2.2 Calculations

Once the samples have been analysed in the laboratory the results are issued as ng/tube (see Appendix 1) for each of the target compounds in order to convert this value to an environmental concentration the following calculation steps are used:

$C_{ppb} = m/(U_{eff} * t_S)$ - (2.2.1)

$D = P_sM/RT_s$ - (2.2.2)

$C_{ug/m3} = C_{ppb} * D$ - (2.2.3)

Where:

C_{ppb} = Concentration of compound in ppb

m = Mass of compound measured by laboratory in ng

t_s = Total sample time in minutes

U_{eff} = The tube uptake rate per compound in ng/ppm.min (see Appendix 2 for details on these)

D = The molecular density of the compound in kg/m^3

P_s = Standard pressure 101.325 kPa

T_s = Standard temperature 298 K

R = Universal gas constant (8.324 $J.K^{-1}.mol^{-1}$)

M = Molecular mass of the compound in g/gmol

$C_{ug/m3}$ = Concentration of compound in $\mu g/m^3$

3 SAMPLE LOCATIONS

The locations of the samples are summarised in Table 3.1 below:

Table 3.1: Sample Locations

Sample Location	Description	Longitude	Latitude
1	Loading bay	S33deg50.718'	E18deg31.523'
2	West fence near containment dams	S33deg50.385'	E18deg31.520'
3	North west fence near Caltex fuel station	S33deg50.186'	E18deg31.555'
4	East fence (Richwood Site)	S33deg50.548'	E18deg32.046'
5	South east fence opposite Bothasig (Bothasig site)	S33deg50.735'	E18deg31.879'
6	Tank farm north	S33deg49.850'	E18deg32.161'
7	Tank farm north west	S33deg49.949'	E18deg31.947'
8	Bothasig CCT station	S33deg51.387'	E18deg32.196'
9	Tableview CCT station	S33deg49.180'	E18deg30.859'
10	Waterfront station	S33deg54.829'	E18deg25.508'
11	Chevron CCT station	S33deg50.728'	E18deg31.516'
12	Chevron Staff Parking	S33deg50.730'	E18deg31.513'

Figures 3.1 and 3.2 below give a view of the samples on the refinery boundary:

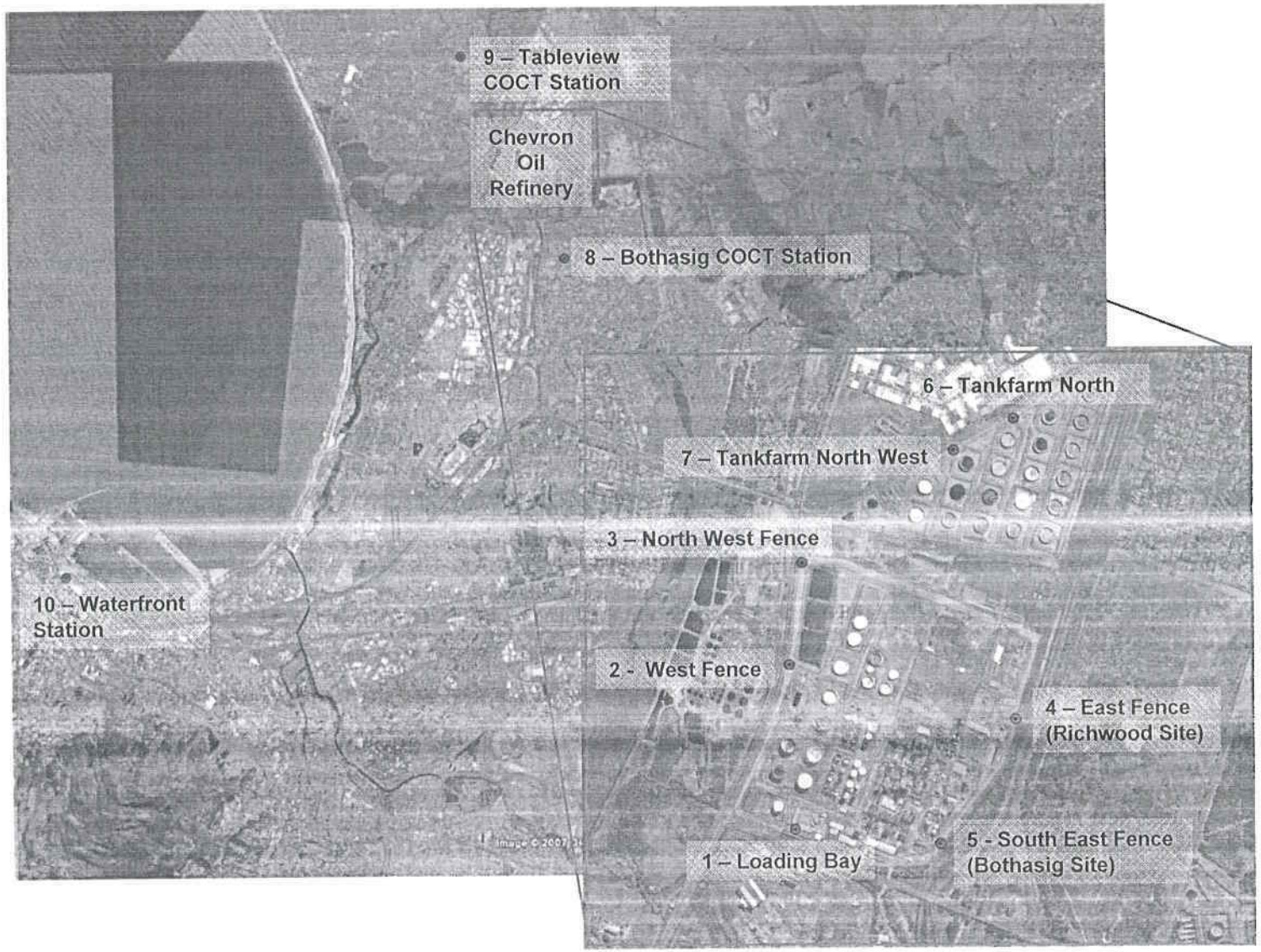


Figure 3.1: Details of Sampling Sites at the Cape Town Refinery

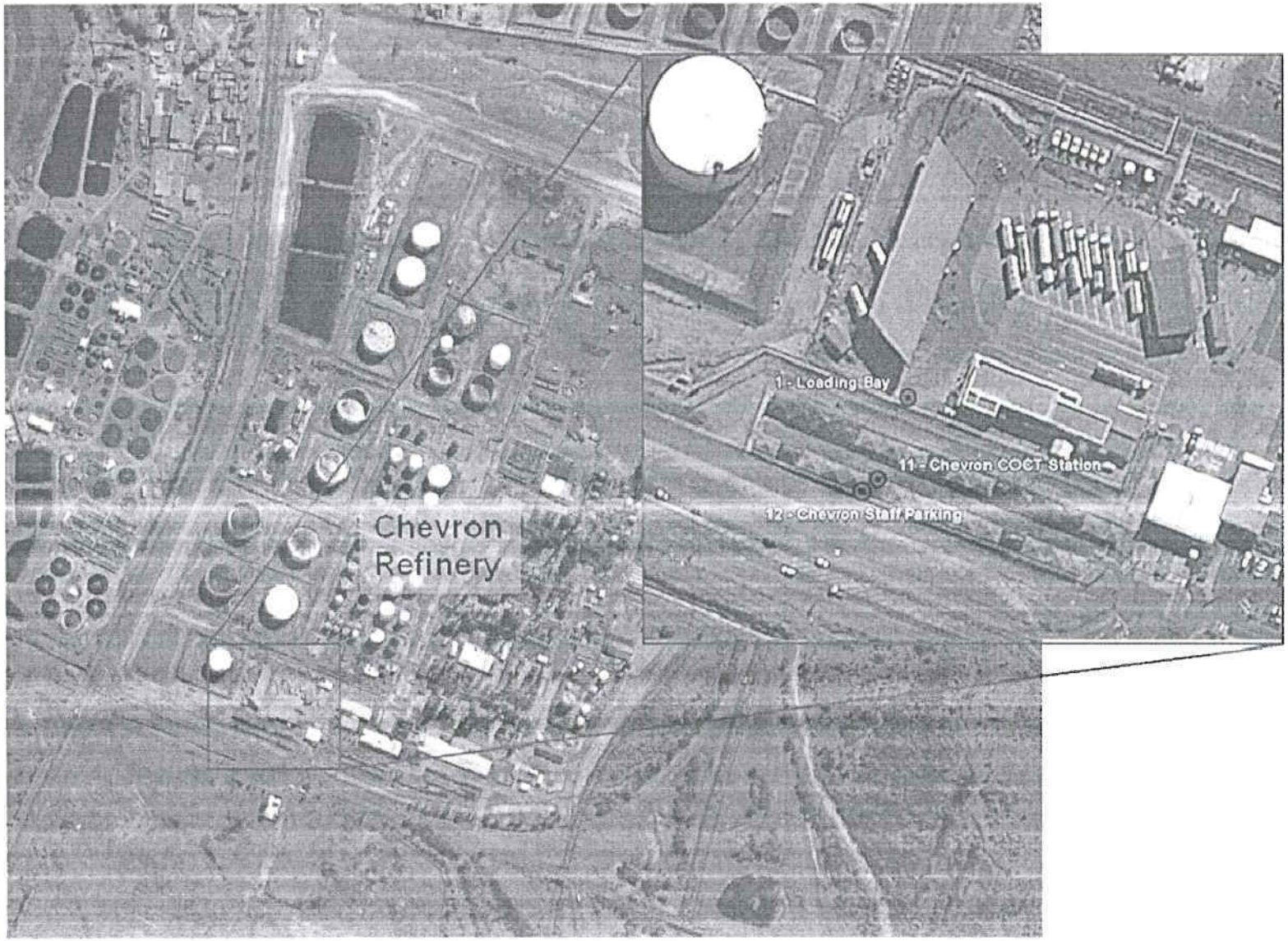


Figure 3.2: Location of additional sampling sites in relation to the Refinery and Loading Bay site

4 SCREENING SURVEY GUIDELINES

A literature review of ambient guidelines for BTEX compounds has resulted in the following proposed guidelines against which to measure the results of the project, included in Table 4.1 below are the values accepted in various international cases:

Table 4.1: BTEX Ambient Guidelines

Averaging Period	Annual					
	SA National Standard (DEA)[1]	CARB[2]	Current EU[3]	Australia[5]	Cape Town[6]	Durban South[7]
Benzene (µg/m^3)	10	60	5	10	5	5
Toluene (µg/m^3)		300		400		240
Xylene (µg/m^3)		700		800		700
Ethylbenzene (µg/m^3)		2000				2000

[1]The South African Department of Environmental Affairs national standard as listed in the Government Gazette No. 32816, published 24 December 2009.

[2] CARB stands for the California Air Resources Board who regulate air quality in California

[3] This is the current European Union standard for Benzene enforced in 2010

[4] These are guidelines used in an for ambient air in New South Wales in Australia

[5] This value was proposed by the City of Cape Town in terms of its Air Quality Management Plan but is as yet not been accepted as a standard

[6] Values were used in the Durban South area to assess the effect of the BTEX compounds on the community the benzene level was based on the EU 2010 target value, the toluene level was based on recommendations of toxicologist from the Netherlands and the other standards were taken from CARB

These were presented to the project team who accepted the Durban South guidelines for use in this project.

5 RESULTS

5.1 Annual Average Results

The annual average summary results are shown in Figures 5.1.1 to 5.1.5 below:

Fig 5.1.1: Annual Average Benzene Concentrations at the Monitoring Locations

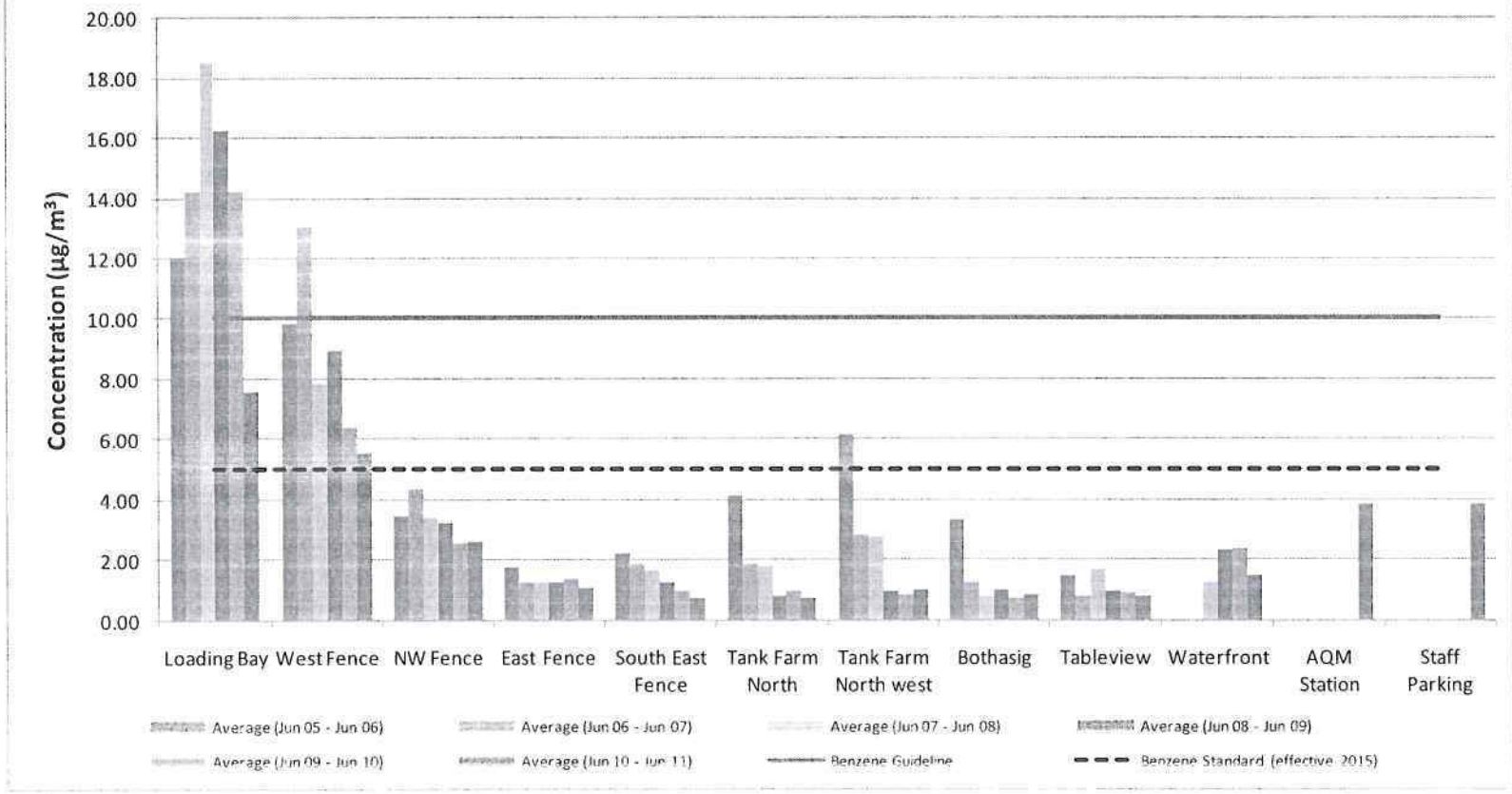


Fig 5.1.2: Annual Average Toluene Concentrations at the Monitoring Locations

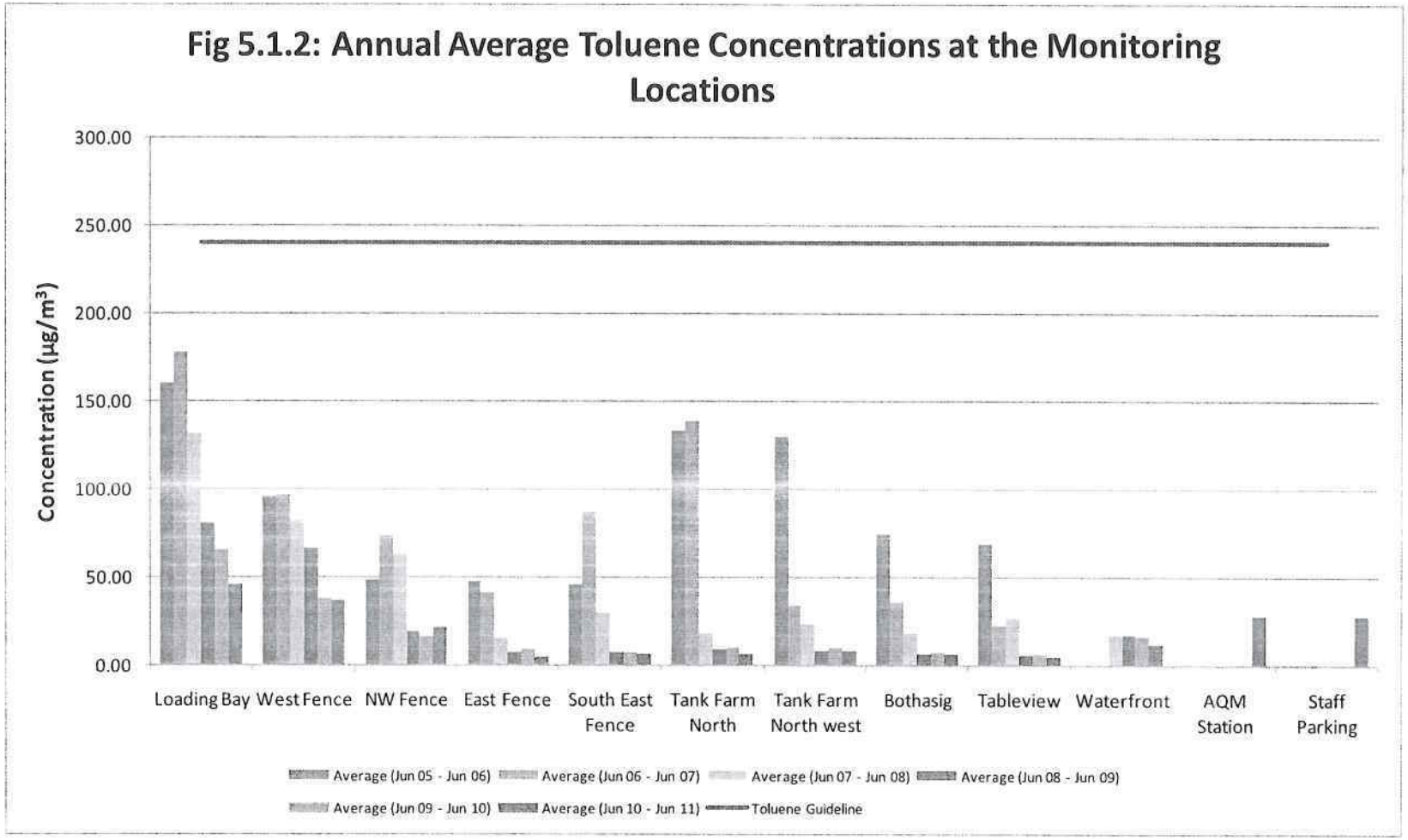


Fig 5.1.3: Annual Average Ethyl Benzene Concentrations at the Monitoring Locations

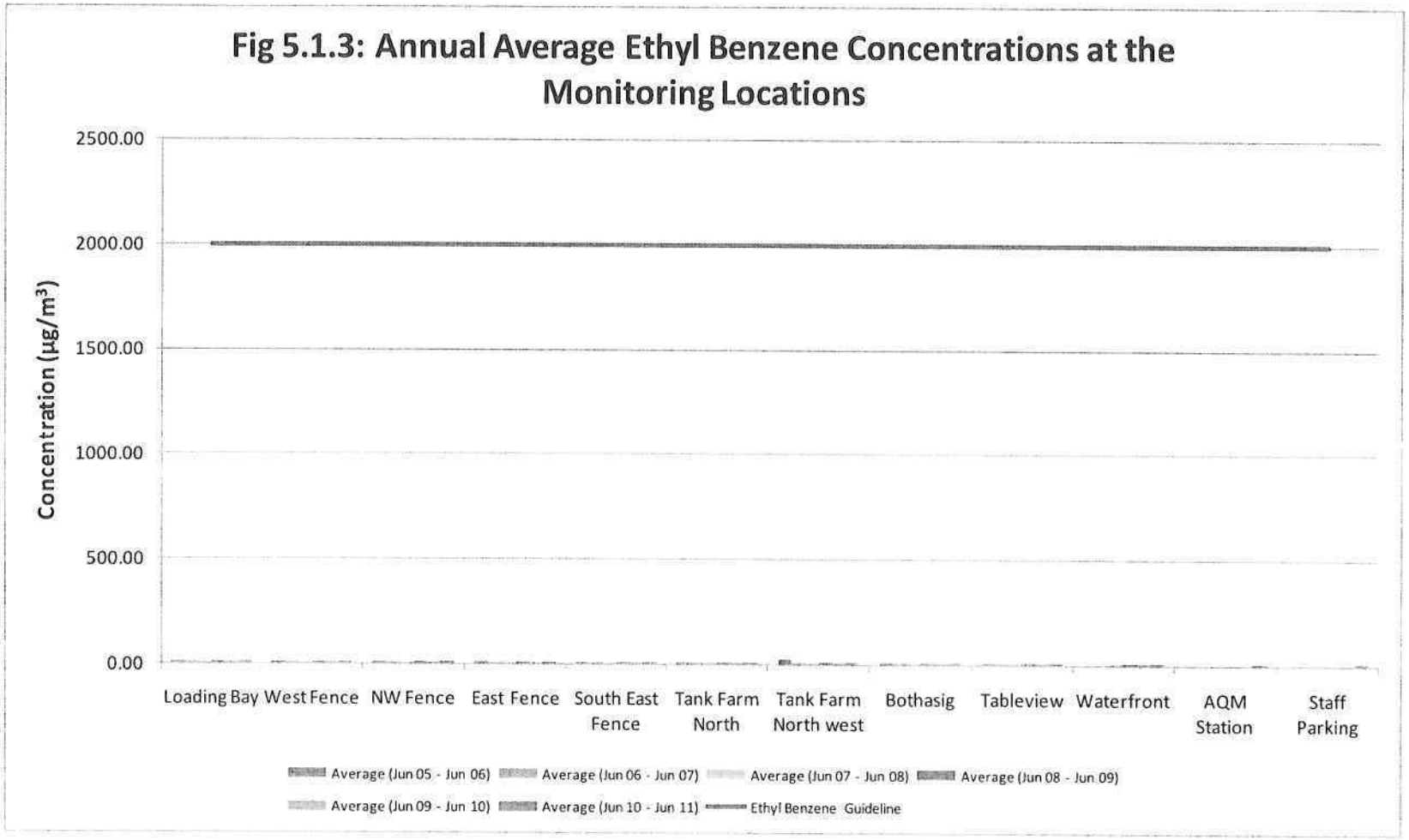


Fig 5.1.4: Annual Average m,p-Xylene Concentrations at the Monitoring Locations

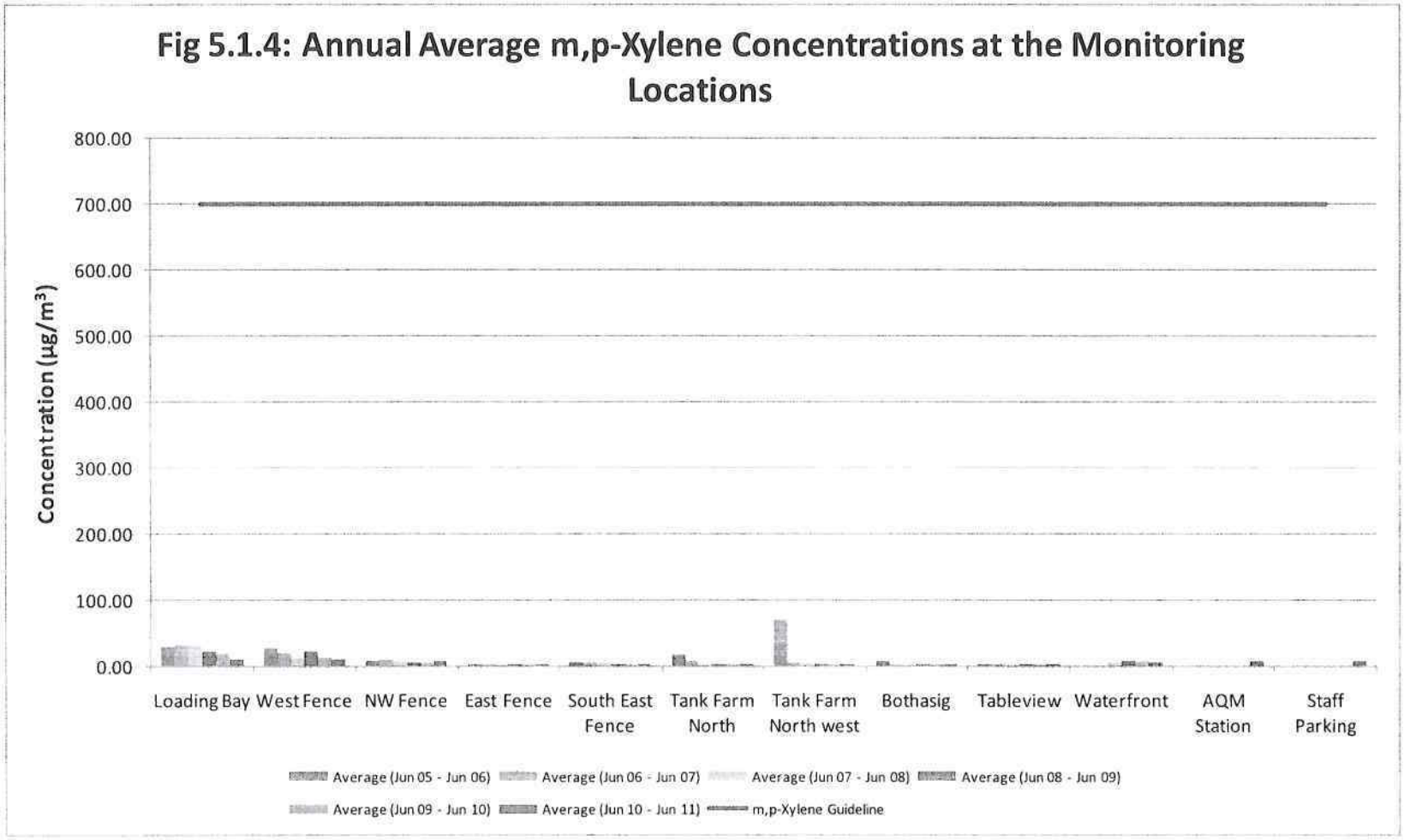
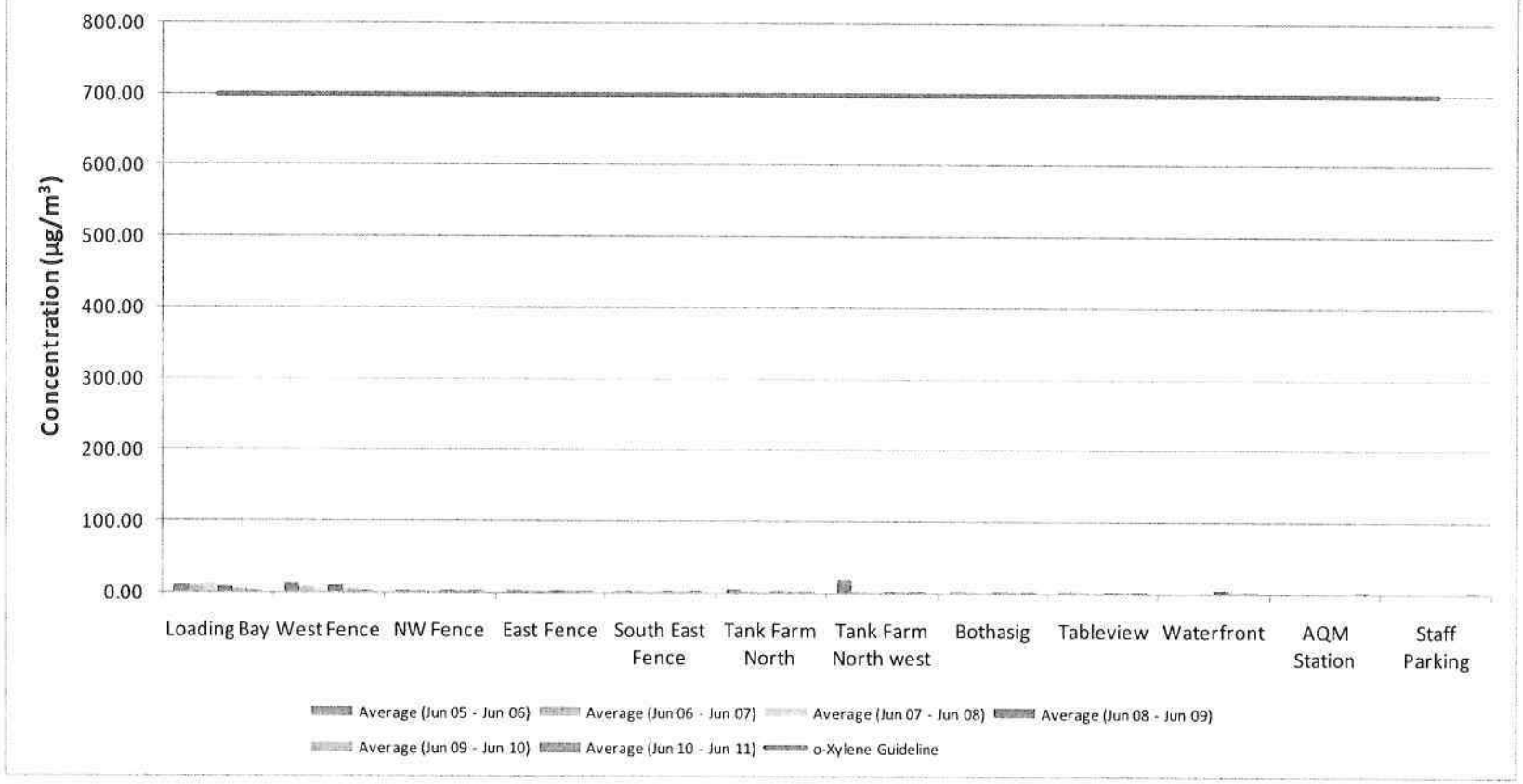


Fig 5.1.5: Average Annual o-Xylene Concentrations at the Monitoring Locations



5.2 Detailed Results

The detailed results for all of the samples taken are shown in Figures 5.2.1 to 5.2.5 below:

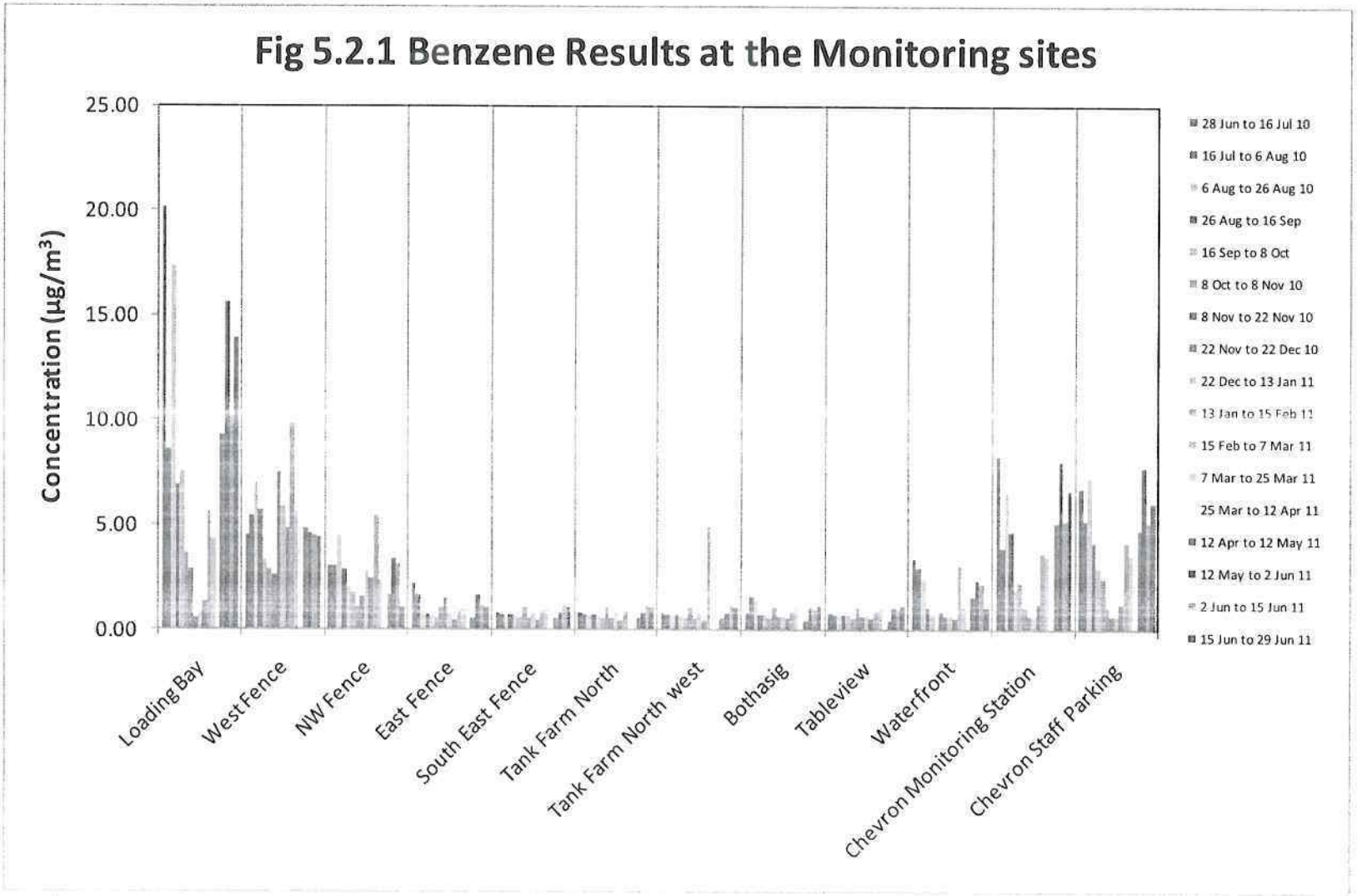


Fig 5.2.2 Toluene Results at the Monitoring sites

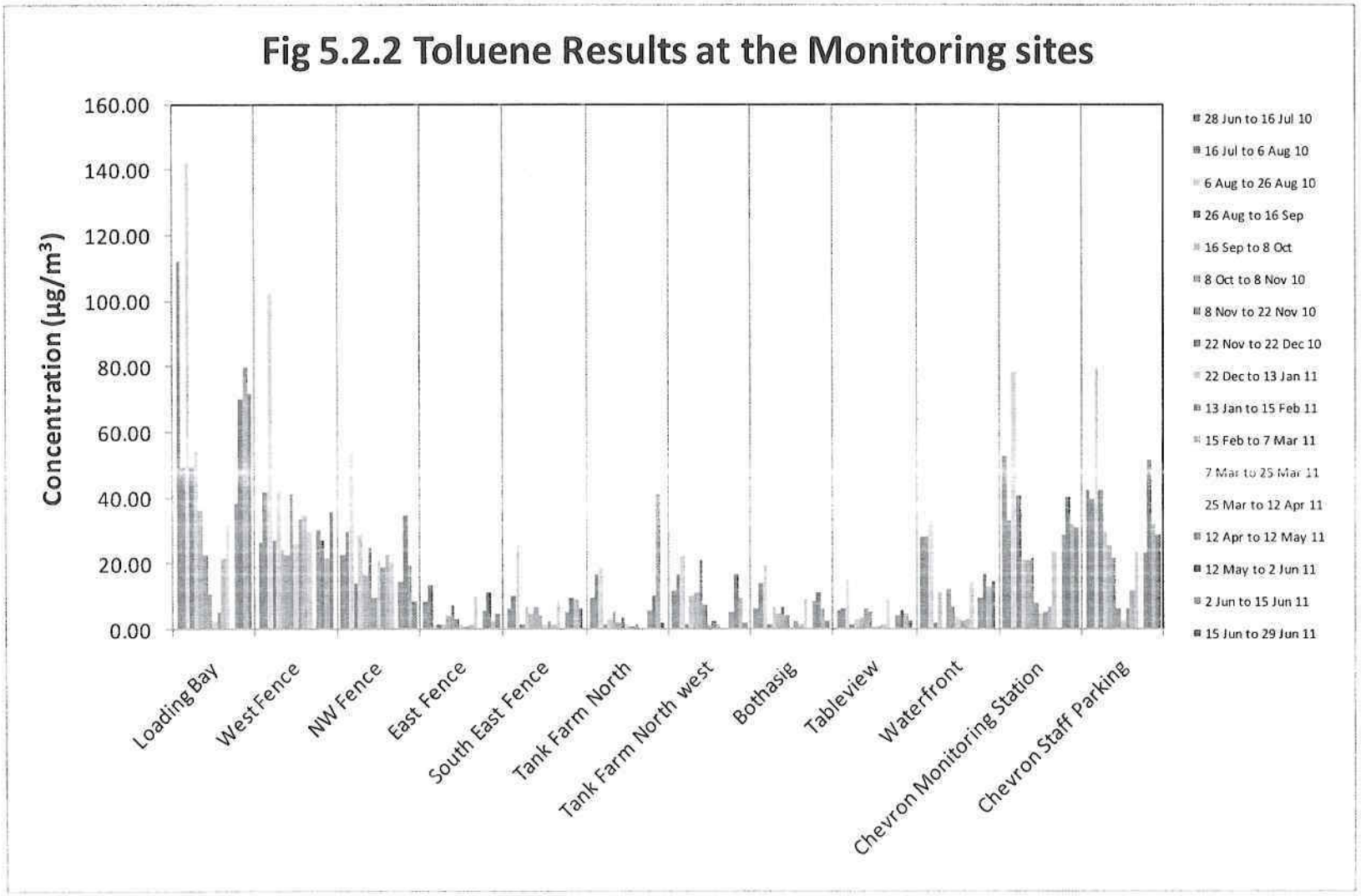


Fig 5.2.3 Ethyl Benzene Results at the Monitoring sites

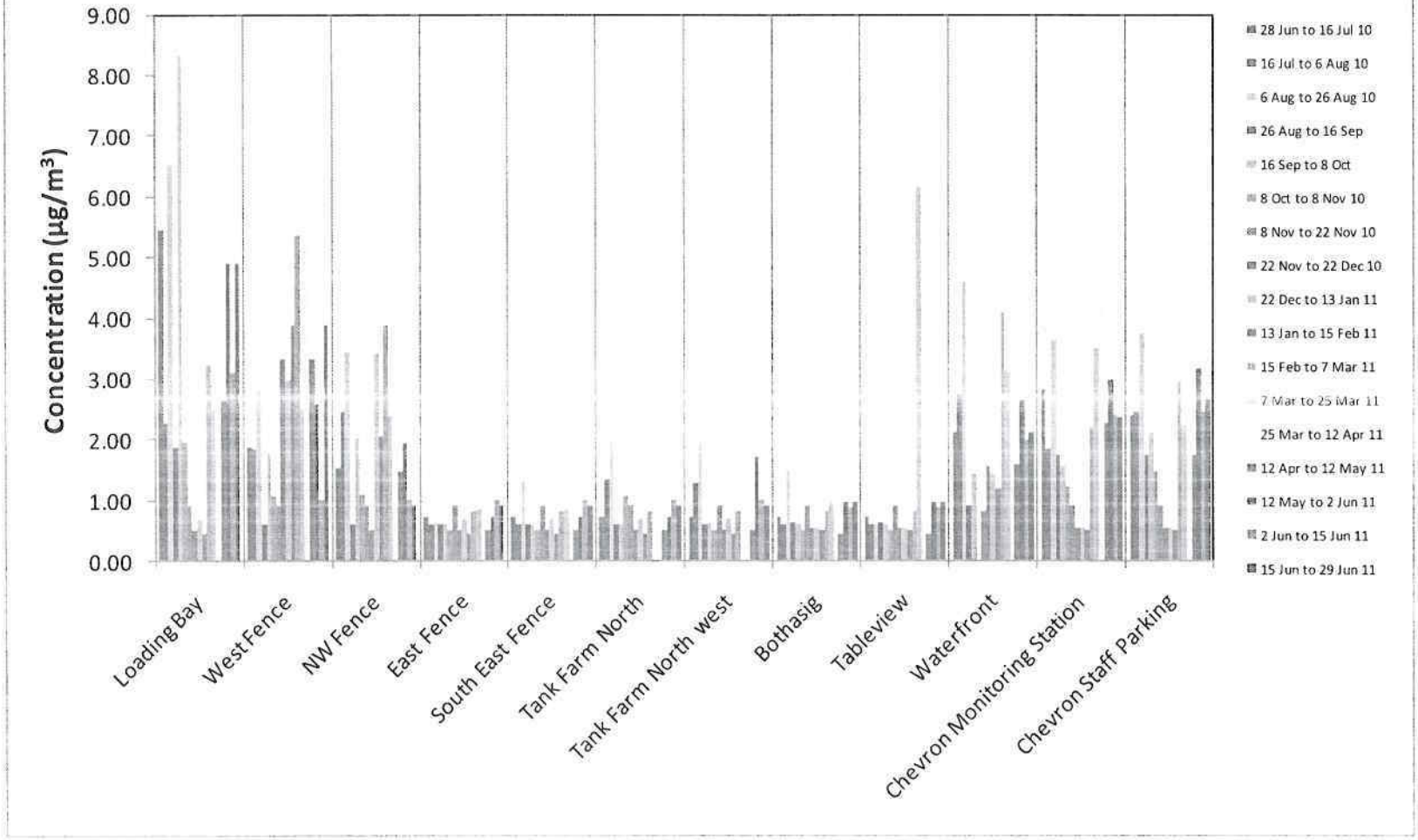


Fig 5.2.4 m,p-Xylene Results at the Monitoring sites

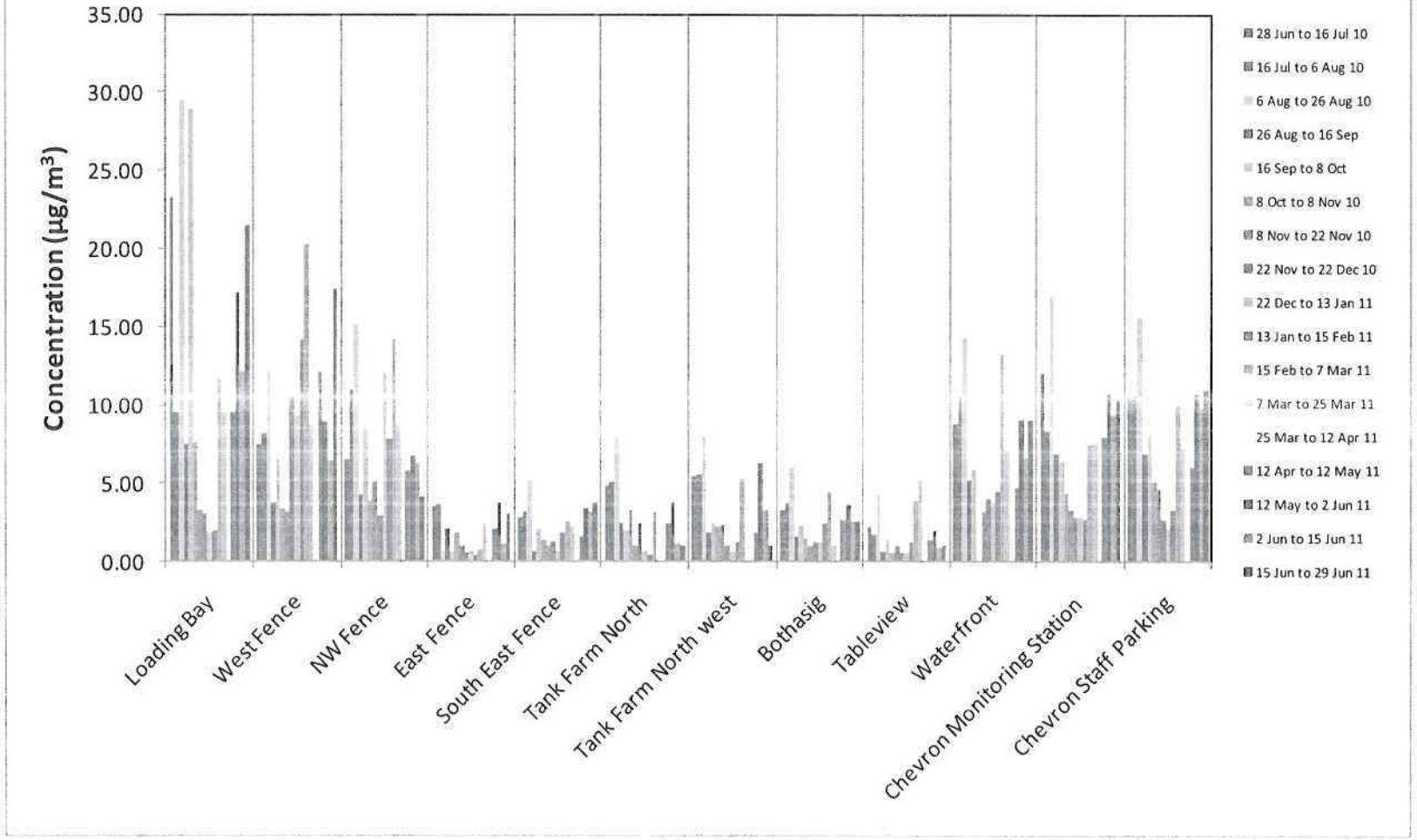
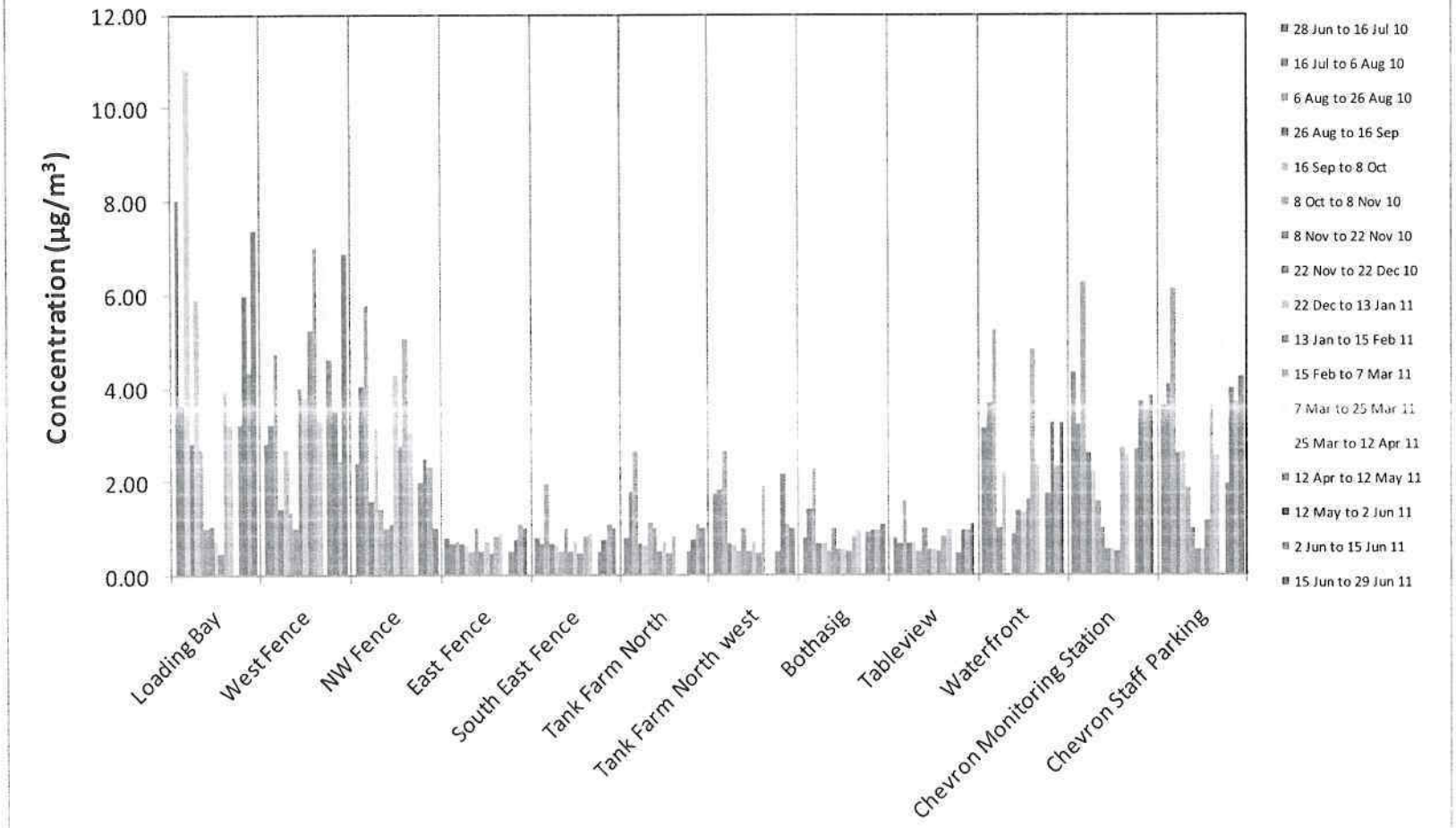
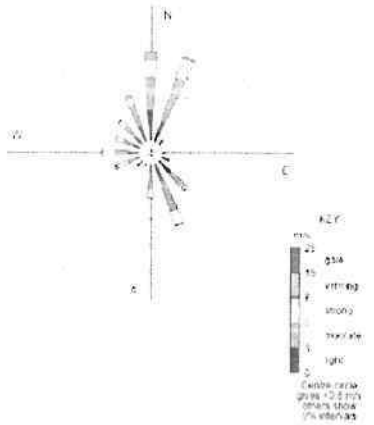


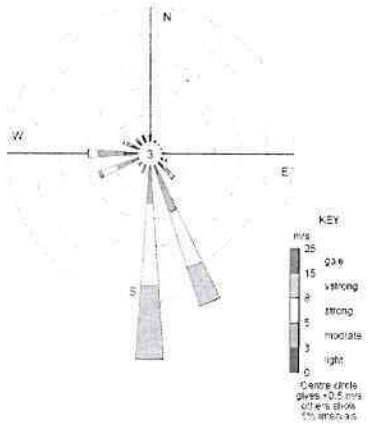
Fig 5.2.5 o-Xylene Results at the Monitoring sites



5.3 Elevated Conditions at the Loading Bay and West Fence

As was shown in Figure 5.1.1 elevated annual average benzene concentrations were noted at the Loading Bay and the West Fence Sites. These concentrations are compared with meteorological data supplied from Chevron's air quality station (see Appendix 3 for all meteorological data for the sampling period) in Table 5.3.1 below in an attempt give an idea of the source of the elevated levels. These examples represent two weeks to one month of data and are typical of seasonal wind patterns and exposure levels measured.

Date Range	Benzene and toluene concentrations at the Loading Bay (µg/m^3)	Benzene and toluene concentrations at the West Fence (µg/m^3)	Wind Rose	Comments
28 June to 16 July 2010	Benzene: 20.13 Toluene: 112.30	Benzene: 4.53 Toluene: 26.32		Prevailing northerly winds with Loading Bay emissions impact the Loading Bay site more than the West Fence site.

Date Range	Benzene and toluene concentrations at the Loading Bay (µg/m^3)	Benzene and toluene concentrations at the West Fence (µg/m^3)	Wind Rose	Comments
22 November to 22 December 2010	Benzene: 0.58 Toluene: 10.77	Benzene: 7.51 Toluene: 41.27		Prevailing strong to very strong southerly and south, south-easterly winds with Loading Bay emissions impact on the West Fence Site more than the Loading Bay Site.

6 CONCLUSIONS

Based on the results above, the following are concluded regarding the annual sampling campaign performed on behalf of Chevron South Africa (Pty) Limited:

- Passive sampling techniques following European (CEN) standards (EN482 and EN13528) were followed during the sampling campaign.
- During the annual sampling period one sample went missing from the Waterfront site between 8th October and 8th November 2010 and one at each of the Tank Farm North and Tank Farm North West sites between 7th and 25th March 2011. These missing samples are attributed to construction work on site when the lamp posts supporting the sample shelters at the refinery were replaced. This represents a 99% data capture for the reporting period.
- After one year of co-located sampling at the loading bay site it has been determined that the outer fence-line is more representative for assessment against ambient standards and it is recommended that a single site at this location (outer fence-line of parking area near loading bay) replace the existing Loading Bay sampler.
- The national ambient air quality annual average standard for benzene (10µg/m^3) was not exceeded at any site during the period under review (June 2010 – June 2011). This represents a marked decrease over the past few years, particularly at the Loading Bay site where annual benzene levels decreased from 14.24µg/m^3 to 7.59µg/m^3 between the 2009 to 2010 and 2010 to 2011 review periods.
- The more stringent annual average standard for benzene of 5µg/m^3 as accepted by the NCamtg (Northern Communities air monitoring task group) was exceeded at both the Loading Bay and West Fence. This standard also represents the future national ambient air quality annual average standard which comes into effect 1st January 2015. However, since the Loading Bay is no longer the most representative site for measuring ambient levels of pollutants the original sampler on the inner fence-line should not therefore be used for ambient assessment (see above).
- Accepted standards and guidelines for toluene, ethyl-benzene and xylene levels were not exceeded for the period under review.
- Based on historical data, the prevailing wind directions are from the north-west and the south and south, south-east. As such it seems likely that the elevated levels at the

Loading Bay and the West Fence sites were as a result of the impacts of emissions from the petrol loading facility.

- This annual report supersedes any interim data and reports issued throughout the year to allow for the consistent statistical treatment of averaging periods.

APPENDIX 1

Detailed Monthly Results:

Benzene

DATE		28 Jun to 16 Jul 10	16 Jul to 6 Aug 10	6 Aug to 26 Aug 10	26 Aug to 16 Sep	16 Sep to 8 Oct	8 Oct to 8 Nov 10	8 Nov to 22 Nov 10	22 Nov to 22 Dec 10	22 Dec to 13 Jan 11	13 Jan to 15 Feb 11	15 Feb to 7 Mar 11	7 Mar to 25 Mar 11	25 Mar to 12 Apr 11	12 Apr to 12 May 11	12 May to 2 Jun 11	2 Jun to 15 Jun 11	15 Jun to 29 Jun 11
Site 1	Loading Bay	20.13	8.58	17.34	6.89	7.55	3.63	2.91	0.58	0.79	1.37	5.61	4.30	12.54	9.26	15.63	10.11	13.93
Site 2	West Fence	4.53	5.44	7.01	5.67	3.29	2.85	2.58	7.51	5.84	4.88	9.78	5.65	11.58	4.86	4.60	4.53	4.40
Site 3	NW Fence	3.02	3.08	4.52	2.87	1.99	1.79	1.08	1.62	2.76	2.44	5.40	2.39	3.38	1.68	3.37	3.14	1.07
Site 4	East Fence	2.18	1.72	0.75	0.72	0.69	0.56	1.08	1.50	0.79	0.51	0.92	0.96	2.61	0.58	1.65	1.16	1.07
Site 5	South East Fenc	0.84	0.72	0.75	0.72	0.69	0.56	1.08	0.58	0.79	0.51	0.92	0.96	0.97	0.58	0.82	1.16	1.07
Site 6	Tank Farm North	0.84	0.71	0.75	0.72	0.69	0.56	1.08	0.58	0.79	0.51	0.91		1.44	0.58	0.82	1.16	1.07
Site 7	Tank Farm North	0.84	0.72	0.75	0.72	0.69	0.56	1.07	0.58	0.79	0.51	4.92		3.03	0.58	0.82	1.16	1.07
Site 8	Bothasig	0.84	1.57	1.44	0.72	0.72	0.56	1.07	0.62	0.62	0.58	0.91	1.08	0.82	0.51	1.07	1.02	1.14
Site 9	Tableview	0.84	0.71	0.72	0.72	0.72	0.56	1.06	0.62	0.62	0.58	0.91	1.08	1.63	0.51	1.07	1.02	1.14
Site 10	Waterfront	3.37	2.98	2.48	1.08	0.72		0.94	0.66	0.62	0.58	3.01	1.08	2.19	1.63	2.40	2.21	1.07
Site 11	Chevron Monitori	8.25	3.94	6.57	4.69	1.94	2.30	1.06	0.62	0.62	1.21	3.65	3.47	7.34	5.12	8.03	5.21	6.63
Site 12	Chevron Staff Pa	6.73	5.21	7.22	4.19	2.94	2.41	1.06	0.62	0.62	1.27	4.19	3.58	7.10	4.76	7.71	5.11	6.06

Ethyl Benzene

DATE		28 Jun to 16 Jul 10	16 Jul to 6 Aug 10	6 Aug to 26 Aug 10	26 Aug to 16 Sep	16 Sep to 8 Oct	8 Oct to 8 Nov 10	8 Nov to 22 Nov 10	22 Nov to 22 Dec 10	22 Dec to 13 Jan 11	13 Jan to 15 Feb 11	15 Feb to 7 Mar 11	7 Mar to 25 Mar 11	25 Mar to 12 Apr 11	12 Apr to 12 May 11	12 May to 2 Jun 11	2 Jun to 15 Jun 11	15 Jun to 29 Jun 11
Site 1	Loading Bay	5.44	2.29	6.52	1.86	8.31	1.97	0.93	0.52	0.71	0.46	3.23	2.50	4.35	2.66	4.89	3.11	4.91
Site 2	West Fence	1.89	1.86	2.80	0.62	1.78	1.06	0.93	3.33	2.99	3.88	5.35	2.50	5.22	3.34	2.59	1.01	3.89
Site 3	NW Fence	1.52	2.47	3.45	0.62	2.02	1.11	0.93	0.52	3.41	2.06	3.88	2.41	0.87	1.46	1.93	1.00	0.93
Site 4	East Fence	0.73	0.62	0.65	0.62	0.59	0.50	0.93	0.52	0.71	0.46	0.83	0.86	2.00	0.52	0.74	1.00	0.93
Site 5	South East Fenc	0.73	0.62	1.30	0.62	0.59	0.50	0.93	0.52	0.71	0.46	0.83	0.86	0.87	0.52	0.74	1.00	0.93
Site 6	Tank Farm North	0.73	1.36	1.96	0.62	0.59	1.06	0.93	0.52	0.71	0.46	0.82		1.30	0.52	0.74	1.01	0.93
Site 7	Tank Farm North	0.73	1.30	1.89	0.62	0.59	0.50	0.93	0.52	0.71	0.46	0.82		1.30	0.52	1.71	1.01	0.93
Site 8	Bothasig	0.73	0.62	1.49	0.62	0.62	0.51	0.92	0.56	0.56	0.52	0.82	0.98	0.74	0.46	0.96	0.88	0.99
Site 9	Tableview	0.73	0.62	0.62	0.62	0.62	0.50	0.92	0.56	0.56	0.52	0.82	6.15	0.74	0.46	0.97	0.88	0.99
Site 10	Waterfront	2.11	2.73	4.58	0.93	1.43		0.81	1.56	1.46	1.20	4.11	3.13	4.24	1.61	2.65	2.00	2.13
Site 11	Chevron Monitori	2.84	1.84	3.63	1.75	1.55	1.21	0.92	0.56	0.56	0.52	2.22	3.52	4.27	2.26	2.99	2.38	2.37
Site 12	Chevron Staff Pa	2.40	2.46	3.75	1.75	2.11	1.46	0.92	0.56	0.56	0.52	2.96	2.25	3.97	1.75	3.18	2.47	2.67

m,p -Xylene

DATE		28 Jun to 16 Jul 10	16 Jul to 6 Aug 10	6 Aug to 26 Aug 10	26 Aug to 16 Sep	16 Sep to 8 Oct	8 Oct to 8 Nov 10	8 Nov to 22 Nov 10	22 Nov to 22 Dec 10	22 Dec to 13 Jan 11	13 Jan to 15 Feb 11	15 Feb to 7 Mar 11	7 Mar to 25 Mar 11	25 Mar to 12 Apr 11	12 Apr to 12 May 11	12 May to 2 Jun 11	2 Jun to 15 Jun 11	15 Jun to 29 Jun 11
Site 1	Loading Bay	23.26	9.57	29.54	7.55	28.86	7.64	3.29	3.05	1.87	2.03	11.72	9.58	15.82	9.48	17.23	12.21	21.51
Site 2	West Fence	7.54	8.21	12.25	3.85	6.56	3.46	3.19	10.52	9.34	14.15	20.29	8.72	18.46	12.12	8.98	6.44	17.42
Site 3	NW Fence	6.58	10.94	15.13	4.26	8.54	3.87	5.15	3.00	12.21	7.87	14.17	8.70	5.36	5.80	6.75	6.33	4.20
Site 4	East Fence	3.61	3.62	0.72	2.06	0.66	1.83	1.03	0.53	0.72	0.46	0.84	2.44	6.59	2.11	3.75	1.11	3.07
Site 5	South East Fenc	2.89	3.21	5.26	0.69	2.10	1.37	1.03	1.32	0.72	1.90	2.59	2.18	2.55	1.69	3.45	3.22	3.79
Site 6	Tank Farm North	4.81	5.13	7.94	2.47	2.03	3.26	1.03	2.47	0.72	0.46	3.15		4.34	2.48	3.82	1.11	1.02
Site 7	Tank Farm North	5.45	5.54	7.93	1.92	2.43	2.29	2.36	1.05	0.72	1.30	5.31		4.34	1.84	6.30	3.33	1.02
Site 8	Bothasig	3.30	3.82	6.05	1.66	2.40	1.53	1.02	1.24	1.30	2.43	4.48	0.99	3.87	2.75	3.70	2.54	2.62
Site 9	Tableview	2.25	1.77	4.34	0.69	1.44	0.51	1.02	0.57	0.57	1.26	3.90	5.23	3.64	1.40	2.05	0.98	1.09
Site 10	Waterfront	8.86	10.61	14.37	5.25	5.89		3.15	4.06	3.73	4.52	13.28	7.11	11.42	4.78	9.04	6.63	9.11
Site 11	Chevron Monitori	12.07	8.29	16.95	6.90	6.37	4.34	3.25	2.82	2.78	2.73	7.56	7.60	15.61	7.93	10.73	9.37	10.39
Site 12	Chevron Staff Pa	10.46	10.55	15.69	6.90	8.22	5.10	4.68	2.71	2.10	3.26	9.96	7.20	14.87	6.06	10.73	9.76	10.93

o-Xylene

DATE		28 Jun to 16 Jul 10	16 Jul to 6 Aug 10	6 Aug to 26 Aug 10	26 Aug to 16 Sep	16 Sep to 8 Oct	8 Oct to 8 Nov 10	8 Nov to 22 Nov 10	22 Nov to 22 Dec 10	22 Dec to 13 Jan 11	13 Jan to 15 Feb 11	15 Feb to 7 Mar 11	7 Mar to 25 Mar 11	25 Mar to 12 Apr 11	12 Apr to 12 May 11	12 May to 2 Jun 11	2 Jun to 15 Jun 11	15 Jun to 29 Jun 11
Site 1	Loading Bay	8.02	3.62	10.81	2.81	5.90	2.70	1.03	1.05	0.72	0.46	3.94	3.22	5.27	3.21	5.99	4.33	7.37
Site 2	West Fence	2.81	3.21	4.76	1.44	2.69	1.32	1.03	4.00	3.81	5.26	6.99	3.31	6.59	4.64	3.52	2.44	6.87
Site 3	NW Fence	2.41	4.03	5.76	1.58	3.15	1.42	1.03	1.10	4.31	2.78	5.09	3.05	1.93	2.00	2.47	2.33	1.02
Site 4	East Fence	0.80	0.68	0.72	0.69	0.66	0.51	1.03	0.53	0.72	0.46	0.84	0.87	2.37	0.53	0.75	1.11	1.02
Site 5	South East Fenc	0.80	0.68	1.95	0.69	0.66	0.51	1.03	0.53	0.72	0.46	0.83	0.87	0.88	0.53	0.75	1.11	1.02
Site 6	Tank Farm North	0.80	1.78	2.67	0.69	0.66	1.12	1.03	0.53	0.72	0.46	0.83		1.31	0.53	0.75	1.11	1.02
Site 7	Tank Farm North	1.76	1.85	2.67	0.69	0.66	0.51	1.03	0.53	0.72	0.46	1.91		1.31	0.53	2.18	1.11	1.02
Site 8	Bothasig	0.80	1.43	2.27	0.69	0.69	0.51	1.02	0.56	0.57	0.53	0.83	0.99	0.74	0.93	0.97	0.98	1.09
Site 9	Tableview	0.80	0.68	1.58	0.69	0.69	0.51	1.02	0.57	0.57	0.53	0.83	0.99	0.74	0.47	0.98	0.98	1.09
Site 10	Waterfront	3.14	3.69	5.25	1.03	2.19		0.90	1.39	1.36	1.63	4.82	2.37	4.28	1.77	3.28	2.31	3.28
Site 11	Chevron Monitori	4.35	3.24	6.28	2.62	2.19	1.58	1.02	0.56	0.57	0.53	2.74	2.57	5.35	2.70	3.71	3.51	3.83
Site 12	Chevron Staff Pa	3.62	4.07	6.15	2.62	2.67	1.89	1.02	0.56	0.57	1.16	3.65	2.57	5.13	1.96	4.00	3.71	4.26

Toluene

DATE		28 Jun to 16 Jul 10	16 Jul to 6 Aug 10	6 Aug to 26 Aug 10	26 Aug to 16 Sep	16 Sep to 8 Oct	8 Oct to 8 Nov 10	8 Nov to 22 Nov 10	22 Nov to 22 Dec 10	22 Dec to 13 Jan 11	13 Jan to 15 Feb 11	15 Feb to 7 Mar 11	7 Mar to 25 Mar 11	25 Mar to 12 Apr 11	12 Apr to 12 May 11	12 May to 2 Jun 11	2 Jun to 15 Jun 11	15 Jun to 29 Jun 11
Site 1	Loading Bay	112.30	49.36	141.91	49.57	54.54	36.47	22.52	10.77	2.57	5.28	21.42	32.68	61.43	38.63	70.27	80.18	71.71
Site 2	West Fence	26.32	41.89	102.47	27.04	41.61	24.32	22.52	41.27	25.72	33.78	34.59	29.73	59.96	30.55	26.81	21.39	35.88
Site 3	NW Fence	22.81	29.92	53.60	13.97	28.74	16.48	24.77	9.87	20.83	18.95	22.74	20.78	14.39	14.37	34.51	19.44	8.51
Site 4	East Fence	8.42	13.61	1.58	1.50	1.43	4.26	7.43	2.87	1.22	0.79	1.43	10.10	16.49	5.93	11.12	2.43	4.48
Site 5	South East Fenc	6.49	10.32	25.23	1.50	6.89	4.69	6.76	3.95	1.22	2.44	1.42	8.76	7.49	5.12	9.71	9.23	6.50
Site 6	Tank Farm North	9.83	16.45	18.94	1.50	3.16	5.47	2.25	3.59	1.23	0.79	1.42		10.98	5.93	9.96	41.32	2.24
Site 7	Tank Farm North	11.58	16.47	22.07	1.50	10.34	11.28	20.90	7.45	1.23	2.45	1.42		12.55	5.21	16.62	9.48	2.24
Site 8	Bothasig	6.52	13.89	19.54	1.51	6.89	4.87	6.91	3.95	0.97	2.44	1.42	8.92	9.25	8.75	11.13	6.19	2.39
Site 9	Tableview	5.81	6.42	14.91	1.51	3.30	3.39	6.44	5.01	0.97	0.90	1.42	9.09	9.63	4.37	5.66	4.49	2.39
Site 10	Waterfront	28.20	28.10	32.81	2.25	11.25		12.61	7.12	3.47	2.78	2.83	14.47	19.46	9.78	16.93	12.83	14.33
Site 11	Chevron Monitori	52.83	32.99	78.28	40.79	20.99	20.89	21.36	8.19	4.54	5.02	6.79	23.55	58.30	28.62	39.90	32.04	31.10
Site 12	Chevron Staff Pa	42.26	39.59	79.65	42.30	29.98	25.24	21.36	6.55	2.51	6.10	11.61	23.55	43.09	23.06	51.54	32.04	28.71

APPENDIX 2

Literature on Tube Uptake Rates:

MARKES international LIMITED

Unit D3, Llantrisant Business Park, Pontyclun, RCT, CF72 8YW, United Kingdom.
Tel: +(44) 1443 230935 Fax: +(44) 1443 231531
http://www.markes.com

Thermal Desorption Technical Support

Note 1: Uptake Rates for Tube Type, Axial Diffusive Samplers

This information has been reproduced from Issue 8 of The Diffusive Monitor with the kind permission of the editor, Dr. R H Brown.

If you wish to be added to the mailing list for future issues of The Diffusive Monitor, please write to Dr M Wright, HSL Broad Lane, Sheffield, S3 7HQ, UK. Fax: (44) 114 289 2768

Diffusive Uptake Rates for Tube Type, Axial Diffusive Samplers

NOTE: This list has been compiled from sources available to CAR/Working Group 5. It is not complete, and although every care has been taken in its preparation, no guarantee can be given of its accuracy. Nor does the list imply a preference for this type of sampler.

Sampling rates are given for a standard 3.5-inch long by ¼-inch O.D. stainless steel tube without the membrane, except where noted.

Separate lists are given for workplace (approx 8 hours) and environmental (approx 4 weeks) exposure periods and exposure concentrations typical of these applications.

Users of the data are strongly advised to consult the original source material to determine the level of confidence and range of applicability of the values.

Workplace Applications
Hydrocarbons

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
1,3-butadiene	Mol.Sieve 13X*	A	1.3	1
	Carbopack X	B	1.64	15
n-pentane	Chrom. 106	A	1.46	1
	Carbopak B	B	1.77	1
n-hexane	Chrom. 106	A	1.77	1
cyclohexane	Chrom. 106	D	1.60	28
	Tenax TA	D	1.32	28

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
benzene	*Tenax* TA	A	1.3	1
	Porapak Q	A	1.37	1
	Tenax GR	B	1.81	1
	Chrom. 106	B	1.72	1
n-heptane	Chrom. 106	A	1.95	1
	Tenax TA	A	1.77	1
	Carbopack B	B	1.94	1
2-methyl hexane	Chrom. 106	D	1.79	28
	Tenax TA	D	1.48	28
3-methyl hexane	Chrom.106	D	1.80	28
	Tenax TA	D	1.48	28
methylcyclohexane	Chrom.106	D	1.88	28
	Tenax TA	D	1.55	28
toluene	Tenax TA	B	1.67	1
	Tenax GR	B	2.12	1
	Chrom. 106	B	1.94	1
	Carbopack B	B	2.06	1
2-methyl heptane	Chrom. 106	D	2.33	28
	Tenax TA	D	1.95	28
n-octane	Chrom. 106	A	2.13	1
	Tenax TA	A	2.00	1
xylene	Tenax TA	B	1.82	1
	Chrom. 106	B	2.10	1
	Tenax GR	B	2.48	1
ethyl benzene	Tenax TA	B	2.0	1
	Tenax GR	B	2.43	1
	Chrom. 106	B	1.9	1
	Porapak Q	D	2.38	1
styrene	**Tenax TA**	A	2.0	1
	Chrom. 106	B	2.15	1
n-nonane	Chrom. 106	A	2.40	1
	Tenax TA	A	2.12	1

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
Iso-propylbenzene	Chrom. 106	C	2.26	1
	Tenax TA	C	2.26	1
	Porapak Q	D	2.5	1
n-propyl benzene	Chrom. 106	D	2.45	28
	Tenax TA	D	2.28	28
trimethylbenzene	Chrom. 106	C	2.37	1
	Tenax TA	C	2.37	1
1,3-dimethyl -4-ethyl benzene	Tenax TA	D	2.45	28
1,4-diethyl benzene	Tenax TA	D	2.56	28
m-ethyl toluene	Chrom. 106	D	2.43	28
	Tenax TA	D	2.25	28
o-ethyl toluene	Chrom. 106	D	2.57	28
	Tenax TA	D	2.44	28
p-ethyl toluene	Chrom. 106	D	2.35	28
	Tenax TA	D	2.21	28
n-decane	Tenax TA	A	2.3	1
	Chrom. 106	A	2.47	30
cumene	Porapak Q	D	2.5	19
α-pinene	Tenax TA	D	2.35	28
	Chrom. 106	A	2.56	30
naphthalene	Tenax TA	A	2.55	30

Halogenated Hydrocarbons

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
methyl chloride	Spherocarb / Unicarb	B	1.3	1
vinyl chloride	Spherocarb / Unicarb	B	2.0	1
1,1-dichloro ethene	Spherocarb / Unicarb	B	2.5	1
trichloro trifluoro ethane	Chrom. 102	B	3.5	1
chloro trifluoro methane	Chrom. 102	B	1.8	1
dichloromethane	Chrom. 106	B	1.56	1
	Chrom. 102	B	1.56	1
1,2-dichloro ethane	Chrom. 102	B	1.9	1
	Chrom. 106	B	2.03	26
	Tenax GR	B	1.72	26

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
halothane	Tenax TA	B	2.59	1
	Chrom. 102	B	3.6	1
	Chrom. 106	B	4.28	36
enflurane	Tenax TA	B	2.29	1
	Chrom. 106	D	2.8	28
	Chrom. 106	B	3.24	36
sevoflurane	Chrom. 106	B	3.09	36
isoflurane	Tenax TA	B	2.20	1
	Chrom. 106	D	2.51	28
	Chrom. 106	B	3.43	36
bromoethane	Chrom. 106	E	2.45	1
bromobenzene	Chrom. 106	D	3.59	28
	Tenax TA	D	3.31	28
trichloromethane	Tenax GR	B	2.18	1
(chloroform)	Chrom. 102	B	2.35	1
	Chrom. 106	B	2.47	26
tetrachloro methane	Tenax GR	B	3.72	1
	Chrom. 102	B	2.87	1
trichloroethene	Chrom. 106	B	2.66	1
	Chrom. 102	B	2.3	1
1,1,1-trichloro ethane	Chrom. 106	B	2.3	1
	Chrom. 102	B	2.3	1
	Tenax GR	B	2.92	1
tetrachloro ethene	Chrom. 106	B	3.1	1
	Tenax TA	B	2.8	1
	Chrom. 102	B	2.6	1
	Tenax GR	B	2.9	26
epichlorohydrin	Chrom. 106	E	2.45	1
allyl chloride	Chrom. 106	D	1.75	28
benzyl chloride	Tenax TA	D	2.72	28
perfluorodimethyl cyclobutane	Carbotrap**	B	15ml/hr	1
perfluoromethyl cyclopentane	Carbotrap**	B	15ml/hr	1
perfluoromethyl cyclohexane	Carbotrap**	B	15ml/hr	1
p-dichlorobenzene	Tenax	C	3.23	34

Esters and Glycol Ethers

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
Methyl acetate	Chrom. 106	A	1.74	30
ethyl acetate	**Chrom. 106**	B	2.0	1
	Tenax TA	B	1.6	1
n-butyl acetate	Tenax TA	B	2.26	1
	Chrom. 106	A	2.6	30
	Tenax GR	B	1.93	26
isobutyl acetate	Chrom. 106	D	2.17	28
	Tenax TA	D	1.91	28
secbutyl acetate	Chrom. 106	D	2.29	28
	Tenax TA	D	1.90	28
t-butyl acetate	Chrom. 106	D	2.26	28
	Tenax TA	D	1.79	28
vinyl acetate	Chrom. 106	D	1.93	28
methyl methacrylate	Porapak Q	B	2.0	1
	Chrom. 106	D	2.14	28
	Tenax TA	D	1.77	28
methyl acrylate	Chrom. 106	D	1.96	28
	Tenax TA	D	1.50	28
butyl acrylate	Tenax TA	B	2.6	1
	Chrom. 106	D	2.11	32
ethylhexyl acrylate	Tenax TA	D	2.99	28
2-methoxy ethanol	Porapak Q	A	1.5	1
	Chrom. 106	B	2.1	1
2-ethoxy ethanol	Tenax	A	1.8	1
2-methoxyethyl acetate	Porapak Q	A	2.8	1
	Chrom. 106	B	2.08	26
	Tenax GR	B	1.81	26
	Tenax TA	B	1.64	26
2-ethoxyethyl acetate	Chrom. 106	B	2.3	1
	Tenax TA	B	2.1	1
	Tenax GR	B	2.08	26
2-butoxyethanol	Chrom. 106	B	2.1	1
	Tenax TA	B	19 7	1
1-methoxy-2-propanol	Chrom. 106	B	1.88	5
	Tenax TA	B	1.56	5
	Tenax GR	B	1.55	26
methoxypropyl acetate	Chrom. 106	B	2.5	26
	Tenax TA	B	2.21	26
	Tenax GR	B	2.23	26
2-methoxypropanol	Chrom. 106	B	1.85	1
	Tenax TA	B	1.52	1
1-ethoxy-2-propanol	Chrom. 106	B	1.94	26
	Tenax GR	B	1.64	26
	Tenax TA	B	1.65	26
2-butoxyethyl acetate	Chrom. 106	B	2.79	26
	Tenax GR	B	2.19	26
	Tenax TA	A	2.8	1
propoxyethanol	Chrom. 106	D	1.94	28
	Tenax TA	D	1.65	28
Dipropylene glycol methyl ether	Chrom. 106	A	2.7	30

Aldehydes and Ketones

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
2-butanone	Chrom. 106	B	1.72	26
	Tenax GR	B	1.37	26
	Tenax TA	B	1.34	26
2-methyl-4-pentanone (MIBK)	Tenax TA	B	1.71	1
	Tenax GR	B	1.69	26
	Chrom. 106	B	2.01	1
cyclohexanone	Tenax TA	D	2.3	1
	Chrom. 106	B	1.96	26, 32
	Tenax GR	B	1.78	26
2-methyl cyclohexanone	Tenax TA	D	2.31	28
3-methyl cyclohexanone	Tenax TA	D	2.22	28
4-methyl cyclohexanone	Tenax TA	D	2.14	28
furfural	Tenax TA	A	2.5	11
hexanal	Tenax TA	D	1.64	28
	Chrom. 106	A	2.06	30
decanal	Tenax TA	D	2.32	28

Alcohols

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
Ethanol	Chrom. 106	A	1.3	30
propan-1-ol	Chrom. 106	D	1.47	28
propan-2-ol	spherocarb	C	2.0	1
(isopropanol)	Chrom. 106	A	1.52	30

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
n-butanol	Chrom. 106	A	1.74	30
	Tenax	D	1.33	28
furfuryl alcohol	Tenax TA	D	2.50	28
tetrahydrofurfuryl alcohol	Chrom. 106	D	2.39	28
	Tenax TA	D	1.90	28

Miscellaneous

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
acrylonitrile	Porapak N	A	1.35	1
	Chrom. 106	D	1.48	28
acetonitrile	Porapak N	A	1.0 -2hr	1
	Porapak N	A	0.8-8hr	1
	Chrom. 106	A	1.48	30
propionitrile	Porapak N	A	1.4-2hr	1
	Porapak N	A	1.3-8hr	1
carbon disulphide	Spherocarb / Unicarb	A	2.6	1
nitrous oxide (note1)	Mol. Sieve 5Å	B	1.25	13
ethylene oxide	Spherocarb / Unicarb	B	1.6	1
Propylene oxide	Chrom. 106	A	1.24	30
1,4-dioxane	Spherocarb / Unicarb	C	3.0	1
allyl glycidyl ether	Chrom. 106	D	2.40	28
	Tenax TA	D	1.83	28
butyl glycidyl ether	Chrom. 106	D	2.61	28
	Tenax TA	D	2.36	28
tetrahydrofuran	Chrom. 106	D	1.64	28
n-methyl pryrrolidone	Tenax TA	C	1.83	28
	Chrom. 106	A	2.41	30
n-vinyl pyrrolidone	Tenax TA	A	2.51	30

Environmental Applications - 1 week

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
1,3-butadiene	Carbopack X	B	1.19	15
Benzene	Tenax TA	B	1.45	1
	Carbograph 1 (note 2)	A	2.14	1
	Chrom. 106	A	1.52	1
	Ambersorb XAD-4	B	1.21	1
Toluene	Carbograph 1	A	2.16	1
	Chrom. 106	A	2.05	1
	Ambersorb XAD-4	B	1.62	1
Xylene	Carbograph 1	A	2.37	1
	Chrom. 106	A	2.42	1

Environmental Applications - 2 weeks

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
benzene	Tenax TA	A	1.03	1
	Chrom. 106	A	1.47± 0.22	29
	Carbograph 1	B	2.02± 0.22	1
	Carbopack X	B	1.99±0.18	35
xylene	Tenax TA	A	1.49	1
	Chrom. 106	A	2.09±0.29	1
	Carbograph 1	A	2.07±0.21	1
ethylbenzene	Chrom. 106	B	2.31± 0.07	1
Trimethyl benzene	Carbopack B	B	2.30	1
toluene	Carbopack X	B	2.23±0.52	35
	Tenax TA	B	1.22	1
	Carbograph 1	A	2.13±0.24	1
	Chrom. 106	A	1.91±0.18	1

Environmental Applications - 4 weeks

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
benzene	Tenax TA*	B	0.70±0.09	1
	Chrom. 106	B	1.28±0.25	1
	Tenax GR	B	0.8	3
	Carbograph 1	B	1.85± 0.15	1
toluene	Tenax TA	A	1.03±0.26	1
	Chrom. 106	B	2.10± 0.03	29
	Chrom. 106	B	1.93± 0.12	31
	Chrom. 106	A	1.82± 0.18	1
	Carbograph 1	A	2.07± 0.26	1
xylene	Tenax TA	A	1.46±0.67	1
	Carbograph 1	A	1.94±0.29	1
	Chrom. 106	A	1.91±0.35	1
ethylbenzene	Chrom. 106	B	2.24	1
	Carbopack B	B	2.30	1

Compound	Sorbent	Level	Uptake Rate	Source / Ref.
trimethyl benzene	Tenax TA	B	2.67	1
	Carbopack B	B	2.30	1
decane	Tenax TA	B	2.93	1
undecance	Tenax TA	B	3.34	1
Tetrachlorobut adiene	Tenax TA	B	3.0	33
Pentachlorobut adiene	Tenax TA	B	3.4	33
Hexachlorobut adiene	Tenax TA	B	3.5	33

Notes

Units are $ng.ppm^{-1}.min^{-1}$; most values are for 8 hrs; environmental values are for 1, 2 or 4 weeks.

bold means prefered sorbent

itallic not recommended because uptake rate varies with time.

* sampler with membrane in diffusion cap

** A nickel disk, rather than the conventional stainless steel gauze, was used to support the Carbotrap sorbent material during method validation for these perfluorocarbon tracer gases. The uptake rates may not be applicable to samples using conventional steel gauzes.

(note 1) rate varies predictably with exposure dose.

(note 2) equivalent to Carbopack B.

Levels

level A = validation equivalent to CEN level 1A

level B = partial validation - see EN 482

level C = calculated - ideal value

level D = calculated from dynamic breakthrough volume

level E = calculated from sorption isotherm

level F = experimental observation

Sources/References

'MDHS' refers to the UK health and Safety Executive (HSE) series of Methods for the Determination of Hazardous Substances. Note also that HSE/HSL Internal Reports can be obtained from the HSE Information Centre, Broad Lane Sheffield, S3 7HQ, UK. Tel: 44 114 289 2345, Fax: 44 114 289 2333

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Markes International updates this list whenever additional data becomes available.

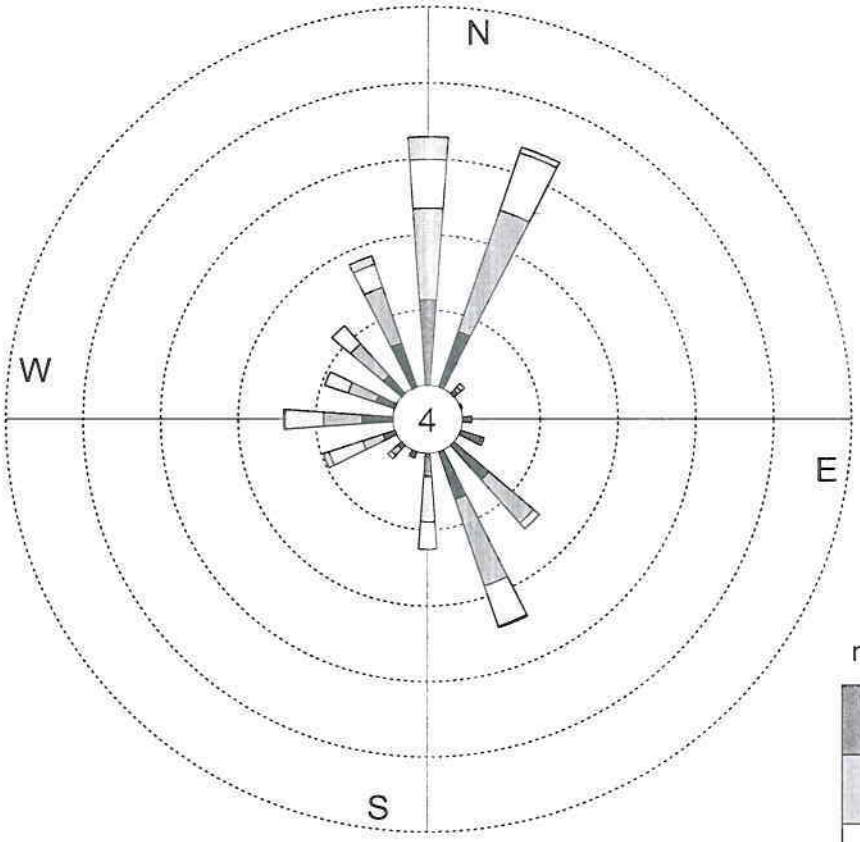
We would be delighted to receive details of any uptake rates that have been measured and are being used in the field - whether for workplace air or environmental applications.

Information on the compounds concerned and the level of validation undertaken should be emailed to enquiries@markes.com

APPENDIX 3

Detailed Wind Roses for the period:

WIND ROSE CHEVRON
FROM 20100628 TO 20100716



KEY

m/s

25 gale

15 vstrong

8 strong

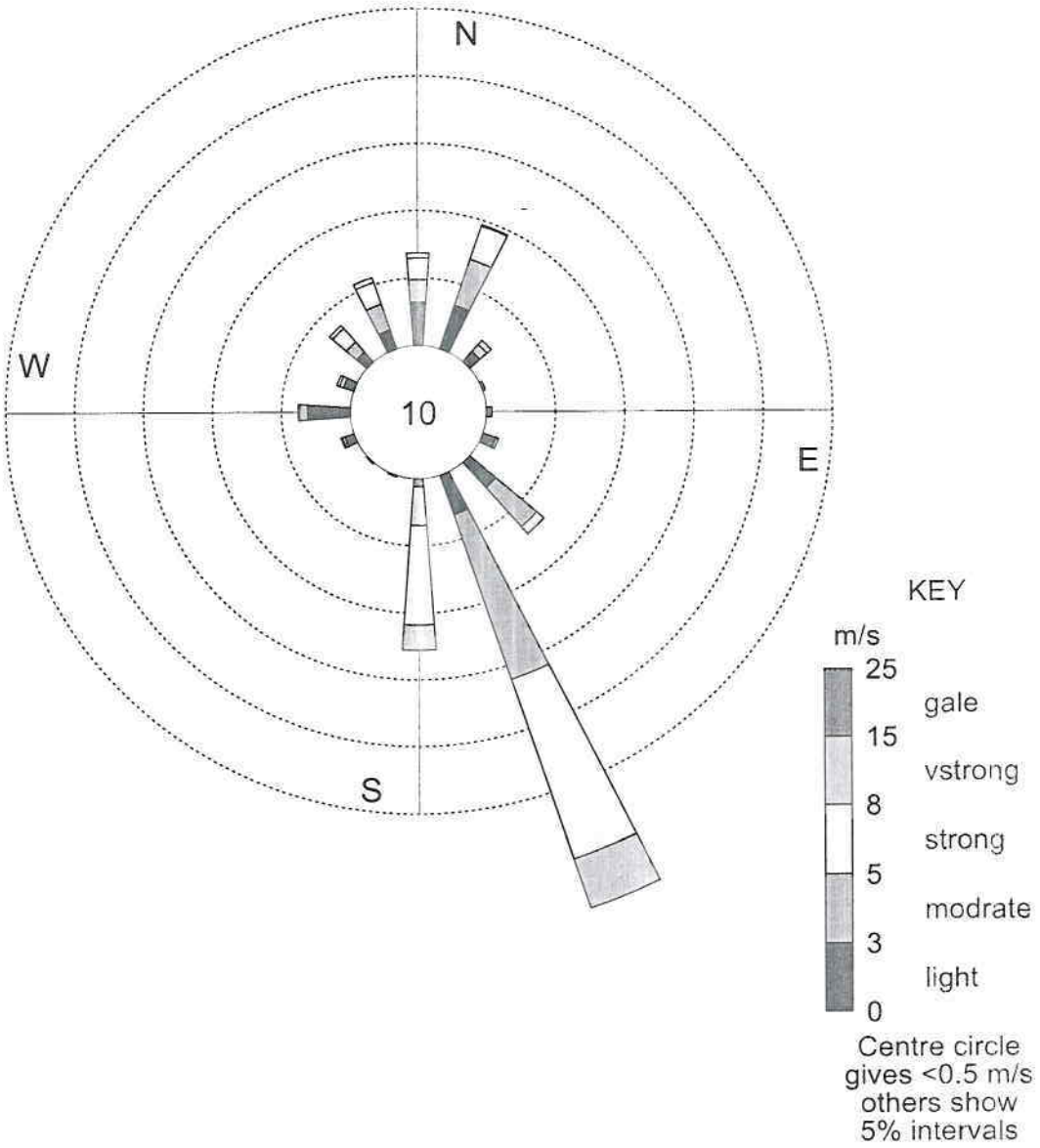
5 modrate

3 light

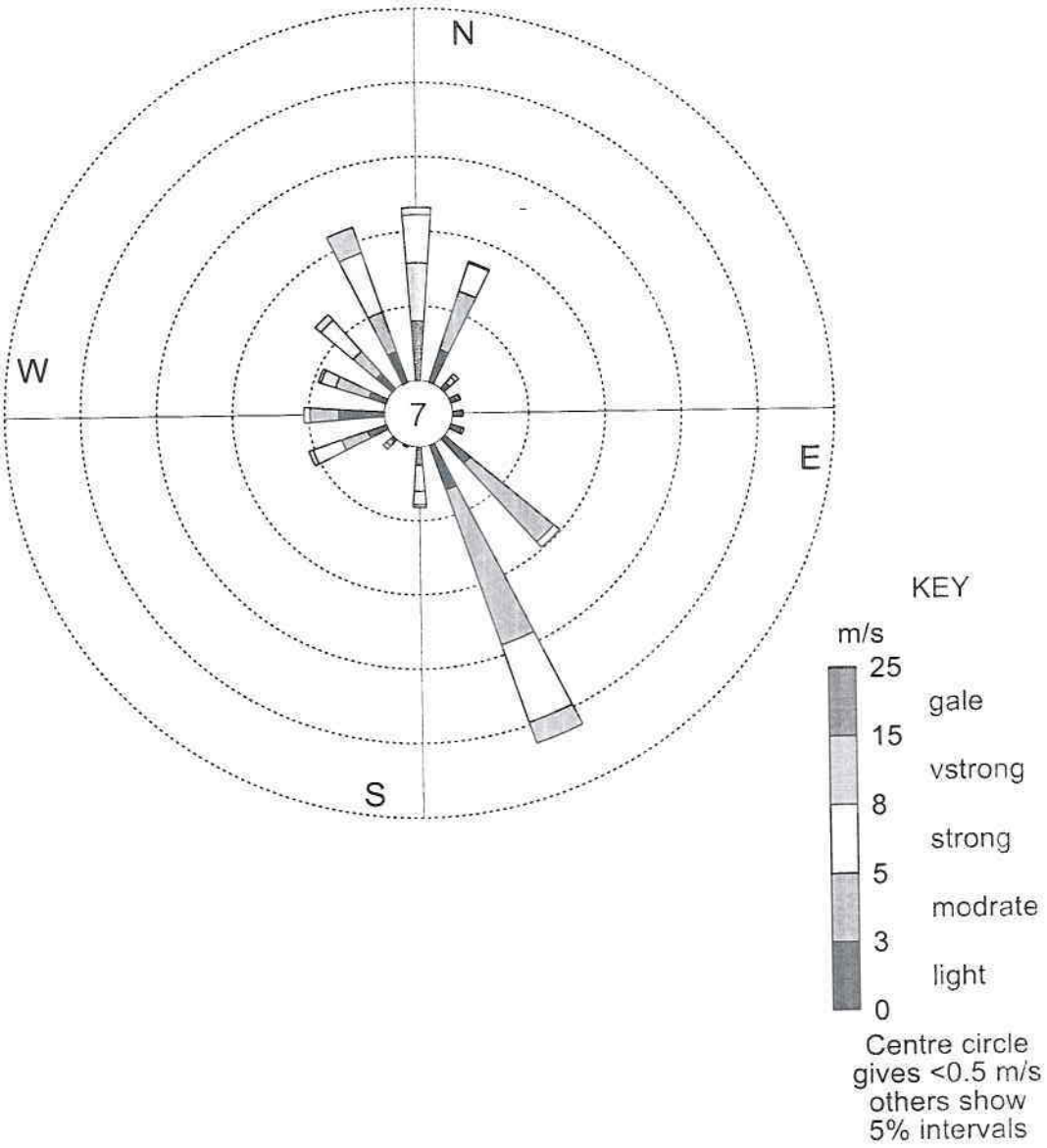
0

Centre circle gives <0.5 m/s others show 5% intervals

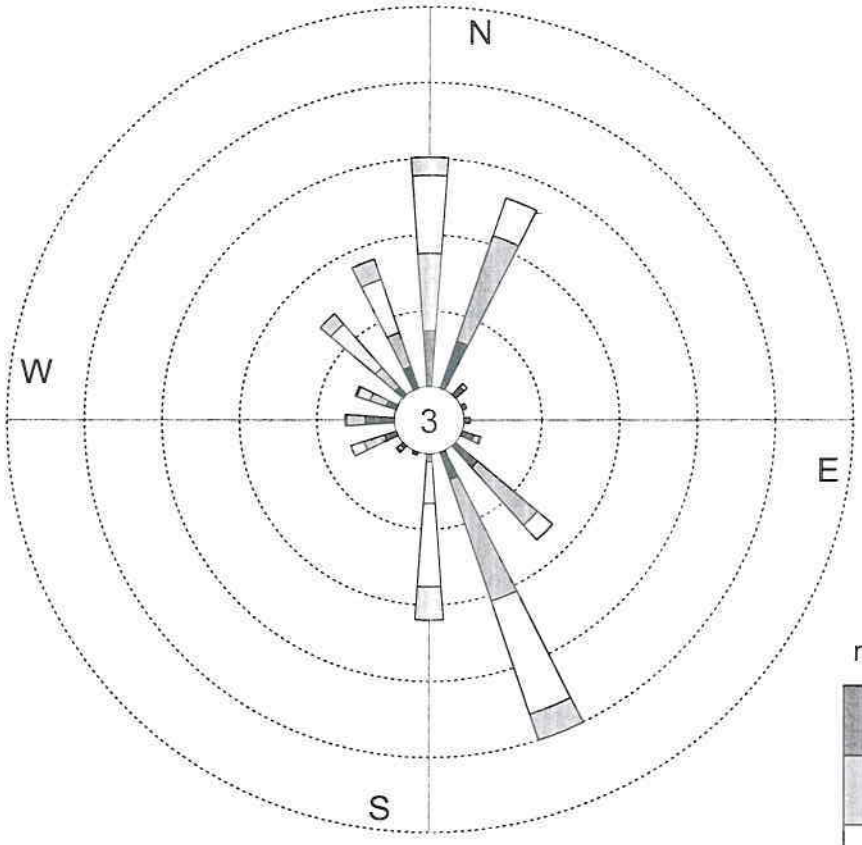
WIND ROSE CHEVRON
FROM 20100716 TO 20100806



WIND ROSE CHEVRON
FROM 20100806 TO 20100826



WIND ROSE CHEVRON
FROM 20100826 TO 20100916



KEY

m/s

25 gale

15 vstrong

8 strong

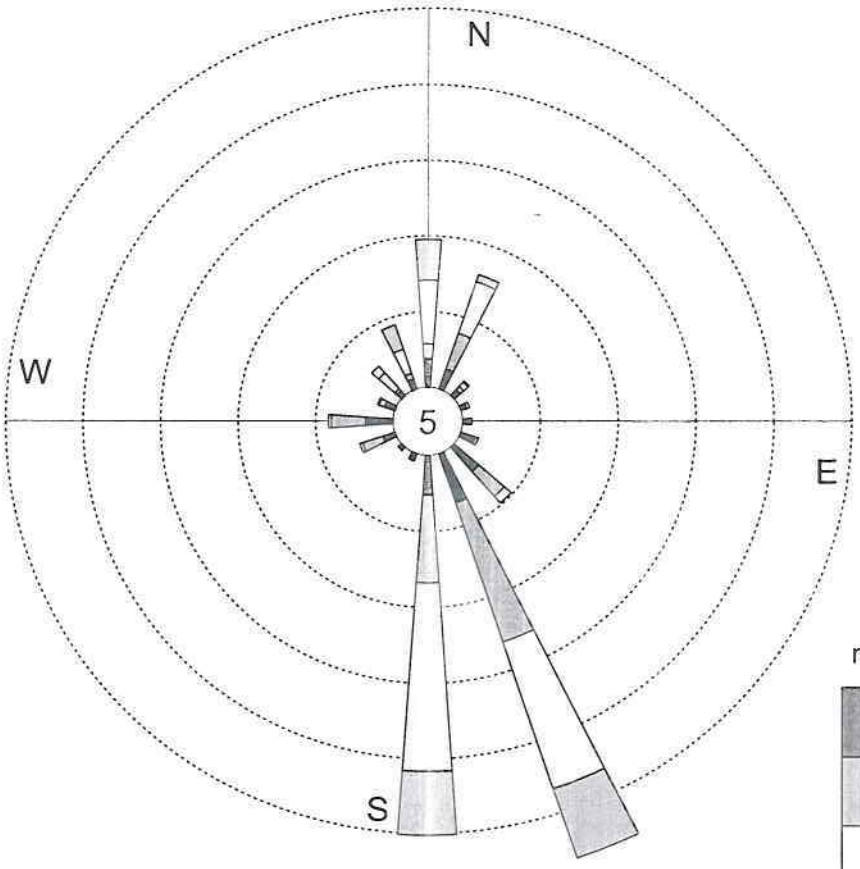
5 modrate

3 light

0

Centre circle gives <0.5 m/s others show 5% intervals

WIND ROSE CHEVRON
FROM 20100916 TO 20101008



KEY

m/s

25 gale

15 vstrong

8 strong

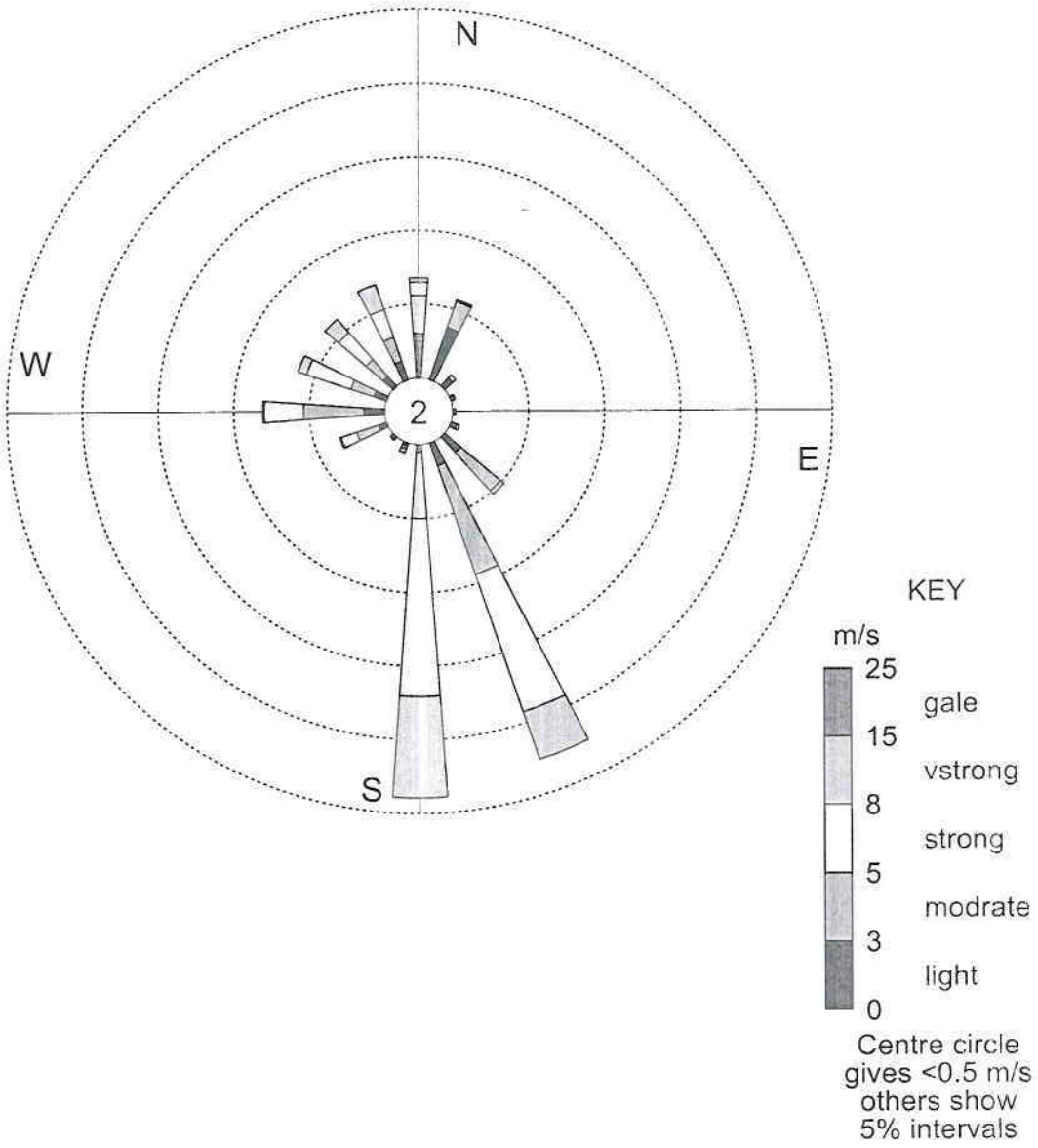
5 modrate

3 light

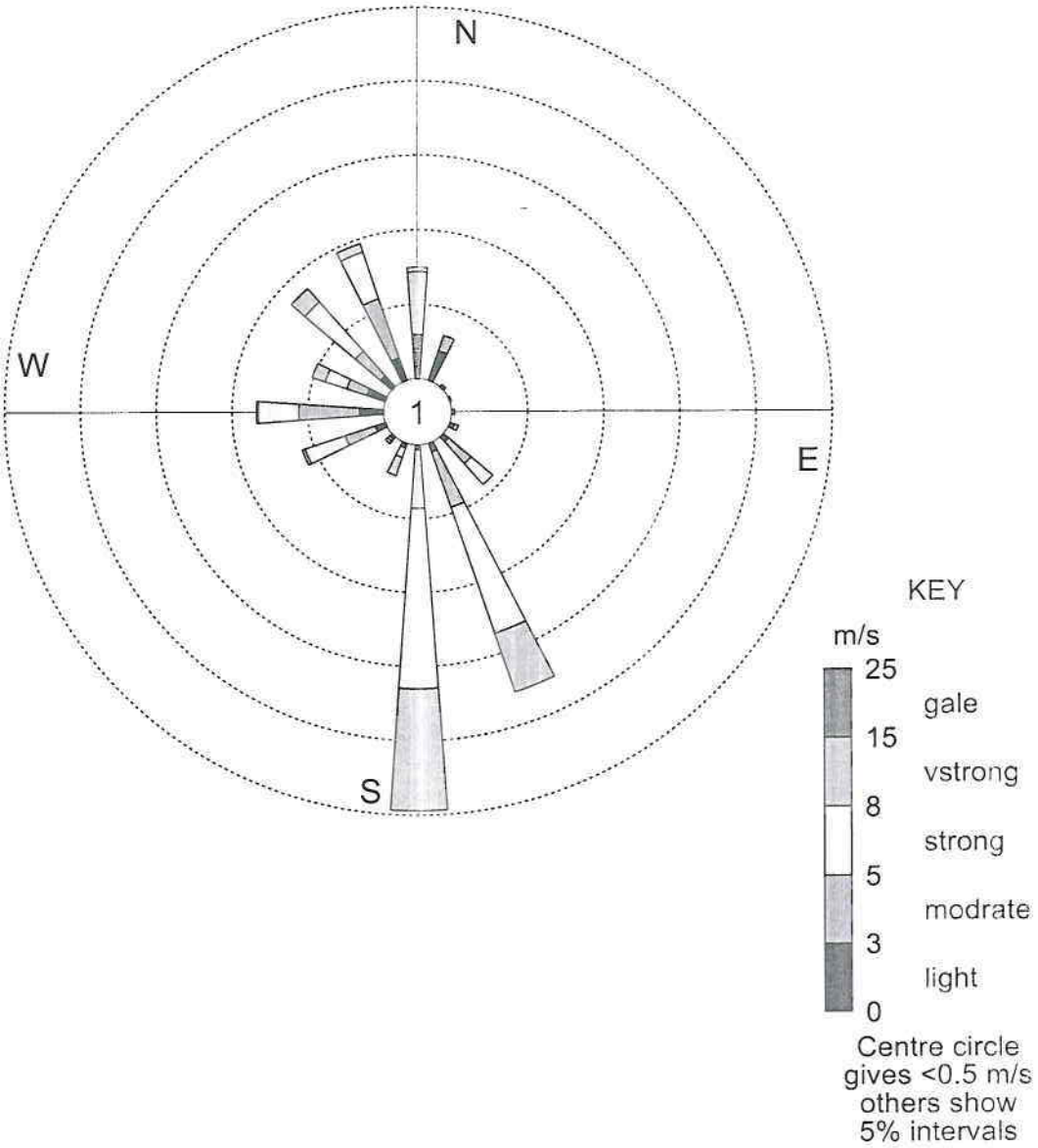
0

Centre circle gives <0.5 m/s others show 5% intervals

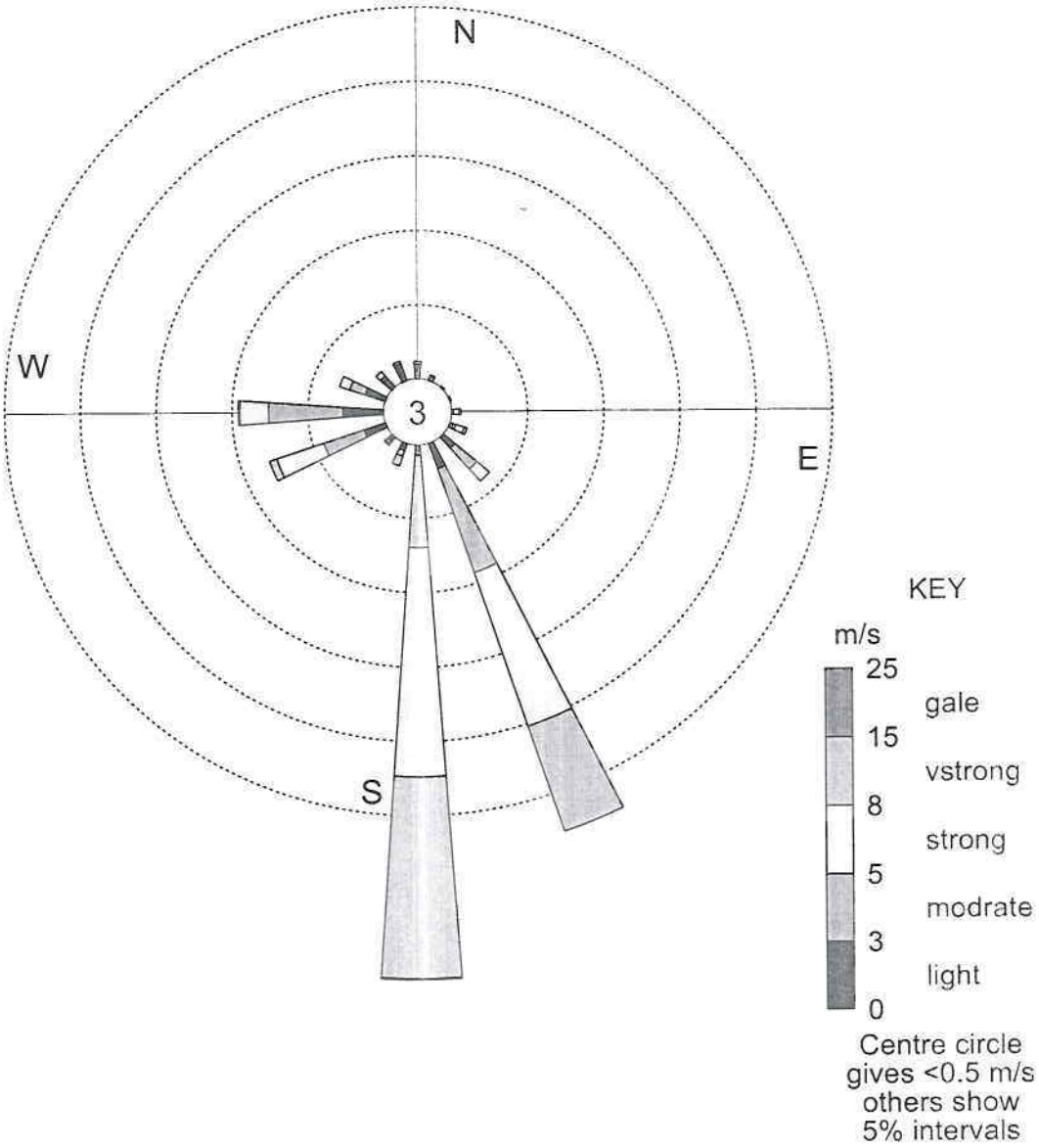
WIND ROSE CHEVRON
FROM 20101008 TO 20101108



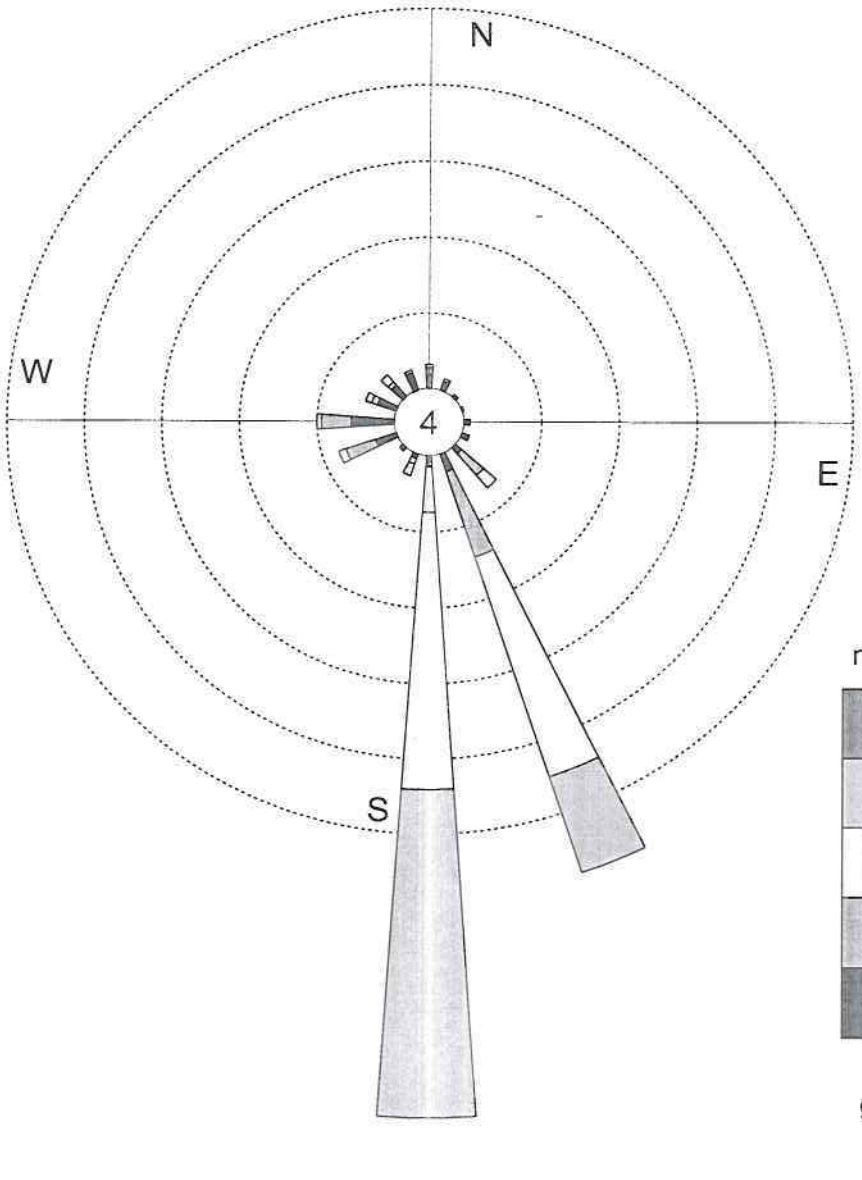
WIND ROSE CHEVRON
FROM 20101108 TO 20101122



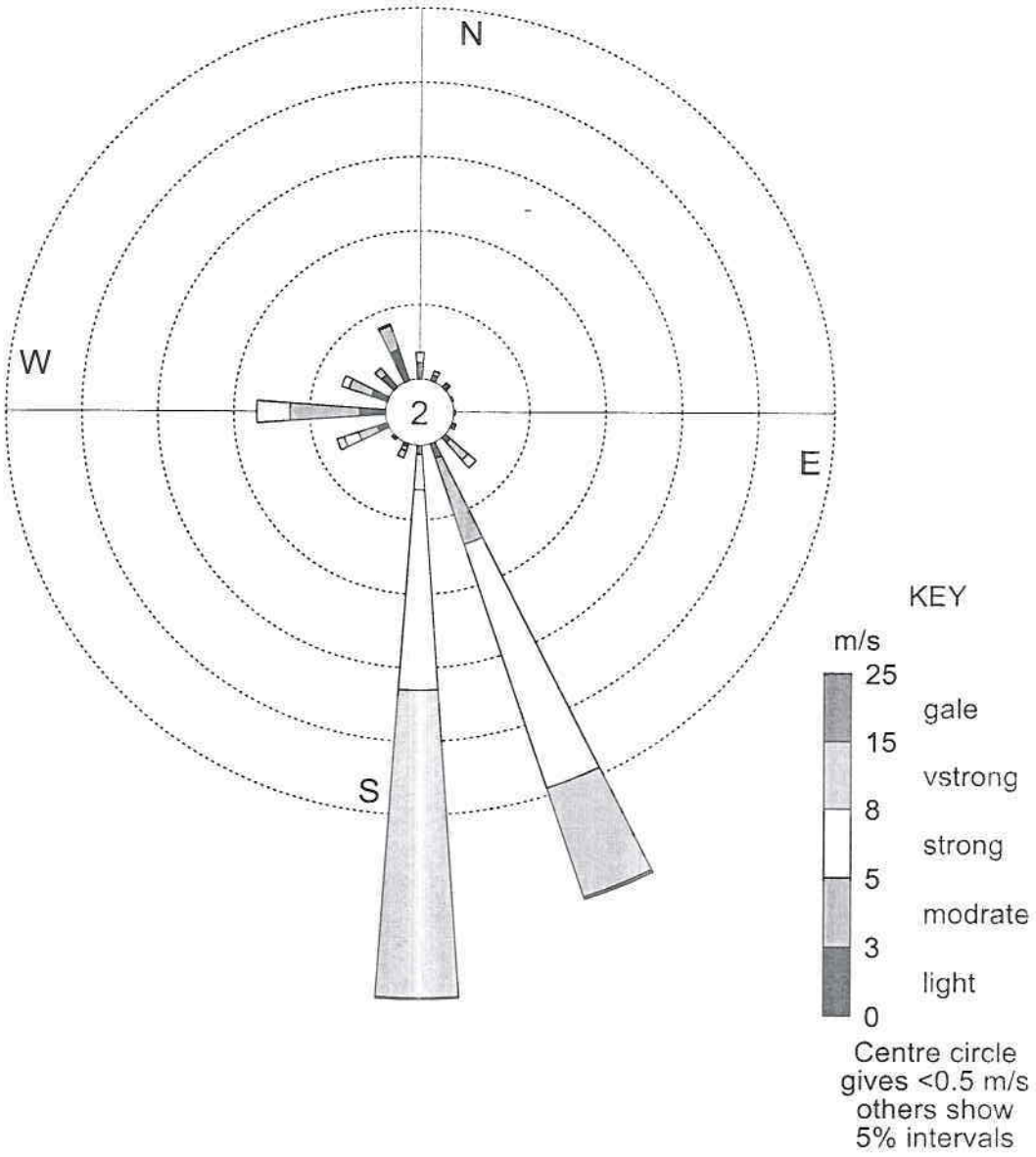
WIND ROSE CHEVRON
FROM 20101122 TO 20101222



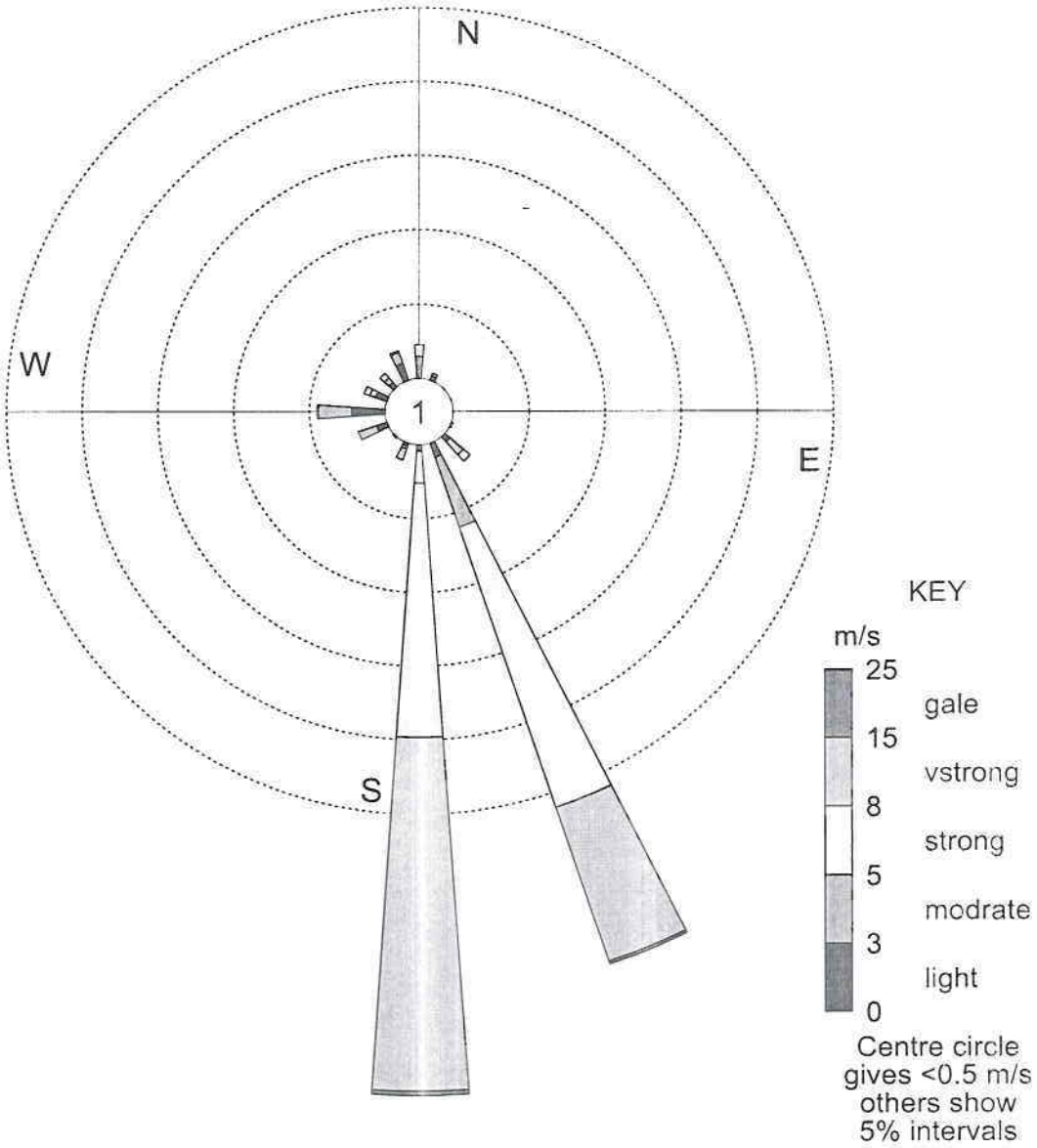
WIND ROSE CHEVRON
FROM 20101222 TO 20110113



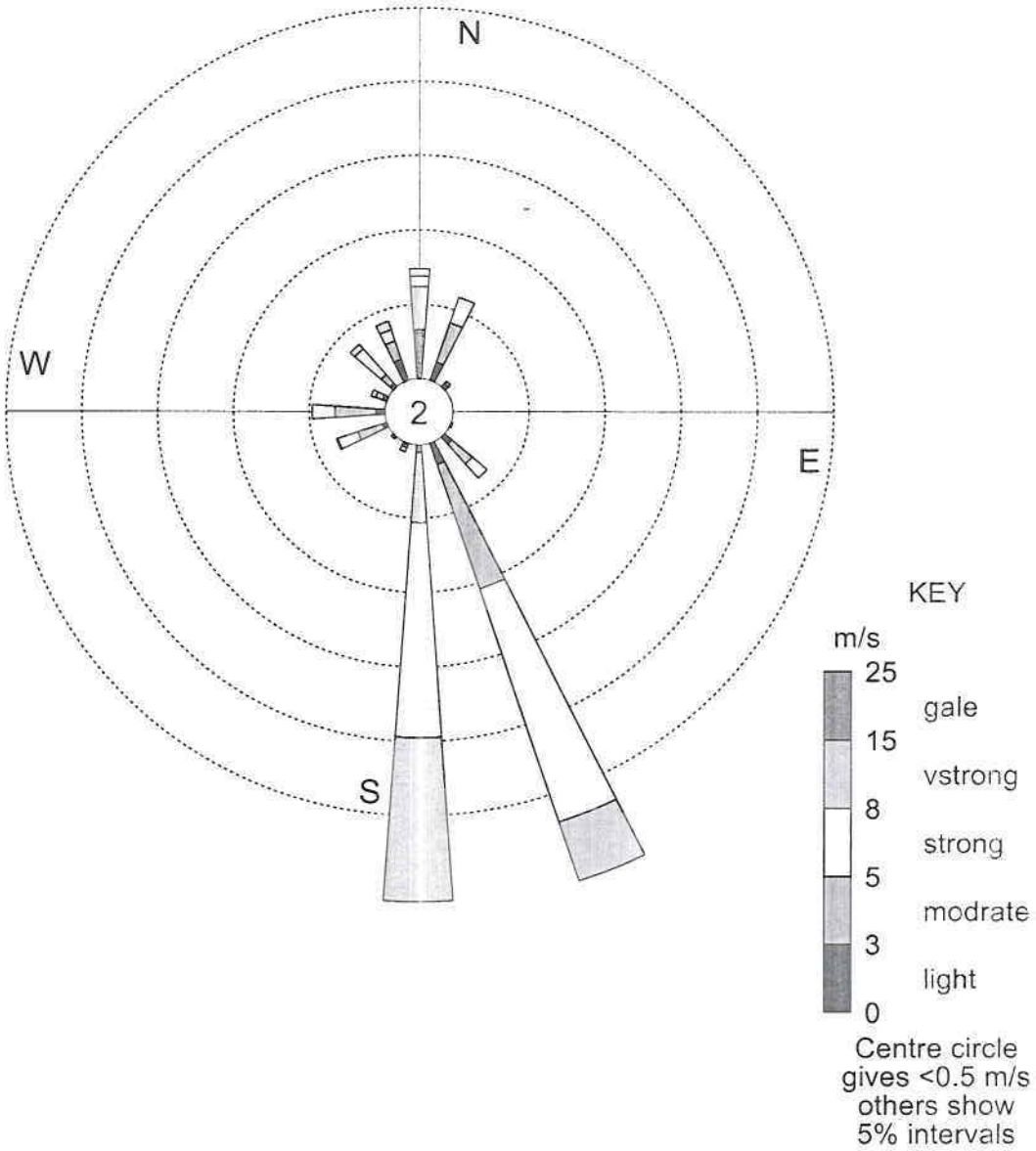
WIND ROSE CHEVRON
FROM 20110113 TO 20110215



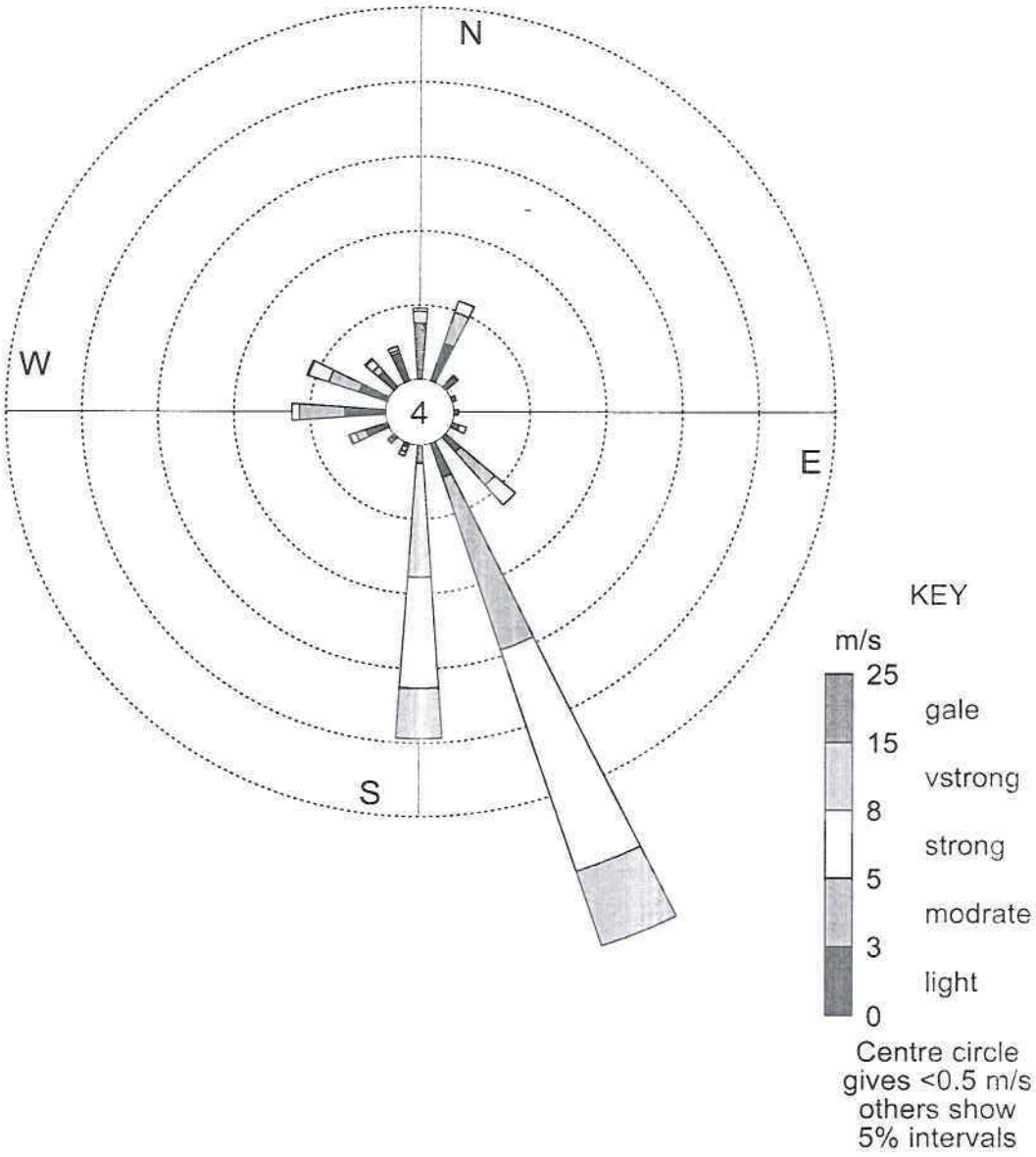
WIND ROSE CHEVRON
FROM 20110215 TO 20110307



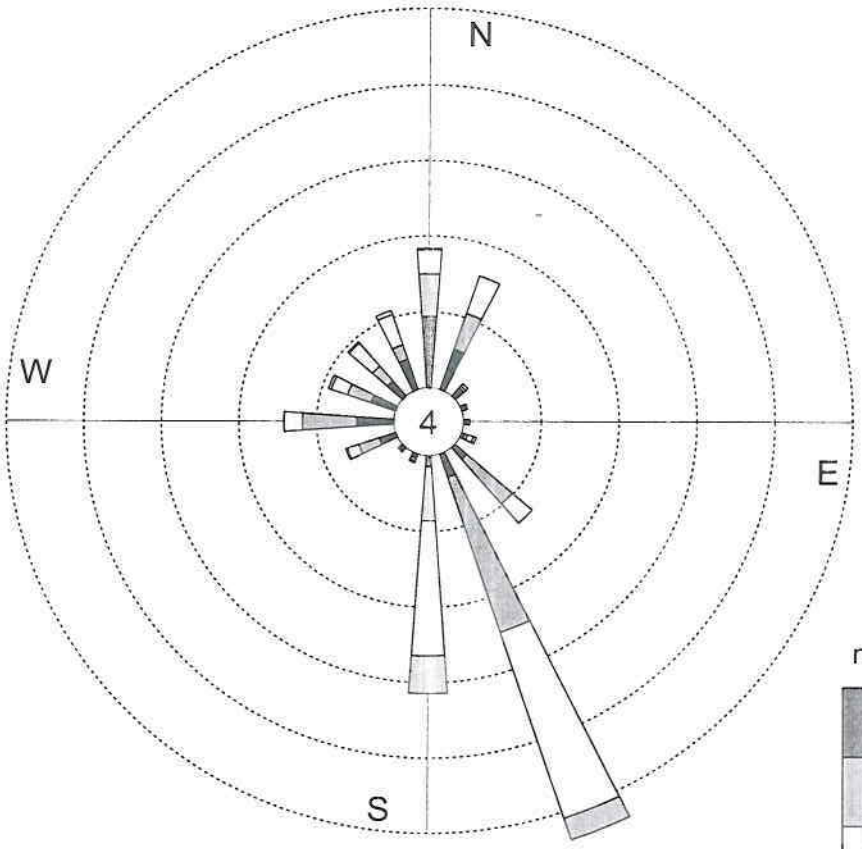
WIND ROSE CHEVRON
FROM 20110307 TO 20110325



WIND ROSE CHEVRON
FROM 20110325 TO 20110412



WIND ROSE CHEVRON
FROM 20110412 TO 20110512



KEY

m/s

25 gale

15 vstrong

8 strong

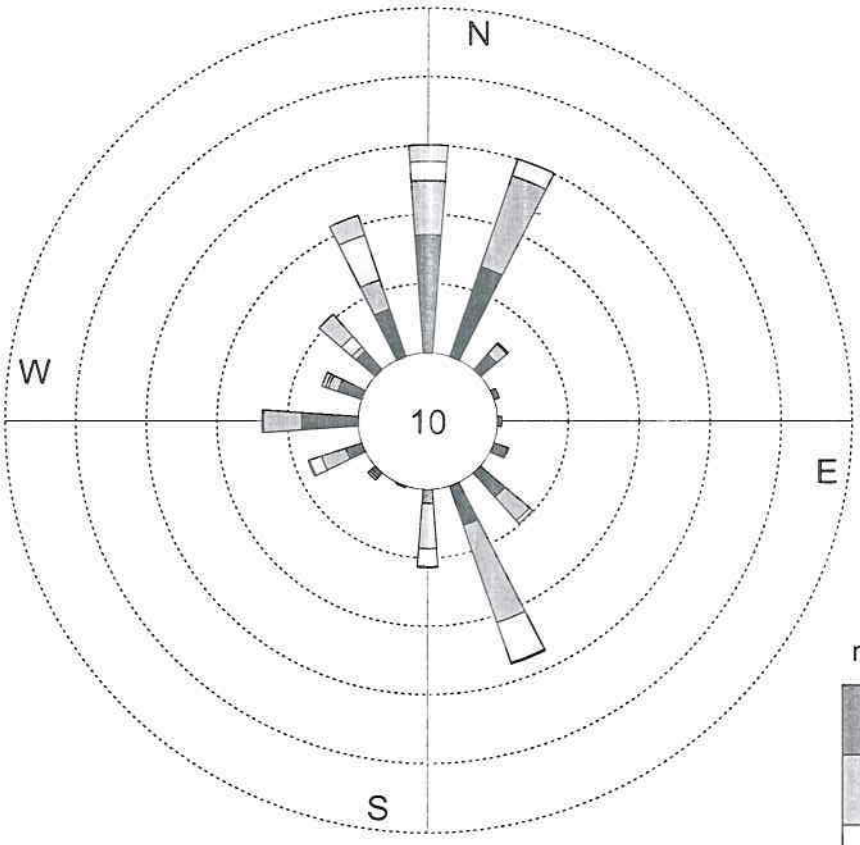
5 modrate

3 light

0

Centre circle gives <0.5 m/s others show 5% intervals

WIND ROSE CHEVRON
FROM 20110512 TO 20110602



KEY

m/s

25 gale

15 vstrong

8 strong

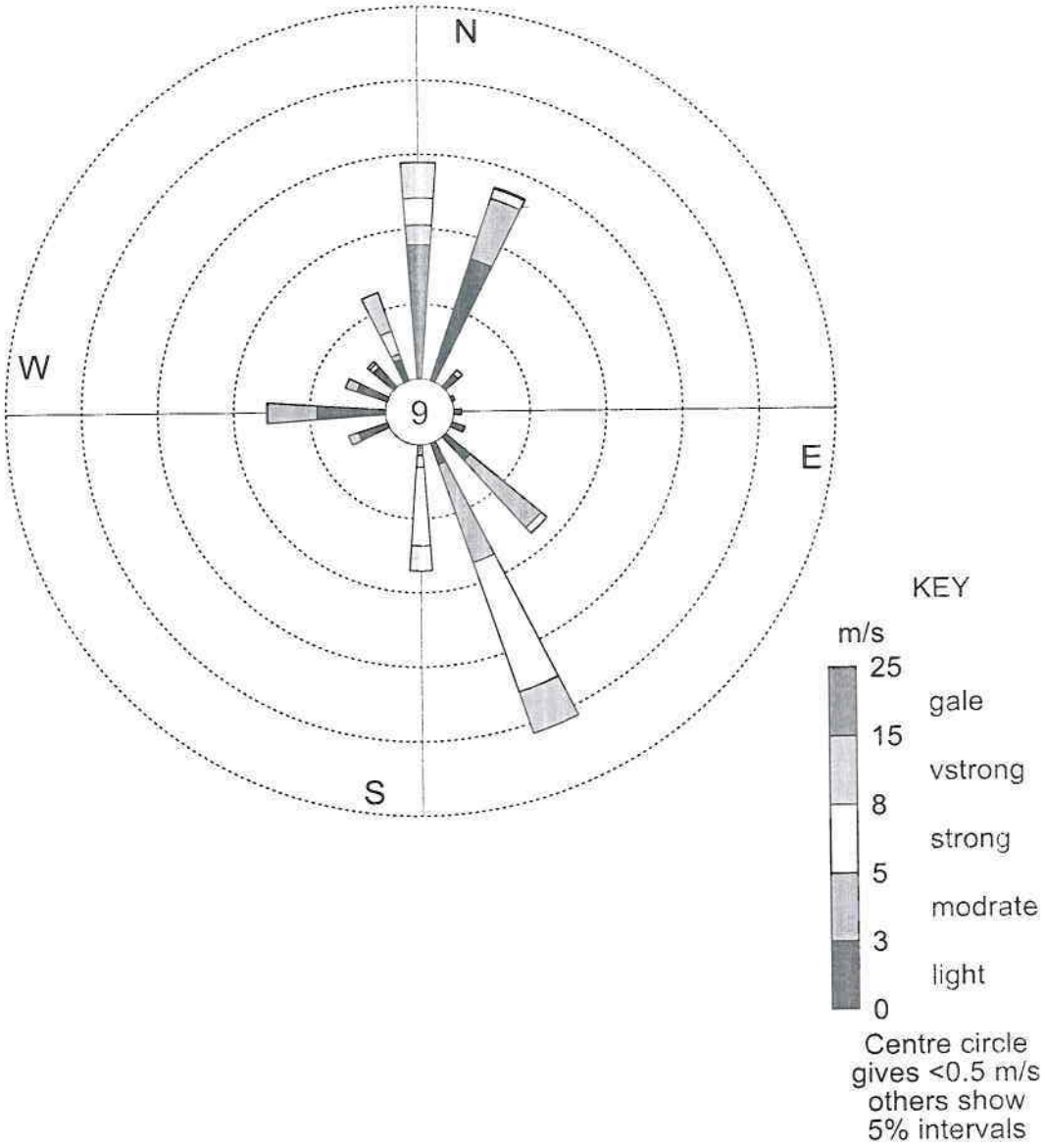
5 modrate

3 light

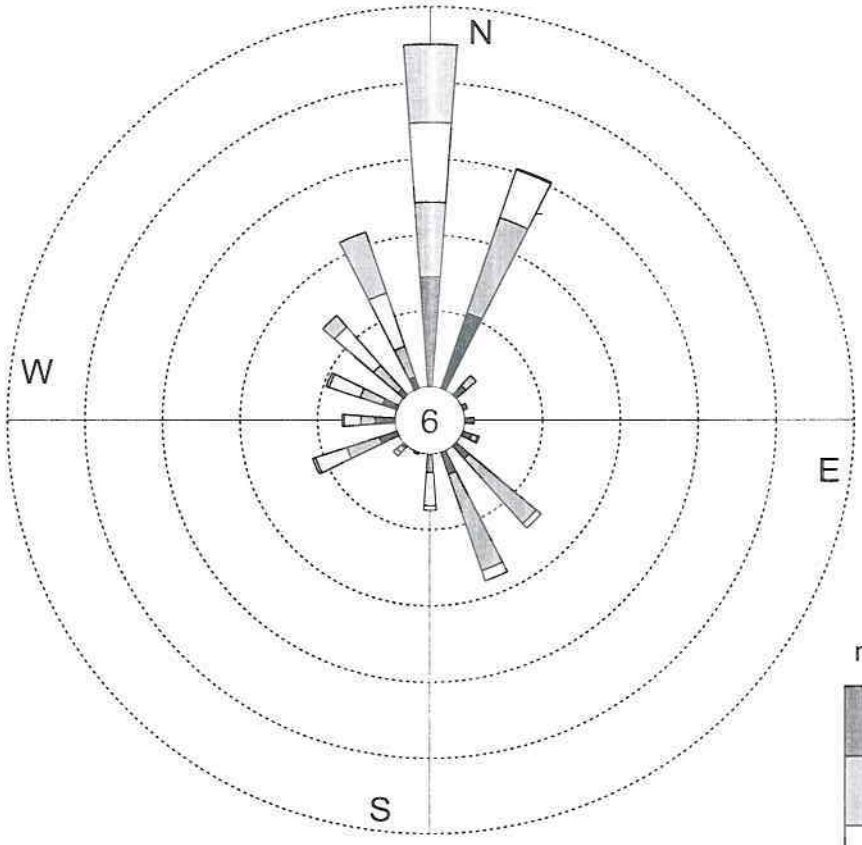
0

Centre circle gives <0.5 m/s others show 5% intervals

WIND ROSE CHEVRON
FROM 20110602 TO 20110615



WIND ROSE CHEVRON
FROM 20110615 TO 20110629



KEY

m/s

25 gale

15 vstrong

8 strong

5 modrate

3 light

0

Centre circle gives <0.5 m/s others show 5% intervals