CORK CITY COUNCIL

KINSALE ROAD LANDFILL SITE

Waste Licence Register No: W0012-02

Annual Environmental Report

January 2013 – December 2013

Prepared by:-

Cork City Council,
Kinsale Road Landfill Site,
Cork.

March 2014

DOCUMENT CONTROL SHEET

Kinsale Road Landfill Site Annual Report

Reporting Period January 2012 to December 2012

User is Responsible for the Revision Status of this Document

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1 INTRODUCTION

1.1 Scope and Purpose of the Report

Cork City Council holds a Waste Licence (Register No. W0012-03) to operate a landfill site at the Kinsale Road, Cork. The aim of this Annual Environmental Report is to provide a review of activities at Kinsale Road landfill site within the past 12 months.

1.2 Background to the Report

The Landfill site at Kinsale Road has been in operation since the 1960's. The site was issued with a waste licence by the Environmental Protection Agency (EPA) on 2nd February 2000 (Register No. 12-1), with a new licence issued on 29th November 2002 (Register No. W0012-02). The most recent licence was issued on 3rd May 2011 (Register No. W0012-03).

In accordance with Condition 11.10 of the Waste Licence, Cork City Council is required to submit to the Agency for its agreement, an Annual Environmental Report for its activities during the previous 12 months.

This report covers the period from January 2013 to December 2013.

1.3 Site Location and Operator details

The landfill is owned and operated by Cork City Council, City Hall, Cork. The address of the facility is as follows.

Kinsale Road Landfill Site,
Ballyphehane,
Curraghconway,
Inchisarsfield,
South City Link Road,
Cork.
The National Grid Reference for the site is 168033E 069658N.

The facility contact details are as below

- Facility Manger: Kevin Ryan
- Contact No: 021 4705913
- Fax No: 021 4319930

- Landfill Technician: Patrick Foley
- Contact No: 021 4705914

- Supervisor: Pascal Cooney

- Junior Foreman: Michael Reck

- Weighbridge Operator
- Contact No: 021 4705920

- Environment Department,
  City Hall,
  Cork
- Contact No: 021 4924726
- Fax No: 021 4924054

- City Hall
- Contact No. 021 4924000 / 4966222

2 SITE DESCRIPTION AND ACTIVITIES

2.1 Description of the Site

The facility is a municipal solid waste and non-hazardous industrial waste disposal facility. The site (including former land filling areas) is approximately 72 hectares.
Landfilling at the site ceased on the 15th July 2009.
Up to the 15th July 2009, the facility accepted domestic and commercial MSW and limited quantities of approved non-hazardous industrial sludges. The facility also includes a Civic Amenity Site and a Landfill Gas Combustion plant that operates on site.

The facility is located within 3 km of Cork City at the South City Link Road, in the townlands of Ballyphehane, Curraghconway and Inchisarsfield. The site occupies a large expanse of low-lying peat bog, bounded by the north and east by the Trabeg River, to the west by the South City Link Road and on the south by the Tramore River and South Ring Road.

The site has been operational since the early 1960's. The majority of the developments (commercial and residential) within 500m of the landfill have occurred subsequent to the commencement of waste disposal operations.

Works are ongoing at the site to upgrade the facility in accordance with the conditions of the Waste Licence. These works include leachate collection and treatment system, surface water collection, road infrastructure as well as final capping and restoration of the site.

2.2 Waste Management activities at the Facility

Waste Activities Licensed at the Kinsale Road Landfill Site are restricted to those outlined in the Waste Licence as outlined below in Tables 2.1 and 2.2.

Table 2.1 Licensed Waste Disposal Activities, in accordance with the Third Schedule of the Waste Management Acts 1996 – 2010.

Class 1.	Deposit on, in or under land (including landfill) [Principal Activity].
Class 2.	Land treatment, including biodegradation of liquid or sludge discards in soils
Class 4.	Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons.
Class 5.	Specially engineered landfill, including placement into lined discrete cells which are capped and isolated from one another and the environment.
Class 7.	Physico-chemical treatment not referred to elsewhere in this Schedule which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 5 or paragraphs 8 to 10 of this Schedule (including evaporation, drying and calcination).
Class 11.	Blending or mixture prior to submission to any activity referred to in a preceding paragraph of this Schedule.
Class 12.	Repacking prior to submission to any activity referred to in a preceding paragraph of this Schedule.
Class 13.	Storage prior to submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where the waste concerned is produced.

Table 2.2 Licensed Waste Recovery Activities, in accordance with the Fourth Schedule of the Waste Management Acts 1996 – 2010.

Class 2.	Recycling or reclamation of organic substances which are not used as solvents (including composting and other biological processes).
Class 3.	Recycling or reclamation of metals and metal compounds.
Class 4.	Recycling or reclamation of other inorganic materials.
Class 10.	The treatment of any waste on land with a consequential benefit for an agricultural activity or ecological system.
Class 11.	Use of waste obtained from any activity referred to in a preceding paragraph of this Schedule.
Class 12.	Exchange of waste for submission to any activity referred to in a preceding paragraph of this Schedule.
Class 13.	Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where such waste is produced.

2.3 Quantities and Composition of Waste Received, Disposed of and Recovered.

Kinsale Road landfill site is licensed to send municipal waste off site for disposal / recovery up to a maximum of 22,000 tonnes of per annum.
Other waste types and quantities allowed for disposal as per Schedule A of the Waste Licence are as per Table 2.3 below.

Table 2.3 Waste Acceptance Criteria

Waste Type			Maximum [Note 2] (Tonnes Per Annum)
Non-Hazardous Wastes Note 1	Mixed Municipal Waste for recovery/disposal off-site *Accepted at Civic Waste Facility*		5,000
	Storage of Waste prior to Recovery *(including glass, beverage/food cans, textiles, paper and cardboard, plastics, timber, metals, non-hazardous batteries, non-hazardous WEEE accepted at the Civic Waste Facility)*		
	Construction & Demolition Waste *Accepted at the facility for recovery and use in site construction works and landfill restoration.*		300,000 [Note 3]
	Residual Municipal Waste for off–site recovery and/or disposal *Accepted at Waste Transfer Station*		22,000 [Note 4]
	Green Waste (for Composting) *Accepted at Civic Waste Facility*		**Note 5**
	Inert Waste - Imported for restoration purposes		**Note 6**
Non-Hazardous Waste Total			**327,000**
Hazardous Wastes **Note 7**	20 01 21	Fluorescent Tubes and other mercury-containing waste	6
	20 01 27 16 05 04	Paints, inks, adhesives and resins containing dangerous substances Gases in pressure containers (including halons) containing dangerous substances)	20
	20 01 34	Batteries and accumulators other than those mentioned in 20 01 33	12
	All Chapter 13 Wastes [Note 8]	Waste Oils	12
	20 01 35	Discarded electrical and electronic equipment other that those mentioned in 20 01 21 & 20 01 23 containing hazardous components.	1,000
Hazardous Waste Total			**1,050**
TOTAL INCLUDING DISPOSAL AND RECOVERY			**328,050**

Note 1: Any proposals to accept other compatible non-hazardous waste types must be agreed in advance by the Agency.
Note 2: The limitation on individual non-hazardous waste types may be varied with the agreement of the Agency subject to the total limit for non-hazardous waste staying the same.
Note 3: The maximum tonnage to be processed at the Construction and Demolition Waste Recovery Area shall not exceed 2,000 tonnes per day, unless subject to the prior agreement of the Agency, subject to Condition 3.27.
Note 4: Acceptance of Residual Municipal Waste at the facility for off-site disposal, other than that received at the Civic Waste Facility from members of the public, shall not take place until such time as the Waste Transfer Station infrastructure has been installed to the satisfaction of the Agency in accordance with Condition 8.2 of this licence.
Note 5: Quantity of Green Waste/ Compost at the facility is limited to a maximum of 2,400m^3 at any one time.
Note 6: Quantity of waste imported for restoration purposes is limited to 100,000 tonnes per annum for a period of two years from the date of grant of licence, unless otherwise agreed by the Agency.
Note 7: Hazardous waste types as detailed, or as may otherwise be agreed in advance by the Agency.
Note 8: All Chapter 13 wastes: *Oil Wastes and Wastes of Liquid Fuels* (except, 13 01 01, 13 03 01, 13 05 01, 13 05 02, 13 05 03, 13 07 01, 13 07 02, 13 07 03 and 13 08 01) of the *European Waste Catalogue and Hazardous Waste List*.

Table 2.3.1 Quantities of Waste received prior to reporting period.

	Non-Hazardous Waste	*Hazardous Waste*
Deposited in landfill prior to report period.	2.737 million tonnes estimated	Not known if any
C&D waste stored at C&D facility prior to report period.	15,000 tonnes	Nil

No waste was landfilled at the site during the reporting period.

Table 2.3.2 Quantities of Waste transferred offsite during the reporting period

	Waste transferred off site in 2013 (tonnes)
Total	**1,141**

Table 2.3.3 Classes of Waste received for recovery / recycling off site.

Waste Description	*EWC Code*	*Name of Recovery Company*
Paper	20 01 01	Greenstar
		Cork Recycling
Metal	20 01 06	Pouladuff Dismantlers
Timber	20 01 07	CTO Environmental
Plastic	20 01 03	Cork Recycling
Glass Bottles	20 01 02	Rehab Recycling Partnership
Aluminium Cans	20 01 05	Rehab Recycling Partnership
Oil	13 00 00	ENVA
Green Waste	20 02 01	CTO Environmental Solutions
Cardboard	20 01 01	Cork Recycling
WEEE	20 01 35	KMK
Aerosols	16 05 04	SLR
Paints	20 01 27	SLR
Car Batteries	16 06 01	KMK
Household Batteries	16 06 01 / 16 06 02 16 06 04 / 20 01 34	KMK

2.3.4 Landfill Inputs and Outputs (Waste and Recycling)

Waste Totals for Kinsale Road Landfill Site - 2013

All weights in tonnes

Commodity	Total
Municipal	1,023
Non Levy	125
Waste Rubble	134
Total Transferred Off Site	**1,148**

Commodity	Total
Rubble imported for capping	797

Domestic Recycling	Total
WEEE Out	624.92
Plastic Bottles	23.38
Plastic Wrappers	17.16
Cardboard	63.90
Paper	103.40
Metal	111.18
Green Waste (CA)	283.90
Timber (CA)	179.96
Glass	35.16
Drink Cans	2.10
Oil	6.80
Paint	14.00
Batteries	3.38
Clothes	10.16
CA Site Recycling Total inc. WEEE Out	1479.40

Commercial Recycling	Total
Timber Waste	4,862
Green Waste	

Total (inc CA Site)	Total
Timber	5,042
Green (inc Xmas Trees)	1,663

2.4 Landfill Capacity

2.4.1 The landfilling of waste at the facility ceased as of 15th July 2009.

2.5 Economic Contribution

Provision made for Site Operations expenditure in the reporting period was €1,066,000

3 SITE DEVELOPMENT WORKS

3.1 Site Development Works during the Reporting Period.

The Waste Licence sets out conditions relating to the completion of certain works within the designated periods following the date of grant of the licence. The works referred to generally formed part of site development works.

M&E works for landfill gas and leachate management

M & E works are ongoing. These include maintenance of the Leachate Conditioning Plant and the continued balancing of the landfill gas field.

Miscellaneous Works Completed in 2013:

1. Ongoing maintenance of Site Roads.
2. Regular cleaning of Gravel Trap at Leachate Conditioning Plant with replacement of gravel as required.
3. CTO Environmental Solutions Ltd. operates a timber reprocessing facility and green waste composting facility on behalf of Cork City Council at the Landfill Site. Shredded timber is sent exclusively to Eirebloc Ltd, Lisarda, Macroom, Co. Cork where it is it is further processed and utilised to manufacture inserts for pallets.
4. Re-drilling and relocation of gas wells in Blue Demons facility (a portion of this area comes under the waste licence) to more suitable location.
5. Additional pump sump installed on northern side of Tramore river (adjacent to timber reprocessing compound) to collect and contain a leachate breakout in the area.
6. Commissioning of 4 no. borehole pumps and 3 no. pump sumps in Contract 10 capping area to collect deep seated leachate within the waste body and leachate from low points below the capped landfill dome.

Commencement of Final Capping and Restoration Works (Contract 9)

The final phase of capping and landscaping for the facility commenced in November 2013
The total area to be capped is 7.5ha.
The works entail the following:

1. Mobilisation to site by the Contractor
2. Regrading including some cut and fill to achieve the required cap profile
3. The installation of new gas wells
4. The installation of a subliner gas collection system (including pipework and drainage geo-composite)
5. The installation of an LLDPE liner or other as approved by the Agency
6. The installation of a subsurface water collection layer (i.e. a drainage geocomposite)
7. The placement of subsoil above the liner
8. The placement of topsoil
9. Grass seeding and landscaping
10. The construction of an access road including pedestrian walkway and cycle way

Capping works are expected to be completed in 2015.

Other planned works for 2014 are:

- SCADA system upgrades (reporting/management system).
- Installation /renewal of control valves and systems to optimise gas collection.
- Installation /renewal of control valves and systems to optimise storm water treatment.
- Upgrading of site roadways.
- Miscellaneous minor capital works and works arising from Operational Procedures.
- Implementation of landscape design plan for the Tramore Valley Park

4 ENVIRONMENTAL INCIDENTS AND COMPLAINTS

4.1 Incidents

All Incidents, Non-Conformances and Non–Compliances are uploaded to the EDEN/ALDER System.

4.2 Complaints

There were no complaints during 2013.

4.3 Review of Nuisance Controls

In accordance with Condition 6 of the Waste License Cork City Council are required to ensure that vermin, birds, flies, mud, dust and litter do not give rise to nuisances at the facility or in the immediate area of the facility.
Cork City Council ensures that the activities are carried out in a manner such that odours do not result in significant impairment or interference with amenities or the environment beyond the facility boundary.
The road network in the vicinity of the facility is kept free from any debris caused by vehicles entering or leaving the facility. Any such debris or deposited materials is removed without delay.

Litter Control
Litter fencing is no longer required at the facility as landfilling has ceased (July 2009).
Litter picking teams are organised as required to collect any wind blown litter or other waste, placed on or in the vicinity of the facility.
All vehicles removing waste and materials from the facility (Civic Amenity Site and Timber Processing & Green Waste Composting facilities) are appropriately covered.

Dust Control
In dry weather, site roads and any other areas used by vehicles are sprayed with water as and when required to minimise airborne dust nuisance.
Prior to exiting the facility, all waste vehicles use the vehicle wash.

Bird Control
This is no longer an issue as all the waste has been covered and final capping of the site is ongoing.

Odour
Odour from the landfill site is minimised through the extraction of landfill gas and through the application of odour control substances as required.
No odour complaints were received during the reporting period.

Flies
Flies are controlled through the use of control substances as deemed necessary by the pest control experts.

Vermin

Vermin are controlled through the use of baiting as deemed necessary by the pest control experts.

Noise

Noise is minimised / controlled by operating the facility between the hours of 8am – 4pm. Contractors may operate between the hours of 8am – 6pm in agreement with the City Council.

Environmental Objectives and Targets

Management Programme

Objective 1: Final Capping and Amenity Park Development				
Responsibility: Facility Management & appointed contractor		**Start Date:** April 2012 **Revised Date:** March 2014		
Target: To restore & cap the northern area of the site to complete site capping and restoration with an aim to developing a regional amenity park				
Task	**Details**	**Due Date**	**By Whom**	**Status**
1	Preliminary discussions held with appointed consultants to discuss the size & scope of the project	April 2012	CCC & RPS Group	Complete
2	CCC to develop a master plan for the site	Nov 2012	CCC & BSM Consultants	Complete
3	Invite expression of interest for prequalification for site capping works	January 2013	CCC & RPS Group	Complete
4	Final contract documents to be prepared for Spring 2013	March 2013	CCC & RPS Group	Complete
5	Invite contractors successful at the prequalification stage to tender for site capping works	July 2013	CCC & RPS Group	Complete
6	Assess received tenders & award contract	August 2013	CCC & RPS Group	Complete
7	Award Contract Wills Bros. Contracting engineers were successful contractors	Aug/ Sept 2013	CCC & RPS Group	Complete
8	Commence site capping works and construction of associated engineering infrastructure and landscaping works	~~October 2013~~ Nov 2013	Wills Bros. Contractor	Ongoing
9	Invite landscape Architect led multi disciplinary teams to tender for landscaping design of landfill site surrounding lands for detailed park design	Q1 2014	CCC / BSM	Ongoing
10	Assess received landscape design tenders & award contract	Q2 2014	CCC / BSM	
11	Invite Landscaping led Contract Teams to tender for Carrying out landscaping works	Q2 2014	CCC / BSM	
12	Assess received landscape construction tenders & award contract	Q2 2014	CCC / BSM	
13	Commence site Landscaping works and associated works	Q3 2014		
14	Works due for completion in 2015	Q3 / Q4 2015		
15	Opening of regional park to the public	Q4 2015 / Q 1 2016		
Objective Complete: Signed: _____ Date: _____				

5.2 Site Management Structure

The Staff Management Structure for the facility is detailed in the Organisational Chart.
The responsibilities of the site staff are listed below.

Facility Manager

The Facility Manager has overall responsibility for operation of the facility in accordance with the conditions of the Waste Licence and best operational practices.

The Facility Manager co-ordinates all of the activities and contractors on site and implements procedures and practices in accordance with the Environmental Management Programme.

Landfill Technician

The Environmental Technician carries out monitoring, sampling and analysis at the facility under the supervision of the facility manager and is based at the landfill site.

Site Supervisor and Junior Foreman

The Supervisor and Junior Foreman are responsible for ensuring that the site staff carry out their designated duties, and liaises with the Facility Manager in the implementation of procedures and practices at the facility. They have completed the FAS "Waste Management" course.

Relief Site Supervisor

The Relief Site Supervisor performs the functions of the Site Supervisor in the event of his / her absence. The Relief Site Supervisor has also completed the FAS "Waste Management" course.

Weighbridge Operator

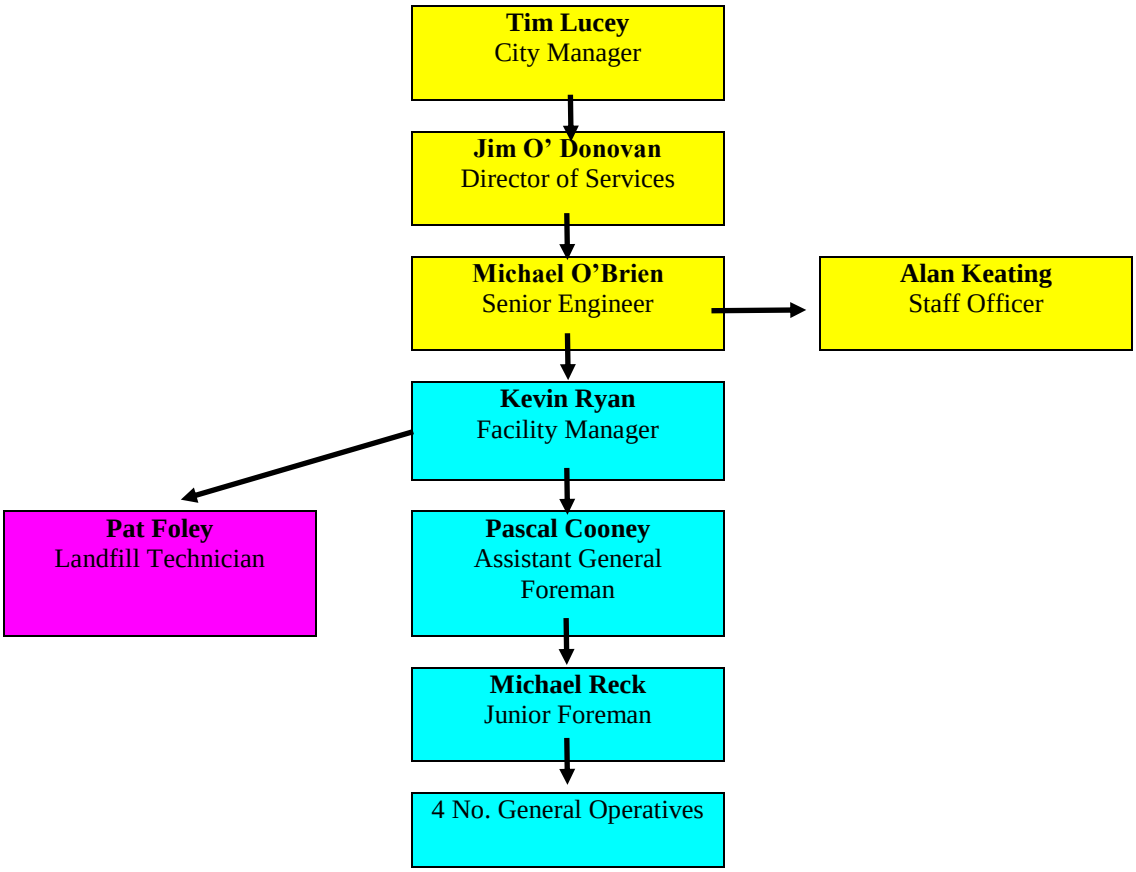
The Weighbridge Operator records incoming waste and controls access to the facility.

Staff Officer Environment

The Staff Officer Environment (not based on site) is responsible for the maintenance of the Waste Licence public file including dealing with queries from the public. Duties also include liaising with waste contractors regarding acceptance of waste and accounts etc.

5.2.1 Organisational Chart

The Management Structure of Kinsale Road Landfill Site, including Environmental Monitoring (Site Technician and Laboratory Analysis) and Administration (City Hall).



5 ENVIRONMENTAL MANAGEMENT PROGRAMME

5.1 Environmental Objectives

1 **Environmental Objective 1:** Final Capping and Amenity Park Development

Location: **D1, D2, D3, D4, D5**

Limit: **350mg/m^2/day**

Dust Deposition Levels 2013

			Limit	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Grid co-ordinates			mg/m2/day	mg/m2/day	mg/m2/day	mg/m2/day	mg/m2/day
168081E,069747N		**D1**	**350**				72
168373E,070046N		**D2**	**350**				76
168600E,069691N		**D3**	**350**				44
168178E,069276N		**D4**	**350**				72
167982E,069648N		**D5**	**350**				94
				No Results	No Results	No Results	

PM10 Monitoring

Location: S3 Heatherton park

Paramater: PM_{10}

Frequency: Continuous

Average PM_{10}	15.1
St. Dev	8.4
Min	2.9
Max	67
Number of Samples	328

Date	HEATHERTON PARK		
01/01/2013		15	
02/01/2013		8.8	
03/01/2013		7.9	
04/01/2013		8.8	
05/01/2013		16	
06/01/2013		15	
07/01/2013		14	
08/01/2013		23	
09/01/2013		34	
10/01/2013		22	
11/01/2013		29	
12/01/2013		11	
13/01/2013		26	
14/01/2013		11	
15/01/2013		17	
16/01/2013		9.6	
17/01/2013		16	
18/01/2013		20	
19/01/2013		24	
20/01/2013		21	
21/01/2013		33	
22/01/2013		42	
23/01/2013		62	***
24/01/2013		26	
25/01/2013		7.5	
26/01/2013		9.6	
27/01/2013		6.7	
28/01/2013		21	
29/01/2013		9.2	
30/01/2013		filter exchange failure	
31/01/2013		filter exchange failure	
01/02/2013		8.3	
02/02/2013		19	
03/02/2013		7.1	
04/02/2013		22	
05/02/2013		10	
06/02/2013		18	
07/02/2013		19	

08/02/2013		27
09/02/2013		22
10/02/2013		8.8
11/02/2013		11
12/02/2013		11
13/02/2013		7.5
14/02/2013		filter exchange/pump failure
15/02/2013		filter exchange/pump failure
16/02/2013		filter exchange/pump failure
17/02/2013		filter exchange/pump failure
18/02/2013		filter exchange/pump failure
19/02/2013		filter exchange/pump failure
20/02/2013		filter exchange/pump failure
21/02/2013		filter exchange/pump failure
22/02/2013		filter exchange/pump failure
23/02/2013		filter exchange/pump failure
24/02/2013		filter exchange/pump failure
25/02/2013		filter exchange/pump failure
26/02/2013		filter exchange/pump failure
27/02/2013		filter exchange/pump failure
28/02/2013		filter exchange/pump failure
01/03/2013		filter exchange/pump failure
02/03/2013		filter exchange/pump failure
03/03/2013		filter exchange/pump failure
04/03/2013		filter exchange/pump failure
05/03/2013		filter exchange/pump failure
06/03/2013		filter exchange/pump failure
07/03/2013		filter exchange/pump failure
08/03/2013		filter exchange/pump failure
09/03/2013		filter exchange/pump failure
10/03/2013		filter exchange/pump failure
11/03/2013		filter exchange/pump failure
12/03/2013		filter exchange/pump failure
13/03/2013		filter exchange/pump failure
14/03/2013		7.5
15/03/2013		8.3
16/03/2013		18
17/03/2013		8.8
18/03/2013		14
19/03/2013		16
20/03/2013		18
21/03/2013		11
22/03/2013		22
23/03/2013		22
24/03/2013		30
25/03/2013		27
26/03/2013		23
27/03/2013		25
28/03/2013		27
29/03/2013		33

30/03/2013		21
31/03/2013		20
01/04/2013		30
02/04/2013		26
03/04/2013		17
04/04/2013		15
05/04/2013		24
06/04/2013		28
07/04/2013		23
08/04/2013		25
09/04/2013		38
10/04/2013		19
11/04/2013		8.8
12/04/2013		10
13/04/2013		12
14/04/2013		27
15/04/2013		27
16/04/2013		20
17/04/2013		19
18/04/2013		8.8
19/04/2013		9.6
20/04/2013		10
21/04/2013		7.9
22/04/2013		10
23/04/2013		6.3
24/04/2013		7.5
25/04/2013		9.6
26/04/2013		7.9
27/04/2013		9.6
28/04/2013		15
29/04/2013		17
30/04/2013		13
01/05/2013		15
02/05/2013		12
03/05/2013		14
04/05/2013		10
05/05/2013		15
06/05/2013		18
07/05/2013		17
08/05/2013		8.3
09/05/2013		7.5
10/05/2013		10
11/05/2013		11
12/05/2013		7.9
13/05/2013		11
14/05/2013		7.9
15/05/2013		13
16/05/2013		11
17/05/2013		11
18/05/2013		8.3

19/05/2013		5
20/05/2013		9.6
21/05/2013		8.8
22/05/2013		13
23/05/2013		17
24/05/2013		13
25/05/2013		11
26/05/2013		9.6
27/05/2013		6.3
28/05/2013		10
29/05/2013		13
30/05/2013		11
31/05/2013		6.3
01/06/2013		12
02/06/2013		10
03/06/2013		5.8
04/06/2013		13
05/06/2013		15
06/06/2013		17
07/06/2013		18
08/06/2013		15
09/06/2013		18
10/06/2013		12
11/06/2013		5
12/06/2013		7.9
13/06/2013		11
14/06/2013		9.2
15/06/2013		10
16/06/2013		8.8
17/06/2013		9.2
18/06/2013		10
19/06/2013		17
20/06/2013		9.2
21/06/2013		9.6
22/06/2013		8.8
23/06/2013		15
24/06/2013		11
25/06/2013		6.3
26/06/2013		16
27/06/2013		12
28/06/2013		7.9
29/06/2013		9.2
30/06/2013		12
01/07/2013		21
02/07/2013		4.6
03/07/2013		4.2
04/07/2013		11
05/07/2013		13
06/07/2013		15
07/07/2013		12

08/07/2013		20
09/07/2013		24
10/07/2013		18
11/07/2013		22
12/07/2013		25
13/07/2013		17
14/07/2013		21
15/07/2013		13
16/07/2013		15
17/07/2013		17
18/07/2013		22
19/07/2013		24
20/07/2013		18
21/07/2013		12
22/07/2013		15
23/07/2013		7.9
24/07/2013		12
25/07/2013		7.5
26/07/2013		8.8
27/07/2013		10
28/07/2013		8.3
29/07/2013		9.6
30/07/2013		8.3
31/07/2013		5.4
01/08/2013		7.1
02/08/2013		10
03/08/2013		9.2
04/08/2013		4.6
05/08/2013		7.9
06/08/2013		7.5
07/08/2013		6.7
08/08/2013		8.8
09/08/2013		12
10/08/2013		8.3
11/08/2013		6.7
12/08/2013		8.8
13/08/2013		6.3
14/08/2013		2.9
15/08/2013		2.9
16/08/2013		7.9
17/08/2013		5.4
18/08/2013		6.3
19/08/2013		15
20/08/2013		13
21/08/2013		11
22/08/2013		5.4
23/08/2013		7.9
24/08/2013		13
25/08/2013		5.4
26/08/2013		8.8

27/08/2013		8.3
28/08/2013		7.1
29/08/2013		6.7
30/08/2013		9.2
31/08/2013		12
01/09/2013		7.9
02/09/2013		8.3
03/09/2013		8.3
04/09/2013		13
05/09/2013		8.8
06/09/2013		9.2
07/09/2013		10
08/09/2013		8.3
09/09/2013		5
10/09/2013		7.1
11/09/2013		6.3
12/09/2013		filter exchange failure
13/09/2013		filter exchange failure
14/09/2013		filter exchange failure
15/09/2013		filter exchange failure
16/09/2013		filter exchange failure
17/09/2013		filter exchange failure
18/09/2013		filter exchange failure
19/09/2013		16
20/09/2013		18
21/09/2013		5.4
22/09/2013		7.5
23/09/2013		13
24/09/2013		26
25/09/2013		23
26/09/2013		12
27/09/2013		28
28/09/2013		29
29/09/2013		24
30/09/2013		20
01/10/2013		11
02/10/2013		21
03/10/2013		12
04/10/2013		11
05/10/2013		9.6
06/10/2013		11
07/10/2013		11
08/10/2013		9.2
09/10/2013		10
10/10/2013		14
11/10/2013		19
12/10/2013		16
13/10/2013		16
14/10/2013		20
15/10/2013		18

16/10/2013		13
17/10/2013		17
18/10/2013		13
19/10/2013		15
20/10/2013		8.8
21/10/2013		15
22/10/2013		17
23/10/2013		13
24/10/2013		15
25/10/2013		45
26/10/2013		9.6
27/10/2013		15
28/10/2013		7.9
29/10/2013		16
30/10/2013		23
31/10/2013		15
01/11/2013		28
02/11/2013		17
03/11/2013		13
04/11/2013		25
05/11/2013		13
06/11/2013		8.8
07/11/2013		11
08/11/2013		12
09/11/2013		25
10/11/2013		9.6
11/11/2013		15
12/11/2013		24
13/11/2013		10
14/11/2013		19
15/11/2013		24
16/11/2013		25
17/11/2013		22
18/11/2013		8.8
19/11/2013		15
20/11/2013		13
21/11/2013		15
22/11/2013		28
23/11/2013		28
24/11/2013		27
25/11/2013		29
26/11/2013		30
27/11/2013		38
28/11/2013		49
29/11/2013		15
30/11/2013		23
01/12/2013		20
02/12/2013		20
03/12/2013		30
04/12/2013		20

05/12/2013		14	
06/12/2013		13	
07/12/2013		7.5	
08/12/2013		7.1	
09/12/2013		12	
10/12/2013		26	
11/12/2013		30	
12/12/2013		25	
13/12/2013		18	
14/12/2013		20	
15/12/2013		14	
16/12/2013		22	
17/12/2013		21	
18/12/2013		13	
19/12/2013		11	
20/12/2013		15	
21/12/2013		15	
22/12/2013		9.6	
23/12/2013		15	
24/12/2013		16	
25/12/2013		67	***
26/12/2013		21	
27/12/2013		15	
28/12/2013		14	
29/12/2013		13	
30/12/2013		13	
31/12/2013		10	

Landfill Gas Monitoring Wells - 2013

Note: n = Number of Samples

WELL NO.	DP3	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.70	5.70
Mean	0.05	0.91
n	37	37
Over limit	0	10

WELL NO.	DP4	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	65.00	4.20
Mean	6.05	0.96
n	37	37
Over limit	4	13

WELL NO.	DP3A	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	7.60
Mean	0.00	1.23
n	26	26
Over limit	0	6

WELL NO.	DP4A	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.60	8.30
Mean	0.02	2.61
n	26	26
Over limit	0	14

WELL NO.	DP3 OLD	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	32.90	1.30
Max	68.40	36.90
Mean	60.17	22.59
n	18	18
Over limit	18	18

WELL NO.	DP4 OLD	
LOCATION	BLUEDEMONS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	14.60	10.60
Mean	5.38	4.22
n	18	18
Over limit	10	12

WELL NO.	LG2	
LOCATION	LANDFILL NORTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	37.00	37.00
Mean	6.44	10.45
n	9	
Over limit	2	6

WELL NO.	LG3	
LOCATION	LANDFILL NORTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.01	0.02
Max	68.40	37.00
Mean	30.95	15.20
n	9	
Over limit	8	6

WELL NO.	LG4	
LOCATION	LANDFILL NORTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	26.00	26.00
Mean	7.40	8.57
n	9	
Over limit	5	6

WELL NO.	LG5	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	4.60
Mean	0.00	0.98
n	105	
Over limit	0	20

WELL NO.	LG5A	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	1.20
Max	30.00	16.00
Mean	9.24	10.38
n	105	
Over limit	98	104

WELL NO.	LG6	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.10	4.90
Mean	0.00	1.00
n	122	
Over limit	0	35

WELL NO.	LG6A	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.20
Max	23.20	16.00
Mean	9.81	8.88
n	122	
Over limit	121	120

WELL NO.	LG7A	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	2.30
Mean	0.00	0.91
n	122	
Over limit	0	22

WELL NO.	LG8A	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	1.80	1.80
Mean	0.03	0.03
n	104	
Over limit	2	1

WELL NO.	LG8	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	1.90
Max	0.00	5.70
Mean	0.00	4.09
n	13	
Over limit	0	13

WELL NO.	LG12	
LOCATION	LANDFILL SOUTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.50
Max	2.20	17.50
Mean	0.42	3.70
n	21	
Over limit	4	19

WELL NO.	LG5	
LOCATION	LANDFILL SOUTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	9.20
Mean	0.00	0.73
n	21	
Over limit	0	1

WELL NO.	LG13	
LOCATION	LANDFILL SOUTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	9.20
Mean	0.00	0.73
n	21	
Over limit	0	1

WELL NO.	LG14	
LOCATION	LANDFILL SOUTH	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	3.40
Max	0.00	11.00
Mean	0.00	6.79
n	21	
Over limit	0	21

WELL NO.	LG46	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	0.00
Mean	0.00	0.00
n	0	
Over limit	0	0

WELL NO.	LG47	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	1.40
Mean	0.00	0.17
n	68	
Over limit	0	0

WELL NO.	LG48	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	0.00
Mean	0.00	0.00
n	6	
Over limit	0	18

WELL NO.	LG49	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	4.80
Mean	0.00	0.60
n	64	
Over limit	0	9

WELL NO.	LG51	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	1.00	4.10
Mean	0.02	0.94
n	70	
Over limit	1	10

WELL NO.	LG52	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	1.50	7.60
Mean	0.05	3.42
n	70	
Over limit	2	56

WELL NO.	LG53	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	0.90
Mean	0.00	0.37
n	69	
Over limit	0	0

WELL NO.	LG54	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.50
Max	0.00	4.30
Mean	0.00	2.36
n	68	
Over limit	0	56

WELL NO.	LG55	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.20
Max	0.00	8.80
Mean	0.00	3.60
n	68	
Over limit	0	62

WELL NO.	LG58	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	2.10
Mean	0.00	0.90
n	70	
Over limit	0	17

WELL NO.	TP9	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	3.30
Max	0.00	9.70
Mean	0.00	6.31
n	69	
Over limit	0	69

WELL NO.	TP12	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.40
Max	0.00	5.50
Mean	0.00	2.52
n	69	
Over limit	0	54

WELL NO.	TP17	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	3.60
Mean	0.00	0.87
n	66	
Over limit	0	12

WELL NO.	TP21	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	0.10
Mean	0.00	0.03
n	6	
Over limit	0	0

WELL NO.	TP27	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	0.00	3.10
Mean	0.00	1.53
n	68	
Over limit	0	34

WELL NO.	TP32	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.70
Max	1.10	8.30
Mean	0.02	4.50
n	70	
Over limit	1	68

WELL NO.	TP33	
LOCATION	GREENHILLS	
LICENSED	N	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.80
Max	0.00	9.80
Mean	0.00	4.70
n	70	
Over limit	0	67

WELL NO.	GH1	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.60
Max	0.00	4.40
Mean	0.00	2.48
n	100	
Over limit	0	86

WELL NO.	GH2	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	16.70	6.40
Mean	0.18	3.28
n	91	
Over limit	1	73

WELL NO.	GH3	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	1.80
Max	0.00	7.50
Mean	0.00	5.07
n	70	
Over limit	0	70

WELL NO.	GH4	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	0.00
Max	1.60	9.40
Mean	0.11	5.18
n	101	
Over limit	1	98

WELL NO.	GH5	
LOCATION	GREENHILLS	
LICENSED	Y	
License Limit	1%	1.50%
	CH4 %	CO2 %
Min	0.00	1.40
Max	0.00	4.90
Mean	0.00	3.42
n	91	
Over limit	0	90

Gas Feed Line to Power Plant / Flare Unit

WELL NO.	FLARE RICH GAS	
LOCATION	LANDFILL	
LICENSED	Y	
	CH4 %	CO2 %
Min	23.70	0.20
Max	37.30	25.50
Mean	30.56	18.18
n	33	

Monitoring for Landfill Gas in Site Buildings

Room ID	Room Number	CH4 %	CO2 %
RECEPTION	1	0	0
CONFERENCE	2	0	0
KITCHEN	3	0	0
NO. 5	5	0	0
BACK OFFICE	6	0	0
SCADA	7	0	0
TECHNICIAN	8	0	0
ENGINEER	9	0	0
GENTS TOILET	10	0	0
SHOWER ROOM	11	0	0
LADIES TOILET	NA	0	0
MANAGER	14	0	0
LABORATORY	NA	0	0
LAB OFFICE	NA	0	0
CANTEEN (REAR)	NA	0	0
WEIGHBRIDGE	NA	0	0
CIVIC AMENITY	NA	0	0
CTO OFFICE	NA	0	0
n		33	33

Groundwater - OverBurden Wells: OB1, OB2, OB3, OB7

Location: Landfill

ANNUAL OVERBURDEN -2013 (mg/l)

		Frequency	Method	Range	Sample	OB1		OB2		OB3		OB7
Vis/Odour		q			Grab	POOR		POOR		POOR		POOR
Amonium		m	ISE	0.01-10		0.07		320		320		34
Ammonia (as N)						0.05		248.96		248.96		26.45
Chloride		q	ArgentSM	1-100		28		31		496		113
D.O.		q	Meter	0.1-20		7.1		3.5		2.6		1.2
Cond.µs/cm		m	Meter	1-200000		540µs		618µs		4,580µs		1,160µs
pH		m	Meter	1.0-14.0		8.1		8.4		8.4		7.3
Temp		m	Meter	1.0-100		11.3.C		8.9.C		12.2.C		9.1.C
Boron		a	GFAA	0.01-1.0		0.06		0.03		1.2		0.06
Cadmium		a	GFAA	0.001-0.5		<0.002		<0.002		<0.002		<0.002
Calcium		a	Titre SM	1-100		96		116		136		64
Chromium		a	GFAA	0.001-0.2		<0.002		<0.002		<0.002		<0.002
Copper		a	AA	0.001-1.0		0.02		0.03		0.04		0.03
Cyanide		a	ISE	0.005-1.0		<0.005		<0.005		<0.005		<0.005
Fluoride		a	ISE	0.5-1.0		0.12		0.07		0.12		0.06

	Frequency		Method	Range	Sample		OB1		OB2		OB3		OB7
Iron	a		AA	0.01-5.0			0.008		0.3		0.25		1.1
Lead	a		GFAA	0.001-0.1			<0.002		<0.002		<0.002		<0.002
Magnesium	a		AA	0.01-5.0			2.5		4.6		40		7.1
Manganese	a		AA	0.01-3.0			0.01		0.8		0.19		0.99
Mercury	a		Hydride-AA				<0.00002		<0.00002		<0.00002		<0.00002
Potassium	q		AA	0.1-5.0			4		4		155		26
Sulphate	a		Turb. SM	1.0-30			40		3		6		3
Sodium	q		AA	0.1-3.0			31		24		225		67
Tot Phos	a		Stann.SM	0.05-0.25			0.03		0.1		0.1		0.1
T.O.N.	q		SM				10		1		1		1
T.O.C.	q		SM	1-100			2		4		71		28
Res/Evap	a		SM	1.0-5000			290		392		1,528		548
Zinc	a		AA	0.01-5.0			0.003		0		0.009		0.008
Alkalinity	a		SM	1-1000			165		290		2,400		380
Nickel	a		GFFA	0.002-1			0.04		0		0.07		0.05

OverBurden: OB1, OB2, OB3, OB7 (mg/l)
Location: Landfill

Quarterly 2013

OB1

DATE	pH.	Temp*C	Cond	NH4	Ammonia	Vis/Od	Cl	O2	TOC	TON
			µS/cm		(N)					
05/03/13	8.03	11.1*C	504	0.1	0.08	GOOD	28.3	7.3	1	5
17/09/13	8.03	16.6*C	527	0.02	0.02	POOR	24	2.2	1	4
02/12/13	7.95	12.8*C	422	0.05	0.04	POOR	23	4.5	8	8

OB2

DATE	pH.	Temp*C	Cond	NH4	Ammonia	Vis/Od	Cl	O2	TOC	TON
			µS/cm		(N)					
05/03/13	7.3	9.6*C	484	0.2	0.16	FAIR	34	2.9	2	7
17/09/13	7.82	12.3*C	516	0.08	0.06	POOR	35	1.5	2	3
02/12/13	7.41	11.5*C	530	0.06	0.05	POOR	35	1.5	6	6

0B3

DATE	pH	Temp*C	Cond	NH4	Ammonia	Vis/Od	Cl	O2	TOC	TON
			µS/cm		(N)					
05/03/13	7.25	11.1*C	4,900	360	280.08	POOR	478	4	95	6
17/09/13	7.78	12.9*C	3,350	270	210.06	POOR	64	1.9	50	1
02/12/13	7.37	12.5*C	3,100	210	163.38	POOR	311	3.6	59	1

OB7

DATE	pH	Temp*C	Cond	NH4	Ammonia	Vis/Od	Cl	O2	TOC	TON
			µS/cm		(N)					
05/03/13	6.62	9.8*C	1,143	66	51.35	POOR	113	2.4	30	1
17/09/13	7.29	13.2*C	680	19	14.78	POOR	56	1.5	15	9
02/12/13	6.71	11.2*C	700	0.11	0.09	POOR	64	2	20	3

OverBurden & Bedrock Depth (m) for 2013

Location: Landfill

	Jan	Feb	Mar	Apr	May	June
BOREHOLE	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)
OB1	1.24	1.33	1.26	1.27	1.46	1.39
OB2	0.61	0.63	0.91	0.8	0.91	0.54
OB3	1.06	1.11	1.26	1.23	1.37	1.27
OB7	0.45	0.44	0.44	0.47	0.54	0.7
BR1	1.15	1.14	1.21	1.19	1.48	1.41
BR2	overflow	overflow	0.36	overflow	0.4	overflow
BR3	1.13	1.09	1.27	1.25	1.46	1.26
BR7	1.35	1.33	1.61	1.47	1.66	1.51
BH1	gone	gone	gone	gone	gone	gone
BH12	gone	gone	gone	gone	gone	gone
KC8	3.94	3.89	4.37	4.05	4.43	4.48

BH1&BH12 removed due to construction works at Black Ash site.

	July	August	September	October	November	December
BOREHOLE	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)	Depth (m)
OB1	1.77	1.69	1.88	1.62	1.51	1.52
OB2	0.97	0.88	1.03	1.56	0.47	0.78
OB3	1.57	1.6	1.54	1.38	1.13	1.53
OB7	0.97	0.87	0.97	0.88	0.72	0.78
BR1	1.87	1.81	1.91	1.65	1.55	1.62
BR2	0.57	0.45	0.67	0.4	0.36	0.36
BR3	1.87	1.73	1.74	1.59	1.17	1.63
BR7	1.87	1.83	2.01	1.76	1.54	1.77
BH1	gone	gone	gone	gone	gone	gone
BH12	gone	gone	gone	gone	gone	gone
KC8	4.97	4.82	5.12	4.52	4.36	4.72

BH1&BH12 removed due to construction works at Black Ash site.

Groundwater NW Wells: NW1, NW2, NW3, NW4, NW5, NW6, NW7, NW8, NW9 (mg/l)

Location: Landfill

Frequency: Annual

	Frequecy	Method	Range	Sample	**NW1**	**NW2**	**NW3**	**NW4**	**NW5**	**NW6**	**NW7**	**NW8**	**NW9**
				Grab									
Vis/Odour	q				POOR	POOR	POOR	POOR	FAIR	POOR	POOR	POOR	POOR
Amonium	m	ISE	0.01-10		1.6	31	19	40	5	110	0.1	8	17
Ammonia (as N)					1.24	24.12	14.78	31.12	3.89	85.58	0.08	6.22	13.23
Chloride	q	Argent SM	1-100		76	35	65	92	30	178	42	52	106
D.O.	q	Meter	0.1-20		2.6	1.8	1.6	2	1.1	2.4	3.2	1.2	1.7
Cond.µs/cm	m	Meter	1-200000		840µs	838µs	518µs	1,052µs	617µs	1,834µs	420µs	296µs	870µs
pH	m	Meter	1.0-11		7.9	7.7	6.6	7.6	8	7.8	8.2	5.1	7.5
Temp	m	Meter	1.0-50		9.9.C	9.1.C	9.2.C	9.7.C	10.1.C	8.1.C	11.8.C	10.8.C	8.9.C
Boron	a	GFAA	0.01-1.0		0.06	0.09	0.02	0.09	0.04	0.4	0.06	<0.02	0.2
Cadmium	a	GFAA	0.001-0.5		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	a	Titre SM	1.0-100		128	76	40	68	80	84	42	30	128
Copper	a	AA	0.001-1.0		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cyanide	a	ISE	0.01-1.0		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	a	ISE	0.5-1.0		0.08	0.09	0.05	0.05	0.06	0.06	0.07	0.06	0.02

	Frequency	Method	Range	Sample	**NW1**	**NW2**	**NW3**	**NW4**	**NW5**	**NW6**	**NW7**	**NW8**	**NW9**
Iron	q	AA	0.01-5.0	Grab	0.52	0.04	0.05	0.96	0.15	0.71	0.37	1.3	0.008
Lead	a	GFFA	0.001-0.1		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Magnesium	a	AA	0.01-5.0		5.9	7.8	3.8	7.1	8.7	8.9	5.4	1.9	9.1
Manganese	a	AA	0.01-3.0		4.2	0.77	0.62	1.3	0.76	0.42	0.33	0.5	0.8
Mercury	a	GFFA			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Potassium	q	AA	0.1-5.0		20	11	13	30	7	72	13	7	20
Sulphate	a	Turb SM	1.0-30		<5	<5	<5	<5	<5	<5	<5	10	10
Sodium	q	AA	0.1-3.0		55	67	60	65	50	85	42	47	45
TotPhos	a	Stann SM	0.05-0.25		0.04	0.1	0.1	0.1	0.02	0.06	0.1	0.06	0.03
T.O.N.	q	SM			5	14	3	2	4	3	14	9	9
Res/Evap	a	SM	1.0-5000		610	499	332	522	374	818	324	218	526
Zinc	a	AA	0.01-5.0		0.005	<0.002	0.01	0.007	0.007	0.007	0.006	0.01	0.008
T.O.C.	q	HACH	15-150		55	19	15	24	19	28	1	7	9
Alkalinity	a	SM	1-1000		370	380	200	440	360	720	150	90	330
Ni	a	GFFA	.002-1		0.08	0.09	0.08	0.1	0.1	0.1	0.11	0.12	0.11
Cr	a	GFFA	.002-1		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

NW Wells: NW1, NW2, NW3, NW4, NW5, NW6, NW7, NW8, NW9 (mg/l)

Frequency: Monthly

NW1				Ammonia	
DATE	pH.	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	6.82	941	15	11.67	44
19/02/13	6.57	745	22	17.12	50
05/03/13	6.63	1,017	22	17.12	57
ANNUAL					
21/05/13	7.51	943	30	23.34	40
18/06/13	7.51	790	0.03	0.02	56
23/07/13	7.05	890	20	15.56	50
20/08/13	7.41	826	1.5	1.17	49
17/09/13	7.04	860	22	17.12	50
08/10/13	7.21	850	2	1.56	42
05/11/13	7.12	880	16	12.45	44
02/12/13	6.82	790	0.17	0.13	50

NW2				Ammonia	
DATE	pH.	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	7.43	920	45	35.01	21
19/02/13	7.36	1000	69	53.68	18
05/03/13	7.32	951	48	37.34	12
ANNUAL					
21/05/13	7.87	790	46	35.79	15
18/06/13	7.55	645	1.5	1.17	15
23/07/13	7.38	720	30	23.34	10
20/08/13	7.4	597	0.02	0.02	13
17/09/13	7.5	650	18	14.00	10
08/10/13	7.35	575	0.8	0.62	10
05/11/13	7.27	620	17	13.23	7
02/12/13	7.35	600	0.14	0.11	14

NW3				Ammonia	
DATE	pH.	Cond µS/cm	NH4.	(N)	TOC.
Trigger levels	5.6-9.0	1500	60		100
08/01/13	6.42	600	32	24.90	17
19/02/13	6.55	685	48	37.34	15
05/03/13	6.29	640	39	30.34	17
ANNUAL					
21/05/13	6.9	580	35	27.23	10
18/06/13	6.71	430	2	1.56	15
23/07/13	6.77	480	20	15.56	15
20/08/13	6.9	444	4	3.11	16
17/09/13	6.78	500	21	16.34	10
08/10/13	6.68	435	2	1.56	12
05/11/13	6.24	560	33	25.67	13
02/12/13	6.45	490	2.2	1.71	14

NW4				Ammonia	
DATE.	pH	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	6.95	1,251	55	42.79	26
19/02/13	6.73	1,252	64	49.79	26
05/03/13	6.66	1,190	57	44.35	34
ANNUAL					
21/05/13	7.38	970	41	31.90	10
18/06/13	7.37	720	0.05	0.04	22
23/07/13	6.79	795	20	15.56	15
20/08/13	7.19	720	5.7	4.43	20
17/09/13	6.72	670	15	11.67	20
08/10/13	7.15	700	10	7.78	15
05/11/13	6.72	1,000	41	31.90	25
02/12/13	6.9	670	0.15	0.12	24

NW5				Ammonia	
DATE	pH.	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	7.11	572	0.05	0.04	19
19/02/13	7.01	622	4	3.11	18
05/03/13	6.87	696	0.11	0.09	22
ANNUAL					
21/05/13	7.72	708	1	0.78	15
18/06/13	7.72	593	1.4	1.09	20
23/07/13	7.41	740	7	5.45	18
20/08/13	7.74	712	0.8	0.62	18
17/09/13	7.63	720	0.6	0.47	20
08/10/13	7.21	690	1	0.78	15
05/11/13	7.53	595	0.11	0.09	19
02/12/13	7.3	480	0.13	0.10	20

NW6				Ammonia	
Date	pH.	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	7.48	2,200	140	108.92	35
19/02/13	7.19	2,170	142	110.48	31
05/03/13	7.17	1,707	80	62.24	22
ANNUAL					
21/05/13	7.48	1,130	31	24.12	10
18/06/13	7.5	1,326	50	38.90	26
23/07/13	7.48	1,500	30	23.34	17
20/08/13	7.6	1,333	40	31.12	21
17/09/13	7.23	1,500	70	54.46	17
08/10/13	7.45	1,500	40	31.12	18
05/11/13	7.29	2,000	140	108.92	31
02/12/13	7.39	1,290	19	14.78	26

NW7				Ammonia	
Date	pH.	Cond µS/cm	NH4.	(N)	TOC.
Trigger levels	5.6-9.0	6000	500		200
08/01/13	7.34	294	0.08	0.06	8
19/02/13	7.3	325	7	5.45	5
05/03/13	7.06	315	0.15	0.12	2
ANNUAL					
21/05/13	7.87	308	0.07	0.05	2
18/06/13	7.46	540	0.04	0.03	9
23/07/13	7.82	305	0.01	0.01	5
20/08/13	7.76	308	0.008	0.01	3
17/09/13	7.67	312	0.6	0.47	7
08/10/13	7.55	350	0.03	0.02	4
05/11/13	7.19	1,750	92	71.58	24
02/12/13	7.12	324	0.17	0.13	4

NW8				Ammonia	
Date	pH.	Cond µS/cm	NH4.	(N)	TOC.
08/01/13	6.13	320	14	10.89	10
19/02/13	6.41	448	27	21.01	6
05/03/13	6.3	420	20	15.56	4
ANNUAL					
21/05/13	6.56	302	13	10.11	5
18/06/13	6.31	280	7	5.45	9
23/07/13	6.29	307	7	5.45	7
20/08/13	6.35	315	6	4.67	7
17/09/13	6.68	380	18	14.00	9
08/10/13	6.35	350	10	7.78	8
05/11/13	6.48	340	21	16.34	8
02/12/13	6.46	320	2	1.56	8

NW9				Ammonia	
Date	**pH**	**Cond µS/cm**	**NH4**	**(N)**	**TOC**
Trigger levels	5.6-9.0	1500	5		35
08/01/13	7.16	1,350	21	16.34	12
19/02/13	6.98	1,396	33	25.67	6
05/03/13	6.85	1,396	26	20.23	5
ANNUAL					
21/05/13	7.23	1,186	0.02	0.02	10
18/06/13	7.41	890	13	10.11	11
23/07/13	7.22	1,200	8	6.22	10
20/08/13	7.48	1,137	12	9.34	7
17/09/13	7.18	1,250	23	17.89	8
08/10/13	7.35	1,100	3	2.33	9
05/11/13	7.24	1,300	31	24.12	12
02/12/13	7.26	1,100	17	13.23	10

Well: NW1, NW2, NW3, NW4, NW5, NW6, NW7, NW8, NW9

Location: Landfill

Jan-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
08/01/2013	NW1	5.38	1.73	3.65
08/01/2013	NW2	5.4	1.14	4.26
08/01/2013	NW3	4.18	0.61	3.57
08/01/2013	NW4	4.6	0.89	3.71
08/01/2013	NW5	15	3.05	11.95
08/01/2013	NW6	3.79	0	3.79
08/01/2013	NW7	4.26	0.8	3.46
08/01/2013	NW8	4.2	0.96	3.24
08/01/2013	NW9	3.5	0	3.5

Feb-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
19/02/2013	NW1	5.38	1.69	3.69
19/02/2013	NW2	5.4	1.14	4.26
19/02/2013	NW3	4.18	0.62	3.56
19/02/2013	NW4	4.6	0.79	3.81
19/02/2013	NW5	15	3.06	11.94
19/02/2013	NW6	3.79	0	3.79
19/02/2013	NW7	4.26	0.79	3.47
19/02/2013	NW8	4.2	0.89	3.31
19/02/2013	NW9	3.5	0	3.5

Mar-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
05/03/2013	NW1	5.38	1.91	3.47
05/03/2013	NW2	5.4	1.52	3.88
05/03/2013	NW3	4.18	0.73	3.45
05/03/2013	NW4	4.6	1.19	3.41
05/03/2013	NW5	15	3.19	11.81
05/03/2013	NW6	3.79	0.55	3.24
05/03/2013	NW7	4.26	1.01	3.25
05/03/2013	NW8	4.2	1.02	3.18
05/03/2013	NW9	3.5	0	3.5

Apr-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
03/04/2013	NW1	5.38	1.84	3.54
03/04/2013	NW2	5.4	1.32	4.08
03/04/2013	NW3	4.18	0.69	3.49
03/04/2013	NW4	4.6	0.99	3.61
03/04/2013	NW5	15	3.12	11.88
03/04/2013	NW6	3.79	0	3.79
03/04/2013	NW7	4.26	0.87	3.39
03/04/2013	NW8	4.2	1.02	3.18
03/04/2013	NW9	3.5	0	3.5

May-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
21/05/2013	NW1	5.38	1.91	3.47
21/05/2013	NW2	5.4	1.62	3.78
21/05/2013	NW3	4.18	0.87	3.31
21/05/2013	NW4	4.6	1.33	3.27
21/05/2013	NW5	15	3.22	11.78
21/05/2013	NW6	3.79	0.8	2.99
21/05/2013	NW7	4.26	1.22	3.04
21/05/2013	NW8	4.2	1.05	3.15
21/05/2013	NW9	3.5	0	3.5

Jun-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
18/06/2013	NW1	5.38	1.77	3.61
18/06/2013	NW2	5.4	1.17	4.23
18/06/2013	NW3	4.18	0.81	3.37
18/06/2013	NW4	4.6	0.98	3.62
18/06/2013	NW5	15	3.16	11.84
18/06/2013	NW6	3.79	0	3.79
18/06/2013	NW7	4.26	1.11	3.15
18/06/2013	NW8	4.2	1.07	3.13
18/06/2013	NW9	3.5	0	3.5

Jul-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
23/07/2013	NW1	5.38	1.92	3.46
23/07/2013	NW2	5.4	2.12	3.28
23/07/2013	NW3	4.18	1.06	3.12
23/07/2013	NW4	4.6	1.84	2.76
23/07/2013	NW5	15	3.36	11.64
23/07/2013	NW6	3.79	1.21	2.58
23/07/2013	NW7	4.26	1.59	2.67
23/07/2013	NW8	4.2	1.17	3.03
23/07/2013	NW9	3.5	0.5	3

Aug-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
20/08/2013	NW1	5.38	1.94	3.44
20/08/2013	NW2	5.4	1.89	3.51
20/08/2013	NW3	4.18	1.02	3.16
20/08/2013	NW4	4.6	1.86	2.74
20/08/2013	NW5	15	3.38	11.62
20/08/2013	NW6	3.79	1.03	2.76
20/08/2013	NW7	4.26	1.53	2.73
20/08/2013	NW8	4.2	1.17	3.03
20/08/2013	NW9	3.5	0.39	3.11

Sep-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
17/09/2013	NW1	5.38	1.87	3.51
17/09/2013	NW2	5.4	2.07	3.33
17/09/2013	NW3	4.18	1.12	3.06
17/09/2013	NW4	4.6	1.74	2.86
17/09/2013	NW5	15	3.41	11.59
17/09/2013	NW6	3.79	1.06	2.73
17/09/2013	NW7	4.26	1.56	2.7
17/09/2013	NW8	4.2	1.26	2.94
17/09/2013	NW9	3.5	0.49	3.01

Oct-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
08/10/2013	NW1	5.38	1.78	3.6
08/10/2013	NW2	5.4	1.99	3.41
08/10/2013	NW3	4.18	1.14	3.04
08/10/2013	NW4	4.6	1.68	2.92
08/10/2013	NW5	15	3.41	11.59
08/10/2013	NW6	3.79	1.1	2.69
08/10/2013	NW7	4.26	1.51	2.75
08/10/2013	NW8	4.2	1.2	3
08/10/2013	NW9	3.5	0.38	3.12

Nov-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
05/11/2013	NW1	5.38	1.74	3.64
05/11/2013	NW2	5.4	1.14	4.26
05/11/2013	NW3	4.18	0.79	3.39
05/11/2013	NW4	4.6	0.92	3.68
05/11/2013	NW5	15	2.97	12.03
05/11/2013	NW6	3.79	0	3.79
05/11/2013	NW7	4.26	0.81	3.45
05/11/2013	NW8	4.2	1.09	3.11
05/11/2013	NW9	3.5	0	3.5

Dec-13

Date	LOCATION	WELL HEIGH	DEPTH (M)	GROUND WATER HEIGHT (mAOD)
02/12/2013	NW1	5.38	1.91	3.47
02/12/2013	NW2	5.4	1.89	3.51
02/12/2013	NW3	4.18	0.95	3.23
02/12/2013	NW4	4.6	1.73	2.87
02/12/2013	NW5	15	3.26	11.74
02/12/2013	NW6	3.79	1.21	2.58
02/12/2013	NW7	4.26	1.37	2.89
02/12/2013	NW8	4.2	1.17	3.03
02/12/2013	NW9	3.5	0.36	3.14

Groundwater Wells: Greenhills North Deep, Greenhills South Shallow, Greenhills South Deep, Greenhills South Shallow, Nemo Shallow & Nemo Deep
Location: Greenhills Estate & Nemo Rangers GAA Pitch
Date: March- December 2013

Greenhills North Deep 2013

					Ammonia							Well	Water	Groundwater
Date	Temp	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	12.1	7.51	2,030	0.44	0.34	489	7.13	41	5	4	41	35	0.78	34.22
17/04/2013	15	7.5	1,684	0.27	0.21	28	7.15	72	10	6	8	35	0.89	34.11
21/05/2013	14.5	7.41	3,970	0.9	0.70	1,223	5.54	13	6	9	18	35	1.39	33.61
18/06/2013	16.4	7.66	2,590	1.4	1.09	795	4.23	3	1	7	30	35	1.39	33.61
23/07/2013	16.7	7.57	3,400	7.2	5.60	898	2.64	5	8	4	14	35	1.74	33.26
20/08/2013	17.5	7.96	2,400	17.3	13.46	574	3.02	126	3	21	96	35	1.74	33.26
10/09/2013	15	7.57	2,660	1.21	0.94	815	3.15	21	1	6	34.4	35	1.73	33.27
01/10/2013	15.4	7.49	1,844	1.38	1.07	503	2.77	33	12	10	5.6	35	1.89	33.11
11/11/2013	14.5	7.43	704	0.5	0.39	69.4	6.42	2	8	10	5.2	35	1.33	33.67
02/12/2013	13.6	7.53	2,940	4.3	3.35	971	5.7	14	5	7	49	35	1.61	33.39

Greenhills North Shallow 2013

					Ammonia							Well	Water	Groundwater
Date	Temp*C	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	10.3	7.41	931	1.3	1.01	21	5.21	102	1	10	50	2.61	1.26	1.35
17/04/2013	15	7.78	466	0.24	0.19	12	9.26	58	2	9	97	2.61	0.81	1.8
21/05/2013	13.8	7.18	1,460	4	3.11	17	4.44	26	2	13	18	2.61	1.51	1.1
18/06/2013	16.4	7.27	1,196	0.66	0.51	19.8	3.27	23	2	13	22.8	2.61	1.32	1.29
23/07/2013	17.1	7.19	2,620	7.1	5.52	507	4.18	33	5	14	23.2	2.61	1.68	0.93
20/08/2013	17.4	7.34	1,893	1.88	1.46	44	3.91	39	7	17	16.8	2.61	1.71	0.9
10/09/2013	15.9	7.33	1,860	16.5	12.84	45	3.55	66	4	23	9.2	2.61	1.69	0.92
01/10/2013	16.2	7.51	1,746	14.2	11.05	65	1.93	132	6	63	20	2.61	1.87	0.74
11/11/2013	14.7	7.18	1,208	2.2	1.71	19.8	2.17	3	2	11	8.8	2.61	1.37	1.24
02/12/2013	12.7	7.21	1,758	1.3	1.01	34	4	28	6	13	72	2.61	1.59	1.02

Greenhills South Deep 2013

					Ammonia							Well	Water	Groundwater
Date	Temp*C	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	12.6	7.47	994	0.19	0.15	239	7.35	132	1	5	56	34.7	1.21	33.49
17/04/2013	15.4	7.79	602	0.31	0.24	58	7.36	39	4	7	70	34.7	1.31	36.39
21/05/2013	14.8	7.46	1,879	1	0.78	616	4.42	7	3	3	20.4	34.7	1.58	33.12
18/06/2013	15.6	7.54	1,558	0.34	0.26	418	4.01	7	5	3	8	34.7	1.54	33.16
23/07/2013	16.8	7.57	1,666	1.3	1.01	432	2.1	15	4	3	22	34.7	1.81	32.89
20/08/2013	15.2	7.72	1,466	0.1	0.08	364	3.35	12	4	3	8	34.7	1.76	32.94
10/09/2013	14.3	7.52	1,561	0.78	0.61	383	2.3	<1	4	3	9.2	34.7	1.74	32.96
01/10/2013	14.9	7.19	1,625	17.7	13.77	383	0.23	113	16	30	40	34.7	1.92	32.78
11/11/2013	14.5	7.49	495	1.1	0.86	39.7	6.74	10	10	14	24.8	34.7	1.46	33.24
02/12/2013	13.4	7.5	1,150	2.8	2.18	244	4.28	23	4	7	36.8	34.7	1.66	33.04

Greenhills South Shallow 2013

					Ammonia							Well	Water	Groundwater
Date	Temp*C	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	12.3	7.25	477	1.2	0.93	37	6.09	71	2	3	27.6	11.94	1.17	10.77
17/04/2013	15.2	7.36	475	1.02	0.79	36	4.74	1	1	2	24	11.94	1.21	10.73
21/05/2013	14.5	7.31	477	1	0.78	52	3.03	10	2	3	11.2	11.94	1.53	10.41
18/06/2013	15.6	7.54	484	0.9	0.70	47	2.17	1	7	3	41	11.94	1.47	10.47
23/07/2013	16.3	7.51	486	1.6	1.24	22.6	2.67	6	5	3	11.2	11.94	1.73	10.21
20/08/2013	15.5	7.43	485	0.77	0.60	37	3.91	7	6	3	1.6	11.94	1.81	10.13
10/09/2013	14.3	7.38	485	0.41	0.32	44	2.58	<1	4	2	1.2	11.94	1.79	10.15
01/10/2013	17	7.41	622	5.66	4.40	81	2.8	55	8	16	42.8	11.94	1.84	10.1
11/11/2013	14.2	7.42	481	1.3	1.01	34	3.15	<1	<1	4	1.2	11.94	1.44	10.5
02/12/2013	13.1	7.51	487	1.4	1.09	48	2.71	1	2	4	21.6	11.94	1.66	10.28

Nemo Shallow (NR1) 2013

					Ammonia							Well	Water	Groundwater
Date	Temp*C	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	12.3	7.12	1,156	22	17.12	211	5.46	26	1	6	38	5.9	0.98	4.92
17/04/2013	14.8	7.09	1,154	22.2	17.27	207	3.99	1	3	6	120	5.9	1.04	4.86
21/05/2013	14.9	7.31	902	20	15.56	130	2.6	8	3	4	10	5.9	1.26	4.64
18/06/2013	15.9	7.44	858	15	11.67	124	2.69	1	8	4	29	5.9	1.08	4.82
23/07/2013	16.1	7.34	787	16	12.45	81	2.69	11	3	4	8	5.9	1.3	4.6
20/08/2013	14.9	7.37	927	5.46	4.25	115	3.52	8	5	4	2	5.9	1.25	4.65
10/09/2013	13.7	7.29	925	12.2	9.49	105	2.93	10	1	5	626	5.9	1.25	4.65
01/10/2013	14.1	7.38	968	15.5	12.06	143	2.89	54	5	6	13.2	5.9	1.21	4.69
11/11/2013	13.7	7.12	896	17	13.23	123	2.32	<1	5	7	5.2	5.9	0.94	4.96
02/12/2013	12.9	7.43	903	16	12.45	108	4.13	14	6	3	2094	5.9	1.2	4.7

Nemo Deep (NR2) 2013

					Ammonia							Well	Water	Groundwater
Date	Temp*C	pH	Conductivity µS/cm	NH4	(N)	chloride	Oxygen	COD	TON	TOC	S. Solids	Height (m)	DEPTH (M)	Height (mAOD)
26/03/2013	12.4	7.51	432	6.1	4.75	41	4.52	88	2	5	107	16.8	0.65	16.15
17/04/2013	15.3	7.43	394	4.5	3.50	34	4.6	91	4	6	10.8	16.8	0.78	16.02
21/05/2013	14.8	7.36	498	5	3.89	41	3.44	1	2	3	10	16.8	1.1	15.7
18/06/2013	16.1	7.32	447	3.3	2.57	22	4.22	1	7	2	9.6	16.8	0.78	16.02
23/07/2013	16.1	7.48	491	4.7	3.66	27	5.67	1	4	2	5.2	16.8	1.19	15.61
20/08/2013	15.5	7.39	502	1.31	1.02	22.6	3.36	21	3	2	7.6	16.8	1.17	15.63
10/09/2013	14.6	7.42	511	2.14	1.66	21	4.08	5	14	2	2	16.8	1.19	15.61
01/10/2013	14.4	7.42	503	3.3	2.57	28	3.08	14	4	2	6.8	16.8	1.14	15.66
11/11/2013	14.4	7.29	302	1.9	1.48	12.7	8.76	11	6	7	24.4	16.8	0.77	16.03
02/12/2013	13.4	7.34	462	4	3.11	27	5.52	6	5	2	90	16.8	1.08	15.72

BedRock Wells: BR1, BR2, BR3, BR7, KC8
Location: Landfill
Frequency: Annual Results

ANNUAL BEDROCK WELLS-2013 (mg/l)

	Frequecy	Method	Range	Sample Grab	BR1	BR2	BR3	BR7	KC7/8
Vis/Odour	q				GOOD	FAIR	POOR	POOR	POOR
Ammonium	m	ISE	0.01-10		0.02	0.04	370	0.07	0.07
Ammonia (as N)					0.02	0.03	287.86	0.05	0.05
Chloride	q	Argent SM	1-100		27	38	553	35	31
D.O.	q	Meter	0.1-20		69	3.7	2.1	1.4	1.1
Cond.µs/cm	m	Meter	1-200000		560µs	418µs	4,980µs	436µs	626µs
pH	m	Meter	1.0-11		8	8.3	8.5	8.3	8.2
Temp	m	Meter	1.0-50		11.2.C	11.5.C	10.7.C	11.4.C	12.2.C
Boron	a	GFAA	0.01-1.0		0.06	0.03	1.4	0.02	0.06
Cadmium	a	GFAA	0.001-0.5		<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	a	Titre SM	1.0-100		90	60	200	64	112
Copper	a	AA	0.001-1.0		0.01	0.01	0.02	0.01	0.03
Cyanide	a	ISE	0.005-1.0		<0.003	<0.005	<0.005	<0.005	<0.005
Iron	q	AA	0.01-5.0	Grab	0.008	0.01	0.24	0.01	0.04
Lead	a	GFFA	0.001-0.1		<0.002	<0.002	<0.002	<0.002	<0.002
Magnesium	a	AA	0.01-5.0		2.6	4.2	45	6	4
Manganese	a	AA	0.01-3.0		0.004	0.17	0.25	0.13	0.02
Mercury	a	Hydride-AA			<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Potassium	q	AA	0.1-5.0		4	3	170	1	4
Sulphate	a	Turb SM	1.0-30		37	25	7	33	54
Sodium	q	AA	0.1-3.0		28	29	342	35	20
Tot Phos	a	Stann SM	0.05-0.25		0.01	0.1	0.2	0.05	0.1
T.O.N.	q	SM			9	7	3	6	1
T.O.C.	a	SM	1.0-5000		248	270	1,656	246	358
Res/Evap	a	AA	0.01-5.0		<0.002	0.003	0.009	0.003	0.003
Zinc	q	HACH	15-150		2	2	65	4	3
Alkalinity	a	SM	1-1000		140	120	2,100	170	260
Nickel	a	GFFA	0.002-1		0.02	0.05	0.06	0.03	0.04
Chromium	a	GFFA	0.002-1		<0.002	<0.002	<0.002	<0.002	<0.002

Monitoring Period: 2013
Quarterly Results

BEDROCK WELLS 2013(mg/l)

BR1

	pH	Temp*C	Cond.µS/cm	NH4	Ammonia (N)	Vis/Od	Cl	O2	TOC	TON
DATE										
05/03/13	7.77	11.1*C	540	0.17	0.13	GOOD	21.3	6.3	1	8
17/09/13	8.14	17.5*C	328	0.03	0.02	GOOD	14	3.6	2	1
02/12/13	8.05	13.1*C	438	0.04	0.03	GOOD	28	4.3	2	17

BR2

	pH	Temp*C	Cond.µS/cm	NH4	Ammonia (N)	Vis/Od	Cl	O2	TOC	TON
DATE										
05/03/13	7.31	11.2*C	397	0.15	0.12	GOOD	28.3	4.1	1	5
17/09/13	7.98	11.5*C	385	0.05	0.04	GOOD	31	2.5	1	9
02/12/13	7.35	11.5*C	390	0.06	0.05	GOOD	23	4.1	2	7

BR3

	pH	Temp*C	Cond.µS/cm	NH4	Ammonia (N)	Vis/Od	Cl	O2	TOC	TON
DATE										
05/03/13	7.23	11*C	5,440	400	311.20	POOR	443	1.9	95	6
17/09/13	7.89	13.7*C	5,450	470	365.66	POOR	106	1.2	90	3
02/12/13	7.52	12.9*C	4,550	380	295.64	POOR	490	3.2	88	3

BR7

	pH	Temp*C	Cond.µS/cm	NH4	Ammonia (N)	Vis/Od	Cl	O2	TOC	TON
DATE										
05/03/13	7.98	11.1*C	411	0.35	0.27	POOR	31.2	2.1	1	4
17/09/13	7.99	12*C	424	0.04	0.03	POOR	22	2	2	1
02/12/13	7.82	11.9*C	342	0.35	0.27	POOR	21	2.5	2	7

KC7/8

	pH	Temp*C	Cond.µS/cm	NH4	Ammonia (N)	Vis/Od	Cl	O2	TOC	TON
DATE										
05/03/13	7.74	11.8*C	855	35	27.23	POOR	28.3	1.3	22	23
17/09/13	8.18	13.1*C	565	0.05	0.04	GOOD	17	1.8	15	2
02/12/13	7.91	12.1*C	490	0.11	0.09	POOR	28	1	3	1

Receiving Water Monitoring- Surface Water Monitoring Locations

Locations: EM0, EM1, EM2, EM6,EM7, EM8 EM11

ANNUAL SURFACE -2013 (mg/l)

	Frequency	Method		Range	Sample	EM0	EM1	EM2	EM11	EM6/10	EM7	EM8
Vis/Odour	W				Grab	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
Ammonium	q	ISE		0.01-10		0.03	0.01	0.01	0.01	0.01	0.02	0.03
Ammonia (N)						0.02	0.01	0.01	0.01	0.01	0.02	0.02
B.O.D.	q	Meter Brit		0.1-8.0		1.6	1.9	1.7	3.3	3.6	9.8	11.4
C.O.D.	q	Closed Tube		1-500		24	36	91	26	37	25	58
Chloride	q	Argent SM		1-100		21	28	31	28	42	28	35
D.O.	q	Meter		0.1-20		11	9.7	10.5	9.2	10.2	8.7	4.1
Cond.µs/cm	q	Meter		1-200000		380µs	364µs	366µs	370µs	452µs	478µs	490µs
pH	q	Meter		05-Nov		8.4	8.3	8.4	8.4	8.5	8.1	8.2
Sus.Sol.	q	Grav		0.1-200		17	19	31	5	8	17	15
Temp.	q	Meter		0-50		8.5.C	10.C	9.6.C	9.1.C	9.3.C	10.1.C	9.8.C
Cadmium	a	GFAA		0.001-0.5		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	a	AA		1-100		60	60	56	56	100	112	120
Chromium	a	GFAA		0.001-0.2		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Copper	a	AA		0.001-1.0		0.02	0.02	0.02	0.02	0.02	0.02	0.02

ANNUAL SURFACE -2013 CONT (mg/l)

	Frequency		Method	Range	Sample	EM0	EM1	EM2	EM11	EM6/10	EM7	EM8
					Grab							
Iron	a		AA	0.01-5.0		0.02	0.04	0.04	0.05	0.03	0.05	0.04
Lead	a		GFAA	0.001-0.1		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Magnesium	a		AA	0.01-5.0		1.9	1.8	1.6	1.6	1.6	1.4	1.1
Manganese	a		AA	0.01-3.0		0.12	0.13	0.12	0.12	0.12	0.12	0.13
Mercury	a		GFAA			<0.00002	<0.00002	<0.00002	<0.00002	<0.0002	<0.0002	<0.0002
Potassium	a		AA	0.1-5.0		13	11	11	12	13	16	16
Sulphate	a		Turb. SM	1.0-3.0		25	27	23	24	31	40	37
Sodium	a		AA	0.1-3.0		12	13	13	14	27	27	30
Tot Phos	a		Stann SM	0.05-0.25		0.05	0.09	0.05	0.04	0.01	0.02	0.03
T.O.N.	a		SM			9	9	10	12	13	13	18
Zinc	a		AA	0.01-5.0		0.007	0.006	0.008	0.006	0.006	0.007	0.007
Ni	a		GFFA	0.002-1		0.01	0.02	0.02	0.02	0.01	0.01	0.02
Alk	a		SM	1-1000		140	130	140	140	160	190	180
Boron	a		GFFA	0.01-1.0		0.03	0.03	0.03	0.03	0.04	0.09	0.08
T.O.C								2	4			

Surface Water Monitoring
Location: Tramore River and Trabeg Stream

TRABEG STREAM 2013 (mg/l)

EM7

DATE	pH	TEMP*C	DO	Cond.	NH4	Ammonia (as N)	BOD	COD	Sus.Sol	Chloride
				µS/cm						
05/03/13	7.87	8.3*C	7.7	630	0.003	0.002	8	35	4	35.3
17/09/13	8.05	13.2*C	1.5	490	0.03	0.023	2	7	6	31
02/12/13	7.47	9.8*C	6.5	525	0.02	0.016	4.2	15	3	32

EM8

DATE	pH	TEMP*C	DO	Cond.	NH4	Ammonia (as N)	BOD	COD	Sus Sol	Chloride
				µS/cm						
05/03/13	7.83	9.3*C	6.8	604	0.005	0.004	10	22	7	28.3
17/09/13	8.17	12.8*C	2.7	584	0.03	0.023	7	12	24	28
02/12/13	7.82	10.4*C	2.5	442	0.01	0.008	7.3	10	3	42

Tramore River (mg/l)

EM0

DATE	pH	TEMP*C	D.O.	Cond.	NH4	Ammonia (as N)	BOD	COD	Sus.Sol	Chloride
				µS/cm						
05/03/13	7.95	8.3*C	10.4	400	0.003	0.002	1.2	17	5	21.2
17/09/13	8.1	15.3*C	7.2	327	0.01	0.008	1.7	5	2	21
02/12/13	8.07	9.9*C	10.2.C	397	0.02	0.016	1.3	5	2	24

EM1

DATE	pH	TEMP*C	D.O.	Cond.	NH4	Ammonia (as N)	BOD	COD	Sus.Sol.	Chloride
				µS/cm						
05/03/13	8	8.1*C	10.2	374	0.002	0.002	0.6	13	2	28.3
17/09/13	8.07	16.0*C	5	296	0.01	0.008	4	14	3	28
02/12/13	7.58	9.9*C	9	373	0.03	0.023	1.3	6	2	28

EM2

DATE	pH	TEMP*C	D.O.	Cond	NH4	Ammonia (as N)	BOD	COD	Sus.Sol	Chloride	TOC
				µS/cm							
05/03/13	7.67	7.1*C	8.2	380	0.002	0.002	1.8	12	2	28.3	2
17/09/13	8.08	15.2*C	4.7	310	0.02	0.016	2.9	12	6	28	2
02/12/13	7.43	8.7*C	7.4	380	0.03	0.023	4.8	15	3	25	2

EM11

DATE	pH	TEMP*C	D.O.	COND	NH4	Ammonia (as N)	BOD	COD	Sus.Sol	Chloride	TOC
				µS/cm							
05/03/13	8.05	8.1*C	9.2	385	0.003	0.002	2.2	22	2	28.3	1
17/09/13	8.21	13.2*C	4	350	0.02	0.016	4.7	7	8	18	1
02/12/13	7.7	9.5*C	7.7	392	0.02	0.016	4.1	7	3	28	4

EM6/10

DATE	pH	TEMP*C	D.O.	COND	NH4	Ammonia (as N)	BOD	COD	Sus.Sol	Chloride
				µS/cm						
05/03/13	8.04	7.7*C	8.8	436	0.002	0.002	1.9	27	3	28.1
17/09/13	8.31	15.9*C	7	474	0.01	0.008	2.9	5	13	42
02/12/13	7.85	9.6*C	7.6	463	0.02	0.016	2.9	8	2	24

Emission Point: SD1
Location: Sewer Outlet
Frequency: Monthly

EMISSIONS TO SEWER 2013(mg/l)

		pH	NH_4	NH_4	Ammonia (as N)	Ammonia (as N)	BOD	BOD	Sulphate	Sulphate	Sus.Sols.	Sus.Sols.
			mg/l	Kg/d	mg/l	Kg/d	mg/l	Kg/d	mg/l	Kg/d	mg/l	Kg/d
Emission Limit Value		<6 to >9			410	248	100	60	150	90	70	42
DATE	m^3/day	pH	NH_4	NH_4	Ammonia (as N)	Ammonia (as N)	BOD	BOD	Sulphate	Sulphate	Sus.Sols.	Sus.Sols.
08/01/13	89	7.5	240	21.4	186.7	16.6	30	2.7	<5	<0.45	45	4.01
19/02/13	184	7.8	168	30.9	130.7	24.0	30	5.5	<5	<0.92	27	4.97
05/03/13	204	7.7	260	53.0	202.3	41.3	50	10.2	<5	<1.02	45	9.18
03/04/13	332	7.9	90	29.9	70.0	23.2	34	11.3	<5	<1.66	34	11.29
21/05/13	360	7.8	170	61.2	132.3	47.6	26	9.4	<5	<1.80	45	16.20
18/06/13	24	7.6	2	0.05	1.6	0.04	20	0.5	<5	<0.12	18	0.43
23/07/14	356	7.8	100	35.6	77.8	27.7	26	9.3	<5	<1.78	20	7.12
20/08/13	291	7.9	80	23.3	62.2	18.1	20	5.8	<5	<1.46	40	11.64
17/09/13	350	7.7	220	77.0	171.2	59.9	60	21.0	<5	<1.75	13	4.55
08/10/13	310	7.5	180	55.8	140.0	43.4	54	16.7	<5	<1.55	4	1.24
05/11/13	399	8.2	80	31.9	62.2	24.8	125	49.9	<5	<2.00	100	39.90
02/12/13	386	7.8	55	21.2	42.8	16.5	47	18.1	<5	<1.93	9	3.47

Emission Point: **SD1**
Location: **Sewer Outlet**
Parameter: **Dissolved Methane**
Emmision Limit Value (discharge to sewer): 0.2mg/l

Date	Inlet (Balance Tank)(mg/l)	FHS Tank (mg/l)	SEWER (mg/l)
17/01/2013	1.03	0.02	<0.01
31/01/2013	0.63	0.02	0.06
20/03/2013	1.37	0.01	<0.01
09/04/2013	0.82	0.02	<0.01
02/05/2013	1.59	0.08	0.01
14/05/2013	1.5	0.06	0.01
30/05/2013	2.02	0.11	0.01
13/06/2013	0.98	0.04	0.01
27/06/2013	1.57	0.04	0.01
16/07/2013	1.66	0.02	0.01
30/07/2013	0.95	0.01	0.01
13/08/2013	2.36	0.02	0.01
12/09/2013	1.25	0.01	0.01
26/09/2013	0.11	0.01	0.01
03/10/2013	2.27	0.03	0.01
08/10/2013	2.73	0.04	0.02
01/11/2013	0.84	<0.01	<0.01
08/11/2013	0.96	0.04	0.01
14/11/2013	1.08	0.06	0.01
21/11/2013	1.36	0.04	0.01
26/11/2013	1.68	0.04	0.01
06/12/2013	3.01	0.05	0.01
10/12/2013	1.05	0.05	0.01
20/12/2013	0.55	<0.01	<0.01

Emission Point Reference: SRP1

Location: Stormpond Inlet

Date	pH	NH4 mg/l	NH4 (as N) mg/l	Conductivity @25*C µs/cm	Chloride mg/l	BOD mg/l	COD mg/l	Temp *C	Suspended solids mg/l	TOC mg/l	**Notes**
Trigger Levels	<6 - >9			>1750						>75	
03/01/2013	7.75	0.5	0.39	699	8.5	1.37	13	11.2	2	21	
16/01/2013	7.82	0.38	0.30	732	11	0.9	25	7.8	3	11.1	
24/01/2013	7.72	0.31	0.24	674	16	1.1	13	7.8	0.8	6.9	
30/01/2013	7.46	0.16	0.12	628	17	0.14	12	9	10.4	11.4	
06/02/2013	7.81	0.17	0.13	662	16	0.21	13	7.8	4	11.9	
21/03/2013											DRY
27/03/2013											DRY
10/04/2013	7.57	0.2	0.16	300	14	1.38	22	8.9	1	3.7	
17/04/2013	7.58	0.31	0.24	505	12.7	1.17	20	11.7	6	9.9	
25/04/2013											DRY
01/05/2013											DRY
09/05/2013	8.25	1.1	0.86	657	12.7	2.41	8	16.7	3	2	
22/05/2013											DRY
29/05/2013											DRY
06/06/2013											DRY
14/06/2013											DRY
18/06/2013	7.85	0.063	0.05	699	11.3	0.63	2	19.4	2.4	7.2	
27/06/2013											DRY
03/07/2013											DRY
11/07/2013											DRY
16/07/2013											DRY
24/07/2013											DRY
15/07/2013											DRY
21/08/2013											DRY
04/09/2013											DRY
11/09/2013											DRY
19/09/2013											DRY
27/09/2013											DRY
03/10/2013											DRY
10/10/2013											DRY
01/11/2013											DRY
05/11/2013	7.92	0.47	0.37	794	15.6	0.89	16	12.3	3	13.3	
12/11/2013	7.82	0.035	0.03	755	14	0.49	9	10.7	2	12.6	
20/11/2013											DRY
27/11/2013											DRY

Date	pH	NH_4 mg/l	NH_4 (as N) mg/l	Conductivity @25*C µs/cm	Chloride mg/l	BOD mg/l	COD mg/l	Temp *C	Suspended solids mg/l	TOC mg/l	Notes
Trigger Levels	<6 - >9			>1750						>75	
05/12/2013											DRY
10/12/2013											DRY
17/12/2013	7.62	0.057	0.04	765	14.18	3.23	18	7.7	0.8	9.9	

Emission Point Reference: SRP5

Location: Reedbed Outlet

Date	pH	NH4 (N) mg/	NH_4 (as N) mg/l	Conductivity @25*C µs/cm	Chloride mg/l	BOD mg/l	COD mg/l	Temp *C	Suspended solids mg/l	TOC mg/l	Notes
Emission Limit Value									35		
03/01/2013	7.85	0.3	0.23	530	8.5	2.42	1	10.1	1	9	
16/01/2013	8.11	0.29	0.23	568	10	1.85	3	7.4	3	5.5	
24/01/2013	7.65	0.4	0.31	472	14	1.57	14	7	1	7.1	
30/01/2013	7.46	0.15	0.12	407	11	1.49	15	8.2	1.2	9.1	
06/02/2013	7.69	0.15	0.12	445	11	1.52	16	7.6	1	9.2	
21/03/2013	8.43	0.11	0.09	382	7.09	2.25	16	9	1	0.5	
27/03/2013	7.75	0.13	0.10	361	13	1.54	8	6.4	1	1	
10/04/2013	7.92	0.4	0.31	632	14	1.53	13	10.8	7	3.6	
17/04/2013	7.37	0.31	0.24	320	12.7	1.04	1	11.3	3.2	7.5	
25/04/2013											DRY
01/05/2013											DRY
09/05/2013	8.42	0.8	0.62	340	12.7	2.09	23	12.9	2.5	3	
22/05/2013											DRY
29/05/2013											DRY
06/06/2013											DRY
14/06/2013											DRY
18/06/2013	7.5	0.078	0.06	311	8.5	1.76	14	16.7	2	10.1	
27/06/2013											DRY
03/07/2013											DRY
11/07/2013											DRY
16/07/2013											DRY
24/07/2013											DRY
15/07/2013											DRY
21/08/2013											DRY
04/09/2013											DRY
11/09/2013											DRY
19/09/2013											DRY
27/09/2013											DRY

Date	pH	NH4 (N) mg/	NH_4 (as N) mg/l	Conductivity @25*C µs/cm	Chloride mg/l	BOD mg/l	COD mg/l	Temp *C	Suspended solids mg/l	TOC mg/l	Notes
Emission Limit Value									35		
03/10/2013											DRY
10/10/2013											DRY
01/11/2013	7.71	0.18	0.14	491	15.6	2.73	73	12	2	9.5	
05/11/2013	7.73	0.1	0.08	478	21.2	1.76	25	10.5	3	12.7	
12/11/2013	8.08	0.019	0.01	476	20	1.19	1	9.5	5	16.1	
20/11/2013	7.67	0.107	0.08	467	19.8	2.1	36	9.8	0.667	17.4	
27/11/2013	7.85	0.23	0.18	424	12.7	3.64	19	7.6	2	10	
05/12/2013	7.98	0.17	0.13	425	12.7	2	36	7.5	2	6	
10/12/2013	7.86	0.23	0.18	421	11.34	4.05	31	10.2	2.8	9.8	
17/12/2013	7.34	0.085	0.07	455	18.43	1.11	23	7.2	0.8	12.8	

Emision Point Reference No: SRP4
Location: Overflow from Stormpond
Date: 2013

No overflow from the stormwater retention pond recorded from January to December 2013

6 ENVIRONMENTAL MONITORING AND CONTROL

The following areas were monitored during the reporting period:

6 Summary Report on Emissions

6.1 Dust

6.2 PM_{10}

6.3 Landfill Gas Monitoring

6.4 Groundwater

- Overburden Wells
- Deep Wells (NW)
- Greenhills & Nemo Rangers Wells
- Bedrock Wells (BR)

6.5 Surface Water Monitoring

6.6 Emissions to Sewer

- Selected Parameters
- Dissolved Methane

6.7 Discharge from Storm Water Pond and Reed Beds

Reports

- Biological Survey of Streams Report
- Air Emissions testing of the Landfill Gas Flare Unit
- PRTR Table for Flare Unit & Gas Utilisation Engine
- Landfill Gas Surface Emissions Survey
- Odour Surveys
  - Q1
  - Q3
  - Q4
- Compost Reports
  - CTO Report
  - Independent Report # 1
  - Independent Report # 2
- Meteorological Data

AN ASSESSMENT OF THE WATER QUALITY STATUS OF SELECTED SITES ON THE TRAMORE AND TRABEG RIVERS USING BIOLOGICAL METHODS

(August - 2013)

Commissioned by: Cork City Council
Carried out by: Aquatic Services Unit – UCC.
(September 2013)

Introduction

As part of the their waste licence conditions for the Kinsale Road Landfill, Cork City Council commissioned the Aquatic Services Unit, to undertake a biological assessment of the water quality status of selected sites on the Tramore and Trabeg rivers. Both rivers flow adjacent to or through the site of the landfill and have in the past, at least, been impacted by leachate from the landfill. The fieldwork for the 2013 monitoring was undertaken in late August.

Methods

Two samples (combined as one composite) were taken at each site using a kick-sample technique, where this was possible. Each sample was collected in areas of moderate to shallow swift current in coarse substrate usually comprising small to large stones and cobbles. The samples were then sieved to remove silt and poured into a white sorting tray. There the macroinvertebrates present are identified and their notional abundance estimated. The macroinvertebrate data arising is then assessed using the same biotic index system used by the Environmental Protection Agency (EPA) in their ongoing monitoring of biological quality in Irish rivers. The index assigns a score to the macroinvertebrate collection at a given site depending on the relative proportion of pollution sensitive and pollution tolerant organisms present. The greater the number and diversity of pollution sensitive types present (particularly, certain mayflies, stoneflies and cased caddis flies) the higher the score or quality class assigned to a given site. The highest score category is Q5 which indicates pristine water quality conditions and is recognised by having a high proportion of pollution sensitive species and very few or any pollution tolerant forms, whereas Q1 at the other end of the scale indicates gross pollution. The table below indicates the Q-value scores, which can be assigned and the corresponding degree of pollution associated with them.

Q-Value	**Degree of Pollution**
Q5, Q4-5, Q4	Unpolluted
Q3-4	Slightly Polluted
Q3, Q2-3	Moderately Polluted
Q2, Q 1-2, Q1	Serious to Gross Pollution

It's important to point out that few sites on the Tramore and Trabeg rivers have sites, which could be said to be ideal for this system of biological monitoring, and some are completely un-suitable (e.g. Sites A and B). In the latter cases the flow is very sluggish and the bottom material consists mainly of mud or peaty mud. In these cases, general observations and experience are used in order to gauge the likely biological water quality status. Furthermore, the second most upstream site on the Tramore River at the 'ford' within the landfill was partially modified since the survey in 2009 by the installation of a crump weir for discharge gauging. This weir has resulted in the water upstream becoming stiller and more sluggish than usual and this appears to be increasing the rate of siltation and plant encroachment at Site C upstream of the landfill, which in 2013 was even more pronounced.

Results

Samples were taken on August 28th 2013 at sites the positions for which were agreed with the EPA and listed in the conditions of the licence.

Site A *(Trabeg River: Upstream Site*)

This is a very sluggish flow site with a muddy bottom covered with 30% filamentous green algae. In-channel there was almost total occlusion of the open water area by macrophytes, with *Phalaris* (Reed Canary-grass) mixed with scattered plants of Water plantain (*Alisma*) dominating the right side of the channel and a mixture of *Apium nodiflorum* (Fool's Watercress) and Rorippa nasturtium-aquaticum (Watercress) dominating the left hand side Immediately upstream the open water was dominated by rafting filamentous green algae with a little *Callitriche* (Starwort) covering about 40% of the water surface was covered by *Callitriche* (Starwort). The flow was almost imperceptible with a very slight cloudiness (Plate 1). These conditions are similar to last year's but with greater open water macrophyte cover in general. Net-sweeps through the aquatic vegetation and surface sediment were dominated the snail (*Lymnaea peregra*) and *Asellus*, a few juvenile *Gammarus*, pea mussels (Sphaeridae), water beetles (haliplids), and a single baetid mayfly nymph. Mud samples contained *Chironomus* and other chironomid midge larvae, *Asellus*, and pea mussels (Sphaeridae). Stickleback and flat worms (*Polycelis*) were also recorded. Overall, while the flow conditions and substrate were not suitable for assigning a Q-value, the conditions would point to a Q-rating of around Q2-3, i.e. similar to last year.

The left bank behind was dominated by Willow, Bramble, Woody Nightshade and Fuchsia, with Nettle and Hedge Bindweed. The right bank was dominated by a mixture of Willow, Angelica, Hedge bindweed, nettle, creeping thistle and Greater Willowherb.

Site B *(Trabeg River: 2nd Site Downstream)*

This site is like Site 1 in being a very slack flow site dominated by a muddy bottom and also with a very slight cloudiness in the water on the day. There was no out-gassing from the muddy sediment noted at the time. The latter with just a patchy covering of filamentous green algae. The channel was being encroached on by a moderate to heavy growth of *Phalaris* and the waters immediately upstream were almost entirely covered by floating Duckweed (*Lemna*) (Plate 2 and 3). A net sweep through the water column and submerged, emergent and floating vegetation was dominated by *Asellus* with smaller numbers of other taxa including Haliplid beetles, *Chironomus*, flatworms (*Dugesia/Polycelis*) and *Lumbriculus variegatus*. A sample of surface mud contained many *Asellus*, and *Chironomus* larvae with frequent *Lymnea peregra* snails. Like Site A, the conditions were unsuitable for Q-ratings, because of the muddy substrate and almost standing water conditions. Conditions were similar to last year and a Q-rating of Q2-3 is suggested.

The left bank was dominated by willow, bramble, nettle and bindweed, while the right banks was dominated by Greater tussock sedge, nettle, Angelica, bindweed, Figwort and Great willow herb (*Epilobium hirsutum*),.

Site C *(Tramore River: most upstream site within the landfill boundary)*

This site is at a fording point in the Tramore River within the precincts of landfill and at the same point is crossed by a kind of bridge for carrying pipes. Since the 2009 sampling, a crump weir has been built at this site for flow gauging and this has had the effect of creating a stilling basin immediately upstream, with water backed-up and very laminar. In-channel, filamentous green algae (very silted) accounted for about 80% cover (including *Vaucheria, Cladophora* and other species). This area has developed a couple of isolated clumps of Sparganium erectum since last year. Upstream of this open-water area the channel was completely encroached by a mix of *Sparganium erectum*, and *Typha,* centrally and by Brooklime (*Veronica beccabunga*) and *Apium* along the right hand margins (Plate 4). Backing this belt farther upstream was 100% in-channel cover of pondweed (*Potamogeton natans*). Downstream of the weir, the channel bed is dominated by long trailing filamentous green algae covering about 90% of the bed and below this *P. natans* constituted about 50% cover with *S. erectum* common also toward the margins of the channel. Willow dominated the bankside vegetation on both sides of the river upstream and downstream of the ford. Kick-samples were taken in the main flow immediately below the weir in a spot with a fast flow over gravel and cobble. The results are at presented in the table below. They indicate polluted conditions very similar to 2012.

Macroinvertebrates in Site C kick-samples

Common Name of Group	**Scientific Name**	**Notional Abundance**
Mayflies	*Baetis*	+++
Non-biting Midges	Chironomidae	++++
Non-biting Midges	*Chironomus*	+
Blackfly larvae	Simuliidae	+
Freshwater Shrimp	*Gammarus*	++
Wandering Snail	*Lymnaea peregra*	++++D
FW Limpet	*Ancylus*	+
Pea mussels	*Sphaeridae*	+++
FW Shrimp	*Gammarus*	+
Water Hoglouse	*Asellus aquaticus*	++++
Water mites	Hydrachnidae	+++
Leech	Helobdella stagnalis	+
Leech	Glossiphonia	++/+
Leech	Trocheta	+
Flatworms	Helminthidae	++/+
Segmented worms	Oligochetae	++/+
EPA Q-value		**Q2 (Q2-3)**

Site D *(Tramore River: 2nd site downstream of boundary)*

The sampling point is at a constriction in the river where the channel flows over a small loose limestone cobble-boulder weir (Plate 5) immediately downstream of a sluggish stretch, which was dominated by Broad-leaved Pondweed (>50% cover), which also accounted for a little less downstream of the weir. The coarse angular cobble at and immediately upstream and downstream of the weir had a heavy cover of filamentous green alga (*Vaucheria* and *Cladophora* 60-80%). The right bank was nettles with scattered *Angelica* and Himalayan balsam (*Impatiens glandulifera*), backed by alder and willow, while the left bank was dominated by nettle and Himalayan balsam with Angelica backed by willow.

In channel, the substrate of the kick-sampling area at the weir comprised angular limestone cobbles and small boulders in a moderate to swift turbulent flow. The water was very slightly milky. Results indicated a very slight deterioration on 2012 (see Table below).

Kick-sample results Site D:

Common Name of Group	**Scientific Name**	**Notional Abundance**
Blackfly larvae	*Simulium*	+++/+
Water Hoglouse	*Asellus aquaticus*	++++D
Non-biting Midges	Chironomidae	++++
FW Limpet	*Ancylus*	+
Ram's Horn snails	*Planorbis sp.*	+
Leeches	*Glossiphonia complanata*	++
Fish	Juvenile eel	1
EPA Q-value		**Q2-3**

Site E *(Tramore River upstream of the landfill: outside the boundary to the west)*

Access to the site remains extremely difficult and a machete had to be used again to allow access. Here the channel, which has been generally over-widened upstream as a result of drainage, narrows through the eye of a small bridge (W6780 6943). The upstream area is becoming completely silted up due to urban siltation and is destined to become a wetland or marsh over the next decade if it continues at the current rate of sedimentation without maintenance dredging. This site was chosen as it is the only one in this section of channel which can be sampled; the listed site (200m u/s) is pure sandy mud and therefore unsuitable. However, the new crump weir within the landfill (Site C) looks as if it may be contributing to the water backing up at this site, so that when it came to kick-sampling under the bridge there was extremely slow flow and all that could be done again in 2013 was to disturb the heavily silted cobbles with the heel of a wader boot and sweep the pond net through the suspension to sample any dislodged invertebrates (Plate 6)

The channel here is 2-3m wide. The site is very shaded and effectively plant free (under the bridge). Immediately upstream of the bridge the channel is much wider (>10m) and, as mentioned already, comprises a deeply silted channel with large stands of *Typha* and *Sparganium erectum*, which are now encroaching on virtually the entire channel in areas, even more since 2012 (Plate 7). . Willow and alder dominates the left bank, while the RHS bank had Willow, Alder prominent also. There is a very large growth of the alien invasive species Japanese Knotweed (*Fallopia japonica*) just upstream of the bridge. The site remains seriously polluted.

Kick-sample results Site E:

Common Name of Group	**Scientific Name**	**Notional Abundance**
Non-biting Midges	*Chironomus*	++++D
Non-biting Midges	*Chironomidae*	++++
Water Hoglouse	*Asellus aquaticus*	++
Segmented worms	Lumbricidae	+++
Wandering snail	*Lymnaea peregra*	+
EPA Q-value		**Q2**

Site F *(150m downstream of the confluence of the Tramore and Trabeg Rivers)*

This site was 150m to 200m downstream of the confluence of the Tramore and Trabeg Rivers (Plate 8). Samples were taken in a shallow riffle where the substrate comprised silted fine gravel and coarse sand with pebble and scattered small cobbles with an occasional boulder in a moderate to moderately swift turbulent flow (Plate 9). The substrate was coated in a light to moderate diatom / algal scum to a cover of about 60%. *Enteromorpha*, was also present, attesting to the very slightly estuarine nature of the site. The left side bank was dominated by a wide marginal stand of *Phalaris* interspersed with *Apium* and Watercress and backed by bramble, gorse nettle and Japanese knotweed. The right banks was dominated *Apium nodiflorum* with *Agrostis stolonifera* (Creeping bent) and scattered *Oenanthe crocata (*Hemlock Water-dropwort*)* backed by willow.

Kick-samples results indicate a fairly similar mix of species but changes in dominance suggest a slight improvement at the site compared to 2012

Kick-sample results Site F:

Common Name of Group	**Scientific Name**	**Notional Abundance**
Non-biting Midges	Chironomidae	+
Water beetle larva	Haliplid	+
Cased Caddis fly larva	*Sericostoma personatum*	+
Water Hoglouse	*Asellus aquaticus*	++
Freshwater shrimp	*Gammarus* sp.	++++D
Jenkin's Spire shell	*Potamopyrgus jenkinsi*	++/+
Pea mussels	Sphaeridae	+
Wandering snail	*Lymnaea peregra*	+
Leeches	*Glossiphonia*	+
Water mites	*Hydracarina*	+
EPA Q-value		**Q2-3 (Q3)**

Conclusion

The 2013 survey produced very similar results to 2012 with only marginal differences in macroinvertebrate communities since then. In general, plant growth appeared to be heavier at all sites with the possible exception of Site F. These changes may have been due to the very warm summer. Site A continued having heavier and slightly more diverse plant community as noted in 2012 which facilitated the use of the site by a more diverse range of macroinvertebrates – water quality remained as in 2012, the same was the case at Site B. At Sites C and D on the Tramore River, the gradual siltation of the channel and encroachment of emergent species such as *Typha* and *Sparganium* is a continuing feature. Overall the water quality hasn't changed greatly that these sites, although Site D appeared to have a marginally less diverse range of invertebrates. Site E upstream of the landfill on the Tramore River has become more encroached upstream with in-channel macrophytes and it is acting as a large

sedimentation basin for silt from upstream. Site F, the most downstream appears to have improved marginally in quality since 2013.

Plate 1 Trabeg River: Site A – Note raft of filamentous green alga between marginal Phalaris stands (28-08-2013)

Plate 2 Trabeg River: Site B showing Duckweed and *Phalaris* (28-08-2013)

Plate 3 Trabeg River: Site B - view of channel downstream (28-08-2013)

Plate 4 Tramore River: Site C - view upstream showing emergent *Sparganium* and *Typha* blocking the channel. (28-08-2013

Plate 5 Tramore River: Site D - view of 'weir' (28-08-2013)

Plate 6 Tramore River: Site E - view of kick-sample site under bridge (28-08-2013)

Plate 7 Tramore River: Site E (view upstream of kick-sampling point, showing heavy in-channel encroachment by macrophytes (28-08-2013)

Plate 8 Tramore River Site F: kick-sampling site (28-08-2013)

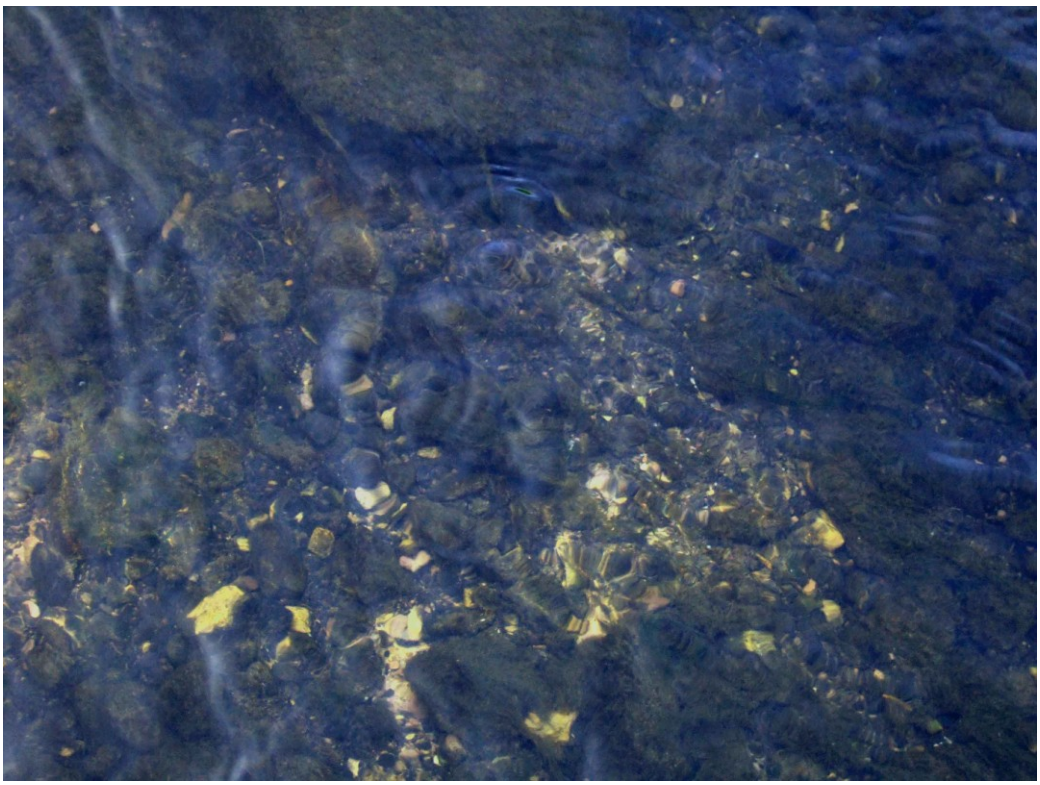


Plate 9 Tramore River Site F: close-up of substrate (28-08-2013)

Report Title	Air Emissions Compliance Monitoring Emissions Report
Company address	Air Scientific Ltd., 32 DeGranville Court, Dublin road, Trim, Co. Meath
Stack Emissions Testing Report Commissioned by	Cork City Council
Facility Name	Kinsale Road Facility
Contact Person	Kevin Ryan
EPA Licence Number	WL012-03
Licence Holder	Cork City Council Kinsale F1
Stack Reference Number	F1
Dates of the Monitoring Campaign	21/01/2014
Job Reference Number	KIRDTL01210114
Report Written By	Dr. John Casey
Report Approved by	Dr. Brian Sheridan
Stack Testing Team	Dr. John Casey
Report Date	10/02/2014
Report Type	Test Report Compliance Monitoring
Version	1
Signature of Approver	Brian Sheridan Technical Manager

Contents

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1. Executive Summary

I. Monitoring Objectives

Overall Aim of the monitoring Campaign

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values as specified in the site licence.

Special Requirements

There were no special requirements.

Target Parameters

Carbon Monoxide (CO)
Oxides of Nitrogen (NOx) as NO_2
Total Volatile Organic Carbon (TOC)
Hydrogen Chloride (HCL)
Hydrogen Fluoride (HF)
Sulphur Dioxide (SO_2)
Stack Gas Temperature
Volume ($m^3.h^{-1}$)

Emission Limit Values

Emission Limit Values / Mass Emissions Limit Values	$mg.m^{-3}$	Kg.h
CO	50	-
NOx as NO_2	150	-
TOC	10	-
HCL	50	-
HF	5	-
SO_2	-	-
Stack Gas Temperature	-	-
Volume (m^3/h)	-	-

Reference Conditions

Reference Conditions	Value
Oxygen Reference %	3
Temperature C	273.15
Total Pressure kPa	101.3
Moisture %	Yes

Executive Summary

Overall Results

	Concentration					Mass Emission		Run 1
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Compliant**	**Units**	**Result**	**Limit**
Carbon Monoxide (CO)	$mg.m^{-3}$	13.23	15.19	50	Yes	kg.h	-	-
Oxides of Nitrogen (NOx) as NO_2	$mg.m^{-3}$	51.63	18.71	150	Yes	kg.h	-	-
Total Volatile Organic Carbon (VOC)	$mgC.m^{-3}$	5.05	0.30	10	Yes	kg.h	-	-
Hydrogen Chloride (HCL)	$mg.m^{-3}$	0.71	0.003	50	Yes	kg.h	-	-
Hydrogen Fluoride (HF)	$mg.m^{-3}$	0.80	0.02	5	Yes	kg.h	-	-
Sulphur Dioxide (SO_2)	$mg.m^{-3}$	4.23	45.81	1000	Yes	kg.h	-	-
Stack Gas Temperature	K	1298.15	-	-	-	-	-	-
Stack Gas Velocity	$m.s^{-1}$	-	-	-	-	-	-	-
Volumetric Flow Rate	$m^3.h^{-1}$	-	-	-	-	-	-	-
Volumetric Flow Rate (Ref.)	$m^3.h^{-1}$	-	-	-	-	-	-	-

Accreditation details

Air Scientific Limited	319T
External Analytical Laboratory	UKAS0605
Other	-

Executive Summary

Monitoring Dates & Times

Parameter	Run	Location ID	Sampling Dates	Sampling Time On	Sampling Time Off	Duration (mins.)
Carbon Monoxide (CO)	Run 1	F1	21/01/2014	11:41:00	12:14:00	00:33:00
	Run 2					
	Run 3					
Oxides of Nitrogen (NOx) as NO_2	Run 1	F1	21/01/2014	11:41:00	12:14:00	00:33:00
	Run 2					
	Run 3					
Total Volatile Organic Carbon (VOC)	Run 1	F1	21/01/2014	11:06:29	11:40:29	00:34:00
	Run 2					
	Run 3					
Hydrogen Chloride (HCL)	Run 1	F1	21/01/2014	10:50:00	11:23:00	00:33:00
	Run 2					
	Run 3					
Hydrogen Fluoride (HF)	Run 1	F1	21/01/2014	11:30:00	12:00:00	00:30:00
	Run 2					
	Run 3					
Sulphur Dioxide (SO_2)	Run 1	F1	21/01/2014	11:41:00	12:14:00	00:33:00
	Run 2					
	Run 3					
Oxygen (%)		F1	21/01/2014	11:41:00	12:14:00	00:33:00

Executive Summary

Process details

Parameter	
Process status	Normal
Capacity (per/hour) (if applicable)	N/a
Continuous or Batch Process	Continuous
Feedstock	Landfill Gas
Abatement System	No
Abatement Systems Running Status	N/A
Fuel	Landfill Gas
Plume Appearance	None
Other information	N/A

Monitoring, Equipment & Analytical Methods

	Monitoring				Analysis	
Parameter	**Standard**	**Technical Procedure**	**Accredited Testing**	**Testing Lab**	**Analytical Technique**	**Analysis Lab**
Carbon Monoxide (CO)	EN15058:2006	SOP 2004	Yes	AirSci	NCIR By Horiba PG-250	AirSci
Oxides of Nitrogen (NOx)	EN14792:2006	SOP 2002	Yes	AirSci	Chemiluminescence	AirSci
Total Volatile Organic Carbon (TOC)	EN12619:2013	SOP 2009	Yes	AirSci	Flame Ionisation Detection	AirSci
Hydrogen Chloride (HCL)	EN1911:2010	SOP 2014	No	AirSci	Ion Chromatography	RPS
Hydrogen Fluoride (HF)	EN15713:2006	SOP 2024	No	AirSci	Ion Chromatography	RPS
Sulphur Dioxide (SO2)	TGN 21	SOP 2012	Yes	AirSci	NDIR Absorption	AirSci
Stack Gas Temperature	EN16911:2013	SOP 2005	Yes	AirSci	Thermocouple	AirSci

List of Equipment

ID	Item of Equipment	Manufacturer	Serial No.
ASLTM12EQ503	SKC Aircheck Sampler	SKC	826934
ASLTM12EQ504	SKC Aircheck Sampler	SKC	826914
ASLTM12EQ508	DryCal DC Lite Primary Flow Metre	BIOS	7298
ASLTM12EQ511	3010 MiniFID	Signal Instruments	17852
ASLTM12EQ513	Horiba PG2500 Portable Gas Analzer	Horiba	2VM969TT
ASLTM12EQ517	Testo 400 Gas Pressure Vacuum and Flow	Chell/Testo	00828828/305
ASLTM12EQ520	Buhler Sample Gas Cooler	Buhler Technologies	100063602044367-001

Sampling Deviations

Parameter	Deviation
Standard ID	Flow measurement not possible EN13284-1
Standard ID	Measurement Uncertainty >10% EN14792, EN15058 due to elevated measurement temperature
Standard ID	-
Standard ID	-

Reference Documents

Risk Assessment (RA)	SOP1011
Site Review (SR)	SOP1015
Site Specific Protocol (SSP)	SOP1015

Executive Summary

Suitability of sampling location

General Information	Value
Permanent/Temporary	Cherrypicker
Inside/ Outside	Cherrypicker

Platform Details		
Irish EPA Technical Guidance Note AG1 / BS EN 15259 Platform Requirements	**Value**	**Comment**
Sufficient Working area to manipulate probe and measuring instruments	N/A	-
Platform has 2 handrails (approx. 0.5m & 1.0 m high)	N/A	-
Platform has vertical base boards (approx. 0.25 m high)	N/A	-
Platform has chains / self closing gates at top of ladders	N/A	-
There are no obstructions present which hamper insertion of sampling equipment	Yes	-
Safe Access Available	Yes	-
Easy Access Available	Yes	-

Sampling Location / Platform Improvement Recommendations
No platform cherrypicker used

BSEN 15259 Homogenity Test Requirements
1: There is no requirement to perform a BSEN15259 Homogenity Test on this stack
E.g. Select Option **1: There is no requirement to perform a BSEN15259 Homogenity Test on this stack** **2: Test results were obtained from previous Homogeneity test carried out by ASL** **3: Test results were obtained from previous Homogeneity test carried out by Alternative contractor** **4: Other: Enter Description**

Stack diagram

2.

II. Appendix I Monitoring Personnel & Equipment

Stack Emissions Monitoring Personnel

Team Leader	**Name**	John Casey
	Qualifications	PhD. (Eng.), MSc. (Agr.), B. Agr. Sc.
	System approval	Air Scientific Limited Approved
		-

III. Appendix II Stack Details & flow characteristics

Preliminary stack survey calculations

General Stack Details		
Stack details	**Units**	**Value**
Date of survey		-
Time of survey		-
Type		Circular
Stack Diameter / Depth, D	m	-
Stack Width, W	m	-
Average Stack Gas Temp., Ta	C	1025
Average Static Pressure, P static	kPa	-
Average Barometric Pressure, Pb	kPa	100.9
Type of Pitot		-
Are Water Droplets Present ?		-
Average Pitot Tube Calibration Coeff, Cp		0.84
Negative flow		-
Highly homogeneous flow stream/gas velocity		-

Sample Port Size	mm	25
Initial Pitot Leak Check	Pa	-
Final Pitot Leak Check	Pa	-
Orientation of Duct		-
Pitot Tube Cp		0.998
Number of Lines Available		1
Number of Lines Used		1

Sampling Line A						
Point	**Distance to duct (m)**	**Pa**	**Temp C**	**Velocity (m/s)**	**Oxygen (%)**	**Angle of Swirl**
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
Average	-	-	-	-	-	-
Min	-	0	0	0.00	0	0
Max	-	0	0	0.00	0	0

Sampling Line B						
Point	**Distance to duct (m)**	**Pa**	**Temp C**	**Velocity (m/s)**	**Oxygen (%)**	**Angle of Swirl**
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
Average	-	0.00	0	0.00	0	0
Min	-	0	0	0.00	0	0
Max	-	0	0	0.00	0	0

Component	Conc. ppm	Conc. Dry % v/v	Conc. Wet % v/v	Molar Mass
Carbon Dioxide CO_2	-	8.7	-	44.01
Oxygen O_2	-	10.2	-	32
Nitrogen N_2	-	81.1	-	28.1
Moisture (H_2O)	-	-	9	18.02

Reference Conditions	Units	Numbers
Temperature	C	273.15
Total Pressure	kPa	101.3
Moisture	%	-
Oxygen (Dry)	%	3

Stack Gas Composition & Molecular Weights								
Component	**Molar Mass M**	**Density Kg/m^3 p**	**Conc. Dry % v/v**	**Dry Volume Fraction r**	**Dry Conc. kg/m^3 pi**	**Conc. wet % v/v**	**Wet Volume Fraction r**	**Wet Conc.kg/m^3 pi**
Carbon Dioxide CO_2	44.01	1.96	8.7	0.087	0.17	8.53	0.09	0.17
Oxygen O_2	32	1.43	10.2	0.102	0.15	10.00	0.10	0.14
Nitrogen N_2	28.1	1.25	81.1	0.811	1.02	79.48	0.79	1.00
Moisture (H_2O)	18.02	0.80	-	-	-	2	0.02	0.02
	-	-	-	-	-	-	-	-
where p=M/22.41	-	-	-	-	-	-	-	-
pi = r x p	-	-	-	-	-	-	-	-

Calculation of Stack Gas Densities		
Determinand	**Units**	**Result**
Dry Density (STP), P STD	$kg.m^{-3}$	-
Wet Density (STP), P STW	$kg.m^{-3}$	-
Dry Density (Actual), P Actual	$kg.m^{-3}$	-
Average wet Density (Actual), P ActualW	$kg.m^{-3}$	-
Where		
P STD = sum of component concentrations, kg/m3 (excluding water vapour)	-	-
P STW = (P STD + pi of H2O) / (1 + (pi of H2O / 0.8036))	-	-
P actual = P STD x (T STP / (P STP)) x (Pa / Ta)	-	-
P actual W (at each sampling point) = P STW x (Ts / Ps) x (Pa / Ta)	-	-

Sampling Plane Validation Criteria	Value	Units	Requirement	Compliance	Method
Lowest Differential Pressure	-	Pa	>5 Pa	N/A	EN13284
Lowest Gas Velocity	-	m/s	-	N/A	-
Highest Gas Velocity	-	m/s	-	N/A	-
Ratio of Above	-	:1	<3:1	N/A	EN13284
Mean Velocity	-	m/s	-	N/A	-
Angle of flow with regard to duct axis	-	degrees	< 15	N/A	EN13284
No local negative flow	-	-	-	N/A	-
Homogeneous flow stream/gas velocity	-	-	-	N/A	-

Calculation of stack Gas Velocity, V	
Velocity at Traverse Point, V = Kcp * Sqroot ((2 * DP) / Density)	-
Where	
Kpt = Pitot tube calibration coefficient	0.84
Compressibility correction factor, assumed at a constant 0.998	0.998

Gas Volumetric Flowrate	Units	Result
Gas Volumetric Flow Rate (Actual)	$m^3.h$	-
Gas Volumetric Flow Rate (STP, Wet)	$m^3. h^{-1}$	-
Gas Volumetric Flowrate (STP, Dry)	$m^3. h^{-1}$	-
Gas Volumetric Flowrate REF to Oxygen	$m^3. h^{-1}$	-

IV. Appendix 3 Individual parameter sampling details and results

Carbon Monoxide Quality Assurance

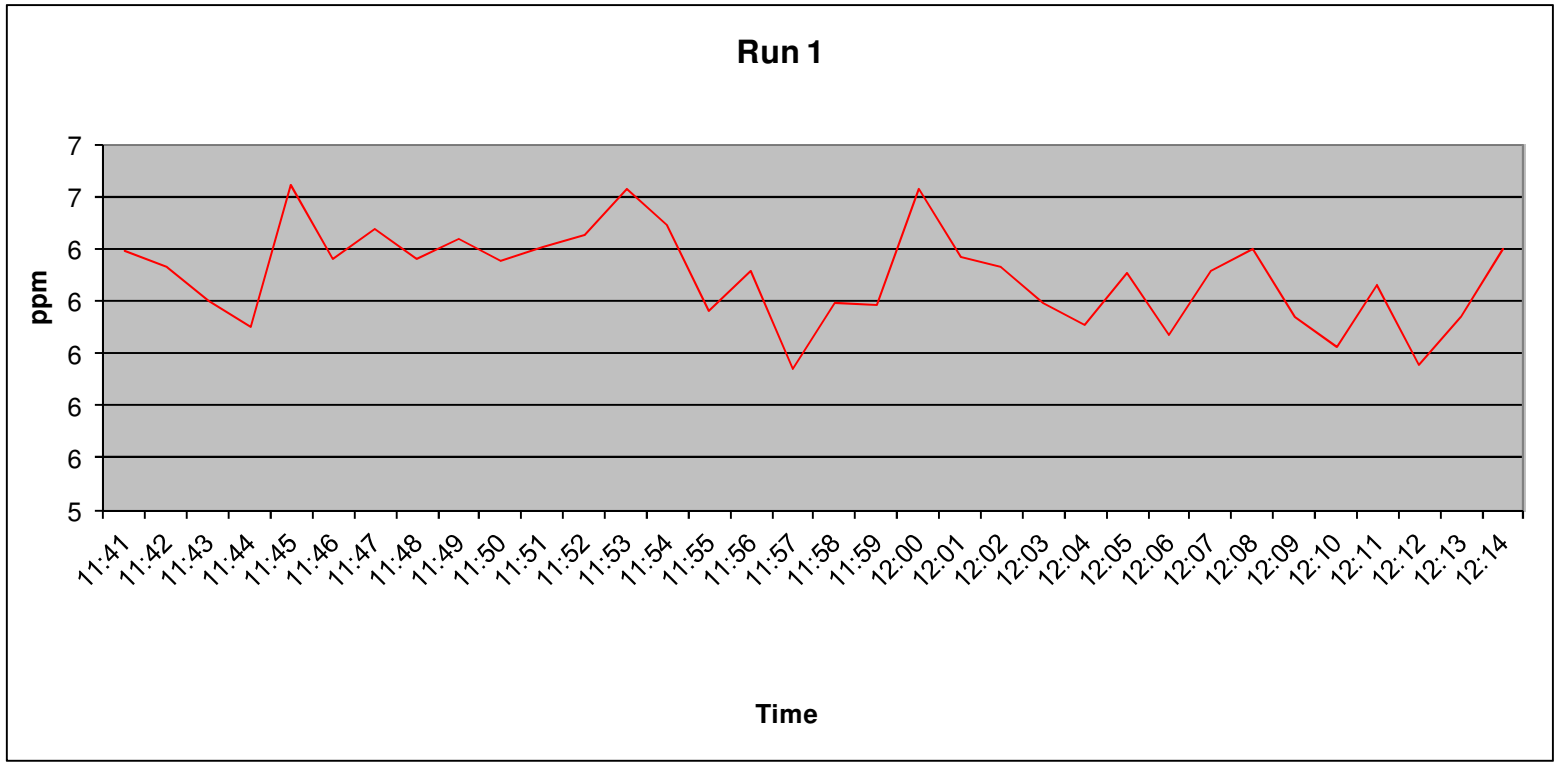
Sampling Details		
Stack ID	F1	-
	Units	**Run 1**
Parameter		
Sampling Times	-	11:41
Sampling Dates	-	21/01/2014
Instrument Range	ppm	200
Span Gas Value	ppm	150.5
Acceptable Gas Range	-	Yes
Quality Assurance	**Units**	**Run 1**
Conditioning Unit Temperature	C	2
Average Temperature	< C	2
Allowable Temperature	-	4
Temperature Acceptable	-	Yes
Pump flow rate	l/min.	0.4
Zero Drift	Units	**Run 1**
Zero Down Sampling Line (Pre)	ppm	0
Zero Down Sampling Line (Post)	ppm	0
Zero drift	ppm	0
Allowable Zero Drift	ppm	5
Zero Drift Acceptable	-	Yes
Span Drift	Units	**Run 1**
Span Down Sampling Line (Pre)	ppm	150.5
Span Down Sampling Line (Post)	ppm	151
Span Drift	ppm	0.5
Allowable Span Drift	ppm	3.01
Span Drift Acceptable (Y/N)	-	Yes
Leak Check		
Span Gas Conc.	ppm	150.5
Recorded Conc. down Line	ppm	150.5
Leak check acceptable (< 2%)	(Y/N)	Yes
Test Conditions	**Units**	**Run 1**
Run Ambient Temperature Range	C	9

Carbon Monoxide Results & Sampling details

Parameter	Units	Run 1
Concentration	$mg.m^{-3}$	13.23
Uncertainty	$mg.m^{-3}$	15.19
Mass Emission	kg.h	-

General Sampling Information	
Parameter	**Value**
Standard	15058
Technical Procedure	2004
Probe material	SS
Filtration Type/Size	PTFE
Heated Head Filter Used	Yes
Heated Line Temperature	189
Span Gas Reference Number	ASLTM13521
Span Gas Expiry Date	-
Span Gas Start Pressure (bar)	20
Gas Cylinder Concentration (ppm)	150.5
Span Gas Uncertainty (%)	<2
Zero Gas Type	Ambient
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	-
Reference Conditions	
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	3

Carbon Monoxide Trend



Carbon Monoxide Measurement Uncertainty

	Units	**Run 1**
Measured Quantities		
Certified Range of Analyser	ppm	1.36 to 1000
Operational Range of Analyser	ppm	200
Measured Reading	ppm	6.30
Measured Quantities	**Units**	**Run 1**
Nonlinerity	ppm	0.9
Temperature Dependent Zero drift	ppm	0.14
Temperature Dependent Span drift	ppm	-0.12
Cross-sensitivity	ppm	0.08
Leak	ppm	0
Calibration Gas Uncertainty	ppm	<2
Parameter	**Units**	**Run 1**
Combined uncertainty	$mg.m^{-3}$	0.95
Expanded uncertainty	$mg.m^{-3}$	1.90
Uncertainty corrected to std conds	$mg.m^{-3}$	15.19
Expanded uncertainty expressed with a level of confidence of 95%	% of ELV	30.38
Expanded uncertainty expressed with a level of confidence of 95%	$mg.m^{-3}$	15.19
Expanded uncertainty expressed with a level of confidence of 95%	% of value	114.86
Requirement in standard is for uncertainty to be < 10% at ELV at standard conditions		

Oxides of Nitrogen Quality Assurance

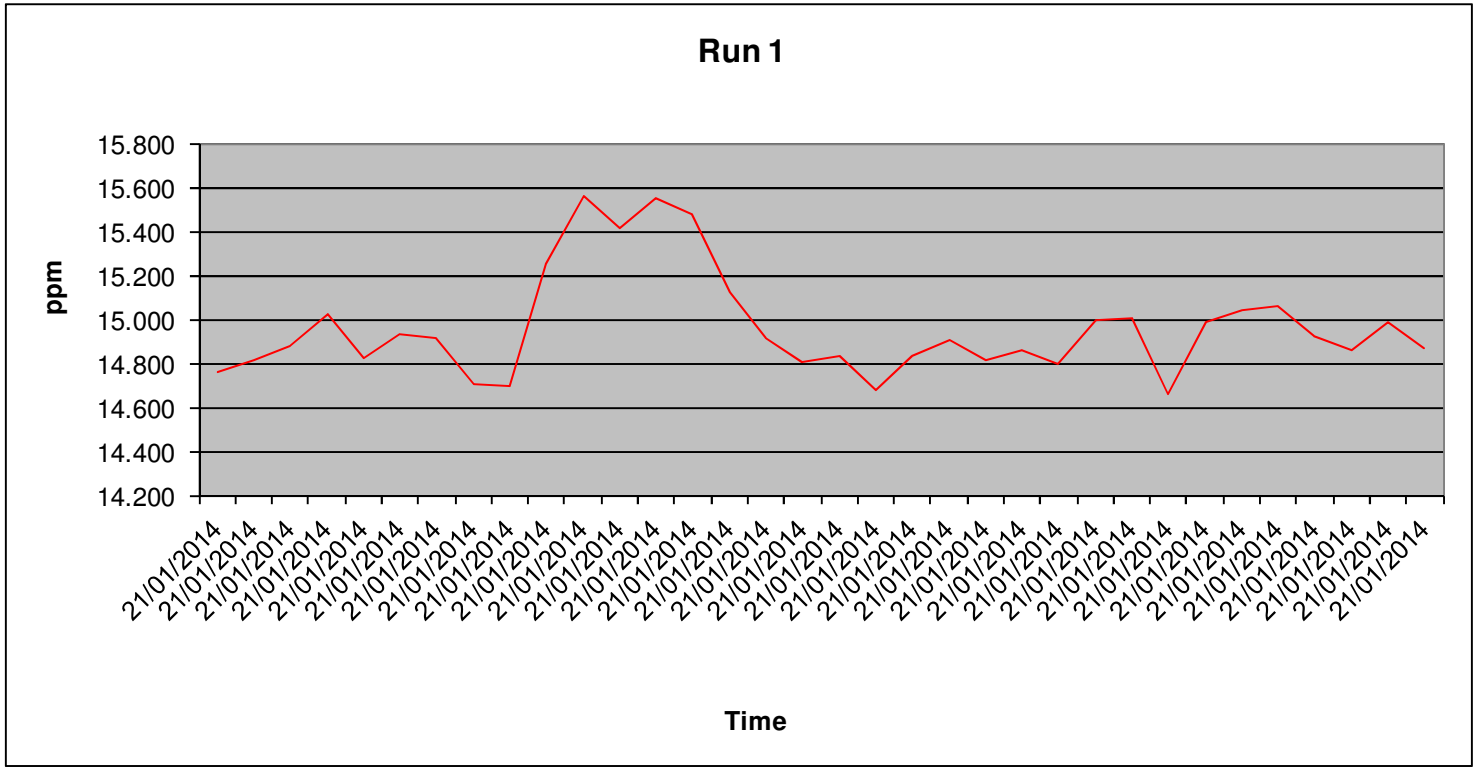
Sampling Details		
Stack ID	F1	-
	Units	**Run 1**
Parameter		
Sampling Times	-	11:41
Sampling Dates	-	21/01/2014
Instrument Range	ppm	250
Span Gas Value	ppm	157
Acceptable Gas Range	-	Yes
Quality Assurance	**Units**	**Run 1**
Conditioning Unit Temperature	C	2
Average Temperature	< C	2
Allowable Temperature	-	4
Temperature Acceptable	-	Yes
Pump flow rate	l/min.	0.4
Zero Drift	Units	**Run 1**
Zero Down Sampling Line (Pre)	ppm	0
Zero Down Sampling Line (Post)	ppm	0
Zero drift	ppm	0
Allowable Zero Drift	ppm	5
Zero Drift Acceptable	-	Yes
Span Drift	Units	**Run 1**
Span Down Sampling Line (Pre)	ppm	157
Span Down Sampling Line (Post)	ppm	159
Span Drift	ppm	2
Allowable Span Drift	ppm	3.1
Span Drift Acceptable (Y/N)	-	Yes
Leak Check		
Span Gas Conc.	ppm	157
Recorded Conc. down Line	ppm	157
Leak check acceptable (< 2%)	(Y/N)	Yes
Test Conditions	**Units**	**Run 1**
Run Ambient Temperature Range	C	9
NOx Converter Efficiency	%	95.5

Oxides of Nitrogen Results & Sampling details

Parameter	Units	Run 1
Concentration	$mg.m^{-3}$	51.63
Uncertainty	$mg.m^{-3}$	18.71
Mass Emission	Kg.h	-

General Sampling Information	
Parameter	**Value**
Standard	14792
Technical Procedure	2002
Probe material	SS
Filtration Type/Size	PTFE
Heated Head Filter Used	Yes
Heated Line Temperature	189
Date & Result of last converter check	95.5 18/10/13
Span Gas Reference Number	ASLTM14500
Span Gas Expiry Date	-
Span Gas Start Pressure (bar)	43
Gas Cylinder Concentration (ppm)	157
Span Gas Uncertainty (%)	<2
Zero Gas Type	N / O2
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	-
Reference Conditions	
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	3

Oxides of Nitrogen Trend



Oxides of Nitrogen Measurement Uncertainty

Measured Quantities	**Units**	**Run 1**
Nonlinearity	%	1.4
Temperature Dependent Zero drift	%	-0.04
Temperature Dependent Span drift	%	-0.25
Cross-sensitivity	%	0.5
Leak	%	0
Calibration Gas Uncertainty	%	<2
Mass Flow Controllers (Dilution) Uncertainty	%	-
NOx Converter Efficiency	%	95.5
Parameter	**Units**	**Run 1**
Combined uncertainty	$mg.m^{-3}$	1.16
Expanded uncertainty	$mg.m^{-3}$	2.31
Uncertainty corrected to std conds	$mg.m^{-3}$	18.71
Expanded uncertainty expressed with a level of confidence of 95%	% of ELV	12.47
Expanded uncertainty expressed with a level of confidence of 95%	$mg.m^{-3}$	18.71
Expanded uncertainty expressed with a level of confidence of 95%	% of value	36.23
Requirement in standard is for uncertainty to be < 10% at ELV at standard conditions		

Total Volatile Organic Carbon Quality Assurance

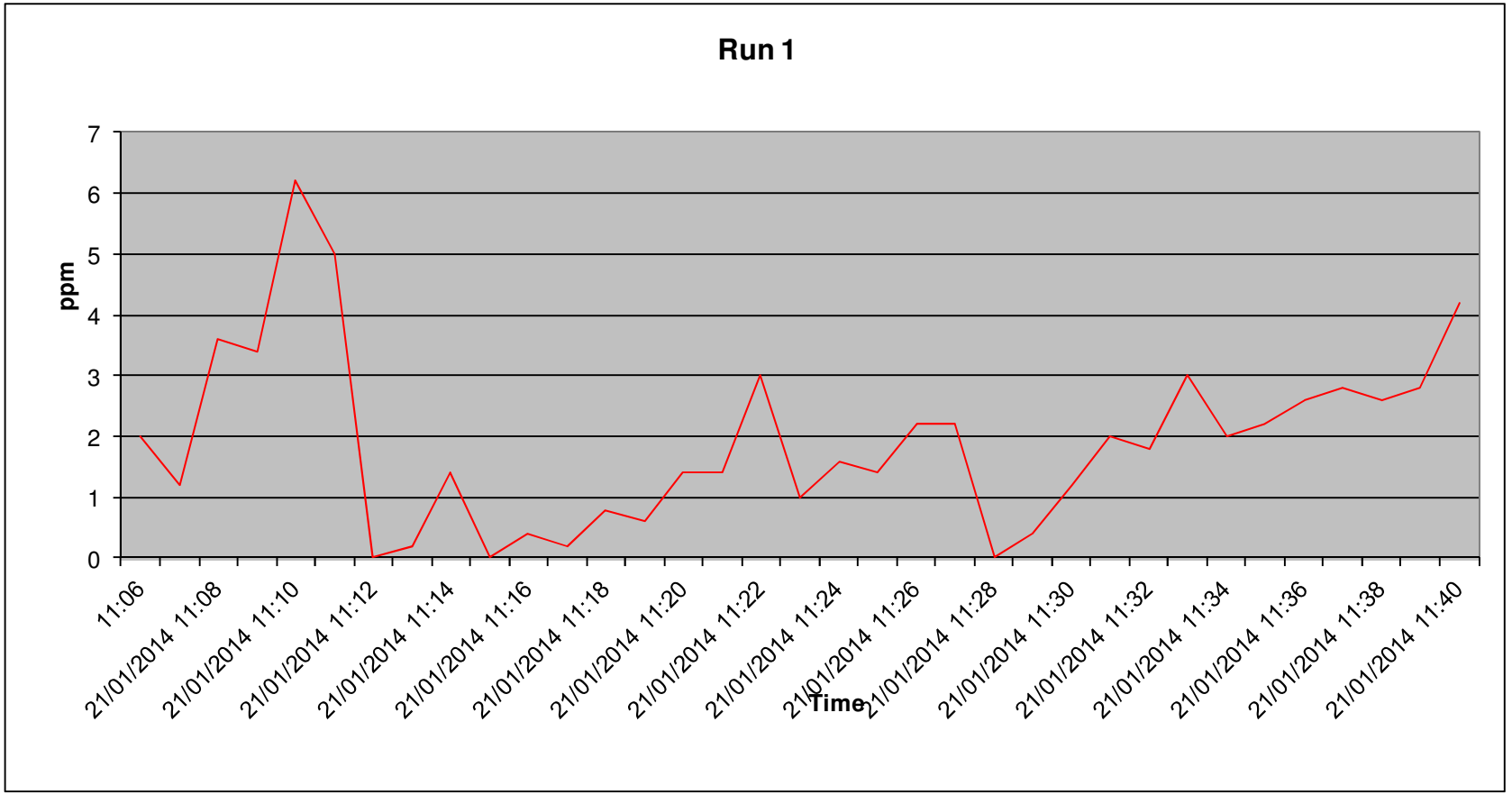
Sampling Details		
Stack ID	F1	-
	Units	**Run 1**
Parameter		
Sampling Times	-	11:06
Sampling Dates	-	21/01/2014
Instrument Range	ppm	100
Span Gas Value	ppm	78
Acceptable Gas Range	-	Yes
Quality Assurance	**Units**	**Run 1**
Oven Temperature	C	193
Average Temperature	< C	193
Temperature Acceptable	-	Yes
Sample line temperature	C	188
Zero Drift	Units	**Run 1**
Zero Down Sampling Line (Pre)	ppm	0
Zero Down Sampling Line (Post)	ppm	1
Zero drift	ppm	1
Allowable Zero Drift	ppm	2
Zero Drift Acceptable	-	Yes
Span Drift	Units	**Run 1**
Span Down Sampling Line (Pre)	ppm	78
Span Down Sampling Line (Post)	ppm	79
Span Drift	ppm	0
Allowable Span Drift	ppm	3.9
Span Drift Acceptable (Y/N)	-	Yes
Leak Check		
Span Gas Conc.	ppm	78
Recorded Conc. down Line	ppm	78
Leak check acceptable (< 2%)	(Y/N)	Yes

Total Volatile Organic Carbon Results and Sampling Details

Parameter	Units	Run 1
Concentration	$mgC.m^{-3}$	5.05
Uncertainty	$mgC.m^{-3}$	0.30
Mass Emission	Kg.h	-

General Sampling Information	
Parameter	**Value**
Standard	12619
Technical Procedure	2009
Probe material	SS
Filtration Type/Size	PTFE
Heated Head Filter Used	Yes
Heated Line Temperature	188
Span Gas Reference Number	ASLTM14ING502
Span Gas Expiry Date	-
Span Gas Start Pressure (bar)	45
Gas Cylinder Concentration (ppm)	77
Span Gas Uncertainty (%)	<2
Zero Gas Type	Ambient
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	-
Reference Conditions	-
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	3

Total Volatile Organic Carbon Trend



Total Volatile Organic Carbon Measurement Uncertainty

	Units	**Run 1**
Measured Quantities		
Certified Range of Analyser	ppm	0.5 to 1000
Operational Range of Analyser	ppm	100
Measured Reading	ppm	1.91
Measured Quantities	Units	**Run 1**
Nonlinerity	%	0.068
Temperature Dependent Zero drift	%	0.3
Temperature Dependent Span drift	%	0.3
Cross-sensitivity	%	-
Leak	%	0
Calibration Gas uncertainty	%	0.58
Parameter	Units	**Run 1**
Combined uncertainty	$mg.m^{-3}$	5.05
Expanded uncertainty	$mg.m^{-3}$	0.30
Expanded uncertainty expressed with a level of confidence of 95%	% of ELV	5.98
Expanded uncertainty expressed with a level of confidence of 95%	% of value	11.96
Expanded uncertainty expressed with a level of confidence of 95%	$mg.m^{-3}$	0.60
		-
Requirement in standard is for uncertainty to be < 10% at ELV at standard conditions		

Hydrogen Chloride Sampling Details & Results

Stack ID	F1	**Run 1**
Sample ID	**KIHCL1**	**mls**
Impinger 1 ID	**KIHCL2**	-
Impinger 2 ID	**KIHCLB**	-
Impinger 3 ID	-	-
Time on	10:50	
Time off	**11:23**	
Leak Check Results		
Prior to test:	2.61	l/min
Post Test:	2.6	l/min
Sample Volume Flow Rate:	2.6	l/min
Standard Requirement:	<2	%
Test Result:	0	%
Test Status	Pass	
Calibration Details		
Pump Number:	SKCD	
Calibration Unit:	ASLTM12EQ508	
Calibration Rate Before Test:	2.61	litres per minute
Calibration Rate After Test:	2.610	litres per minute
Average sample Volume:	2.6	litres per minute
Sample Test Time:	33	minutes
Pump Gas Temperature:	5	^{O}C
Pump Sample Pressure:	100.9	kPa
Actual Sample Volume:	0.08580	m^3
Normalised Gas Volume:	0.08392	Nm^3

Hydrogen Chloride Quality Assurance

Stack ID	F1	-
Date	21/01/2014	-
Start time	-	10:50:00
Finish Time	-	11:23:00
	Units	**Run 1**
Leak test results		
Mean Sampling Rate	l/min	2.6
Pre-sampling leak rate	l/min	2.61
Post-sampling leak rate	l/min	2.6
Leak rate	l/min	0
Acceptable leak rate (<2%)	Y/N	Yes
Filtration		
Filter Material	-	N/A
Filter Size	mm	N/A
Max. Filter Temp	degrees	N/A
Absorbers Type	Glass/PTFE/ Other	PTFE
Absorption Solution	-	Di H2O
Absorption Efficiency		
Total	ug	0.2
Impinger 1	ug	0.09
Absorption efficiency	%	-
Acceptable Absorption Eff.	>95% (Y/N)	N
Blank sample		
Blank sample ID	-	HCLB
Blank result	mg/m^3	0
Acceptable Blank	<10% ELV (Y/N)	Y
Testing laboratory		
Laboratory Name	-	UKAS0605
Test certificate Number	-	WK14-0552

Hydrogen Chloride Results & Measurement Uncertainty

Stack ID	F1	**Run 1**
Date	-	
Start time	10:50	
Finish Time	11:23	
Results		
Laboratory Result	0.13	ug/ml
Impinger final Volume	265	ml
Factor	1.028	
Concentration	0.04	mg
Sample Volume	0.084	Nm^3
Emissions Concentration	0.42	$mg.m^{-3}$
Mass Emissions	-	$kg.h^{-1}$

	Units	**Run 1**
	Units	Run 1
Parameter		
Combined Uncertainty	$mg.m^{-3}$	0.002
Expanded uncertainty as percentage of measured value	% of measured value	4.07
Expanded uncertainty in units of measurement	$mg.m^{-3}$	0.003
Expanded uncertainty as percentage of limit value	% Of ELV	0.01

Hydrogen Fluoride Sampling Details & Results

Sampling Details		**Run 1**
Stack ID	F1	
Start time	11:30	
Finish Time	12:00	
Leak Check Results		
Prior to test:	2.83	l/min
Post Test:	2.82	l/min
Sample Volume Flow Rate:	2.83	l/min
Standard Requirement:	<2	%
Test Result:	0	%
Test Status	Pass	
Calibration Details		
Pump Number:	SKC4	
Calibration Unit:	ASLTM12EQ508	
Calibration Rate Before Test:	2.83	litres per minute
Calibration Rate After Test:	2.82	litres per minute
Average sample Volume:	2.83	litres per minute
Sample Test Time:	30	minutes
Pump Gas Temperature:	5	^{O}C
Pump Sample Pressure:	100.9	kPa
Actual Sample Volume:	0.08490	m^3
Normalised Gas Volume:	0.08304	Nm^3

Hydrogen fluoride Quality Assurance

Start time	-	11:30:00
Finish Time	-	12:00:00
	Units	**Run 1**
Leak test results		
Mean Sampling Rate	l/min	2.83
Pre-sampling leak rate	l/min	2.83
Post-sampling leak rate	l/min	2.82
Leak rate	l/min	0.06
Acceptable leak rate (<2%)	Y/N	Yes
Filtration		
Filter Material	-	N/A
Filter Size	mm	N/A
Max. Filter Temp	degrees	N/A
Absorbers Type	Glass/PTFE/ Other	Glass
Absorption Solution	-	0.1m NaOH
Absorption Efficiency		
Total	ug	0.1
Impinger 1	ug	0.06
Absorption efficiency	%	40
Acceptable Absorption Eff.	>95% (Y/N)	N
Blank sample		
Blank sample ID	-	KIHFB
Blank result	mg/m^3	0
Acceptable Blank	<10% ELV (Y/N)	Y

Hydrogen Fluoride Results & Measurement Uncertainty

Sampling Details		**Run 1**
Stack ID	F1	
Date	-	
Start time	11:30:00	
Finish Time	12:00:00	
Results		
Laboratory Result	0.16	ug/ml
Impinger final Volume	245	ml
Factor	1.013	
Concentration	0.04	mg
Sample Volume	0.08	Nm^3
Emissions Concentration	0.48	$mg.m^{-3}$
Mass Emissions	-	$Kg.h^{-1}$

	Units	**Run 1**
	Units	Run 1
Parameter		
Combined Uncertainty	$mg.m^{-3}$	0.010
Expanded uncertainty as percentage of measured value	% of measured value	4.088
Expanded uncertainty in units of measurement	$mg.m^{-3}$	0.020
Expanded uncertainty as percentage of limit value	% Of ELV	0.397

Sulphur Dioxide Quality Assurance

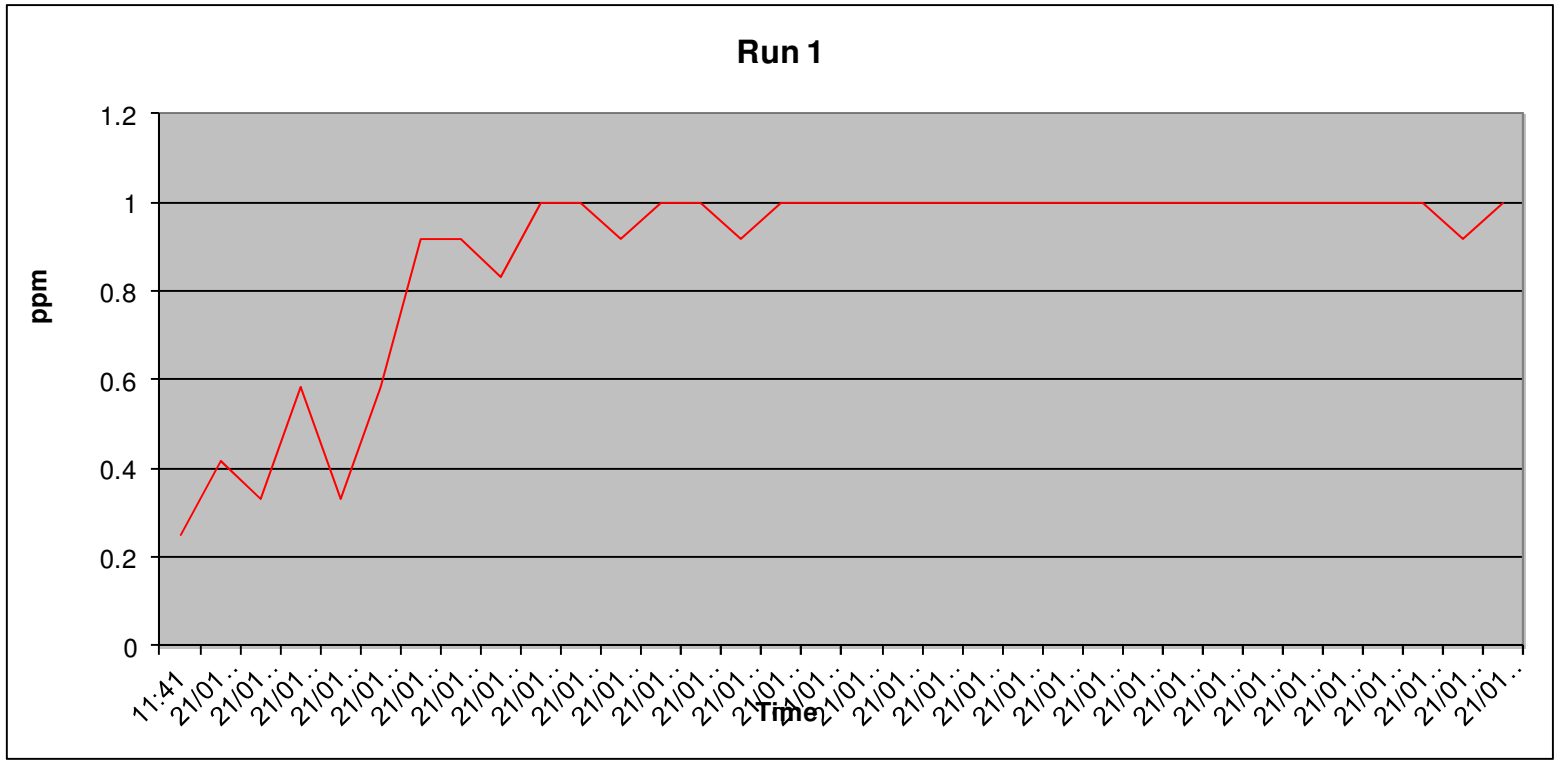
Sampling Details		
Stack ID	F1	-
	Units	**Run 1**
Parameter		
Sampling Times	-	11:41
Sampling Dates	-	21/01/2014
Instrument Range	ppm	1000
Span Gas Value	ppm	512
Acceptable Gas Range	-	Yes
	-	-
Quality Assurance	**Units**	**Run 1**
Conditioning Unit Temperature	C	3
Average Temperature	< C	3
Allowable Temperature	-	4
Temperature Acceptable	-	Yes
Pump flow rate	l/min.	0.5
	-	-
Zero Drift	Units	**Run 1**
Zero Down Sampling Line (Pre)	ppm	0
Zero Down Sampling Line (Post)	ppm	0
Zero drift	ppm	0
Allowable Zero Drift	ppm	20
Zero Drift Acceptable	-	Yes
	-	-
Span Drift	Units	**Run 1**
Span Down Sampling Line (Pre)	ppm	512
Span Down Sampling Line (Post)	ppm	508
Span Drift	ppm	4
Allowable Span Drift	ppm	10.24
Span Drift Acceptable (Y/N)	-	Yes
	-	-
Leak Check		
Span Gas Conc.	ppm	512
Recorded Conc. down Line	ppm	512
Leak check acceptable (< 2%)	(Y/N)	Yes
	-	-
Test Conditions	**Units**	**Run 1**
Run Ambient Temperature Range	C	9

Sulphur Dioxide Results & Sampling details

Parameter	Units	Run 1
Concentration	$mg.m^{-3}$	4.23
Uncertainty	$mg.m^{-3}$	45.81
Mass Emission	kg.h	-

General Sampling Information	
Parameter	**Value**
Standard	TGN 21
Technical Procedure	2012
Probe material	SS
Filtration Type/Size	PTFE
Heated Head Filter Used	Yes
Heated Line Temperature	189
Date & Result of last converter check	-
Span Gas Reference Number	ASLLK13ING522
Span Gas Expiry Date	-
Span Gas Start Pressure (bar)	25
Gas Cylinder Concentration (ppm)	512
Span Gas Uncertainty (%)	<2
Zero Gas Type	N
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	-
Reference Conditions	
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	3

Sulphur Dioxide Trend



Sulphur Dioxide Measurement Uncertainty

	Units	Run 1
Measured Quantities		
Certified Range of Analyser	ppm	2.14 to 1000
Operational Range of Analyser	ppm	1000
Measured Reading	ppm	0.88
Measured Quantities	**Units**	**Run 1**
Nonlinearity	%	0.8
Temperature Dependent Zero drift	%	0.8
Temperature Dependent Span drift	%	2
Cross-sensitivity	%	1.5
Leak	%	0
Calibration Gas Uncertainty	%	<2 %
Parameter	**Units**	**Run 1**
Combined uncertainty	$mg.m^{-3}$	2.88
Expanded uncertainty	$mg.m^{-3}$	5.75
Uncertainty corrected to std conds	$mg.m^{-3}$	45.81
Expanded uncertainty expressed with a level of confidence of 95%	% of ELV	4.58
Expanded uncertainty expressed with a level of confidence of 95%	$mg.m^{-3}$	45.81
Expanded uncertainty expressed with a level of confidence of 95%	% of value	1083
Requirement in standard is for uncertainty to be < 10% at ELV at standard conditions		

European PRTR Table Kinsale Rd Landfill flare

Table 1. Table for European-PRTR requirements for Landfill flare

	Carbon Monoxide (CO) (kg/yr)	**Carbon dioxide (CO_2) (kg/yr)**	**Nitrogen Oxides (NO_x as NO_2) (kg/yr)**	**TNMVOC's (kg/yr)**	**Sulphur dioxide (SO_2) (kg/yr)**	**Total particulates (kg/yr)**	**Methane (kg/yr)**
Totals	76	991,341	297		25	-	29
Emission Limits	500,000	100 million	100,000	100,000	150,000	50,000	100,000
Compliance	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

[2] denotes that the total values reported are based on 24 hr per day 365 days per year operation. If the hours of operation are known through site records then the total actual amount can be calculated by calculating the yearly total to an hourly figure and then multiply by the number of hours operation (e.g. Emissions (kg/yr) / 8760 hrs = kg/hr × hours operation = Total emission in kg/yr).

ODOUR & ENVIRONMENTAL CONSULTANTS

Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath

Tel: +353 46 9437922
Mobile: +353 87 6829011
E-mail: info@odourireland.com
john@odourireland.ie
Website: www.odourireland.com

W0012-03-VOC/SURFACEEMISSIONS/2013/1 LANDFILL GAS SURFACE EMISSIONS SURVEY AT KINSALE ROAD LANDFILL FACILITY, BALLYPHEHANE, CURRAGHCONWAY, INCHISARSFIELD, SOUTH CITY LINK ROAD, CORK., CORK.

PERFORMED BY ODOUR MONITORING IRELAND ON BEHALF OF CORK CITY COUNCIL

PREPARED BY:	Dr. John Casey
ATTENTION:	Mr. Kevin Ryan
LICENCE NUMBER:	W0012-3
LICENCE HOLDER:	Cork City Council
FACILITY NAME:	Kinsale Landfill Facility
DATE OF MONITORING VISIT:	10th Sept. 2013
NAME AND ADDRESS OF CLIENT ORGANISATION:	Kinsale Road landfill facility, Ballyphehane, Curraghconway, Inchisarsfield, South City Link Road, Cork., Cork
NAME AND ADDRESS OF MONITORING ORGANISATION:	Odour Monitoring Ireland, Unit 32 DeGranville Court, Dublin Road, Trim, Co. Meath
DATE OF REPORTING:	03rd Oct. 2013
NAME AND THE FUNCTION OF THE PERSON APPROVING THE REPORT:	Dr. Brian Sheridan, Managing Partner, Odour Monitoring Ireland
REPORT NUMBER:	2012916(1)
REVIEWERS:	

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DOCUMENT AMENDMENT RECORD

Client: ***Cork City Council***

Title: W0012-03-VOC/SurfaceEmissions/2013/1 Landfill Gas Surface emissions Survey at Kinsale Road landfill facility, Ballyphehane, Curraghconway, Inchisarsfield, South City Link Road, Cork., Cork.

Project Number: 2013916			**Document Reference:** W0012-03-VOC/SurfaceEmissions/2013/1		
2013916(1)	Document for review	JWC	BAS	JWC	03/10/2013
Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

Executive Summary

Cork City Council commissioned Odour Monitoring Ireland to perform a landfill gas surface emissions survey of Kinsale Road landfill facility (i.e. Waste licence number 12-03) in order to ascertain any likely sources of landfill gas surface emissions from the landfill site. Landfill gas surface emissions are the predominant source of odour emissions from landfills in Ireland. The survey was carried out on the 10th Sept. 2013.

The site including former landfill areas occupies approximately 72 Ha. The acceptance of waste ceased on the 15th July 2009.

During the surface emissions survey, the following tasks were performed on site:

1. Identification the key mechanisms that lead to the release of landfill gas surface emissions from the site.
2. Identify geographically on a site map, the locations of landfill gas surface emissions in order to perform remediation of the identified surface emissions areas.

The following conclusions were drawn from survey:

- Three zones of surface emissions were identified within the landfill facility that exceeded recommended trigger levels. These zones are identified geographically on a site map contained in *Appendix I* of this report. There were 2 surface emissions zone greater than or equal to 500 ppm VOC around identified features. There was 1 surface emissions zone greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.
- Five zones of surface emissions were identified within the landfill facility that exceeded recommended trigger levels on the 27/02/2012. There were 5 surface emissions zone greater than or equal to 500 ppm VOC around identified features. There were 0 surface emissions zones greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

1. Introduction

1.1. Background to work

Odour Monitoring Ireland was commissioned by Cork City Council to perform a specified independent Volatile organic compound surface emissions survey at Kinsale Road landfill facility. The assessment involved a Volatile organic compound (VOC) surface emissions survey of the landfill facility in order to ascertain the VOC emission points and mark them upon a map for remediation. This report presents a summary of the findings of a VOC surface emissions survey at Kinsale Road landfill facility, Ballyphehane, Curraghconway, Inchisarsfield, South City Link Road, Cork. The report is based on scientific measurements and observations made during a site visit conducted on the 10th Sept. 2013.

1.2. Scope of work

The main aims of the survey included:

- Surface emissions monitoring in accordance with AG6 requirements.
- Discussion meeting with landfill manager once survey was complete in order to communicate main surface emissions areas for immediate remediation, where necessary.
- Identification of short-term mitigation measured to be implemented within the landfill site to reduce surface emissions,

2. Techniques used

This section describes the techniques used throughout the study. The surface emissions surveying and reporting was performed by Dr. John Casey, Odour Monitoring Ireland. Dr. John Casey has preformed surface emissions monitoring survey's on behalf of Odour Monitoring Ireland for regulatory bodies in Ireland and Northern Ireland, local authorities in Ireland, private waste operators in Ireland and borough councils in Northern Ireland. A full documented list of previous survey's is available upon request.

2.1. "Odour hog" monitoring within the landfill

The "Odour hog" (i.e. Version 2, 4 years old with less than 3.5 second response time for the FID) VOC analyser is a portable, intrinsically safe, survey VOC dual monitor, which provides fast and accurate readings of organic and inorganic vapours. A Photo ionisation detector (PID) uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionised. A PID does not respond to methane. A FID is similar to a flame thermocouple detector, but measures the ions from the flame instead of the heat generated. The FID detects the methane fraction, which provides greater sensitivity in terms of methane surface emissions detection but not necessarily odour hence why the PID data is also interpreted. The FID/PID analyser was calibrated with certified reference material isobutylene and methane before commencement of the survey, see calibration certificates for gases used in Appendix II. The calibration readings were rechecked in accordance with AG6 requirements.

Using the continuous kinematic "Odour hog" with integrated GPS (i.e Magellan Professional with sub centimetre accuracy post processed), the capping of the landfill was surveyed for potential surface emissions areas. Those areas identified were geo-referenced and highlighted for remediation. This technique is useful for comparison in surface emissions area within the same landfill facility on different surveys. The surface emissions maps generated for the particular facility can be used to assess the effectiveness of implemented mitigation techniques and to qualitatively assess the nature of surface emissions from the facility. All surface emissions surveying was carried out in accordance with *"Surface VOC Emissions Monitoring on Landfill Facilities (AG6)".*

Efforts should be made to attain surface emissions <100 ppm from open surfaces and <500 ppm around features such as vertical wells, leachate collection sumps, leachate slope risers and other projections out of the waste body (Casey et al., 2008). These are minimum standards, which should lead to greater landfill collection efficiencies thus reducing the impact on the general environment.

2.2. Meteorological conditions

Table 2.1 illustrates the predominant wind direction during the monitoring exercise. The meteorological conditions were characterised for the day of monitoring and were as follows:

Table 2.1. Meteorological conditions during TVOC survey.

10th Sept. 2013	
Average wind speed 4 m s^{-1}	Wind direction southerly
Temperature 14^0C	1009 mbar
Dry weather	Capping moisture content low
Relative Humidity 69%	Cloud cover 2 Okta

During the TVOC and gas field survey, wind deviated from a southerly direction. Capping moisture content was low.

2.3 Current landfill gas collection infrastructure on the facility

There is a total of 4 vertical deep borehole wells (pumps to be installed in latter part 2012), 10 periphery pumping stations and 46 gravity condensate / leachate removal devices on the facility. There are 2 no. installed and operational landfill gas enclosed flares (1,250 m^3/hr (Duty), & 2,500 m^3/hr (Duty) capacity. At the time of the survey the enclosed flare was in operation. The central dome of the site (20 ha) is capped (*see Figure 6.1*).

3. Results

3.1. Volatile organic compound surface emissions locations identified within Kinsale Road landfill facility

Figure 6.2 and Table 3.1 illustrates the results obtained for the capping surface emissions survey. A total of 3 individual surface emissions zones were identified. Each surface emissions zone is discussed separately in this manner in order to allow for the development of remediation strategies to mitigate the individual surface emissions areas.

Table 3.1. Capping VOC surface emissions locations results with source identities correlating with *Figure 6.2 (see Appendix I)*.

Location ID	Easting (m)	Northing (m)	Max VOC conc. (ppm)	Identification and Mitigation	Recommended trigger levels
K1	168280	69673	625	Discrete Feature: Permanent Cap, Vertical Well P4LW3. Investigate and remediate the cause of the surface emissions.	<500ppm
K2	168271	69707	721	Discrete Feature: Permanent Cap, Sump. Investigate and remediate the cause of the surface emissions.	<500ppm
K3	168362	69770	186	Discrete Feature: Permanent Cap, Area. Investigate and remediate the cause of the surface emissions.	<100ppm

Three sources of landfill gas surface emissions were identified (*see Figures 6.2 and Table 3.1*) within the landfill.

Surface emissions locations K1 and K2 appeared to be present as a result of landfill gas flux from features. These are localised sources.

There were 2 surface emissions zones greater than or equal to 500 ppm around identified features. There was 1 surface emissions zone greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

3.2. Close out meeting with landfill manager

Following completion of the surface emissions survey, the surface emissions team and the landfill manager discussed all aspects and general conclusions of the survey. The landfill manager was informed of the potential areas of surface emissions.

4. Conclusions

The following conclusions were drawn from the survey of Kinsale Road Landfill facility:

- The surface emissions contour map generated from the kinematic Volatile organic compound (VOC) survey illustrated surface areas of landfill gas emissions.
- Surface emissions locations K1 and K2 appeared to be present as a result of landfill gas flux from features. These are localised sources.
- There were 2 surface emissions zones greater than or equal to 500 ppm around identified features. There was 1 surface emissions zone greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

5. References

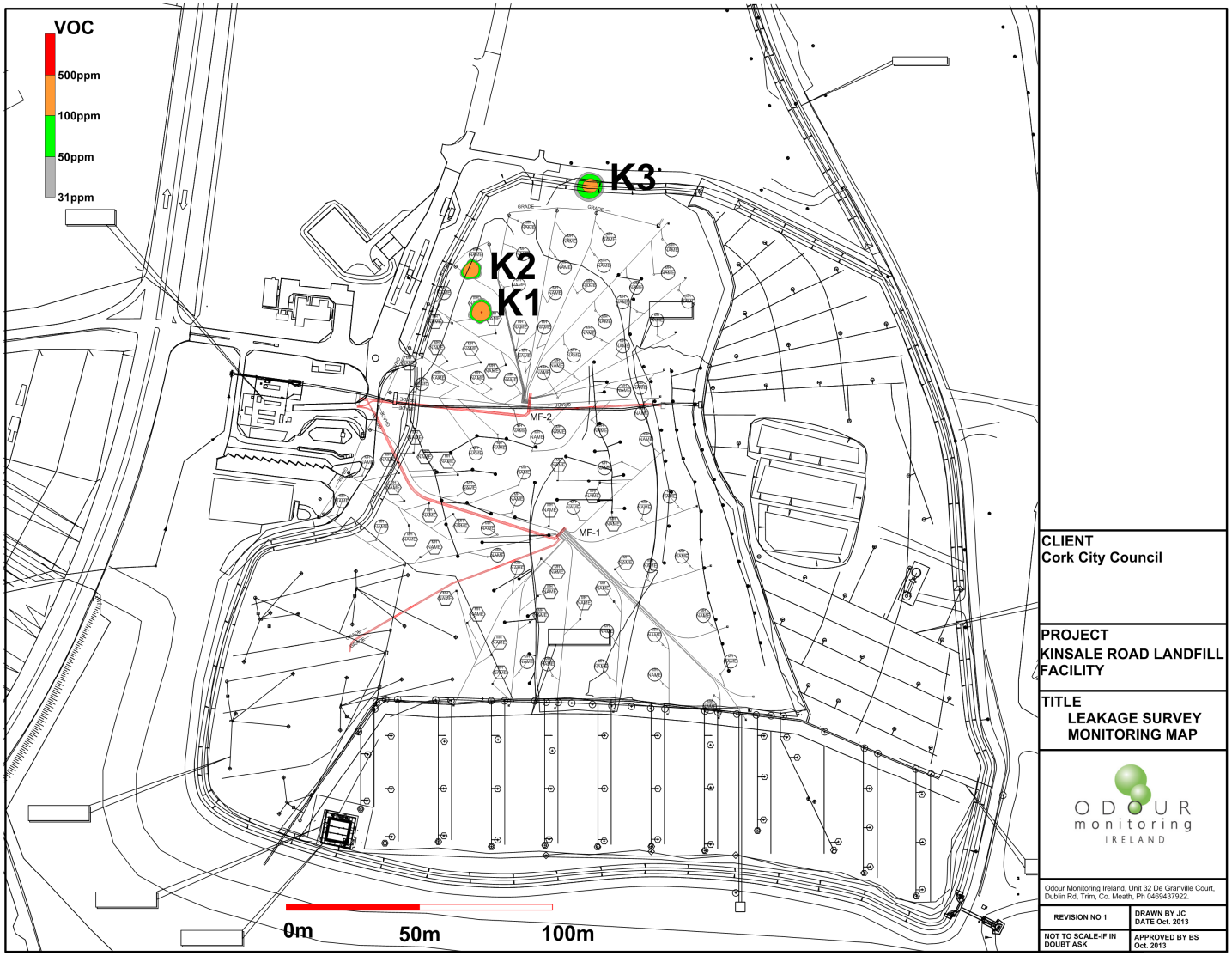
- Casey, J.W., Sheridan, B.A., Henry, M., Reynolds, K., (2008). Effective tools for managing odours from landfill facilities. International Conference on Environmental Odour Monitoring and Control**,** Rome, Italy**,** July 6-8, 2008**.**

6. *Appendix I*- Volatile organic compound surface emissions contour map & Cell capping outline & LFG infrastructure map

Figure 6.1. Cell capping outline & LFG infrastructure on the facility.


Permanent Cap & Survey Area
MF-2
MF-1
0m
50m
100m
CLIENT
Cork City Council
PROJECT
KINSALE ROAD LANDFILL FACILITY
TITLE
CAPPING OUTLINE
ODOUR monitoring IRELAND
Odour Monitoring Ireland, Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath. Ph 0469437922.
REVISION NO 1
DRAWN BY JC
DATE Oct. 2013
NOT TO SCALE-IF IN DOUBT ASK
APPROVED BY BS
Oct. 2013

Figure 6.2. Landfill gas surface emissions monitoring within the landfill facility (colour scale area indicating TVOC gas colour scale).


VOC
500ppm
100ppm
50ppm
31ppm
K3
K2
K1
MF-2
MF-1
0m
50m
100m
CLIENT
Cork City Council
PROJECT
KINSALE ROAD LANDFILL FACILITY
TITLE
LEAKAGE SURVEY MONITORING MAP
ODOUR monitoring IRELAND
Odour Monitoring Ireland, Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath, Ph 0469437922
REVISION NO 1
DRAWN BY JC
DATE Oct. 2013
NOT TO SCALE-IF IN DOUBT ASK
APPROVED BY BS
Oct. 2013

7. Appendix II-Calibration certificates and procedures.

7.1 Span & Calibration procedure

Necessary Calibration gases: Zero gas (0ppm), 100ppm and 500ppm methane (Calibration certificates below).

Calibration is carried out in accordance with manufacturers guidelines.

Location: Zero span instrument onsite.

Frequency: Before, midway through, and after the surface emissions survey, typically therefore at 3-4 hour intervals. If the survey only lasts 2 to 3 hours the instrument is checked before and after the event.

Instrument settling: The FID is switched on and left to settle for a period of 30 minutes minimum.

Span Procedure: The zero and span gases shall be introduced under the same flow and pressure conditions using the sample probe at the end of the sample line. The adjustment procedure shall be as follows:

a) Feed the zero gas (0ppm) into the FID and set the zero;

b) Feed the span gas (100ppm) and adjust the instrument accordingly;

c) Feed the zero gas into the FID once more and check that the reading returns to zero; if not repeat steps a) to c).

d) repeat procedure A to C to verify

Equipment is maintained and operated as specified by the manufacturer.

Scientific & Technical [redacted] Gases Ltd [redacted]

Certificate of Composition 29485-6-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I

Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt

(Kg) 0.12 Gross Wt (Kg) 1.2

Component	Requested Value	Certified Value
METHANE	500PPM	500PPM
AIR (ZERO GRADE)	BALANCE	BALANCE

Pressure 1000PSI Volume 112LTR

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1956 Date 10/02/2010

Scientific & Technical
[redacted] Gases Ltd [redacted]

Certificate of Composition 29485-1-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt (Kg) 0.12 Gross Wt (Kg) 1.2

Component	Requested Value	Certified Value
AIR ZERO GRADE	ZERO GRADE	

Pressure 1000PSI Volume 1000PSI

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1002 Date 10/02/2010

Scientific & Technical [redacted] Gases Ltd [redacted]

Certificate of Composition 29485-5-1

Order No E-MAIL Cylinder No Customer ODOUR MONITORING I

Cylinder Valve C10 Our Ref 29485 Cylinder Size 112DA Nett Wt

(Kg) 0.12 Gross Wt (Kg) 1.2

Component	Requested Value	Certified Value
METHANE	100PPM	100PPM
AIR (ZERO GRADE)	BALANCE	BALANCE

Pressure 1000PSI Volume 112LTR

Please note all units are in *MOL%* and accuracy is +/-2%. Relative mixtures traceable to standards calibrated at the National Physics Labratory, Teddington, Middlesex, England

Certified by S. Banks UN NO 1956 Date 10/02/2010

ODOUR & ENVIRONMENTAL CONSULTANTS

Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath

Tel: +353 46 9437922
Mobile: +353 86 8550401
E-mail: info@odourireland.com
www.odourireland.com

ODOUR, HYDROGEN SULPHIDE, MERCAPTANS AND ORGANIC ACIDS SAMPLING AND ANALYSIS WITHIN KINSALE ROAD LANDFILL, QTR.1 2013

PERFORMED ON BEHALF OF CORK CITY COUNCIL BY ODOUR MONITORING IRELAND

PREPARED BY:	Dr. John Casey
ATTENTION:	Mr. Kevin Ryan
DATE:	03rd Oct. 2013
REPORT NUMBER:	2013915(1)
DOCUMENT VERSION:	Document Ver. 001
REVIEWERS:	

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Section **Page number**

Document Amendment Record

Client: ***Cork City Council***

Title: Odour, Hydrogen sulphide, Mercaptans and organic acids sampling and analysis within Kinsale Road landfill, Kinsale Rd, Cork – Quarter 1 2013.

Project Number: 2013915(1)			**Document Reference:** Ambient air monitoring in the vicinity of Kinsale Road landfill, Kinsale Rd, Cork- Quarter 1 2013		
2013915(1)	Document for review	JWC	BAS	BAS	03/10/2013
Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

1. Introduction and scope

1.1 Introduction

Odour Monitoring Ireland was commissioned by Kinsale Road Landfill, Cork City Council to perform:

- Odour sampling and analysis in accordance with the EN13725:2003,
- Hydrogen sulphide (H_2S) sampling and analysis using a Gold leaf Jerome analyser,
- Continuous Total volatile organic compound (TVOC) utilising a ppb Photo ionisation detector (PID),
- Ambient air sampling and analysis for Mercaptans and Organic acids using active pumped sorbent tubes and analysis by thermal desorption gas chromatography mass spectrometry (TD GCMS) (EPA TO17).

Sampling and analysis of Odour, Hydrogen sulphide (H_2S), Mercaptans and Organic acids is easily performed using established sampling and analysis methodologies. Odour sampling and analysis was performed in accordance with the EN13725:2003. All materials in contact with the inlet sample air stream were either stainless steel, Teflon or Nalophan. All sample bags were flushed with odourless air before commencement of the study. Lab based olfactometry is very limited in its ability to assess ambient odour concentrations unless they are in significant high concentration whereby downwind odour concentrations are in the region of greater than 100 Ou_E m^{-3}.

Grab Hydrogen sulphide sampling and analysis was performed using a Jerome gold leaf analyser. The range of detection for this instrument is from 3 ppb to 50ppm. Active pumped sampling of Mercaptans and organic acids was performed using thermal desorption sorbent tubes followed by gas chromatography mass spectrometry analysis.

Results for this survey are presented in *Section 3*. All ambient odour threshold concentrations were less than 84 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location O1. All ambient air concentrations of TVOC's were low at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

1.2 Scope of the work

The main objectives of this study include:

- Sampling and analysis of odours at 7 pre-selected locations in accordance with EN13725:2003,
- Sampling and analysis of H_2S at 7 pre-selected locations using a Jerome gold leaf analyzer. Sampling and analysis of H_2S will be performed at each of the 7 pre-selected locations.
- Sampling and analysis of Mercaptan and Organic acids at 7 pre-selected locations using active diffusion tubes. Analysis will be performed using gas chromatography mass spectrometry (GCMS) whereby the top 5 compound concentrations of Mercaptan and organic acids will be reported. If such compounds were not present, additional volatile organic compounds were reported.

2. Materials and methods

This section describes the materials and methods used throughout the monitoring on the 10th Sept. 2013.

2.1 Monitoring locations

Appendix A.1 illustrates a graphical display of the monitoring locations in the vicinity of the landfill. *Table 2.1* illustrates the geo-referenced easting and northing 6 grid coordinates for each monitoring location.

Table 2.1 Sampling locations for odour, H_2S, TVOC and active tube sampling.

Sampling location	Description	Coordinates	
-	-	Easting	Northing
O1	Western boundary, NW of civic amenity site	168081	69747
O2	Northern boundary	168373	70046
O3	Eastern boundary	168600	69691
O4	Southern boundary	168178	69276
O5	Outside main gate of landfill. Off the Kinsale Rd	167982	69648
O6	Inlet of leachate conditioning plant	168222	69651
O7	Outlet of leachate plant	165576	69457

2.2 Meteorological data

Table 2.2 illustrates the meteorological conditions recorded during the monitoring period.

Table 2.2 Meteorological conditions during the monitoring period.

Parameter	**Day 1- 10/09/13**
Wind direction (From)	Southerly
Wind speed (m s^{-1})	3
Barometric pressure	1004
Temperature (^{0}C)	14

2.3 Odour sampling

In order to obtain air samples for odour assessment, a static sampling method was used where air samples were collected in 60 litre pre-conditioned Nalophan^{NA} bags using a vacuum sampling device over a ten to twenty minute period. The sampler operates on the 'lung principle', whereby the air is removed from a rigid container around the bag by a battery powered SKC vacuum pump at a rate of 3 to 5 *l* min^{-1}. This caused the bag to fill through a stainless steel and PTFE tube whose inlet is placed in ambient air, with the volume of sample equal to the volume of air evacuated from the rigid container. All odour-sampling bags were pre-conditioned and flushed with odourless lab air to remove any interference from the sample material.

2.4 Olfactometry

Olfactometry using the human sense of smell is the most valid means of measuring odour (Dravniek et al, 1986) and at present is the most commonly used method to measure the concentration of odour in air (Hobbs et al, 1996). Olfactometry is carried out using an instrument called an olfactometer. Three different types of dynamic dilution olfactometers exist:

- Yes/No Olfactometer
- Forced Choice Olfactometer
- Triangular Forced Choice Olfactometer.

In the dynamic dilution olfactometer, the odour is first diluted and is then presented to a panel of screened panellists of no less than four (CEN, 2003) Panellists are previously screened to ensure that they have a normal sense of smell (Casey et al., 2003). According to the CEN standard this screening must be performed using a certified reference gas *n*-butanol. This screening is applied to eliminate anosmia (low sensitivity) and super-noses (high sensitivity). The odour analysis has to be undertaken in a low odour environment such as an air-conditioned odour free laboratory. Analysis should be performed preferably within 8 to 12 hours of sampling.

2.5 Odour measurement in accordance with the EN13725:2003

An ECOMA TO8 dynamic yes/no olfactometer was used throughout the measurement period to determine the odour threshold concentration of the sample air. The odour threshold concentration is defined as the dilution factor at which 50% of the panel can just detect the odour. Only those panel members who pass screening tests with n-butanol (certified reference gas, CAS 72-36-3) and who adhered to the code of behaviour were selected as panellists for olfactometry measurements (CEN, 2003). Odour measurement was carried out in an odour free laboratory in accordance with EN13725:2003.

2.5.1 What is an odour unit?

The odour concentration of a gaseous sample of odourant is determined by presenting a panel of selected screened human panellists with a sample of odourous air and varying the concentration by diluting with odourless gas, in order to determine the dilution factor at the 50% detection threshold. The Z_{50} value (threshold concentration) is expressed in odour units (Ou_E m^{-3}).

The European odour unit is that amount of odourant(s) that, when evaporated into one cubic metre of neutral gas (nitrogen), at standard conditions elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM) evaporated in one cubic meter of neutral gas at standard conditions. One EROM is that mass of a substance (n-butanol) that will elicit the Z_{50} physiological response assessed by an odour panel in accordance with this standard. *n*-Butanol is one such reference standard and is equivalent to 123µg of n-butanol evaporated in one cubic meter of neutral gas at standard conditions (CEN, 2003).

2.6 Characteristics of landfill odours

Odours from landfills may arise due to:

- Fugitive landfill gas emission from active, intermediate and/or temporary cover on waste;
- Uncontrolled landfill gas leakages from side embankments and/or top surface within landfill;
- Volatilisation and air flow stripping of odourous gases from active face/active cell;
- Puff odour emissions from tipping and spreading of waste,
- Uncontrolled emissions from landfill flaring system and leachate treatment facility, etc. This is a non-exhaustive list.

Over 300 compounds have been identified as contributors to landfill odours. These compounds are either components of waste placed in the landfills or are degradation products. Carbon dioxide and methane make up the main constituent percentage of landfill gas and are essentially non-odorous. Other odourous compounds include organic acids (acetic acid, butyric acid; hexanoic acid), terpenes (limonene, alpha Pinene, alpha Carene), mercaptans (methanthiol, ethanthiol, etc.), amines (ethanolamine, dimethylamine, trimethylamine, etc.) and Hydrogen sulphide (Sheridan, 2003). Most of these compounds have very low odour threshold concentrations as illustrated in *Table 2.3*. Different concentrations and mixtures of these compounds can intensify or reduce odour threshold concentration, determined as synergism and antagonism, respectively.

Table 2.3 Odour threshold concentration of various odourous compounds commonly found in the air streams of landfill gas.

Compound name	Molecular Formula	Odour description	Odour threshold (ppm (v/v))
Mercaptans			
Allyl mercaptan	CH_2CHCH_2SH	Disagreeable, garlic	0.0001
Methyl mercaptan	CH_3SH	Rotten cabbage	0.0005
Propyl mercaptan	C_3H_7SH	Unpleasant	0.0005
Ethyl mercaptan	C_2H_5SH	Decayed cabbage	0.0003
Sulphides			
Hydrogen sulphide	H_2S	Rotten eggs	0.0005
Dimethyl di sulphide	$C_2H_6S_2$	Rotten cabbage/vegetables	0.0003- 0.0068
Carbon disulphide	CS_2	Intense Rubber/skunk	0.006-0.010
Amines			
Trimethyl amine	$(CH_3)_3N$	Pungent, fishy	0.0004
n-Butyl amine	$CH_3(CH_2)NH_2$	Sour, ammonia	0.080
Organic acids			
Acetic acid	CH_3COOH	Sour	1.0
Butyric acid	$CH_3(CH_2)_2COOH$	Sweet rancid	0.0004
Valeric acid	$CH_3(CH_2)_4COOH$	Rancid	0.0008

2.7 Hydrogen sulphide sampling and analysis

H_2S is commonly associated with landfills, WWTP and sludge operations. It is used as an indicator gas for the assessment of significant odour nuisance in the vicinity of landfills. Published data suggests that in order to prevent significant nuisance associated with landfill and composting operations Hydrogen sulphide concentrations should not exceed 30 ppb in the ambient environment. The only instrument capable of providing comparison with such reference levels is a Jerome metre or ppb continuous H_2S gas analyser. Both instruments are real time data-logging H_2S analysers. During this survey, Odour Monitoring Ireland used the Jerome gold leaf analyser for the measurement of ambient hydrogen sulphide levels.

H_2S measurement was performed during odour sampling. The Jerome metre is the only instrument capable of measurement H_2S in real time over the measurement range 3 ppb to 50 ppm in 1 ppb increments.

2.8 Active ambient sorbent tube monitoring for Mercaptans and Organic acids

Active sorbent tube analysis involves the adsorption/absorption of ambient specific volatile organic compound group through active sorption and analysis using thermal desorption gas chromatography mass spectrometry (TD GCMS). TD GCMS provides both semi-quantitative and qualitative results. Careful analysis of the results will allow for the identification of specific compounds that may be responsible for ambient odour but will not provide a basis of quantification of odour due to the complexities of odour synergistic. Isolation of the emission source and active sampling using an USEPA flux chamber will provide the only method of providing accurate quantification and development of emission rates. This is not required within this scope of work.

A specific two-bed sorption tube is used for accurate capture of Mercaptans and Organic acids. Tenax/Unicarb silcosteel coated active sorption tubes were used to bind the compounds upon the tube during the exposure event. Silcosteel coating upon the tube is provided to prevent reactive species such as Mercaptans breaking down and therefore will provide accurate capture for desorption upon the thermal desorption GCMS. They are then transported to the analysis laboratory in flexible airtight containers. Odour Monitoring Ireland is provided with a list of all compounds detected upon the sorption tubes whereby all Mercaptans and Organic acid species are presented within the report. The total volatile organic compounds were presented from the tube screen. All detection concentration results are presented in $\mu g\ m^{-3}$.

2.9 Continuous TVOC monitoring using a ppb Photo-ionisation detector (PID)

Additionally, Odour Monitoring Ireland performed ambient total volatile organic compounds (TVOC) analysis in ppb with a Photo-ionisation Detector (PID) at each selected location during odour sampling. A PID uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC's molecules are ionised. Therefore, PID measurements are non-destructive and therefore maintain sample integrity where samples can be bagged and used for further analysis (Sheridan, 2004).

3. Results

This section presents the result obtained throughout the study period.

3.1 Odour threshold concentration results

Tables 3.1 illustrate the odour threshold concentration results obtained during the monitoring period. All sampling and analysis was performed in accordance with the EN13725:2003.

Table 3.1. Odour threshold concentration results following monitoring of Kinsale Road Landfill, Kinsale Road, Cork.

Code	Date/Time	Sample number	Odour threshold conc. (OuE m^{-3})	Comment
1	10/09/2013	O1	84	No distinct odour
2	10/09/2013	O2	72	No distinct odour
3	10/09/2013	O3	62	No distinct odour
4	10/09/2013	O4	62	No distinct odour
5	10/09/2013	O5	78	No distinct odour
6	10/09/2013	O6	67	No distinct odour
7	10/09/2013	O7	53	No distinct odour

The odour results presented on *Table 3.1* indicate that maximum odour concentration of 84 Ou_E/m^3 was recorded at Sample locations O1.

3.2 Hydrogen sulphide and Total volatile organic compounds (TVOC) results

Table 3.2 illustrates the hydrogen sulphide and TVOC results obtained during the monitoring period.

Table 3.2. Hydrogen sulphide and TVOC (PID) measured during the odour and VOC audit at Kinsale Road Landfill, Kinsale Road, Cork.

Date/Time	Sample location	H2S (ppb)	TVOC (ppb)
10/09/2013	O1	3	7
10/09/2013	O2	3	7
10/09/2013	O3	3	5
10/09/2013	O4	3	5
10/09/2013	O5	3	9
10/09/2013	O6	3	7
10/09/2013	O7	3	11

Notes: [1] denotes that Jerome H_2S analyser lower limits of detection is 3 ppb with a resolution of 1 ppb.

The hydrogen sulphide results presented on *Table 3.2* indicates no significant amount of hydrogen sulphide was detected within and in the vicinity of the Kinsale Road Landfill. The TVOC (as measured with the PID) results are presented on *Table 3.2*.

3.3 Speciated Volatile organic compound results

Tables 3.3 to 3.10 illustrate the speciated VOC results obtained during the monitoring period. All monitoring was performed in accordance with methodologies contained within USEPA Method TO17 and MDHS 72.

Table 3.3. Active sampling results for monitoring location O1.

Location	Compound	Concentration ($\mu g/m^3$)
O1	No compound defined	0
	Total Volatile Organic Compounds	0.89

Table 3.4. Active sampling results for monitoring location O2.

Location	Compound	Concentration ($\mu g/m^3$)
O2	No compound defined	0
	Total Volatile Organic Compounds	1.08

Table 3.5. Active sampling results for monitoring location O3.

Location	Compound	Concentration ($\mu g/m^3$)
O3	No compound defined	0
	Total Volatile Organic Compounds	1.21

Table 3.6. Active sampling results for monitoring location O4.

Location	Compound	Concentration ($\mu g/m^3$)
O4	No compound defined	0
	Total Volatile Organic Compounds	0.77

Table 3.7. Active sampling results for monitoring location O5.

Location	Compound	Concentration ($\mu g/m^3$)
O5	No compound defined	0
	Total Volatile Organic Compounds	0.99

Table 3.8. Active sampling results for monitoring location O6.

Location	Compound	Concentration ($\mu g/m^3$)
O6	No compound defined	0
	Total Volatile Organic Compounds	1.31

Table 3.9. Active sampling results for monitoring location O7.

Location	Compound	Concentration ($\mu g/m^3$)
O7	No compound defined	0
	Total Volatile Organic Compounds	0.76

Table 3.10. TVOC concentration results from monitoring locations at Kinsale Road Landfill, Kinsale Rd, Cork.

Monitoring Location	Analysis	TVOC concentration (ug/m^3)
O1	TVOC	0.89
O2	TVOC	1.08
O3	TVOC	1.21
O4	TVOC	0.77
O5	TVOC	0.99
O6	TVOC	1.31
O7	TVOC	0.76

Tables 3.3 to 3.10 illustrate the active sorption GCMS screens obtained during the survey period. As can be observed no compounds were defined during the monitoring event. *Table 3.10* illustrates a comparison between the total speciated volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

4. Conclusions

The following conclusions are drawn from the study:

1. All sampling and analysis was performed in accordance with the EN13725:2003.
2. All ambient odour threshold concentrations were less than 84 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location at O1.
3. Hydrogen sulphide concentrations recorded at each monitoring location were less than 3ppb in ambient air.
4. *Table 3.3* to *3.10* illustrates total volatile organic carbon in the air stream at all monitoring locations during the active sampling exercise. All ambient air concentrations were low and well within any respective exposure threshold concentrations.
5. *Table 3.10* illustrates a comparison between the total volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

5. *Appendix I* –Monitoring locations in graphical format

ODOUR & ENVIRONMENTAL CONSULTANTS

Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath

Tel: +353 46 9437922
Mobile: +353 86 8550401
E-mail: info@odourireland.com
www.odourireland.com

ODOUR, HYDROGEN SULPHIDE, MERCAPTANS AND ORGANIC ACIDS SAMPLING AND ANALYSIS WITHIN KINSALE ROAD LANDFILL, QTR.3 2013

PERFORMED ON BEHALF OF CORK CITY COUNCIL BY ODOUR MONITORING IRELAND

PREPARED BY:	Dr. John Casey
ATTENTION:	Mr. Kevin Ryan
DATE:	03rd Oct. 2013
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Title: Odour, Hydrogen sulphide, Mercaptans and organic acids sampling and analysis within Kinsale Road landfill, Kinsale Rd, Cork – Quarter 3 2013.

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1. Introduction and scope

1.1 Introduction

Odour Monitoring Ireland was commissioned by Kinsale Road Landfill, Cork City Council to perform:

- Odour sampling and analysis in accordance with the EN13725:2003,
- Hydrogen sulphide (H_2S) sampling and analysis using a Gold leaf Jerome analyser,
- Continuous Total volatile organic compound (TVOC) utilising a ppb Photo ionisation detector (PID),
- Ambient air sampling and analysis for Mercaptans and Organic acids using active pumped sorbent tubes and analysis by thermal desorption gas chromatography mass spectrometry (TD GCMS) (EPA TO17).

Sampling and analysis of Odour, Hydrogen sulphide (H_2S), Mercaptans and Organic acids is easily performed using established sampling and analysis methodologies. Odour sampling and analysis was performed in accordance with the EN13725:2003. All materials in contact with the inlet sample air stream were either stainless steel, Teflon or Nalophan. All sample bags were flushed with odourless air before commencement of the study. Lab based olfactometry is very limited in its ability to assess ambient odour concentrations unless they are in significant high concentration whereby downwind odour concentrations are in the region of greater than 100 Ou_E m^{-3}.

Grab Hydrogen sulphide sampling and analysis was performed using a Jerome gold leaf analyser. The range of detection for this instrument is from 3 ppb to 50ppm. Active pumped sampling of Mercaptans and organic acids was performed using thermal desorption sorbent tubes followed by gas chromatography mass spectrometry analysis.

Results for this survey are presented in *Section 3*. All ambient odour threshold concentrations were less than 84 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location O1. All ambient air concentrations of TVOC's were low at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

1.2 Scope of the work

The main objectives of this study include:

- Sampling and analysis of odours at 7 pre-selected locations in accordance with EN13725:2003,
- Sampling and analysis of H_2S at 7 pre-selected locations using a Jerome gold leaf analyzer. Sampling and analysis of H_2S will be performed at each of the 7 pre-selected locations.
- Sampling and analysis of Mercaptan and Organic acids at 7 pre-selected locations using active diffusion tubes. Analysis will be performed using gas chromatography mass spectrometry (GCMS) whereby the top 5 compound concentrations of Mercaptan and organic acids will be reported. If such compounds were not present, additional volatile organic compounds were reported.

2. Materials and methods

This section describes the materials and methods used throughout the monitoring on the 10th Sept. 2013.

2.1 Monitoring locations

Appendix A.1 illustrates a graphical display of the monitoring locations in the vicinity of the landfill. *Table 2.1* illustrates the geo-referenced easting and northing 6 grid coordinates for each monitoring location.

Table 2.1 Sampling locations for odour, H_2S, TVOC and active tube sampling.

Sampling location	Description	Coordinates	
-	-	Easting	Northing
O1	Western boundary, NW of civic amenity site	168081	69747
O2	Northern boundary	168373	70046
O3	Eastern boundary	168600	69691
O4	Southern boundary	168178	69276
O5	Outside main gate of landfill. Off the Kinsale Rd	167982	69648
O6	Inlet of leachate conditioning plant	168222	69651
O7	Outlet of leachate plant	165576	69457

2.2 Meteorological data

Table 2.2 illustrates the meteorological conditions recorded during the monitoring period.

Table 2.2 Meteorological conditions during the monitoring period.

Parameter	**Day 1- 10/09/13**
Wind direction (From)	Southerly
Wind speed (m s^{-1})	3
Barometric pressure	1004
Temperature (^{0}C)	14

2.3 Odour sampling

In order to obtain air samples for odour assessment, a static sampling method was used where air samples were collected in 60 litre pre-conditioned Nalophan^{NA} bags using a vacuum sampling device over a ten to twenty minute period. The sampler operates on the 'lung principle', whereby the air is removed from a rigid container around the bag by a battery powered SKC vacuum pump at a rate of 3 to 5 *l* min^{-1}. This caused the bag to fill through a stainless steel and PTFE tube whose inlet is placed in ambient air, with the volume of sample equal to the volume of air evacuated from the rigid container. All odour-sampling bags were pre-conditioned and flushed with odourless lab air to remove any interference from the sample material.

2.4 Olfactometry

Olfactometry using the human sense of smell is the most valid means of measuring odour (Dravniek et al, 1986) and at present is the most commonly used method to measure the concentration of odour in air (Hobbs et al, 1996). Olfactometry is carried out using an instrument called an olfactometer. Three different types of dynamic dilution olfactometers exist:

- Yes/No Olfactometer
- Forced Choice Olfactometer
- Triangular Forced Choice Olfactometer.

In the dynamic dilution olfactometer, the odour is first diluted and is then presented to a panel of screened panellists of no less than four (CEN, 2003) Panellists are previously screened to ensure that they have a normal sense of smell (Casey et al., 2003). According to the CEN standard this screening must be performed using a certified reference gas *n*-butanol. This screening is applied to eliminate anosmia (low sensitivity) and super-noses (high sensitivity). The odour analysis has to be undertaken in a low odour environment such as an air-conditioned odour free laboratory. Analysis should be performed preferably within 8 to 12 hours of sampling.

2.5 Odour measurement in accordance with the EN13725:2003

An ECOMA TO8 dynamic yes/no olfactometer was used throughout the measurement period to determine the odour threshold concentration of the sample air. The odour threshold concentration is defined as the dilution factor at which 50% of the panel can just detect the odour. Only those panel members who pass screening tests with n-butanol (certified reference gas, CAS 72-36-3) and who adhered to the code of behaviour were selected as panellists for olfactometry measurements (CEN, 2003). Odour measurement was carried out in an odour free laboratory in accordance with EN13725:2003.

2.5.1 What is an odour unit?

The odour concentration of a gaseous sample of odourant is determined by presenting a panel of selected screened human panellists with a sample of odourous air and varying the concentration by diluting with odourless gas, in order to determine the dilution factor at the 50% detection threshold. The Z_{50} value (threshold concentration) is expressed in odour units (Ou_E m^{-3}).

The European odour unit is that amount of odourant(s) that, when evaporated into one cubic metre of neutral gas (nitrogen), at standard conditions elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM) evaporated in one cubic meter of neutral gas at standard conditions. One EROM is that mass of a substance (n-butanol) that will elicit the Z_{50} physiological response assessed by an odour panel in accordance with this standard. *n*-Butanol is one such reference standard and is equivalent to 123µg of n-butanol evaporated in one cubic meter of neutral gas at standard conditions (CEN, 2003).

2.6 Characteristics of landfill odours

Odours from landfills may arise due to:

- Fugitive landfill gas emission from active, intermediate and/or temporary cover on waste;
- Uncontrolled landfill gas leakages from side embankments and/or top surface within landfill;
- Volatilisation and air flow stripping of odourous gases from active face/active cell;
- Puff odour emissions from tipping and spreading of waste,
- Uncontrolled emissions from landfill flaring system and leachate treatment facility, etc. This is a non-exhaustive list.

Over 300 compounds have been identified as contributors to landfill odours. These compounds are either components of waste placed in the landfills or are degradation products. Carbon dioxide and methane make up the main constituent percentage of landfill gas and are essentially non-odorous. Other odourous compounds include organic acids (acetic acid, butyric acid; hexanoic acid), terpenes (limonene, alpha Pinene, alpha Carene), mercaptans (methanthiol, ethanthiol, etc.), amines (ethanolamine, dimethylamine, trimethylamine, etc.) and Hydrogen sulphide (Sheridan, 2003). Most of these compounds have very low odour threshold concentrations as illustrated in *Table 2.3*. Different concentrations and mixtures of these compounds can intensify or reduce odour threshold concentration, determined as synergism and antagonism, respectively.

Table 2.3 Odour threshold concentration of various odourous compounds commonly found in the air streams of landfill gas.

Compound name	Molecular Formula	Odour description	Odour threshold (ppm (v/v))
Mercaptans			
Allyl mercaptan	CH_2CHCH_2SH	Disagreeable, garlic	0.0001
Methyl mercaptan	CH_3SH	Rotten cabbage	0.0005
Propyl mercaptan	C_3H_7SH	Unpleasant	0.0005
Ethyl mercaptan	C_2H_5SH	Decayed cabbage	0.0003
Sulphides			
Hydrogen sulphide	H_2S	Rotten eggs	0.0005
Dimethyl di sulphide	$C_2H_6S_2$	Rotten cabbage/vegetables	0.0003- 0.0068
Carbon disulphide	CS_2	Intense Rubber/skunk	0.006-0.010
Amines			
Trimethyl amine	$(CH_3)_3N$	Pungent, fishy	0.0004
n-Butyl amine	$CH_3(CH_2)NH_2$	Sour, ammonia	0.080
Organic acids			
Acetic acid	CH_3COOH	Sour	1.0
Butyric acid	$CH_3(CH_2)_2COOH$	Sweet rancid	0.0004
Valeric acid	$CH_3(CH_2)_4COOH$	Rancid	0.0008

2.7 Hydrogen sulphide sampling and analysis

H_2S is commonly associated with landfills, WWTP and sludge operations. It is used as an indicator gas for the assessment of significant odour nuisance in the vicinity of landfills. Published data suggests that in order to prevent significant nuisance associated with landfill and composting operations Hydrogen sulphide concentrations should not exceed 30 ppb in the ambient environment. The only instrument capable of providing comparison with such reference levels is a Jerome metre or ppb continuous H_2S gas analyser. Both instruments are real time data-logging H_2S analysers. During this survey, Odour Monitoring Ireland used the Jerome gold leaf analyser for the measurement of ambient hydrogen sulphide levels.

H_2S measurement was performed during odour sampling. The Jerome metre is the only instrument capable of measurement H_2S in real time over the measurement range 3 ppb to 50 ppm in 1 ppb increments.

2.8 Active ambient sorbent tube monitoring for Mercaptans and Organic acids

Active sorbent tube analysis involves the adsorption/absorption of ambient specific volatile organic compound group through active sorption and analysis using thermal desorption gas chromatography mass spectrometry (TD GCMS). TD GCMS provides both semi-quantitative and qualitative results. Careful analysis of the results will allow for the identification of specific compounds that may be responsible for ambient odour but will not provide a basis of quantification of odour due to the complexities of odour synergistic. Isolation of the emission source and active sampling using an USEPA flux chamber will provide the only method of providing accurate quantification and development of emission rates. This is not required within this scope of work.

A specific two-bed sorption tube is used for accurate capture of Mercaptans and Organic acids. Tenax/Unicarb silcosteel coated active sorption tubes were used to bind the compounds upon the tube during the exposure event. Silcosteel coating upon the tube is provided to prevent reactive species such as Mercaptans breaking down and therefore will provide accurate capture for desorption upon the thermal desorption GCMS. They are then transported to the analysis laboratory in flexible airtight containers. Odour Monitoring Ireland is provided with a list of all compounds detected upon the sorption tubes whereby all Mercaptans and Organic acid species are presented within the report. The total volatile organic compounds were presented from the tube screen. All detection concentration results are presented in $\mu g\ m^{-3}$.

2.9 Continuous TVOC monitoring using a ppb Photo-ionisation detector (PID)

Additionally, Odour Monitoring Ireland performed ambient total volatile organic compounds (TVOC) analysis in ppb with a Photo-ionisation Detector (PID) at each selected location during odour sampling. A PID uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC's molecules are ionised. Therefore, PID measurements are non-destructive and therefore maintain sample integrity where samples can be bagged and used for further analysis (Sheridan, 2004).

3. Results

This section presents the result obtained throughout the study period.

3.1 Odour threshold concentration results

Tables 3.1 illustrate the odour threshold concentration results obtained during the monitoring period. All sampling and analysis was performed in accordance with the EN13725:2003.

Table 3.1. Odour threshold concentration results following monitoring of Kinsale Road Landfill, Kinsale Road, Cork.

Code	Date/Time	Sample number	Odour threshold conc. (OuE m^{-3})	Comment
1	10/09/2013	O1	84	No distinct odour
2	10/09/2013	O2	72	No distinct odour
3	10/09/2013	O3	62	No distinct odour
4	10/09/2013	O4	62	No distinct odour
5	10/09/2013	O5	78	No distinct odour
6	10/09/2013	O6	67	No distinct odour
7	10/09/2013	O7	53	No distinct odour

The odour results presented on *Table 3.1* indicate that maximum odour concentration of 84 Ou_E/m^3 was recorded at Sample locations O1.

3.2 Hydrogen sulphide and Total volatile organic compounds (TVOC) results

Table 3.2 illustrates the hydrogen sulphide and TVOC results obtained during the monitoring period.

Table 3.2. Hydrogen sulphide and TVOC (PID) measured during the odour and VOC audit at Kinsale Road Landfill, Kinsale Road, Cork.

Date/Time	Sample location	H2S (ppb)	TVOC (ppb)
10/09/2013	O1	3	7
10/09/2013	O2	3	7
10/09/2013	O3	3	5
10/09/2013	O4	3	5
10/09/2013	O5	3	9
10/09/2013	O6	3	7
10/09/2013	O7	3	11

Notes: [1] denotes that Jerome H_2S analyser lower limits of detection is 3 ppb with a resolution of 1 ppb.

The hydrogen sulphide results presented on *Table 3.2* indicates no significant amount of hydrogen sulphide was detected within and in the vicinity of the Kinsale Road Landfill. The TVOC (as measured with the PID) results are presented on *Table 3.2*.

3.3 Speciated Volatile organic compound results

Tables 3.3 to 3.10 illustrate the speciated VOC results obtained during the monitoring period. All monitoring was performed in accordance with methodologies contained within USEPA Method TO17 and MDHS 72.

Table 3.3. Active sampling results for monitoring location O1.

Location	Compound	Concentration ($\mu g/m^3$)
O1	No compound defined	0
	Total Volatile Organic Compounds	0.89

Table 3.4. Active sampling results for monitoring location O2.

Location	Compound	Concentration ($\mu g/m^3$)
O2	No compound defined	0
	Total Volatile Organic Compounds	1.08

Table 3.5. Active sampling results for monitoring location O3.

Location	Compound	Concentration ($\mu g/m^3$)
O3	No compound defined	0
	Total Volatile Organic Compounds	1.21

Table 3.6. Active sampling results for monitoring location O4.

Location	Compound	Concentration ($\mu g/m^3$)
O4	No compound defined	0
	Total Volatile Organic Compounds	0.77

Table 3.7. Active sampling results for monitoring location O5.

Location	Compound	Concentration ($\mu g/m^3$)
O5	No compound defined	0
	Total Volatile Organic Compounds	0.99

Table 3.8. Active sampling results for monitoring location O6.

Location	Compound	Concentration ($\mu g/m^3$)
O6	No compound defined	0
	Total Volatile Organic Compounds	1.31

Table 3.9. Active sampling results for monitoring location O7.

Location	Compound	Concentration ($\mu g/m^3$)
O7	No compound defined	0
	Total Volatile Organic Compounds	0.76

Table 3.10. TVOC concentration results from monitoring locations at Kinsale Road Landfill, Kinsale Rd, Cork.

Monitoring Location	Analysis	TVOC concentration (ug/m^3)
O1	TVOC	0.89
O2	TVOC	1.08
O3	TVOC	1.21
O4	TVOC	0.77
O5	TVOC	0.99
O6	TVOC	1.31
O7	TVOC	0.76

Tables 3.3 to 3.10 illustrate the active sorption GCMS screens obtained during the survey period. As can be observed no compounds were defined during the monitoring event. *Table 3.10* illustrates a comparison between the total speciated volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

4. Conclusions

The following conclusions are drawn from the study:

1. All sampling and analysis was performed in accordance with the EN13725:2003.
2. All ambient odour threshold concentrations were less than 84 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location at O1.
3. Hydrogen sulphide concentrations recorded at each monitoring location were less than 3ppb in ambient air.
4. *Table 3.3* to *3.10* illustrates total volatile organic carbon in the air stream at all monitoring locations during the active sampling exercise. All ambient air concentrations were low and well within any respective exposure threshold concentrations.
5. *Table 3.10* illustrates a comparison between the total volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

5. *Appendix I* –Monitoring locations in graphical format

ODOUR & ENVIRONMENTAL CONSULTANTS

Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath

Tel: +353 46 9437922
Mobile: +353 86 8550401
E-mail: info@odourireland.com
www.odourireland.com

ODOUR, HYDROGEN SULPHIDE, MERCAPTANS AND ORGANIC ACIDS SAMPLING AND ANALYSIS WITHIN KINSALE ROAD LANDFILL, QTR.4 2013

PERFORMED ON BEHALF OF CORK CITY COUNCIL BY ODOUR MONITORING IRELAND

PREPARED BY: Dr. John Casey
ATTENTION: Mr. Kevin Ryan
DATE: 06th Jan. 2014
REPORT NUMBER: 2014005(1)
DOCUMENT VERSION: Document Ver. 001
REVIEWERS:

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Section **Page number**

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Client: ***Cork City Council***

Title: Odour, Hydrogen sulphide, Mercaptans and organic acids sampling and analysis within Kinsale Road landfill, Kinsale Rd, Cork – Quarter 4 2013.

Project Number: 2014005(1)			**Document Reference:** Ambient air monitoring in the vicinity of Kinsale Road landfill, Kinsale Rd, Cork- Quarter 4 2013		
2014005(1)	Document for review	JWC	BAS	BAS	06/01/2014
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1. Introduction and scope

1.1 Introduction

Odour Monitoring Ireland was commissioned by Kinsale Road Landfill, Cork City Council to perform:

- Odour sampling and analysis in accordance with the EN13725:2003,
- Hydrogen sulphide (H_2S) sampling and analysis using a Gold leaf Jerome analyser,
- Continuous Total volatile organic compound (TVOC) utilising a ppb Photo ionisation detector (PID),
- Ambient air sampling and analysis for Mercaptans and Organic acids using active pumped sorbent tubes and analysis by thermal desorption gas chromatography mass spectrometry (TD GCMS) (EPA TO17).

Sampling and analysis of Odour, Hydrogen sulphide (H_2S), Mercaptans and Organic acids is easily performed using established sampling and analysis methodologies. Odour sampling and analysis was performed in accordance with the EN13725:2003. All materials in contact with the inlet sample air stream were either stainless steel, Teflon or Nalophan. All sample bags were flushed with odourless air before commencement of the study. Lab based olfactometry is very limited in its ability to assess ambient odour concentrations unless they are in significant high concentration whereby downwind odour concentrations are in the region of greater than 100 Ou_E m^{-3}.

Grab Hydrogen sulphide sampling and analysis was performed using a Jerome gold leaf analyser. The range of detection for this instrument is from 3 ppb to 50ppm. Active pumped sampling of Mercaptans and organic acids was performed using thermal desorption sorbent tubes followed by gas chromatography mass spectrometry analysis.

Results for this survey are presented in *Section 3*. All ambient odour threshold concentrations were less than 72 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location O1. All ambient air concentrations of TVOC's were low at all monitoring locations. Monitoring location O3 recorded the highest TVOC concentration.

1.2 Scope of the work

The main objectives of this study include:

- Sampling and analysis of odours at 7 pre-selected locations in accordance with EN13725:2003,
- Sampling and analysis of H_2S at 7 pre-selected locations using a Jerome gold leaf analyzer. Sampling and analysis of H_2S will be performed at each of the 7 pre-selected locations.
- Sampling and analysis of Mercaptan and Organic acids at 7 pre-selected locations using active diffusion tubes. Analysis will be performed using gas chromatography mass spectrometry (GCMS) whereby the top 5 compound concentrations of Mercaptan and organic acids will be reported. If such compounds were not present, additional volatile organic compounds were reported.

2. Materials and methods

This section describes the materials and methods used throughout the monitoring on the 05th Nov. 2013.

2.1 Monitoring locations

Appendix A.1 illustrates a graphical display of the monitoring locations in the vicinity of the landfill. *Table 2.1* illustrates the geo-referenced easting and northing 6 grid coordinates for each monitoring location.

Table 2.1 Sampling locations for odour, H_2S, TVOC and active tube sampling.

Sampling location	Description	Coordinates	
-	-	Easting	Northing
O1	Western boundary, NW of civic amenity site	168081	69747
O2	Northern boundary	168373	70046
O3	Eastern boundary	168600	69691
O4	Southern boundary	168178	69276
O5	Outside main gate of landfill. Off the Kinsale Rd	167982	69648
O6	Inlet of leachate conditioning plant	168222	69651
O7	Outlet of leachate plant	165576	69457

2.2 Meteorological data

Table 2.2 illustrates the meteorological conditions recorded during the monitoring period.

Table 2.2 Meteorological conditions during the monitoring period.

Parameter	**Day 1- 05/11/13**
Wind direction (From)	Southerly
Wind speed (m s^{-1})	4
Barometric pressure	1010
Temperature (^{0}C)	9

2.3 Odour sampling

In order to obtain air samples for odour assessment, a static sampling method was used where air samples were collected in 60 litre pre-conditioned Nalophan^{NA} bags using a vacuum sampling device over a ten to twenty minute period. The sampler operates on the 'lung principle', whereby the air is removed from a rigid container around the bag by a battery powered SKC vacuum pump at a rate of 3 to 5 *l* min^{-1}. This caused the bag to fill through a stainless steel and PTFE tube whose inlet is placed in ambient air, with the volume of sample equal to the volume of air evacuated from the rigid container. All odour-sampling bags were pre-conditioned and flushed with odourless lab air to remove any interference from the sample material.

2.4 Olfactometry

Olfactometry using the human sense of smell is the most valid means of measuring odour (Dravniek et al, 1986) and at present is the most commonly used method to measure the concentration of odour in air (Hobbs et al, 1996). Olfactometry is carried out using an instrument called an olfactometer. Three different types of dynamic dilution olfactometers exist:

- Yes/No Olfactometer
- Forced Choice Olfactometer
- Triangular Forced Choice Olfactometer.

In the dynamic dilution olfactometer, the odour is first diluted and is then presented to a panel of screened panellists of no less than four (CEN, 2003) Panellists are previously screened to ensure that they have a normal sense of smell (Casey et al., 2003). According to the CEN standard this screening must be performed using a certified reference gas *n*-butanol. This screening is applied to eliminate anosmia (low sensitivity) and super-noses (high sensitivity). The odour analysis has to be undertaken in a low odour environment such as an air-conditioned odour free laboratory. Analysis should be performed preferably within 8 to 12 hours of sampling.

2.5 Odour measurement in accordance with the EN13725:2003

An ECOMA TO8 dynamic yes/no olfactometer was used throughout the measurement period to determine the odour threshold concentration of the sample air. The odour threshold concentration is defined as the dilution factor at which 50% of the panel can just detect the odour. Only those panel members who pass screening tests with n-butanol (certified reference gas, CAS 72-36-3) and who adhered to the code of behaviour were selected as panellists for olfactometry measurements (CEN, 2003). Odour measurement was carried out in an odour free laboratory in accordance with EN13725:2003.

2.5.1 What is an odour unit?

The odour concentration of a gaseous sample of odourant is determined by presenting a panel of selected screened human panellists with a sample of odourous air and varying the concentration by diluting with odourless gas, in order to determine the dilution factor at the 50% detection threshold. The Z_{50} value (threshold concentration) is expressed in odour units (Ou_E m^{-3}).

The European odour unit is that amount of odourant(s) that, when evaporated into one cubic metre of neutral gas (nitrogen), at standard conditions elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM) evaporated in one cubic meter of neutral gas at standard conditions. One EROM is that mass of a substance (n-butanol) that will elicit the Z_{50} physiological response assessed by an odour panel in accordance with this standard. *n*-Butanol is one such reference standard and is equivalent to 123µg of n-butanol evaporated in one cubic meter of neutral gas at standard conditions (CEN, 2003).

2.6 Characteristics of landfill odours

Odours from landfills may arise due to:

- Fugitive landfill gas emission from active, intermediate and/or temporary cover on waste;
- Uncontrolled landfill gas leakages from side embankments and/or top surface within landfill;
- Volatilisation and air flow stripping of odourous gases from active face/active cell;
- Puff odour emissions from tipping and spreading of waste,
- Uncontrolled emissions from landfill flaring system and leachate treatment facility, etc. This is a non-exhaustive list.

Over 300 compounds have been identified as contributors to landfill odours. These compounds are either components of waste placed in the landfills or are degradation products. Carbon dioxide and methane make up the main constituent percentage of landfill gas and are essentially non-odorous. Other odourous compounds include organic acids (acetic acid, butyric acid; hexanoic acid), terpenes (limonene, alpha Pinene, alpha Carene), mercaptans (methanthiol, ethanthiol, etc.), amines (ethanolamine, dimethylamine, trimethylamine, etc.) and Hydrogen sulphide (Sheridan, 2003). Most of these compounds have very low odour threshold concentrations as illustrated in *Table 2.3*. Different concentrations and mixtures of these compounds can intensify or reduce odour threshold concentration, determined as synergism and antagonism, respectively.

Table 2.3 Odour threshold concentration of various odourous compounds commonly found in the air streams of landfill gas.

Compound name	Molecular Formula	Odour description	Odour threshold (ppm (v/v))
Mercaptans			
Allyl mercaptan	CH_2CHCH_2SH	Disagreeable, garlic	0.0001
Methyl mercaptan	CH_3SH	Rotten cabbage	0.0005
Propyl mercaptan	C_3H_7SH	Unpleasant	0.0005
Ethyl mercaptan	C_2H_5SH	Decayed cabbage	0.0003
Sulphides			
Hydrogen sulphide	H_2S	Rotten eggs	0.0005
Dimethyl di sulphide	$C_2H_6S_2$	Rotten cabbage/vegetables	0.0003- 0.0068
Carbon disulphide	CS_2	Intense Rubber/skunk	0.006-0.010
Amines			
Trimethyl amine	$(CH_3)_3N$	Pungent, fishy	0.0004
n-Butyl amine	$CH_3(CH_2)NH_2$	Sour, ammonia	0.080
Organic acids			
Acetic acid	CH_3COOH	Sour	1.0
Butyric acid	$CH_3(CH_2)_2COOH$	Sweet rancid	0.0004
Valeric acid	$CH_3(CH_2)_4COOH$	Rancid	0.0008

2.7 Hydrogen sulphide sampling and analysis

H_2S is commonly associated with landfills, WWTP and sludge operations. It is used as an indicator gas for the assessment of significant odour nuisance in the vicinity of landfills. Published data suggests that in order to prevent significant nuisance associated with landfill and composting operations Hydrogen sulphide concentrations should not exceed 30 ppb in the ambient environment. The only instrument capable of providing comparison with such reference levels is a Jerome metre or ppb continuous H_2S gas analyser. Both instruments are real time data-logging H_2S analysers. During this survey, Odour Monitoring Ireland used the Jerome gold leaf analyser for the measurement of ambient hydrogen sulphide levels.

H_2S measurement was performed during odour sampling. The Jerome metre is the only instrument capable of measurement H_2S in real time over the measurement range 3 ppb to 50 ppm in 1 ppb increments.

2.8 Active ambient sorbent tube monitoring for Mercaptans and Organic acids

Active sorbent tube analysis involves the adsorption/absorption of ambient specific volatile organic compound group through active sorption and analysis using thermal desorption gas chromatography mass spectrometry (TD GCMS). TD GCMS provides both semi-quantitative and qualitative results. Careful analysis of the results will allow for the identification of specific compounds that may be responsible for ambient odour but will not provide a basis of quantification of odour due to the complexities of odour synergistic. Isolation of the emission source and active sampling using an USEPA flux chamber will provide the only method of providing accurate quantification and development of emission rates. This is not required within this scope of work.

A specific two-bed sorption tube is used for accurate capture of Mercaptans and Organic acids. Tenax/Unicarb silcosteel coated active sorption tubes were used to bind the compounds upon the tube during the exposure event. Silcosteel coating upon the tube is provided to prevent reactive species such as Mercaptans breaking down and therefore will provide accurate capture for desorption upon the thermal desorption GCMS. They are then transported to the analysis laboratory in flexible airtight containers. Odour Monitoring Ireland is provided with a list of all compounds detected upon the sorption tubes whereby all Mercaptans and Organic acid species are presented within the report. The total volatile organic compounds were presented from the tube screen. All detection concentration results are presented in $\mu g\ m^{-3}$.

2.9 Continuous TVOC monitoring using a ppb Photo-ionisation detector (PID)

Additionally, Odour Monitoring Ireland performed ambient total volatile organic compounds (TVOC) analysis in ppb with a Photo-ionisation Detector (PID) at each selected location during odour sampling. A PID uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC's molecules are ionised. Therefore, PID measurements are non-destructive and therefore maintain sample integrity where samples can be bagged and used for further analysis (Sheridan, 2004).

3. Results

This section presents the result obtained throughout the study period.

3.1 Odour threshold concentration results

Tables 3.1 illustrate the odour threshold concentration results obtained during the monitoring period. All sampling and analysis was performed in accordance with the EN13725:2003.

Table 3.1. Odour threshold concentration results following monitoring of Kinsale Road Landfill, Kinsale Road, Cork.

Code	Date/Time	Sample number	Odour threshold conc. (OuE m^{-3})	Comment
1	05/11/2013	O1	72	No distinct odour
2	05/11/2013	O2	67	No distinct odour
3	05/11/2013	O3	57	No distinct odour
4	05/11/2013	O4	57	No distinct odour
5	05/11/2013	O5	72	No distinct odour
6	05/11/2013	O6	62	No distinct odour
7	05/11/2013	O7	49	No distinct odour

The odour results presented on *Table 3.1* indicate that maximum odour concentration of 72 Ou_E/m^3 was recorded at Sample locations O1.

3.2 Hydrogen sulphide and Total volatile organic compounds (TVOC) results

Table 3.2 illustrates the hydrogen sulphide and TVOC results obtained during the monitoring period.

Table 3.2. Hydrogen sulphide and TVOC (PID) measured during the odour and VOC audit at Kinsale Road Landfill, Kinsale Road, Cork.

Date/Time	Sample location	H2S (ppb)	TVOC (ppb)
05/11/2013	O1	3	5
05/11/2013	O2	3	5
05/11/2013	O3	3	5
05/11/2013	O4	3	5
05/11/2013	O5	3	8
05/11/2013	O6	3	5
05/11/2013	O7	3	6

Notes: [1] denotes that Jerome H_2S analyser lower limits of detection is 3 ppb with a resolution of 1 ppb.

The hydrogen sulphide results presented on *Table 3.2* indicates no significant amount of hydrogen sulphide was detected within and in the vicinity of the Kinsale Road Landfill. The TVOC (as measured with the PID) results are presented on *Table 3.2*.

3.3 Speciated Volatile organic compound results

Tables 3.3 to 3.10 illustrate the speciated VOC results obtained during the monitoring period. All monitoring was performed in accordance with methodologies contained within USEPA Method TO17 and MDHS 72.

Table 3.3. Active sampling results for monitoring location O1.

Location	Compound	Concentration ($\mu g/m^3$)
O1	No compound defined	0
	Total Volatile Organic Compounds	0.77

Table 3.4. Active sampling results for monitoring location O2.

Location	Compound	Concentration ($\mu g/m^3$)
O2	No compound defined	0
	Total Volatile Organic Compounds	0.81

Table 3.5. Active sampling results for monitoring location O3.

Location	Compound	Concentration ($\mu g/m^3$)
O3	No compound defined	0
	Total Volatile Organic Compounds	0.85

Table 3.6. Active sampling results for monitoring location O4.

Location	Compound	Concentration ($\mu g/m^3$)
O4	No compound defined	0
	Total Volatile Organic Compounds	0.68

Table 3.7. Active sampling results for monitoring location O5.

Location	Compound	Concentration ($\mu g/m^3$)
O5	No compound defined	0
	Total Volatile Organic Compounds	0.55

Table 3.8. Active sampling results for monitoring location O6.

Location	Compound	Concentration ($\mu g/m^3$)
O6	No compound defined	0
	Total Volatile Organic Compounds	1.54

Table 3.9. Active sampling results for monitoring location O7.

Location	Compound	Concentration ($\mu g/m^3$)
O7	No compound defined	0
	Total Volatile Organic Compounds	0.65

Table 3.10. TVOC concentration results from monitoring locations at Kinsale Road Landfill, Kinsale Rd, Cork.

Monitoring Location	Analysis	TVOC concentration (ug/m^3)
O1	TVOC	0.77
O2	TVOC	0.81
O3	TVOC	0.85
O4	TVOC	0.68
O5	TVOC	0.55
O6	TVOC	1.54
O7	TVOC	0.65

Tables 3.3 to 3.10 illustrate the active sorption GCMS screens obtained during the survey period. As can be observed no compounds were defined during the monitoring event. *Table 3.10* illustrates a comparison between the total speciated volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O6 recorded the highest TVOC concentration.

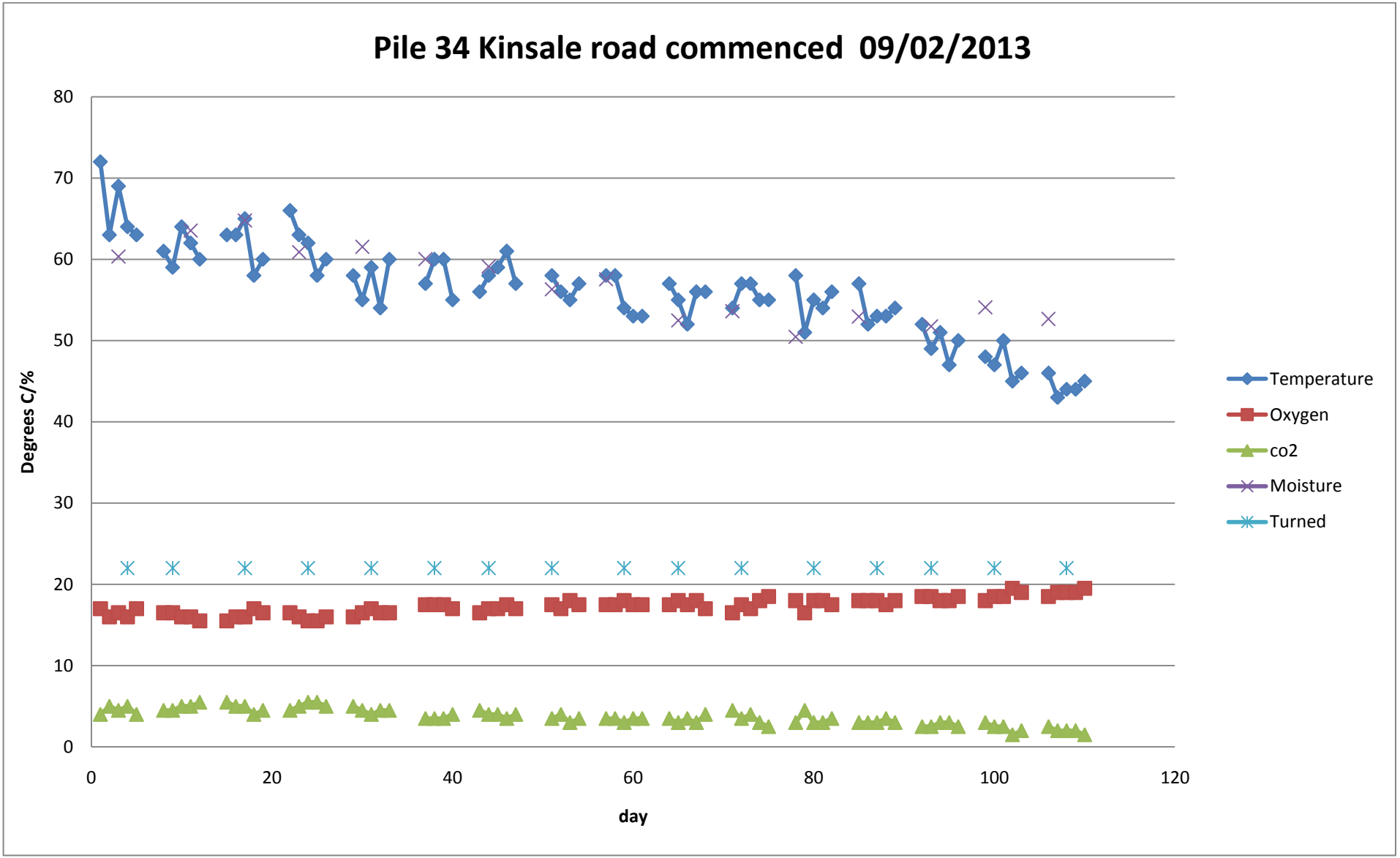
4. Conclusions

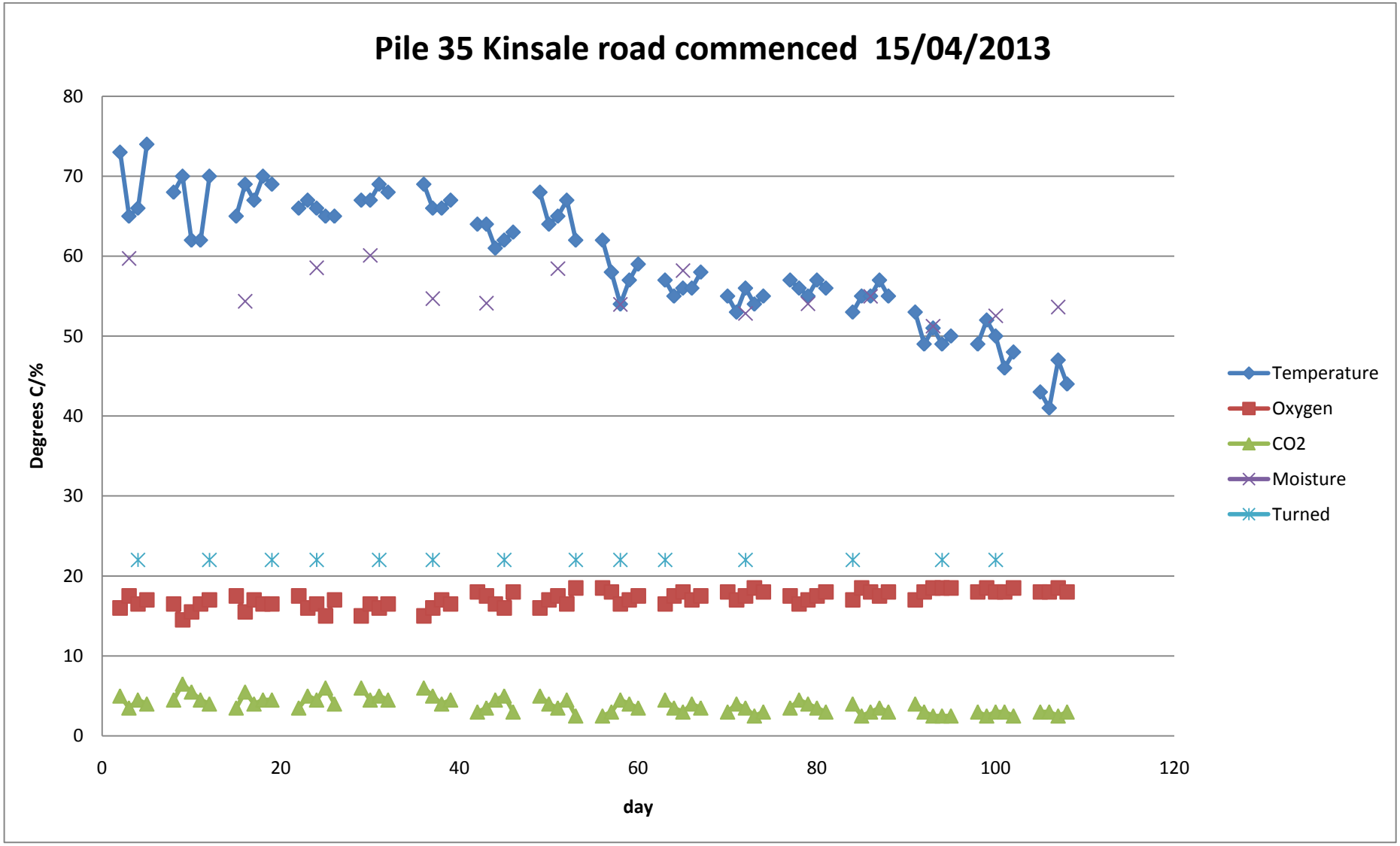
The following conclusions are drawn from the study:

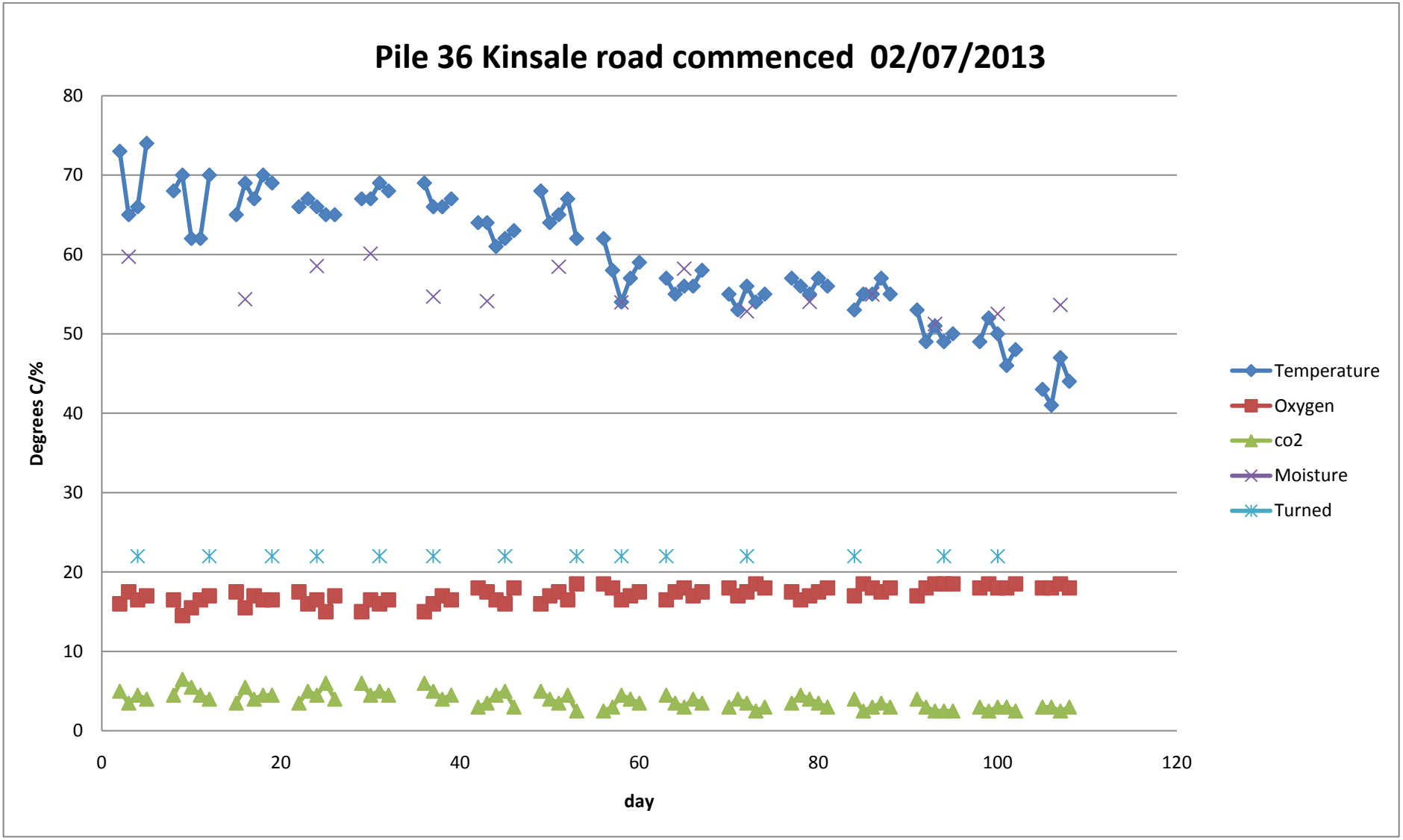
1. All sampling and analysis was performed in accordance with the EN13725:2003.
2. All ambient odour threshold concentrations were less than 72 Ou_E m^{-3}. The highest odour threshold concentration was detected at monitoring location at O1.
3. Hydrogen sulphide concentrations recorded at each monitoring location were less than 3ppb in ambient air.
4. *Table 3.3* to *3.10* illustrates total volatile organic carbon in the air stream at all monitoring locations during the active sampling exercise. All ambient air concentrations were low and well within any respective exposure threshold concentrations.
5. *Table 3.10* illustrates a comparison between the total volatile organic compounds (TVOC's) detected at all monitoring locations. Monitoring location O6 recorded the highest TVOC concentration.

5. *Appendix I* –Monitoring locations in graphical format

COMPOST DATA – KINSALE ROAD LANDFILL SITE 2013




Pile 35 Kinsale road commenced 15/04/2013
Degrees C/%
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
day
Temperature
Oxygen
CO2
Moisture
Turned


Pile 36 Kinsale road commenced 02/07/2013
Degrees C/%
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
day
Temperature
Oxygen
co2
Moisture
Turned

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Independent Analytical Supplies

Test Report

Lab Report Number:	**9903F03**	**Analysis Number:**	**99A/65625**

Customer ID:	CTO.E1	**Analysis Type:**	Misc. Tests (99A)
Contact Name:		**Delivery By:**	Customer
Company Name:	CTO ENVIRONMENTAL SOLUTIONS LTD	**Sample Card Number:**	17415/4
Address:	ROSTELLAN MIDDLETON CO CORK	**Sample Condition:**	Acceptable
Sample Type:	Compost	**Date Sample Received:**	18/06/2013
Sample Reference:	COMPOST	**Date Analysis Commenced:**	18/06/2013
Sample Description:	KINSALE ROAD MARCH 2013	**Date Certificate Issued:**	28/06/2013

Parameter	Method	Result	Unit
Arsenic*	ICP-MS	4.47	mg/kg DM
Cadmium*	ICP-MS	0.49	mg/kg DM
Chromium*	ICP-MS	13.15	mg/kg DM
Copper*	ICP-MS	49.4	mg/kg DM
Mercury*	ICP-MS	0.20	mg/kg DM
Nickel*	ICP-MS	14.4	mg/kg DM
Lead*	ICP-MS	60.5	mg/kg DM
Zinc*	ICP-MS	161.7	mg/kg DM
AT4 over 4 days*	OxiTop Control System SOP 2010	0.6	mg O2/g DM
Chloride*	Ion Selective Electrode	not poss	mg/kg
Carbon Nitrogen Ratio*	Calculation	12:1	R
Dry Matter*	Drying @ 105°C	51.36	%
E-Coli*^	Pour Plate	240	mpn/g
Potassium*	ICP-MS	6923	mg/kg DM
Kjeldahl Nitrogen*	Kjeldahl Nitrogen	1.5	%
Organic Matter	Dry Ashing @ 500 SOP 2007	32.4	%
Total Phosphorus*	ICP-MS	2589	mg/kg DM
pH*	Electrometry SOP 2001	8.9	pH units
Salmonella**^	ELISA	ND	25g
Sulphate 2:1 Water:Soil (SO3)*	BS 1377 : Part3 : 1990	not poss	%
Total Organic Carbon*	Oxidation & Colourimetry	not poss	mg/l
Mean of AT4*	Calculation	0.58	mg O2/g DM
Standard Deviation of AT4*	Calculation	0.01	

Signed: WD McCall Date: 28/06/2013

Wendy McCall - Laboratory Manager

*** = not INAB Accredited ^ = Subcontracted**

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.1275

IAS LABORATORIES, Unit 4 Bagenalstown Bus. Park, Bagenalstown, Co. Carlow,

Phone: 00353 59 9721022 Fax: 00353 59 9721897 Email: ias@iaslabs.ie Web: www.iaslabs.ie

IAS LABORATORIES

Independent Analytical Supplies

Test Report

Lab Report Number:	**2790G03**	**Analysis Number:**	**99A/67560**

Customer ID:	CTO.E1	**Analysis Type:**	Misc. Tests (99A)
Contact Name:	AIDAN STAFFORD	**Delivery By:**	Courier
Company Name:	CTO ENVIRONMENTAL SOLUTIONS LTD	**Sample Card Number:**	20548/4
Address:	ROSTELLAN MIDDLETON CO CORK	**Sample Condition:**	Acceptable
Sample Type:	Compost	**Date Sample Received:**	23/10/2013
Sample Reference:	COMPOST SAMPLES	**Date Analysis Commenced:**	23/10/2013
Sample Description:	KINSALE ROAD JULY 2013	**Date Certificate Issued:**	19/11/2013

Parameter	Method	Result	Unit
Arsenic	ICP-MS	<1	mg/kg DM
Cadmium	ICP-MS	0.38	mg/kg DM
Chromium	ICP-MS	6.63	mg/kg DM
Copper	ICP-MS	19.5	mg/kg DM
Mercury	ICP-MS	0.32	mg/kg DM
Nickel	ICP-MS	7.3	mg/kg DM
Zinc	ICP-MS	99.5	mg/kg DM
Lead	ICP-MS	31.3	mg/kg DM
AT4 over 4 days	OxiTop Control System SOP 2010	12.8	mg O2/g DM
Chloride	Ion Selective Electrode	not poss	mg/kg
Carbon Nitrogen Ratio	Calculation	20:1	R
Dry Matter	Drying @ 105°C	59.9	%
Potassium	ICP-MS	8527	mg/kg DM
Kjeldahl Nitrogen	Kjeldahl Nitrogen	1.8	% DM
Organic Matter	Dry Ashing @ 500 SOP 2007	66.3	%
Total Phosphorus	ICP-MS	2267	mg/kg DM
pH	Electrometry SOP 2001	7.1	pH units
Sulphate 2:1 Water:Soil (SO3)	BS 1377 : Part3 : 1990	not poss	%
Total Organic Carbon	Oxidation & Colourimetry	not poss	mg/l
Presumptive E-Coli^	Based in ISO 7251 (2005)	>1100	mpn/g
Mean of AT4	Calculation	12.75	mg O2/g DM
Salmonella^	Based on RayAL ELISA	Not detected	/ 25g
Standard Deviation of AT4	Calculation	0.07	

Signed: WD McCall Date: 19/11/2013

Wendy McCall - Laboratory Manager

^ = Subcontracted

IAS LABORATORIES, Unit 4 Bagenalstown Bus. Park, Bagenalstown, Co. Carlow,

Phone: 00353 59 9721022 Fax: 00353 59 9721897 Email: ias@iaslabs.ie Web: www.iaslabs.ie

Average Meteorological Data for 2013 - Cork Airport

Date	Rainfall (mm)	Potential Evaporation (mm)	Evaporation (mm)	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Wind Speed (kt)	Predominant Wind Direction (degree)	Mean MSL Pressure (hpa)	Mean Relative Humidity (%)
January	5.1	0.3	0.4	8.3	3.6	10	200.8	1010.7	93.8
February	1.8	0.6	0.9	7.6	2.6	10.8	198.9	1018.8	87
March	4.4	0.9	1.4	6.7	1.9	12.1	141.3	1006.5	85.6
April	3.2	1.7	2.7	10.6	4.1	12.3	204	1013.5	82.3
May	2.1	2.3	3.6	13.4	6.6	11.9	273.9	1014	81.6
June	3.9	2.8	4.2	17.3	9.6	9.4	209.5	1018.6	81.9
July	2.2	3.4	4.7	21.3	13.3	7	194.8	1019.2	83.5
August	1.7	2.1	3.1	19	11.7	8.6	243.5	1017.4	86.3
September	1.4	1.4	2	16.6	10.4	9.3	228.8	1016.3	89.1
October	5.9	0.7	1	14.7	9.2	9.6	202.9	1008.1	92.9
November	2.1	0.5	0.6	9.4	4	7.6	278.2	1020.5	86.2
December	6.8	0.3	0.5	9.2	3.5	11.7	223.2	1009.2	91.2