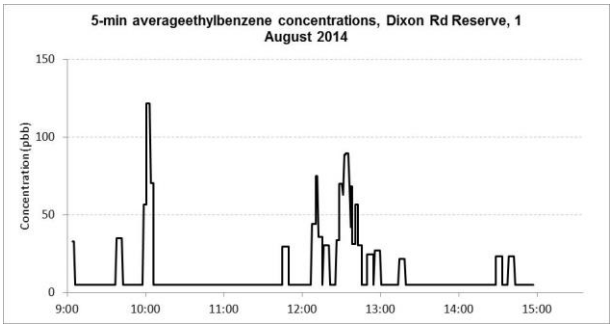
Description of Event

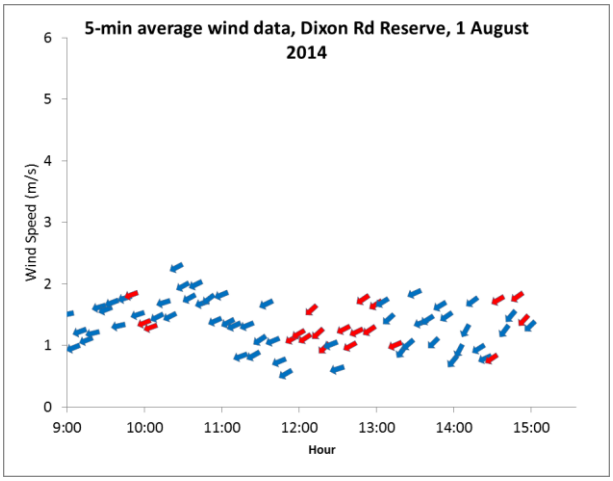
Winds were from the east to east-southeast during the peak 5 minute averaged measurement at time.

Back trajectory analysis indicates that winds possibly did not originate from the direction of the KIA but possibly from a nearby source or the Kwinana Freeway.

1 August 2014







Pollutant

Ethylbenzene

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	130
1 hour	33

Guideline

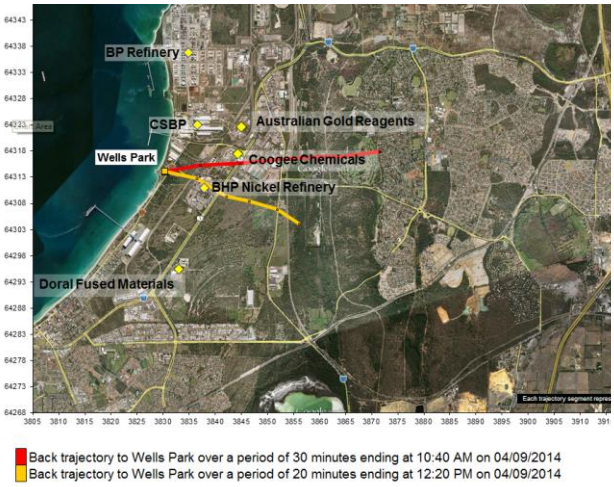
Time average	Concentration (ppb)
1 hour	1800

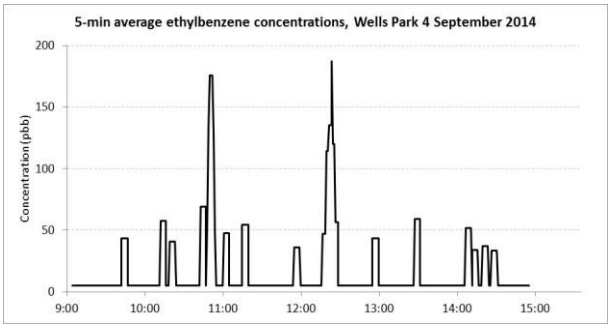
Description of Event

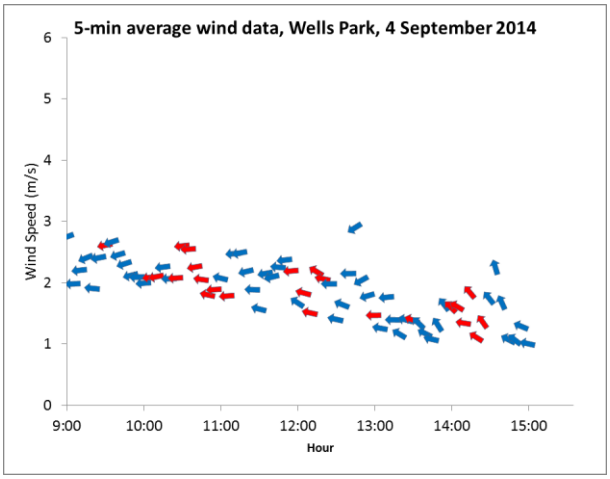
Winds were from the northeast during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

4 September 2014







Pollutant

Ethylbenzene

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	190
1 hour	32

Guideline

Time average	Concentration (ppb)
1 hour	1800

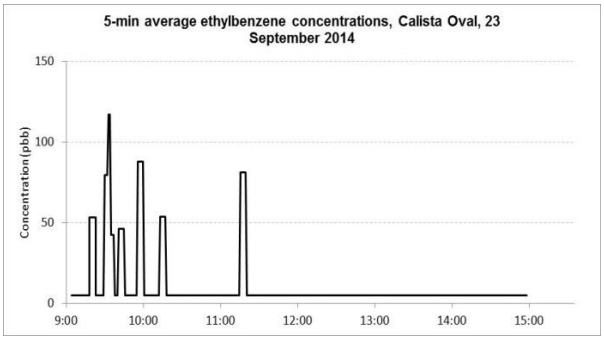
Description of Event

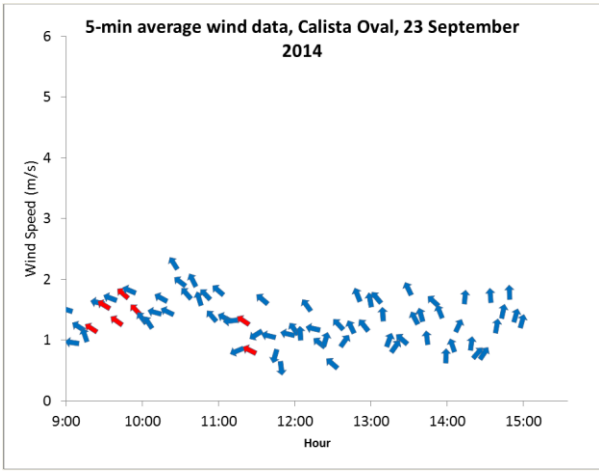
Winds were from the east and southeast during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

23 September 2014

Back trajectory to Calista Oval over a period of 60 minutes ending at 09:35 AM on 23/09/2014





Pollutant

Ethylbenzene

Monitoring Site

Calista Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	120
1 hour	28

Guideline

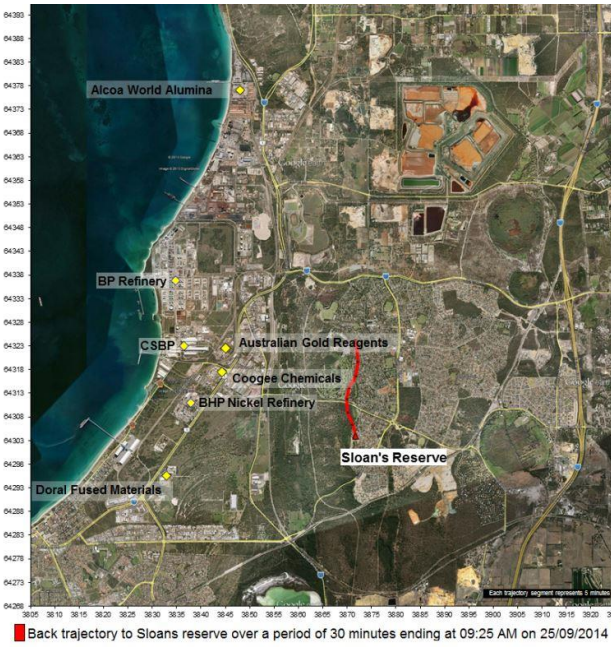
Time average	Concentration (ppb)
1 hour	1800

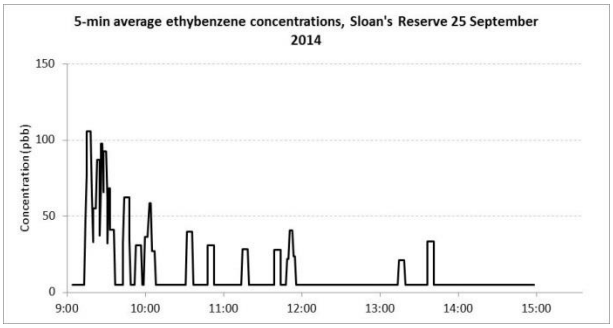
Description of Event

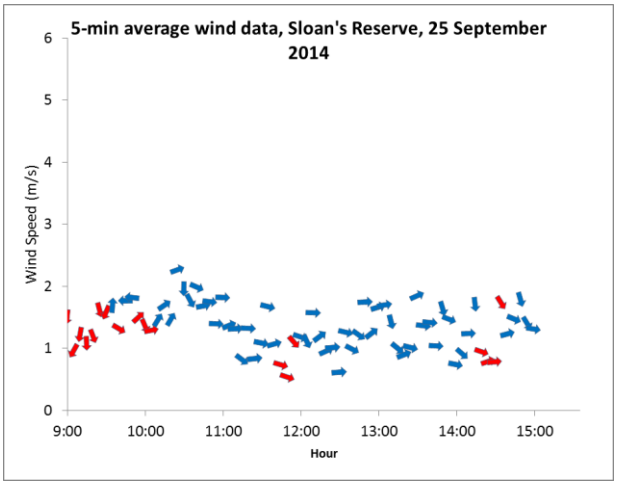
Winds were from the southeast during the peak 5 minute averaged measurement.

Back trajectory analysis indicates that winds possibly did not originate from the direction of the KIA but possibly a nearby source or the Kwinana Freeway.

25 September 2014







Pollutant

Ethylbenzene

Monitoring Site

Sloans Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	110
1 hour	38

Guideline

Time average	Concentration (ppb)
1 hour	1800

Description of Event

Winds were from the north to north-northwest during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

Appendix H: Short-term ammonia peaks and potential sources

Introduction

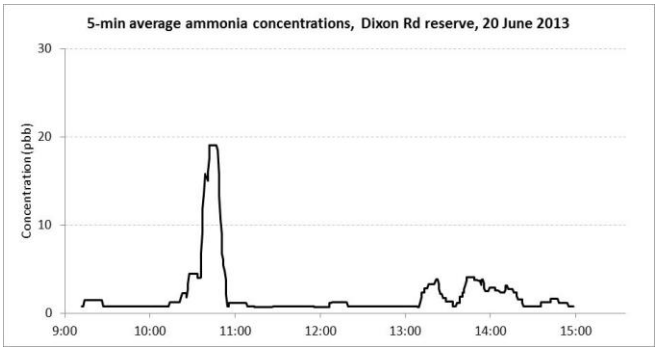
The following pages contain information specific to short-term ammonia peaks measured by the OP-FTIR during the project. Each analysis is provided in date order and includes a back trajectory, concentration and wind plots together with information on the highest concentrations reached and possible sources.

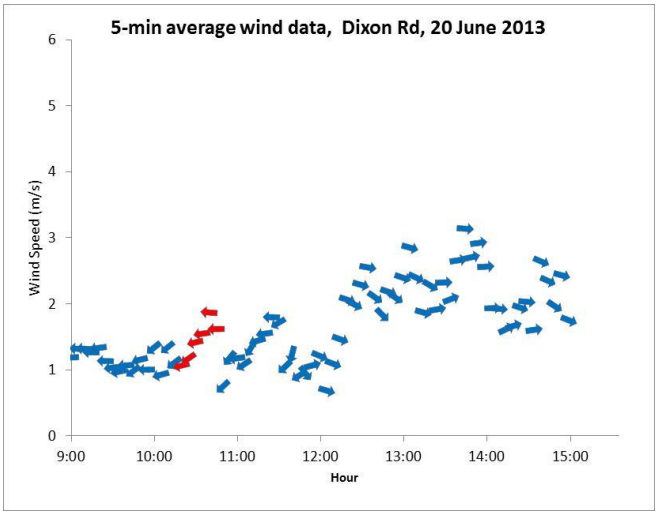
Each days' back trajectory is specific to one event and shows a possible path that a parcel of air may have taken through space to have arrived at a particular location at a certain time. It does no more than use the wind speed and direction information recorded at the particular monitoring site to track a simple path backwards to a possible origin site. Some major assumptions made in the calculation of these back trajectories, such as the meteorological conditions remain the same over the entire region and no air dispersion throughout the path, create large uncertainties in the predicted path and must be acknowledged. Notwithstanding, the back trajectories as calculated provide a reasonable first approximation for the possible path taken by an air parcel in arriving at its destination.

Plots of concentrations in parts per billion have been provided as five minute averages. These smoothed plots, compiled from the OP-FTIR 37 second scans, are indicative of concentrations throughout the day's operation. An additional graph shows the wind speed and direction over the course of the day. Wind speed is shown on the y-axis and time on the x-axis. Wind directions are displayed as arrows on the graph and red arrows represent those winds coming from the direction of emission sources during concentration peaks. Different sites will have different directions specific to the KIA.

20 June 2013

Back trajectory to Dixon Road over a period of 70 minutes ending at 10:45 AM on 20/06/2013





Pollutant

Ammonia

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	19
1 hour	6

Guideline

Time average	Concentration (ppb)
1 hour	480

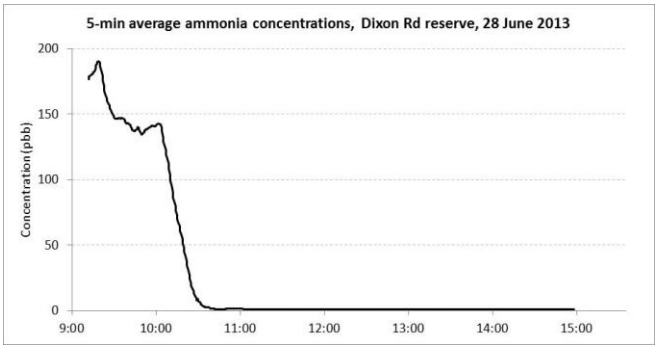
Description of Event

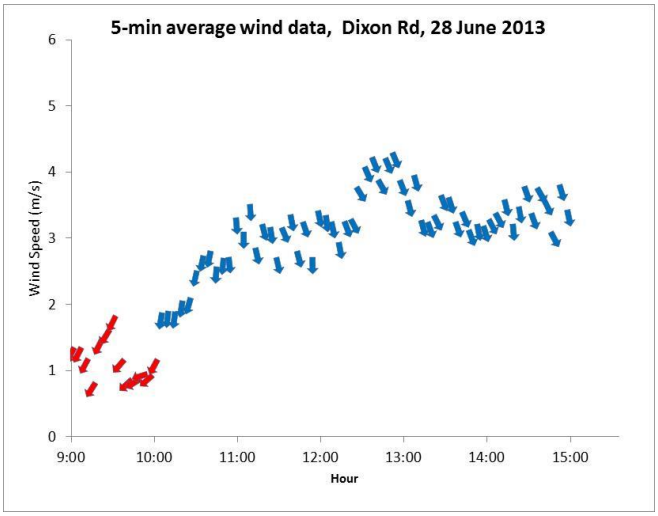
Winds were from the east during the peak 5 minute averaged measurements at 10:45am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

28 June 2013

Back trajectory to Dixon Road over a period of 60 minutes ending at 10:05 AM on 28/06/2013





Pollutant

Ammonia

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	190
1 hour	160

Guideline

Time average	Concentration (ppb)
1 hour	480

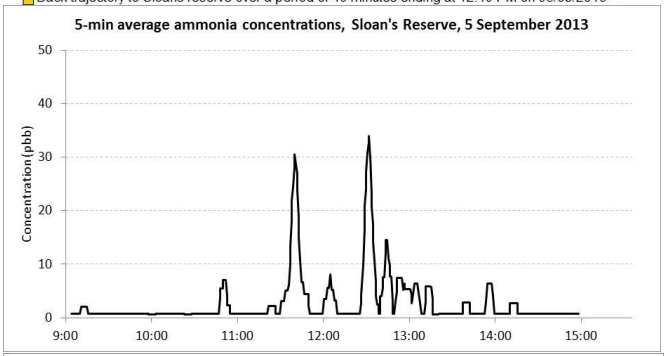
Description of Event

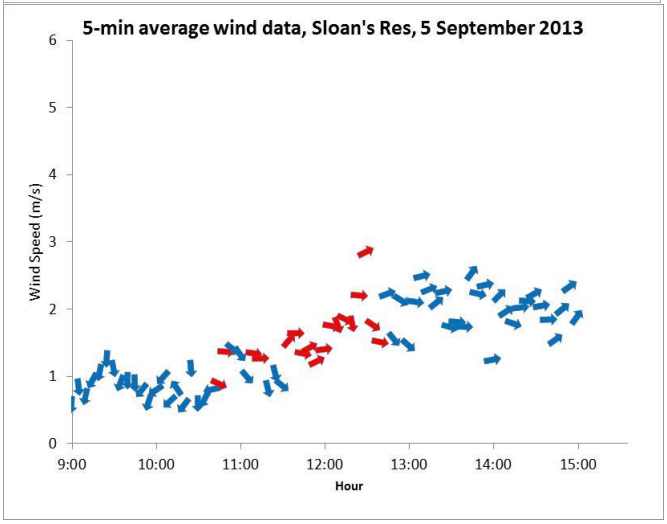
Winds were from the northeast during the peak 5 minute averaged measurements between 9am and 10:15am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

5 September 2013

Back trajectory to Sloans reserve over a period of 60 minutes ending at 11:45 AM on 05/09/2013
Back trajectory to Sloans reserve over a period of 40 minutes ending at 12:40 PM on 05/09/2013





Pollutant

Ammonia

Monitoring Site

Sloan's Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	35
1 hour	15

Guideline

Time average	Concentration (ppb)
1 hour	480

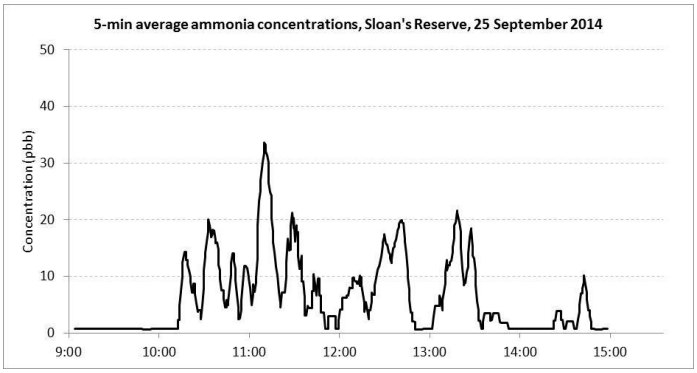
Description of Event

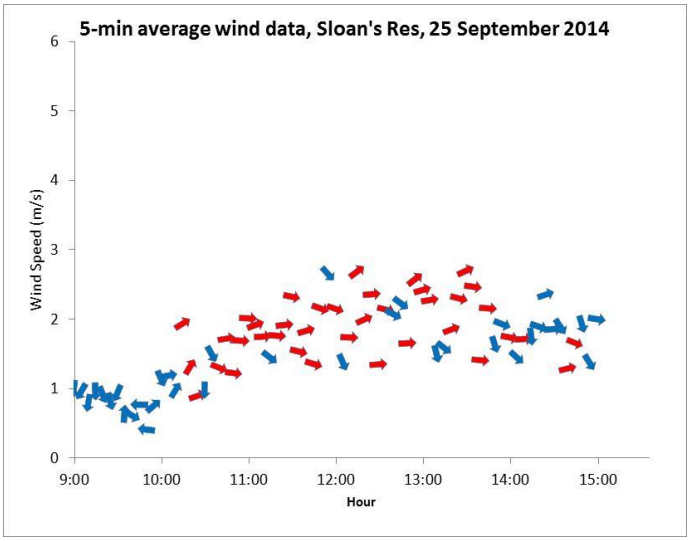
Winds were approximately from the west during the peak 5 minute averaged measurements at 11:50am and 12:40pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

25 September 2013

Back trajectory to Sloans reserve over a period of 50 minutes ending at 11:35 AM on 25/09/2014
Back trajectory to Sloans reserve over a period of 40 minutes ending at 01:40 PM on 25/09/2014





Pollutant

Ammonia

Monitoring Site

Sloan's Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	35
1 hour	19

Guideline

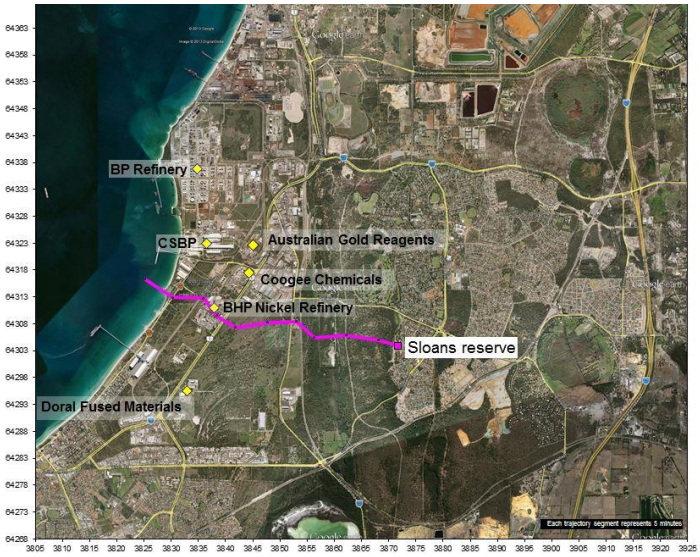
Time average	Concentration (ppb)
1 hour	480

Description of Event

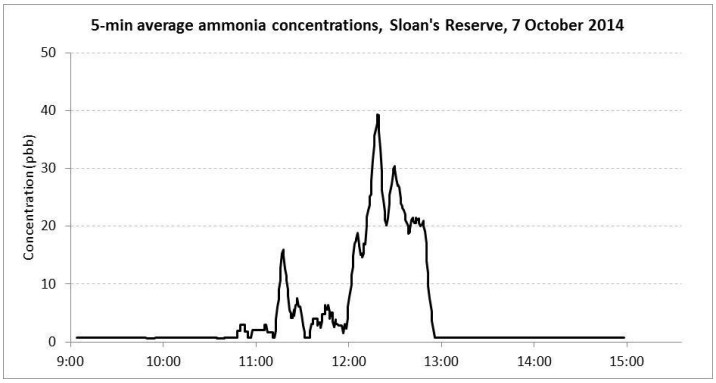
Winds were approximately from the west during the peak 5 minute averaged measurements at 11:20am, 12:40pm and 1:30pm.

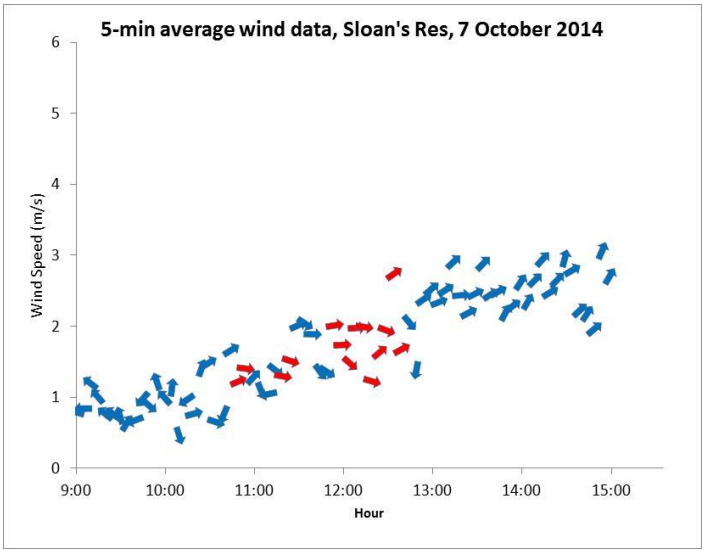
Back trajectory analysis indicates that winds originated from the direction of the KIA.

7 October 2013



Back trajectory to Sloans reserve over a period of 50 minutes ending at 12:20 PM on 07/10/2014





Pollutant

Ammonia

Monitoring Site

Sloan's Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	40
1 hour	20

Guideline

Time average	Concentration (ppb)
1 hour	480

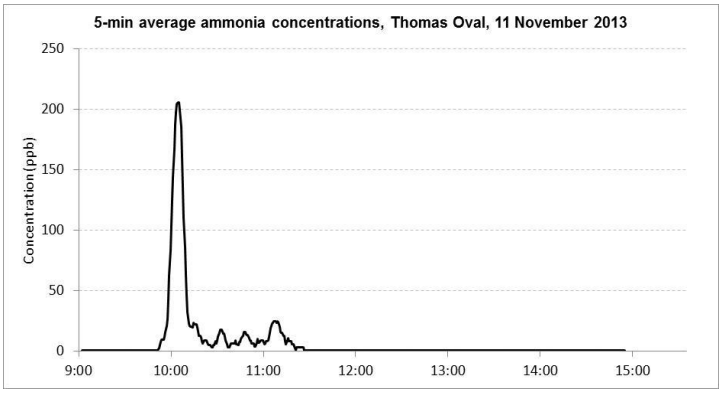
Description of Event

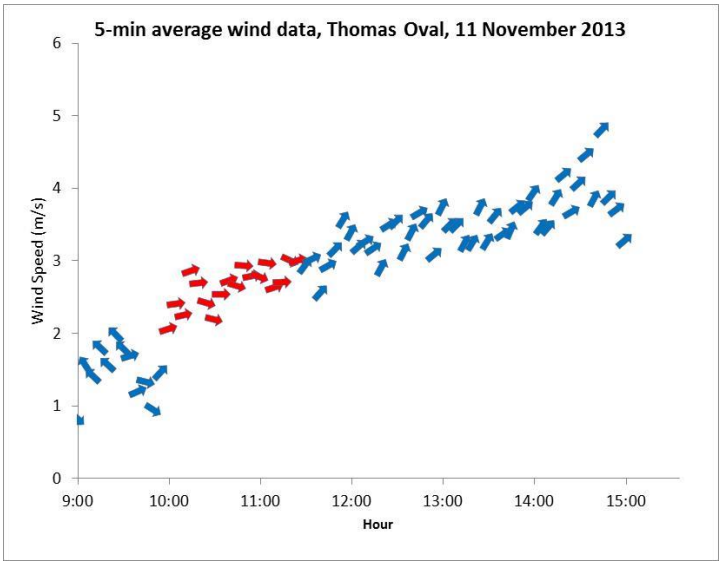
Winds were from the west during the peak 5 minute averaged measurement at 12:30pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

11 November 2013

Back trajectory to Thomas Oval over a period of 30 minutes ending at 10:15 AM on 11/11/2013





Pollutant

Ammonia

Monitoring Site

Thomas Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	210
1 hour	37

Guideline

Time average	Concentration (ppb)
1 hour	480

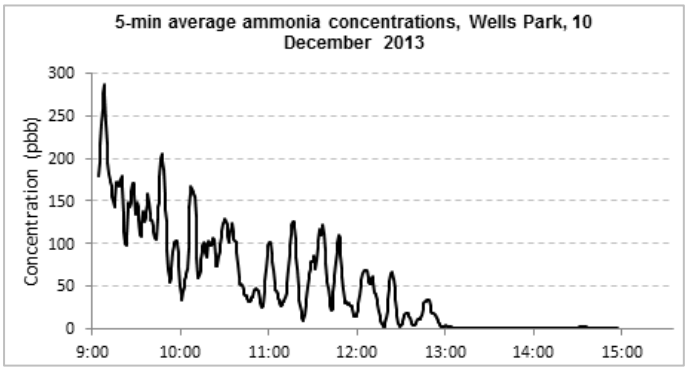
Description of Event

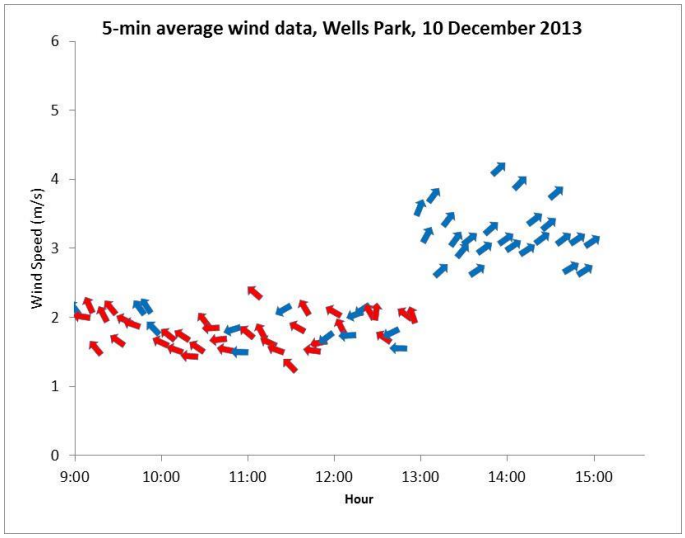
Winds were from the west during the peak 5 minute averaged measurement at 10:10am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

10 December 2013

Back trajectory to Wells Park over a period of 30 minutes ending at 09:40 AM on 10/12/2013





Pollutant

Ammonia

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	290
1 hour	140

Guideline

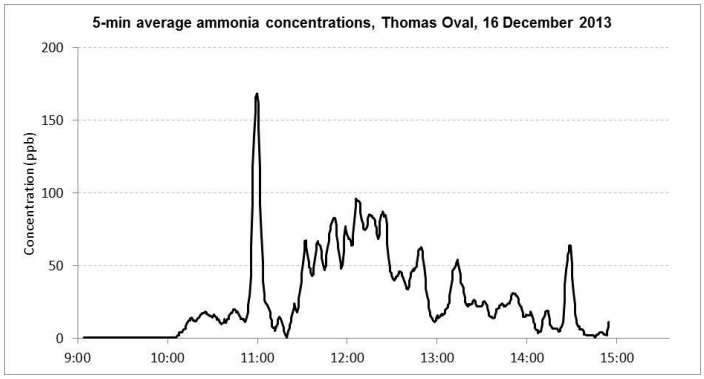
Time average	Concentration (ppb)
1 hour	480

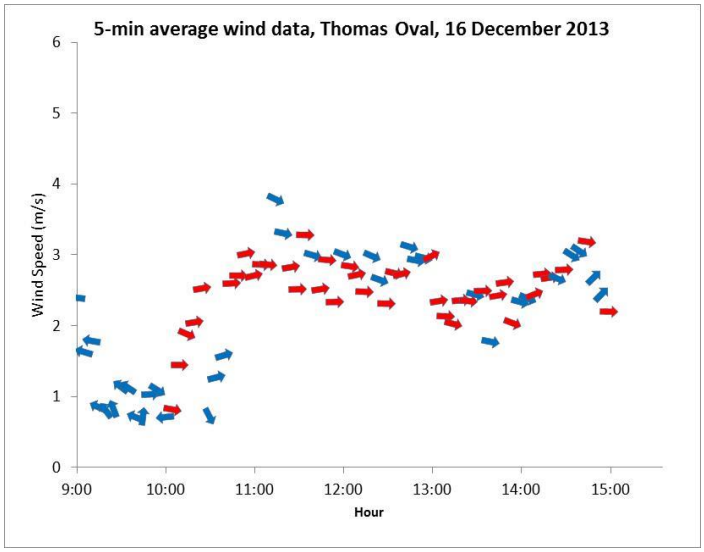
Description of Event

Winds were from the east to southeast during the peak 5 minute averaged measurement at 09:10am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

16 December 2013





Pollutant

Ammonia

Monitoring Site

Thomas Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	170
1 hour	59

Guideline

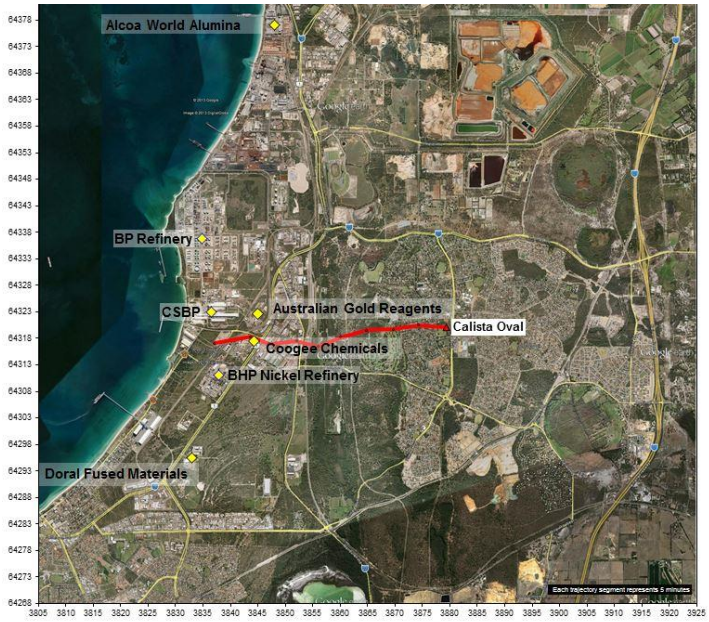
Time average	Concentration (ppb)
1 hour	480

Description of Event

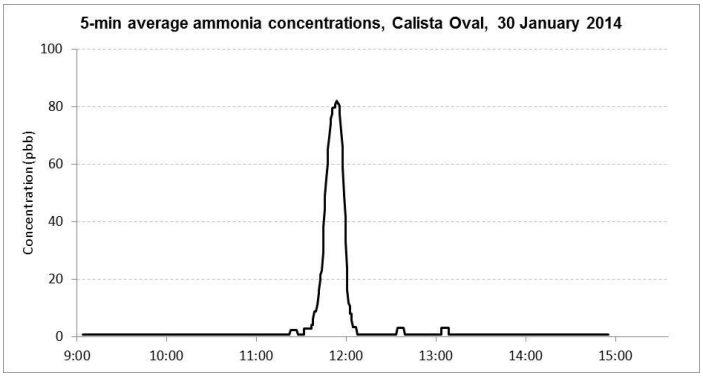
Winds were from the west during the peak 5 minute averaged measurement at 11am.

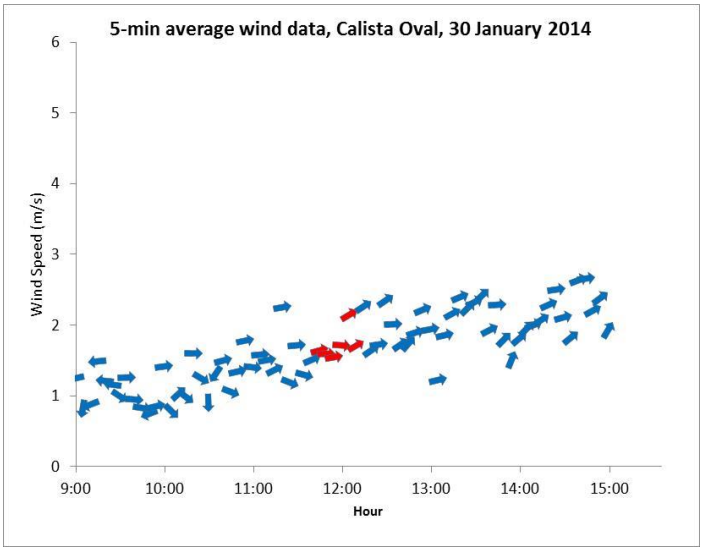
Back trajectory analysis indicates that winds originated from the direction of the KIA.

30 October 2013



Back trajectory to Calista Oval over a period of 50 minutes ending at 12:00 PM on 30/01/2014





Pollutant

Ammonia

Monitoring Site

Calista Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	84
1 hour	20

Guideline

Time average	Concentration (ppb)
1 hour	480

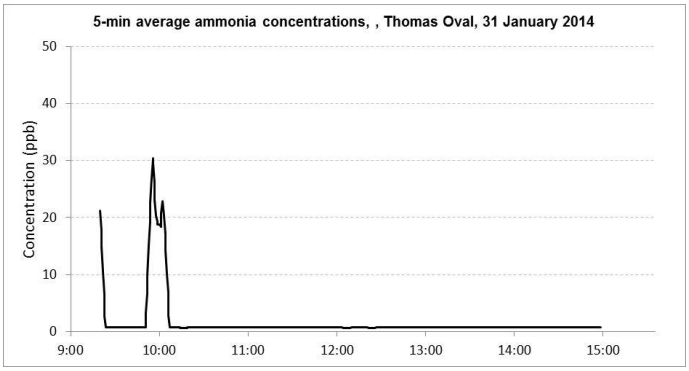
Description of Event

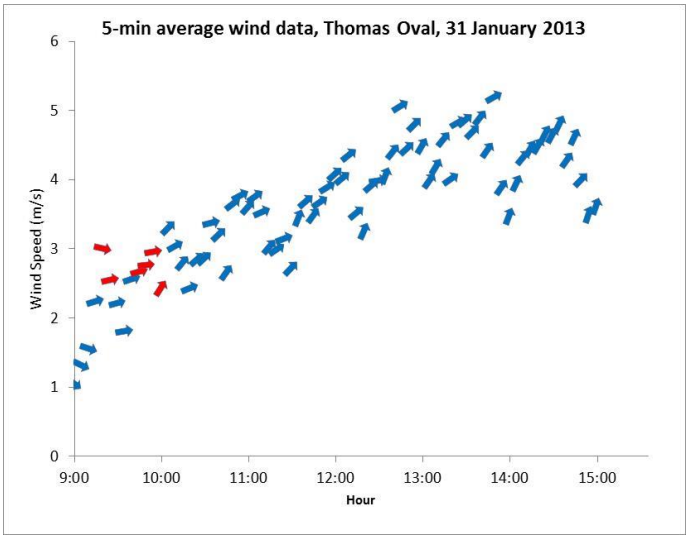
Winds were from the west during the peak 5 minute averaged measurement at 12pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

31 January 2014

Back trajectory to Thomas Oval over a period of 20 minutes ending at 09:55 AM on 31/01/2014





Pollutant

Ammonia

Monitoring Site

Thomas Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	30
1 hour	7

Guideline

Time average	Concentration (ppb)
1 hour	480

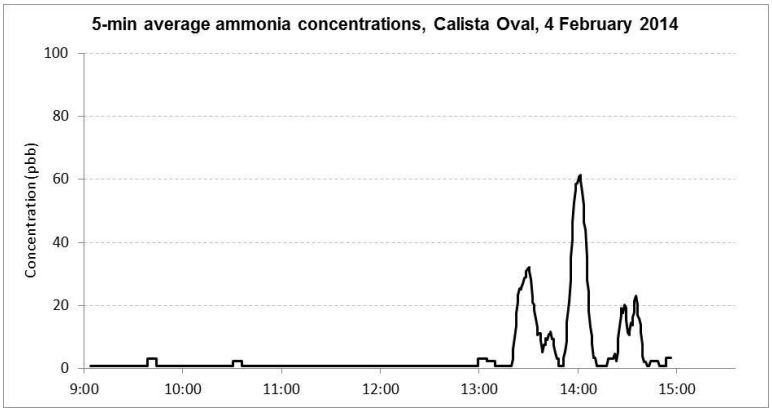
Description of Event

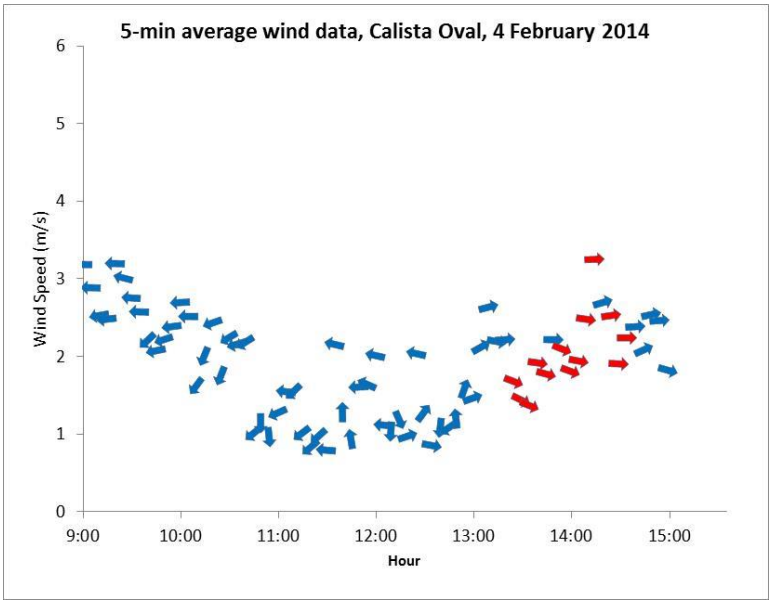
Winds were from the west to southwest during the peak 5 minute averaged measurement at 10am.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

04 February 2014

Back trajectory to Calista Oval over a period of 40 minutes ending at 01:35 PM on 04/02/2014
Back trajectory to Calista Oval over a period of 40 minutes ending at 02:10 PM on 04/02/2014
Back trajectory to Calista Oval over a period of 30 minutes ending at 02:30 PM on 04/02/2014





Pollutant

Ammonia

Monitoring Site

Calista Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	62
1 hour	12

Guideline

Time average	Concentration (ppb)
1 hour	480

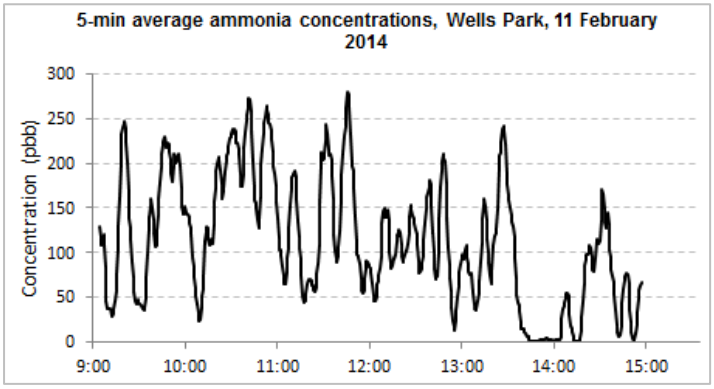
Description of Event

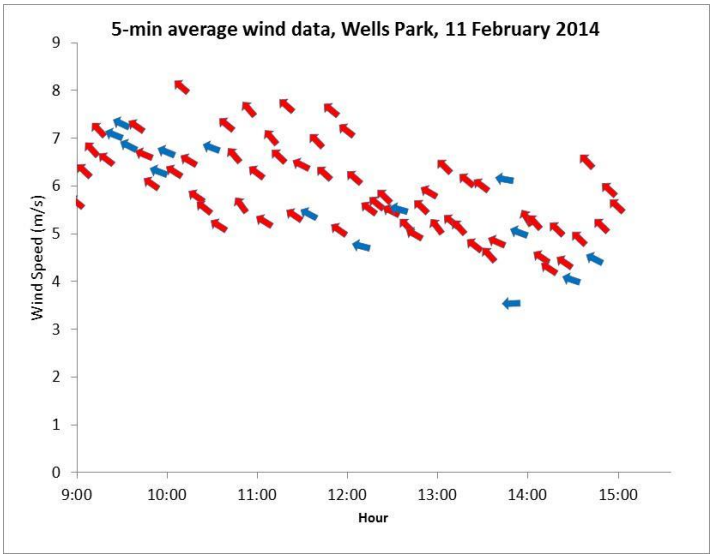
Winds were from the west during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

11 February 2014

Back trajectory to Wells Park over a period of 10 minutes ending at 10:40 AM on 11/02/2014





Pollutant

Ammonia

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	280
1 hour	170

Guideline

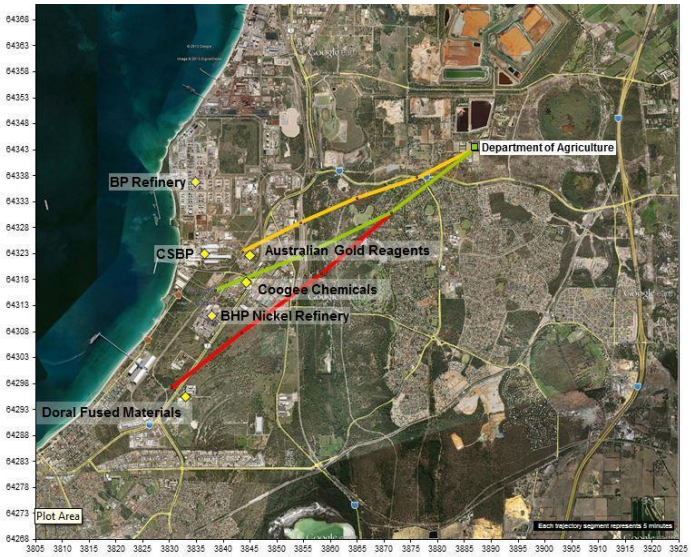
Time average	Concentration (ppb)
1 hour	480

Description of Event

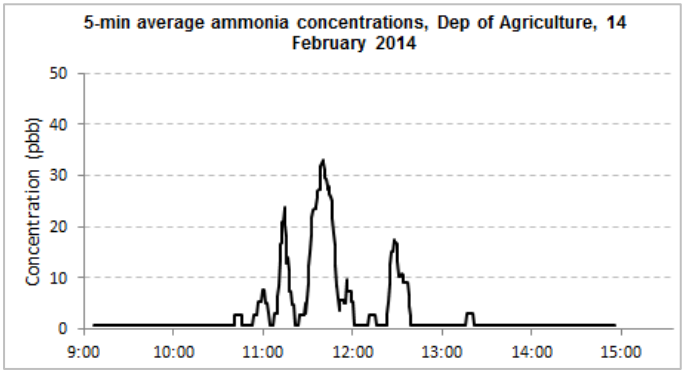
Winds were from the southeast during the peak 5 minute averaged measurements.

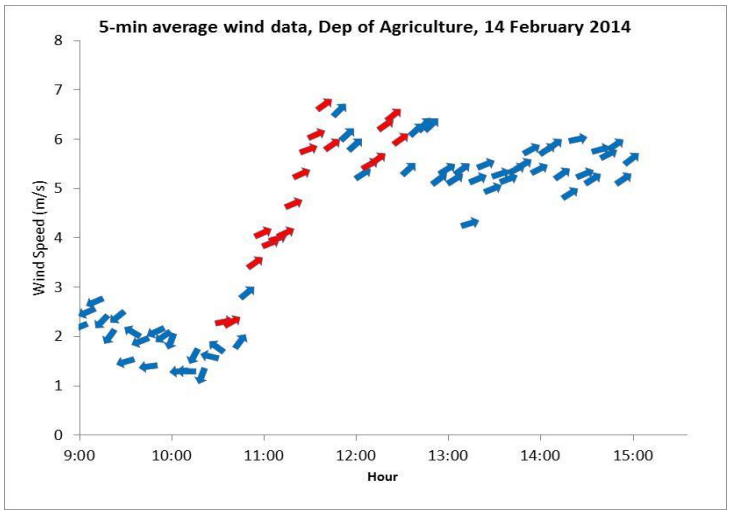
Back trajectory analysis indicates that winds originated from the direction of the KIA.

14 February 2014



Back trajectory to Department of Agric. over a period of 20 minutes ending at 12:25 PM on 14/02/2014
Back trajectory to Department of Agric. over a period of 20 minutes ending at 11:10 AM on 14/02/2014
Back trajectory to Department of Agric. over a period of 20 minutes ending at 11:35 AM on 14/02/2014





Pollutant

Ammonia

Monitoring Site

Department of Agriculture

Highest Concentration

Time average	Concentration (ppb)
5 minute	34
1 hour	10

Guideline

Time average	Concentration (ppb)
1 hour	480

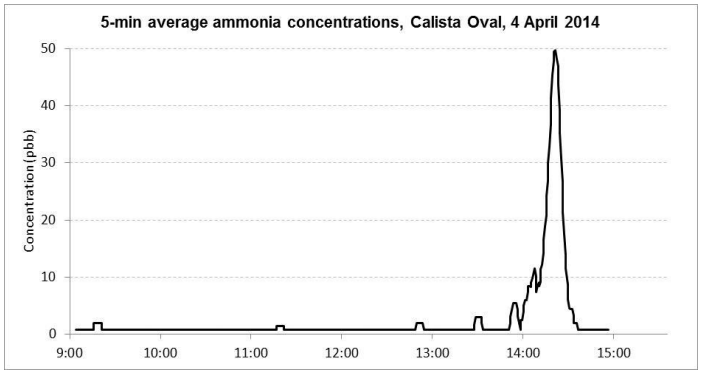
Description of Event

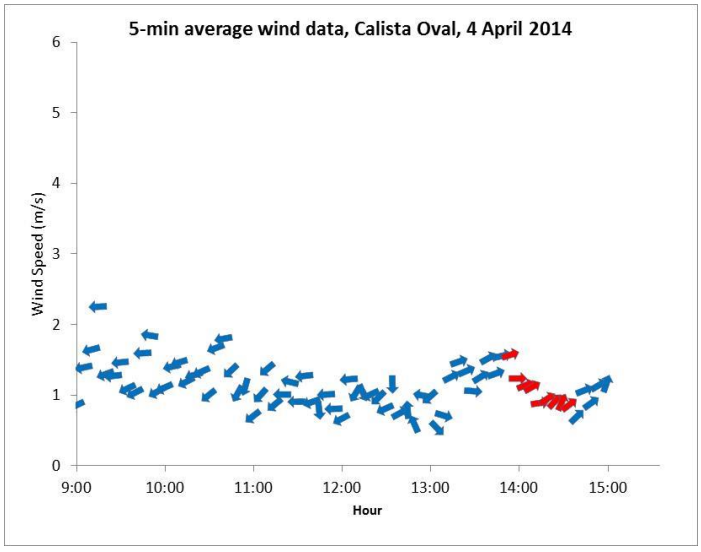
Winds were from the southwest during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

04 April 2014

Back trajectory to Calista Oval over a period of 90 minutes ending at 02:40 PM on 04/04/2014





Pollutant

Ammonia

Monitoring Site

Calista Oval

Highest Concentration

Time average	Concentration (ppb)
5 minute	50
1 hour	12

Guideline

Time average	Concentration (ppb)
1 hour	480

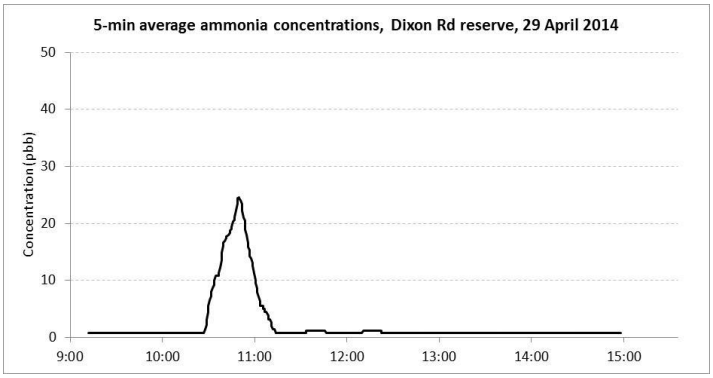
Description of Event

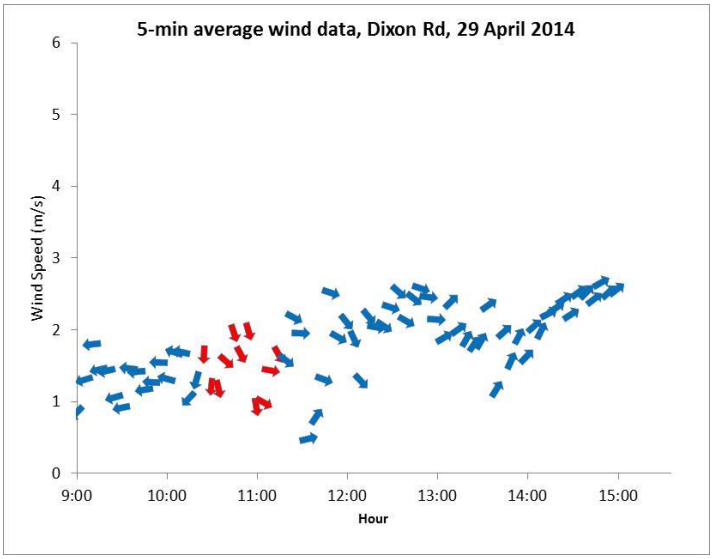
Winds were from the west southwest during the peak 5 minute averaged measurements at 2:20pm.

Back trajectory analysis indicates that winds originated from the direction of the KIA.

29 April 2014

Back trajectory to Dixon Road over a period of 30 minutes ending at 11:00 AM on 29/04/2014





Pollutant

Ammonia

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	25
1 hour	9

Guideline

Time average	Concentration (ppb)
1 hour	480

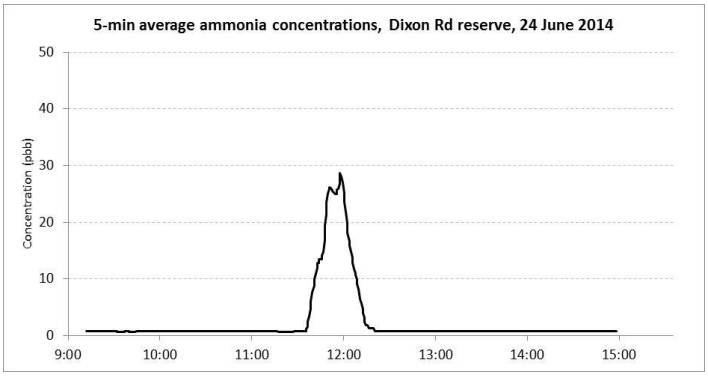
Description of Event

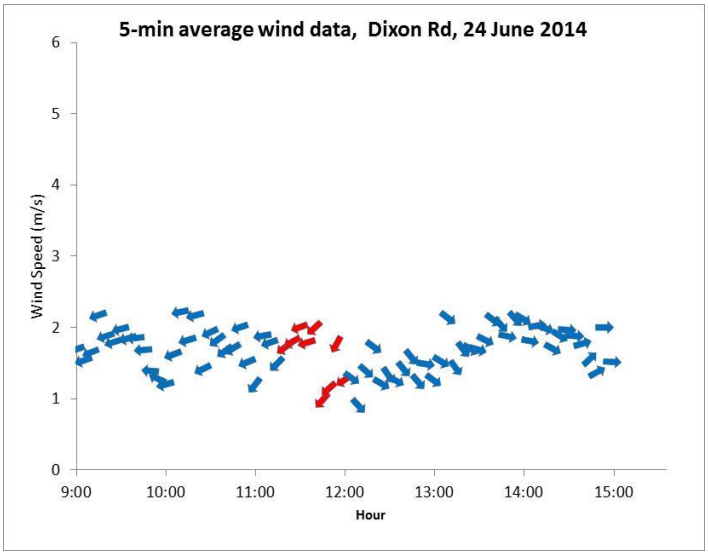
Winds were from the north to northwest during the peak 5 minute averaged measurement at 11:00am.

Back trajectory analysis indicates that winds did not originate from the direction of the KIA.

24 June 2014

Back trajectory to Dixon Road over a period of 20 minutes ending at 12:00 PM on 24/06/2014





Pollutant

Ammonia

Monitoring Site

Dixon Road Reserve

Highest Concentration

Time average	Concentration (ppb)
5 minute	29
1 hour	9

Guideline

Time average	Concentration (ppb)
1 hour	480

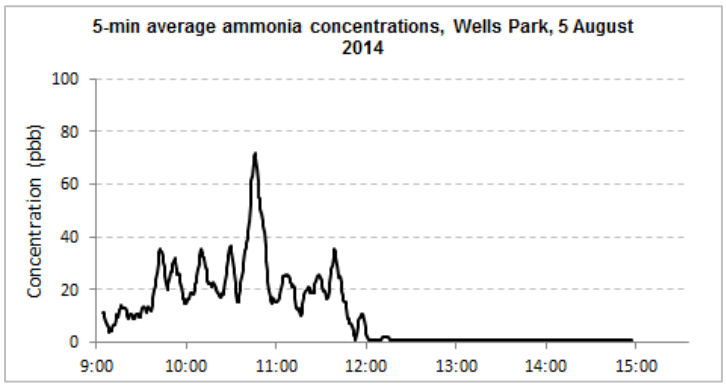
Description of Event

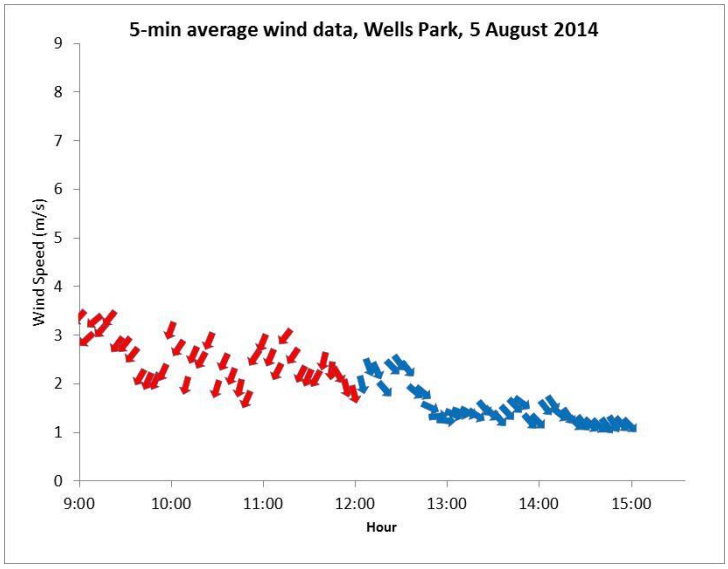
Winds were from the northeast during the peak 5 minute averaged measurement at 12:00pm.

Back trajectory analysis indicates that winds possibly originated from the direction of the KIA.

5 August 2014

Back trajectory to Wells Park over a period of 30 minutes ending at 10:40 AM on 05/08/2014





Pollutant

Ammonia

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	75
1 hour	30

Guideline

Time average	Concentration (ppb)
1 hour	480

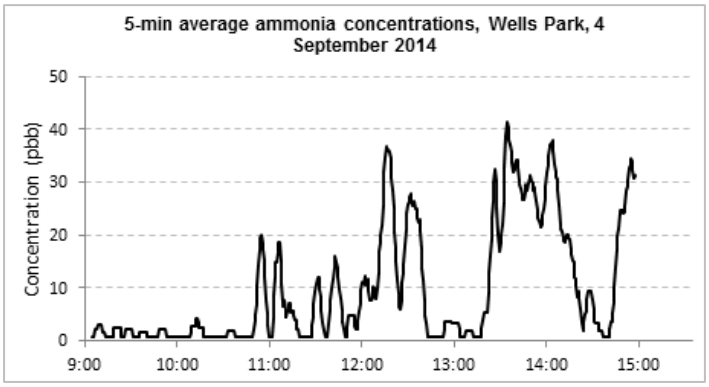
Description of Event

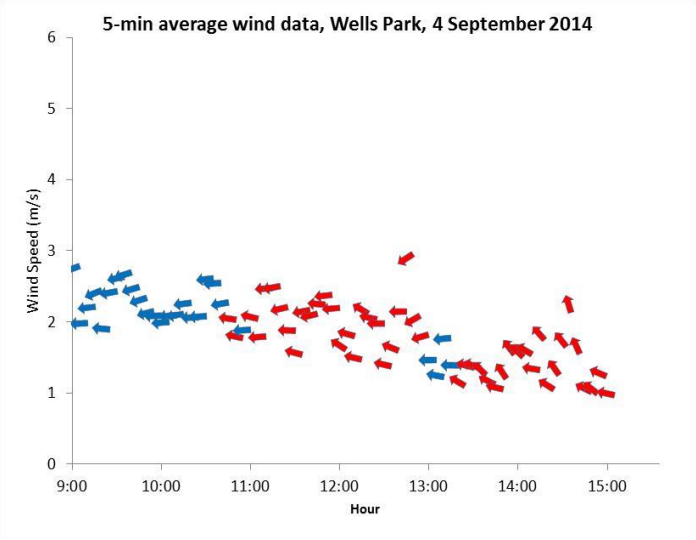
Winds were from the northeast during the peak 5 minute averaged measurement at 10:50am.

Back trajectory analysis indicates that winds possibly originated from the direction of the KIA.

4 September 2014

Back trajectory to Wells Park over a period of 40 minutes ending at 01:45 PM on 04/09/2014





Pollutant

Ammonia

Monitoring Site

Wells Park

Highest Concentration

Time average	Concentration (ppb)
5 minute	42
1 hour	19

Guideline

Time average	Concentration (ppb)
1 hour	480

Description of Event

Winds were from the east to southeast during the peak 5 minute averaged measurements.

Back trajectory analysis indicates that winds originated from the direction of the KIA.