ASSESSING ODOUR EFFECTS AT A LANDFILL

Doug Boddy[1]

[1] MWH Global, PO Box 9176, Auckland 1149, New Zealand (email: doug.boddy@mwhglobal.com).

1. Introduction

MWH Global was commissioned by the Horowhenua District Council (HDC) to undertake an odour impact assessment for the landfill located in Levin, Manawatu-Wanganui, New Zealand.

This study evaluates the potential odour effects that may arise during the operation of the landfill using a variety of methodologies and techniques, which enabled the principal emission sources at the landfill to be identified and assessed.

This study reviews the recent odour complaints record for the site and identifies a number of potential adverse impacts associated with the operation of the landfill. A number of mitigation measures are recommended to reduce the likelihood of further odour nuisance effects arising in the surrounding community.

2. Background

2.1. Assessment Techniques

The following assessment techniques were used in this study:

- Review the landfill odour complaints record;
- Subjective field odour investigation / sniff test (18 and 19 November 2014);
- Odour emissions monitoring at 6 sources onsite using a flux chamber in accordance with AS/NZS 4323.3:2001 Stationary Source Emissions: Part 3 Determination of Odour Concentration by Dynamic Olfactometry (18 and 19 November 2014);
- Surface emissions monitoring walkover survey. Methane was used as an indicator determinant (or surrogate) of odorous landfill gas (LFG), or to determine potential peak emission (hotspot) locations, such as areas where the final capping layer has been compromised (e.g. cracking has occurred), or where the intermediate cover is ineffective (18 and 19 November 2014);
- A detailed assessment involving atmospheric dispersion modelling using CALPUFF using odour emissions monitoring data as input; and,
- Continuous ambient air quality monitoring for hydrogen sulphide by ultraviolet (UV) fluorescence (17 March to 18 June 2015).

2.2. Project Site Location

The Levin landfill is located at 665 Hōkio Beach Road, Levin and covers an area of approximately 72 hectares (ha). The landfill is in undulating sand dune country and is surrounded by pastoral farming.

The landfill is located approximately 6 km to the west-north-west of Levin town centre, 38 km north-east of Paraparaumu Airport and 43 km south-west of Palmerston North. The location of the landfill is shown in Figure 1.

2.3. Sensitive Receptors

A desk-study was undertaken to identify discrete receptors deemed sensitive to changes in the baseline odour conditions as a result of discharges to air from the landfill. A total of 16 sensitive receptors were identified (hereafter receptors ‘R1’ to ‘R16’) within a radius of 1,000 m from the landfill boundary.

The nearest potentially affected sensitive receptors are all residential properties and are situated to the north-east, east and north-west of the site and are shown in Figure 2.

3. Odour Assessment

3.1. Odour Complaints

There is a history of odour complaints from the owners of the nearest residential property to the landfill (hereafter receptor ‘R1’). It is, however, not known whether these complaints have been verified by Horizons Regional Council (HRC).

The complaints record kept by HDC for the period between 13 February 2014 and 3 September 2014 (202 days in duration) was reviewed. During this period there were 69 complaints; and they all related to receptor ‘R1’. As the complaints record does not make a complete year (i.e. 365 days), analysis of the data is more difficult (particularly as the data is not complete over the warmer months in spring and summer), however, the record does

indicate that, on average, a complaint was received by HDC once every 3 days.

The complaints received by HDC regarding odour from the Levin landfill between 13 February 2014 and 3 September 2014 is shown graphically in Figure 3. The figure indicates that on 9 separate occasions 2 complaints were made on the same day, whilst 3 complaints were made on the same day on 2 occasions.

The frequency of odour complaints is therefore considered to be fairly high, particularly given the scale of the landfill and the activities undertaken onsite and, rather interestingly, given the relatively low frequency of winds from the south-west which would carry odour released onsite towards the complainant's property. Furthermore, the majority of the complaints indicated that odour was detected between 6:00 am and 8:00 am (46%) and between 4:00 pm and 7:00 pm (37%), however, on some occasions the odour event duration was several hours (e.g. all day or all night).

The complaints record also indicates that it is unlikely that seasonal changes in odour emissions at the site (e.g. warmer atmospheric conditions causing higher bacterial activity in the leachate pond or high intensity odorous waste such as food waste being tipped at the working face) will have a significant difference in terms of the potential to cause odour nuisance beyond the site boundary. Rather, it would appear as though there is a long-term emission source or sources which are releasing odour at the site.

This study seeks to identify the location of these emission sources and to make recommendations regarding the control of odour at the site.

3.2. Subjective Field Odour Assessment

A subjective field odour investigation (or sniff test) was undertaken at various locations across the landfill in accordance with the guidance contained in MfE (2003). The principal odour sources at the landfill were identified at the following locations:

- Leachate collection manhole; and,
- Stage 2 (three emission hotspots on an area with intermediate cover consisting of sand and mulch).

Figure 4 shows the odour source locations and landfill site boundary.

3.3. Odour Emissions Monitoring

Odour concentrations and emission rates were determined in accordance with AS/NZS 4323.3:2001 and via dynamic dilution olfactometry (DDO) by collecting triplicate samples at the following monitoring locations at the landfill:

- Location A Leachate pond;
- Location B Leachate collection manhole;
- Location C Stage 2 landfill surface (open pipe or gas collection wellhead near Stage 2 eastern boundary);
- Location D Working face (4 separate 'roaming' locations);
- Location E Stage 2 landfill surface (2 m west of Location C near eastern boundary of Stage 2);
- Location F Stage 2 landfill surface (pipe protruding from surface near Stage 2 southern boundary).

The highest odour concentration and emission rate was measured at the leachate collection manhole: 57,000 OU/m^3 and 23.8 OU/s/m^2, respectively. The results indicate that, at the time that the monitoring was undertaken, the odour emissions from the leachate pond and working face were relatively low compared with the leachate collection manhole. The mean odour concentrations determined at the leachate pond and working face were 220 OU/m^3 and 2,240 OU/m^3, respectively.

3.4. Monitoring for Methane

A landfill surface emission monitoring walkover survey was undertaken across the landfill using a pre-calibrated Bascom-Turner Gas-Rover^{TM} portable methane monitor (Model VGO-321). The instrument was mostly operated in "survey" mode (response time was approximately 0.6 seconds). However, at the leachate collection manhole and at the Stage 2 emission hotspots, the instrument automatically switched to "monitor" mode (response time was approximately 1 second), due to the high concentrations of methane (CH_4) measured at these locations.

A GPS unit was used during the walkover survey to determine accurate geo-spatial data (e.g. tracks and waypoints) at a time-resolution of 1 second. The clock on the GPS unit was synchronised with the Gas-Rover and the 1-second mean concentration and spatial data were post-processed in Microsoft Excel.

The 1-second mean methane concentrations were recorded by the Gas-Rover^{TM} in units of parts per million by volume ('ppmv' or simply 'ppm'), percent methane by volume (i.e. concentration in ppm divided by 10,000) and as percent of the lower explosive limit (LEL) for methane by volume (i.e. 100% LEL = 50,000 ppm or 5% by volume). A methane concentration of 1 ppm equates to 0.7 milligrams per cubic metre (mg/m^3) at an air temperature of 20 °C.

The 1-second mean concentrations of methane measured during the walkover survey indicated that the principal sources of methane at the landfill were the leachate collection manhole (maximum

concentration of 380,500 ppm) and the 3 emission hotspots located on Stage 2 (concentration maxima ranging from 5,827 ppm to 39,007 ppm).

3.5. Atmospheric Dispersion Modelling

An atmospheric dispersion modelling assessment was conducted for odour through the use of the CALPUFF model (version 6.42). The aim of the dispersion modelling was not to confirm or deny the odour complaints history for the site but to assess the potential benefits associated with undertaking a number of mitigation options (assessed as four separate modelling scenarios). Furthermore, there is an accepted degree of uncertainty regarding results generated by dispersion modelling, particularly for odour. The following dispersion modelling scenarios were assessed:

- Scenario 1 Baseline emissions (as measured in November 2014);
- Scenario 2 Baseline emissions except with a proposed biofilter to control odour from the leachate collection manhole;
- Scenario 3 Baseline emissions except with the implementation of effective capping across Stage 2 (e.g. clay layer) to eliminate/reduce the Stage 2 odour emissions;
- Scenario 4 A combination of Scenarios 2 and 3 (i.e. baseline emissions, but with a proposed biofilter at the leachate collection manhole and Stage 2 effective capping).

The 99.9th percentile (99.9%ile) 1-hour mean ground-level odour concentrations predicted at each discrete sensitive receptor location by CALPUFF for Scenarios 1 to 4 are shown in Table 1.

The 99.9th percentile 1-hour mean ground-level odour concentrations predicted by the model for Scenario 1 is shown in the isopleth (contour) plot in Figure 5.

Table 1 and Figure 5 indicate that the highest 99.9th percentile 1-hour mean odour concentration predicted at any location beyond the site boundary for Scenario 1 (existing or baseline conditions) was 0.5 OU/m^3, whilst the highest concentration predicted at any sensitive receptor location was 0.2 OU/m^3 (receptor 'R1').

The results for Scenario 1 (Figure 5) also indicate that the maximum onsite concentration was predicted to be 4 OU/m^3 on Stage 2 and slightly to the east of the Stage 2 boundary fence. This would suggest that there is the potential for offensive or objectionable odours at these locations, which is in agreement with the results of the field odour investigation, which determined that odour was present at a higher intensity at these locations.

Assuming a modelling uncertainty factor of 10 (i.e. the predicted modelling results are multiplied by 10), the highest 99.9th percentile 1-hour mean odour concentration predicted at any location beyond the site boundary for Scenario 1 would be 5 OU/m^3, whilst the highest concentration predicted at any sensitive receptor location would be 2 OU/m^3. In other words, the adjusted modelling results (after applying a conservative arbitrary correction factor) would indicate that there is the potential for odour nuisance effects at receptor 'R1', which would corroborate the odour complaints record.

However, the adjusted modelling results (after correction) also indicate that there are unlikely to be odour nuisance effects at receptor 'R1'. For example, the results for Scenario 3 suggest that with the implementation of effective cover (e.g. clay layer) across Stage 2 the maximum 99.9th percentile 1-hour mean concentration at receptor 'R1' would be 1 OU/m^3, which means that odour has the potential to be detected from time-to-time but is unlikely to be objectionable or offensive (i.e. result in a nuisance complaint).

The adjusted results for Scenario 2 indicate that with the implementation of a biofilter at the leachate collection manhole to control odour from the manhole there is unlikely to be a significant reduction in odour concentrations beyond the site boundary: the maximum 99.9th percentile 1-hour mean concentration at receptor 'R1' would be similar to the existing or baseline conditions (Scenario 1) at 2 OU/m^3. In other words, based on the site's complaints record, there is still the potential for odour nuisance effects at receptor 'R1' unless the Stage 2 fugitive emissions are effectively controlled. The recommended improvements to the leachate collection manhole have a greater potential to alleviate health and safety concerns regarding work undertaken at and within the manhole rather than to result in a significant reduction in odour nuisance effects, based on the modelling results.

3.6. Monitoring for Hydrogen Sulphide

An API 100E UV fluorescence sulphur dioxide (SO_2) analyser coupled to an API M501 catalytic hydrogen sulphide (H_2S) oxidiser with an Environics 6103 gas calibrator and an Ecotech zero air scrubber was used in this study. The instruments were housed in an air-conditioned enclosure held to 20 °C. The analyser was used to measure ambient concentrations of H_2S at sensitive receptor 'R1' over a period of 3 months between 17 March and 18 June 2015. The sampling port was positioned at a height of 2 m above ground level, and an ultrasonic anemometer was co-located with the sampling port to measure wind speed and direction.

The performance of the analyser was audited using an auto-calibration gas dilution system every 72 hours and during routine servicing. Data were streamed to a website in real-time for continuous performance monitoring. Instrument maintenance and performance between span and zero cycles was carried out to the requirements of AS 3580.4.1-2008. Small adjustments for zero- and span-drift were applied to the data during post-processing assuming linear drift model between 72 hour check cycles.

The results of the ambient air quality monitoring are shown in Table 2 for the period between 17 March and 18 June 2015. For the 1-minute mean H_2S data, the percent valid data achieved was 91%, while the percent data capture and data loss achieved were 92% and 8%, respectively.

Exceedances of the New Zealand Ambient Air Quality Guideline (AAQG) of 7 $\mu g/m^3$ as a 1-hour mean (or 5 ppb at 20 °C) were measured on 23 separate occasions, which represents 1% of the total 1-hour periods (2,221 hours). The top-10 exceedances of the 1-hour mean AAQG are shown in Table 3.

The majority of the exceedances occurred during westerly (W) winds (43%), west-north-westerly (WNW) winds (22%) and west-south-westerly (WSW) winds (13%). Winds from the direction of the landfill (i.e. south-west (SW) and south-south-west (SSW)), occurred only 9% and 4% of the time, respectively. Furthermore, the monitoring data indicate that the exceedances occurred during the evening or early morning and under calm to low wind conditions of between 0.2 m/s and 0.7 m/s.

The 1-hour mean wind speed and wind direction frequency for the monitoring period is shown as a wind rose in Figure 6. The figure indicates that the predominant wind directions measured at the site were from the W, WSW and east (E). Unfortunately, there was a relatively low frequency of winds that blew from the landfill towards the monitoring site (i.e. SW and SSW).

Figure 7 shows the 1-hour mean concentrations of H_2S measured at the site as a pollution rose, i.e. it presents the same data as per the wind rose shown in Figure 6, however, the wind speed data were substituted for the H_2S concentration data. The figure indicates that the highest H_2S concentrations were measured during winds blowing from the W, WSW and WNW. In other words, based on the data for the 3-month period, the figure indicates that there is likely to be another emission source of H_2S, other than the landfill, located to the WNW of the monitoring site.

Figure 8 shows the 1-hour mean concentrations of H_2S measured at the site as a polar plot, or a bivariate plot of concentrations varying by wind speed and wind direction. The figure shows the H_2S concentrations in polar coordinates by both 1-hour mean wind speed and wind direction. Mean concentrations were calculated for wind speed-direction 'bins' (e.g. wind speeds of 0–1, 1–2 m/s, and wind directions of 0–22.5, 22.5–45 degrees etc.). The figure further corroborates the suggestion that there is likely to be another emission source of H_2S located to the NW of the monitoring site; as the highest concentrations were measured during low wind speeds (<1 m/s) originating from the NW.

4. Odour Mitigation Measures

Mitigation measures recommended include:

- Implement an Odour Management Plan;
- Apply effective capping (e.g. clay layer) across Stage 2 to eliminate emission hotspots;
- Extract odorous air from the leachate collection manhole for treatment (e.g. by biofiltration);
- Control odour at the leachate pond (e.g. by reducing residence time, avoiding certain wind conditions for planned maintenance, aeration);
- Control odour at the working face (e.g. keep an adequate supply of daily cover, inspect cover integrity, deep burial of malodourous waste).

5. Conclusions

The 3-month continuous H_2S monitoring results indicate that there is likely to be another emission source of H_2S located to the NW of the monitoring site, which may also have contributed to the past odour nuisance events at receptor 'R1'.

Employing the above mitigation measures at the Levin landfill will reduce the likelihood of further odour nuisance effects arising in the community as a result of odour emissions at the landfill.

Acknowledgments

The author wishes to acknowledge the assistance provided by HDC, AirQuality Limited and the owners of the property referred to herein as receptor 'R1', and also the use of the 'openair' R package.

References

Carslaw, D.C. and K. Ropkins, (2012). openair — an R package for air quality data analysis. *Environ. Model. Softw.*, Vol 27–28, 52–61.

MfE, (2003). Good practice guide for assessing and managing odour in New Zealand, Ministry for the Environment (MfE), June 2003.

Figures

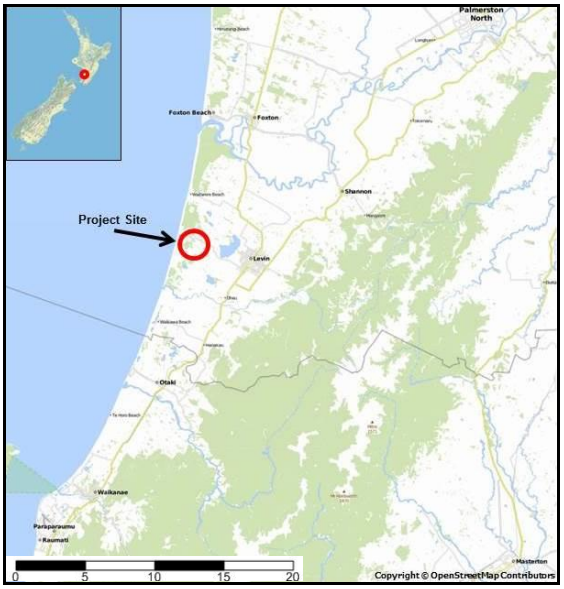

Figure 1. Project site location

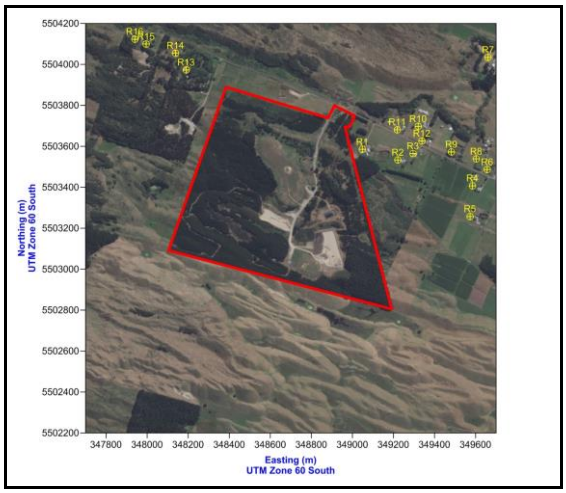

Figure 2. Sensitive receptor locations

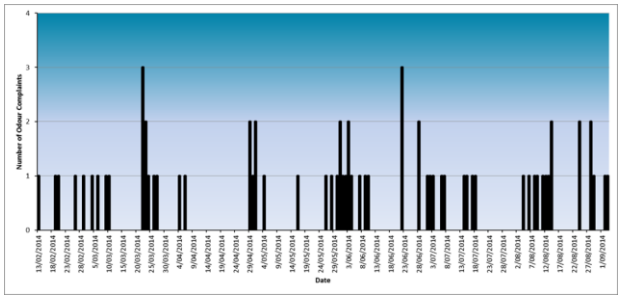

Figure 3. Odour complaints record for the site for 13 February 2014 to 3 September 2014

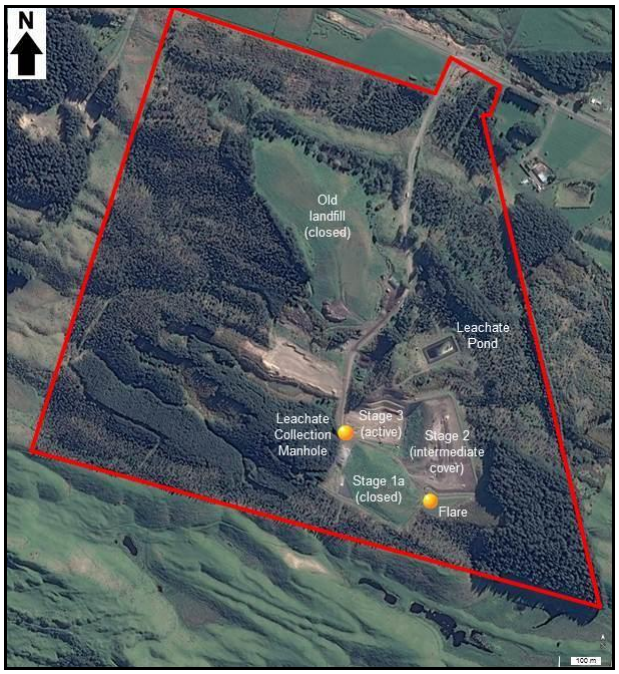

Figure 4. Odour source locations and landfill site boundary (solid red line)

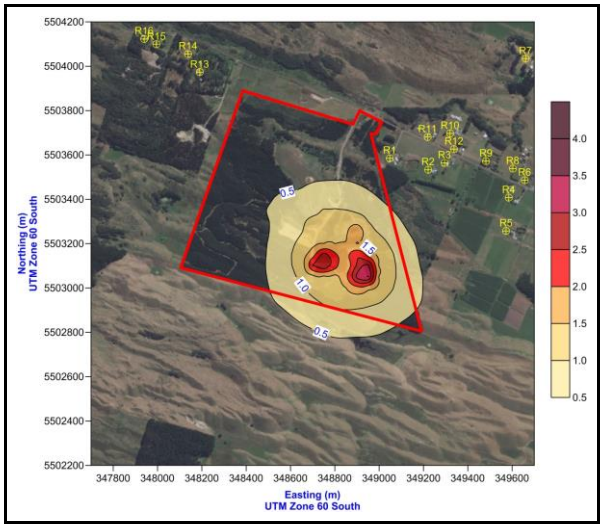

Figure 5. Scenario 1: 99.9%ile 1-hour mean ground-level odour concentrations (OU/m^3)

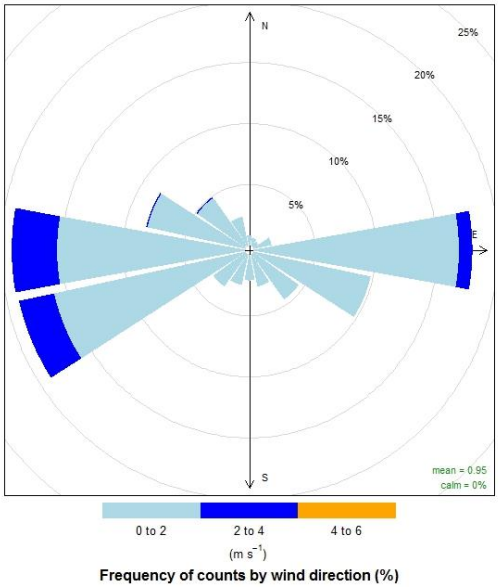

Figure 6. Wind rose showing 1-hour mean wind speed and direction for 17 March to 18 June 2015

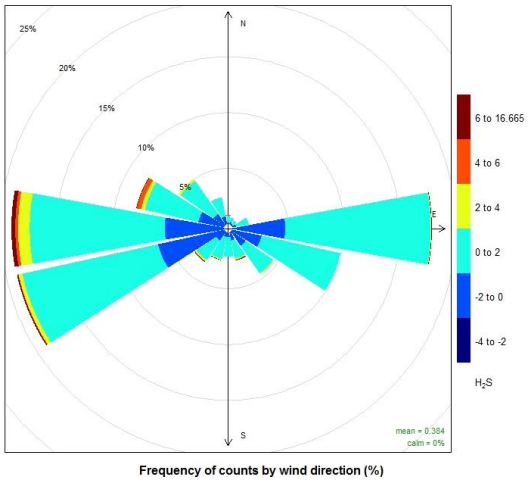

Figure 7. Pollution rose for 1-hour mean H_2S (ppb) and wind direction

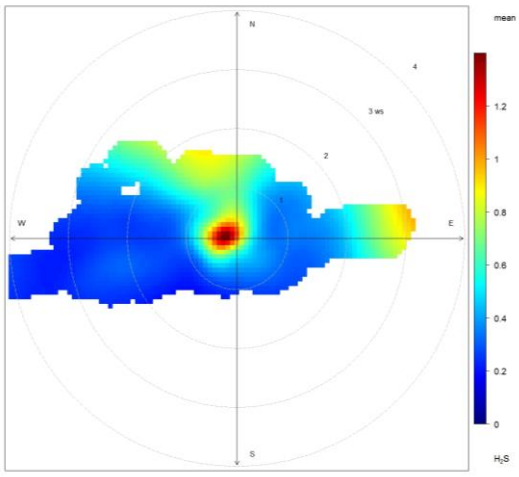

Figure 8. Polar plot for 1-hour mean H_2S (ppb), wind speed and wind direction

Tables

Table 1. Predicted 1-hour mean (99.9%ile) ground-level odour concentrations (OU/m^3)

Receptor	Scenario 1	Scenario 2	Scenario 3	Scenario 4
R1	0.24	0.23	0.10	0.10
R2	0.18	0.17	0.08	0.07
R3	0.16	0.16	0.07	0.07
R4	0.14	0.14	0.05	0.05
R5	0.15	0.15	0.06	0.06
R6	0.13	0.13	0.05	0.05
R7	0.10	0.09	0.04	0.04
R8	0.13	0.13	0.05	0.05
R9	0.14	0.14	0.06	0.05
R10	0.15	0.14	0.06	0.06
R11	0.15	0.15	0.06	0.06
R12	0.14	0.14	0.06	0.06
R13	0.13	0.13	0.05	0.05
R14	0.11	0.11	0.05	0.04
R15	0.09	0.09	0.04	0.04
R16	0.09	0.09	0.04	0.04

Table 2. Ambient H_2S concentrations

Averaging Period	H_2S Concentration (ppb)
1-minute mean	0.4
1-minute minimum	0.0
1-minute maximum	43.1
1-hour mean	0.4
1-hour minimum	0.0
1-hour maximum	16.7
24-hour mean	0.4
24-hour minimum	0.0
24-hour maximum	2.1

Table 3. Top-10 exceedances of the 1-hour mean AAQG for 17 March to 18 June 2015

Date / Time	Wind Speed (m/s)	Wind Direction (degrees)	H_2S Conc-entration (ppb)
16/06/2015 20:00	0.3	260	16.7
16/06/2015 19:00	0.2	166	12.4
19/05/2015 20:00	0.4	272	10.1
4/06/2015 21:00	0.2	280	9.7
27/05/2015 2:00	0.3	100	9.2
6/06/2015 0:00	0.3	199	8.5
25/05/2015 19:00	0.2	264	8.4
16/06/2015 21:00	0.2	258	7.2
27/05/2015 22:00	0.7	230	6.8
5/06/2015 2:00	0.4	245	6.6