ANNUAL ENVIRONMENTAL REPORT 2016

TRAMORE WASTE DISPOSAL SITE

TRAMORE INTAKE & TRAMORE BURROWS

TRAMORE CO. WATERFORD

Waste Licence Register No. W0075-02

Report Compiled by;
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Introduction

Waterford County Council was granted a Waste License (Ref 75 – 1) by the Environmental Protection Agency for the continued operation of an existing unlined landfill and civic waste facility at Tramore Co. Waterford on 25th September 2001. This is the fourteenth Annual Environmental Report, which has been prepared to meet the requirements of Condition 11.8 of Waste License W0075-02 and includes the monitoring period 1st January 2016 to 31st December 2016.

The Civic Amenity Facility at Tramore Landfill was closed indefinitely on 20th November, 2009.

1. Reporting Period

This is the fourteenth Annual Environmental Report for the Tramore Landfill Facility, which covers the period 1st January 2016 to 31st December 2016.

2. Waste Activities carried out at the Facility

No longer applicable

Waste Management Act 1996: Third Schedule

Class 12. Repackaging prior to submission to any activity referred to in a preceding paragraph of this Schedule:

No longer applicable

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:

No longer applicable

Waste Management Act, 1996, Fourth Schedule

Class 2. Recycling or reclamation of organic substances, which are not used as solvents (including composting and other biological transformation processes):

No longer applicable

Class 3. Recycling or reclamation of metals and metal compounds:

No longer applicable

Class 4. Recycling or reclamation of other inorganic materials:

No longer applicable

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:

No longer applicable

Class 13. Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than the temporary storage, pending collection, on the premises where such waste is produced:

No longer applicable

3. Calculated Remaining Capacity of the Site

The Landfill has ceased accepting waste after 31st December 2005.

4. Year in which Final Capacity is expected to be reached

Final capacity has been reached on the 31st December 2005.

5. Licensed Methods of Deposition of Waste

THE CIVIC AMENITY SITE WAS CLOSED INDEFINITELY ON 20th NOVEMBER, 2009

6. Environmental-Monitoring

INTRODUCTION

This report is a compilation of environmental monitoring carried out on behalf of Waterford City and County Council at Tramore Landfill, principally during the period January 2016 to December 2016.

Monitoring of surface waters, groundwaters, and leachate quality, as well as ecological monitoring, was carried out in accordance with the waste licence 75-2, conditions 8, and schedule D.
Sampling sites are as set out in table 1, and appendix 1.

SURFACE WATER STATIONS	GROUNDWATER STATIONS	LEACHATE STATIONS	NOISE	TOXICITY ASSESSMENT	ECOLOGICAL SURVEY	SEDIMENT & SHELLFISH
SW 1,2,3,4,5,6 Weekly visual/odour inspection Quarterly and annual chemical analysis	BH 2,5,8,9,10 RC 4,5 Monthly levels. Quarterly and annual chemical & microbiological analysis Note: BH2 to be redesignated a leachate borehole.	BH 1/1, 7 RC 6a LT1, LT2, LT3, LT4, LT5 Weekly levels. Quarterly and annual chemical analysis	B1, B2 Annual survey	Leachate Annual assessment of toxicity of leachate using appropriate organisms.	Annual ecological / biological survey of backstrand. Survey of birdlife and habitats.	Annual chemical quality of sediments, cockles and mussels from backstrand. Microbiological quality of shellfish from backstrand.

Table 1. Sampling sites and monitoring requirements

Baseline Monitoring

One of the purposes of compliance monitoring is to determine if there has been a release of contaminants to the environmental media, and to demonstrate compliance with landfill licence conditions. ***Baseline monitoring*** is monitoring which serves as a reference point to which later monitoring results are compared. For the purpose of this report, results obtained during the first licensed year of operation, September 2001 to September 2002, will be used as baseline monitoring data.

Key Parameters

In line with EPA reporting recommendations[1], results trends for key parameters are presented for surface waters (BOD), groundwaters (Ammonia) and leachates (Ammonia).

[1] EPA – Landfill Monitoring Manual, 2nd Ed, 2004

Interference in metals analysis of aqueous samples from Tramore landfill and environs due to salinity.

The test method used to determine metals concentrations in aqueous samples from Tramore landfill is ICP-MS. Elements present in seawater can interfere with the test. The presence of chloride and other elements present in seawater combine with each other and the test carrier gas to form compounds which have the same atomic weights as some of the target test elements. The detector then wrongly identifies and measures these compounds as target test elements and thus gives falsely high results.

According to the Varian ICP-MS Application Note 32, the analysis of samples containing high levels of chloride typically produces polyatomic species in the plasma, which cause major interference in the most abundant isotopes of As V, Cr and Ni. The presence of other major elements such as Na, Ca and Mg in seawater can also produce polyatomic interference on isotopes of Cu, Co and Zn.

An example of this is the interference by chloride in the ICP-MS test for Arsenic. Chlorine, which has an atomic weight of c35, combines with the test carrier gas argon (mass 40). This Ar Cl complex has a combined mass of c75, which is close to atomic weight of Arsenic (75), and which leads to falsely high results.

A list of typical polyatomic interferences for the elements arsenic, chromium, copper and zinc are given in table 1.

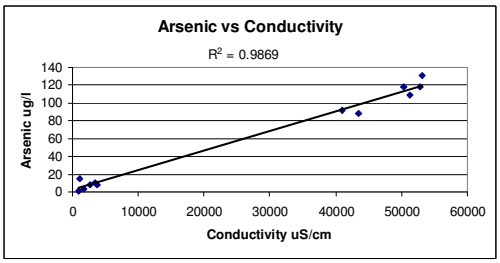
Table 1. Typical polyatomic interference – extract from Varian ICP-MS Application note 32.

Test target element	**Polyatomic interference**
^{75}Arsenic	$^{40}Ar\ ^{35}Cl$, $^{40}Ca\ ^{35}Cl$
^{52}Chromium	$^{40}Ar\ ^{12}C$, $^{40}Ca\ ^{12}C$, $^{35}Cl\ ^{16}O^{1}H$, $^{38}Ar\ ^{14}N$
^{63}Copper	$^{40}Ar\ ^{23}Na$, $^{40}Ca\ ^{23}Na$
^{64}Zinc	$^{32}S\ ^{16}O_2$, $^{32}S_2$, $^{36}Ar\ ^{14}N_2$, $^{40}Ar\ ^{23}Na\ ^{1}H$, $^{40}Ar\ ^{24}Mg$

Examination of the Q2 2006 results of metals analysis from Tramore landfill provides evidence for such interference. Using conductivity as a proxy measure of salinity, it can be seen – see figures 1a-d - that there is a direct and strong correlation between salinity and measured metal concentration for arsenic, chromium,

copper and zinc. This holds true, even for open seawater samples, which would be expected to have very low levels of these metals.

Thus the reported results for these metals in saline samples (conductivity > 5000 us/cm) are unreliable and should be disregarded.



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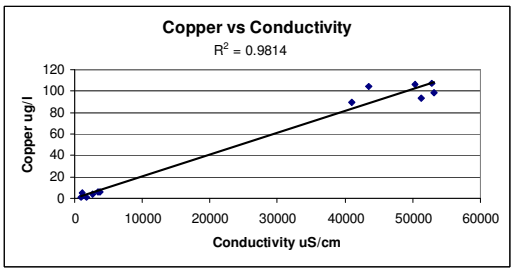

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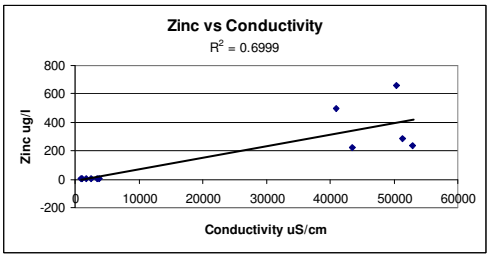

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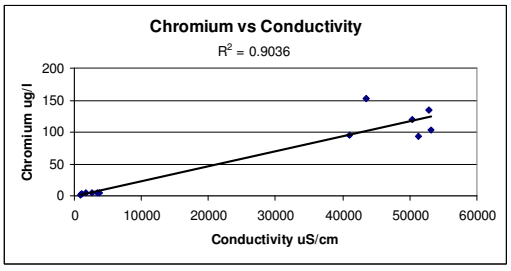


1d

Figure 1a-1d. Relationship between metals concentrations and conductivity in aqueous samples from Tramore landfill and environs, for the 2nd quarter period 2006.

7.1. SURFACE WATER.

7.1.1 Introduction

The surface water sampling sites are SW 1, 2, 3,4,5,6, as per appendix 1. Sampling was carried out by Jim McGarry, Brownstown, Kilkieran, Co. Kilkenny. Samples were analysed by ALcontrol Laboratories, Unit 7-8 Hawarden Business Park, Manor Road, Hawarden, Deeside, UK in each quarter of 2016.

Results are presented in tables 7.1.1 to 7.1.4, and Appendix B.

There are difficulties involved in monitoring surface water pollution from landfills adjacent to estuaries, as the salinity of the samples can interfere with many of the tests, (*ammonia, COD, arsenic, copper*).

Additionally, many of the ions, which are considered indicators of leachate contamination, are also major components of sea/brackish water, *(chloride*, *sulphate, sodium, magnesium, calcium, boron).*

Following the convention of previous reports on Tramore landfill, the results are compared to the standards in the Drinking Water Regulations (SI no. 106, 2009), and Bathing Water Regulations (SI no. 155, 1992).

Additionally, water quality criteria used in a recent DOELG / EPA report *("An Assessment of the Trophic Status of Estuaries and Bays in Ireland",* DOELG/EPA, 2001) are used also. These standards are presented in the tables of results for comparison.

Where possible, results are also compared to results of baseline monitoring carried out between September '01 and September '02

7.1.2 Results

Visual and odour examination indicated that there was no obvious contamination at any of the sites. There was no observed odour or floating materials, which would interfere with bathing water use. Some of the samples at sites SW1-3 from the inner back strand were cloudy, but this is normal due to the effect of tidal flushes on silt and sand.

The conductivity results indicate that sites S1 to S4 have varying degrees of brackishness, while sites SW5 and SW6 are saline.

pH and temperature are normal at all sites over the monitoring period and fall within relevant quality standards.

Dissolved oxygen levels were generally satisfactory at all the sites.

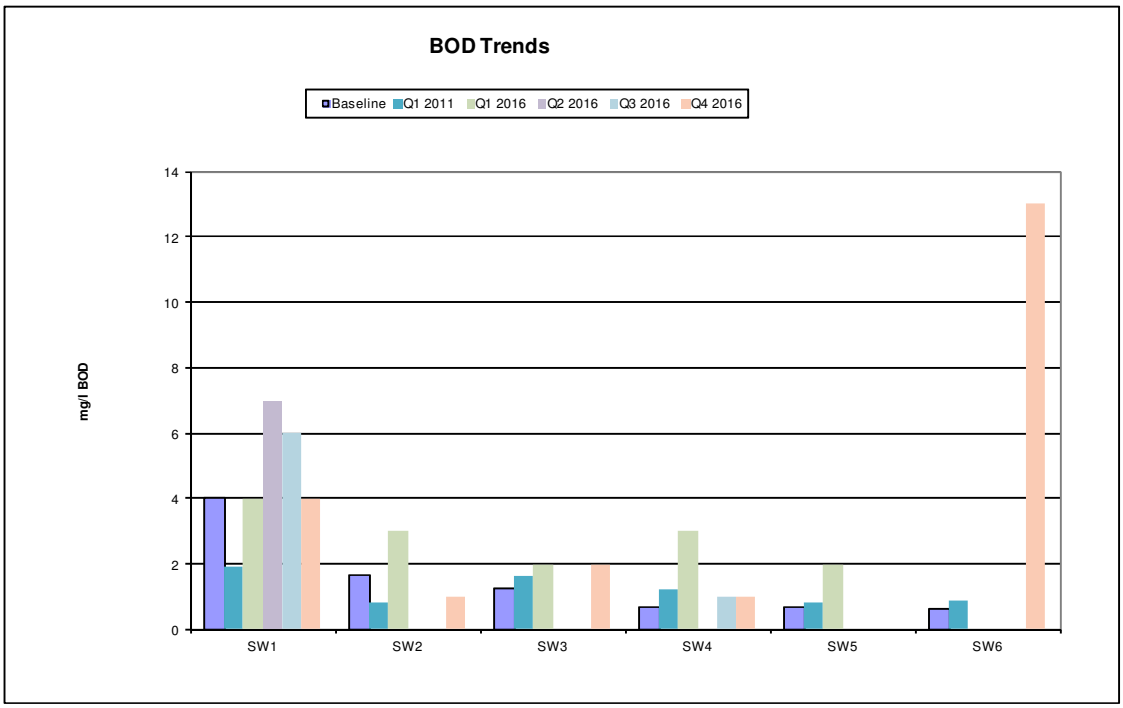
Suspended solids levels seem quite high at times at many of the sampling stations, and this may be due to test interference by salt or silt/sand entrainment in the samples, as the BOD values do not indicate the presence of significant amounts of organic matter.

Ammonia values were similar to the previous reporting period, with a decreasing trend being noted at SW1 and SW2.

Key Parameter – BOD

The BOD test is a measure of the amount of oxygen consumed by microorganisms in breaking down organic matter in water.

Respiration by phytoplankton or their decay, can also lead to oxygen depletion during the BOD test resulting in a high BOD value. Natural seawaters are likely to have a BOD value < 2 mg/l BOD.



BOD Trends 2016

BOD was generally low at all the surface water sites during 2016, although elevated levels of BOD were found at SW6 during quarter 4.

7.1.3 Discussion

The results of analysis indicate an improvement at SW1 with regards to organic matter and nutrients. It is known that an off-site storm-water discharge discharges to SW1. A constructed wetland was installed in 2011 in order to attenuate contamination at this location. There is no indication of any effect from the landfill on the surface water sites.

Quarter 1

SW1, SW2, SW3, SW4 and SW5 sites were sampled this round. BOD and ammonia were low at all sites. Suspended solids were elevated though saline or sand interference in the tests is suspected. SW5 in particular would be expected to have low suspended solids apart from possible suspension of sand. Elevated COD results were recorded at SW2, 3, 4 and 5, but deemed to be due to saline interference in the test. Given the good physicochemical water quality, there was no evidence of impact from the landfill.

Quarter 2

SW1, SW2, SW3, SW4, and SW5 sites were sampled this round. BOD was generally low at all sites, although there was a slightly elevated level at SW1.Suspended solids were elevated though saline or sand interference in the tests is suspected. SW5 in particular would be expected to have low suspended solids apart from possible suspension of sand. Elevated COD results were recorded at SW2, 3, 4 and 5, but deemed to be due to saline interference in the test. Given the good physicochemical water quality, there was no evidence of impact from the landfill.

Quarter 3

SW1, SW3, SW4, SW5 and SW6 sites were sampled this round. BOD was generally low at all sites, although there was a slightly elevated level at SW1.Suspended solids were elevated though saline or sand interference in the tests is suspected. They were elevated to a lesser degree this quarter compared to the previous one. SW5 in particular would be expected to have low suspended solids apart from possible suspension of sand. Elevated COD results were recorded at throughout, but are deemed to be due to saline interference in the test. E – Coli levels were well below threshold levels as referenced in the Bathing Water Regulations 2008. Given the good physicochemical water quality, there was no evidence of impact from the landfill.

Quarter 4

SW1, SW2, SW3, SW4, SW5 and SW6 sites were sampled this round. BOD was generally low at all sites, although there was a slightly elevated level at SW6.Suspended solids were elevated though saline or sand interference in the tests is suspected. Results were slightly elevated in comparison to the previous quarter. SW5 in particular would be expected to have low suspended solids apart from possible suspension of sand. Elevated COD results were recorded at throughout, but are deemed to be due to saline interference in the

test. E – Coli levels were well below threshold levels as referenced in the Bathing Water Regulations 2008. Given the good physicochemical water quality, there was no evidence of impact from the landfill.

Surface Water Quality Standards

Reference Water quality standard	Parameter	Limits
SURFACE WATER REGS 2009	BOD	4 (Below is good)
SURFACE WATER REGS 2009	Dissolved Oxygen % Saturation	70-130% TRANSITIONAL 80-120 COASTAL
SURFACE WATER REGS 2009	Total Oxidised Nitrogen	2.6 mg/l N at 0 psu 0.25 mg/l N at 34.5 psu
BATHING WATER REGS 2008	E coli per 100 mls	Excellent <250 Good <500 Sufficient <1000 Poor >1000

Table 7.1.1 Tramore Landfill Surface Water Monitoring Q1 2016

Tramore Landfill W0075-02 - Surface Water Results - Quarter 1 2016									
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW03**	**SW01**	**SW02**
Parameters	**Units**	**Date sampled**							
		28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	29-Mar	28-Mar
Visual Inspection/Odour		clear	clear	clear	clear	clear	clear	clear	clear
Temp	oC	8.9	9.5	8.5	7.7	8.6	9.2	8.5	9.3
pH	units	7.4	8.4	8.2	8.2	8.1	7.6	7.9	7.7
Cond	uS/cm	889	nm	nm	nm	nm	2620	1046	1193
Salinity	%	nm	33.9	33.9	32.4	33.4	nm	nm	nm
BOD	mg/l	4	3	2	3	2	3		2
COD	mg/l	13.6	475	374	431	374	<14	24.7	32.7
Sus Solids	mg/l	0.8	12.8	13	26.6	46.4	1.4	15.2	7
Ammonia Total (as N)	mg/l	<0.2	0.207	<0.2	<0.3	<0.4	0.362	0.363	0.281
Chloride(asCl)	mg/l	133	19400	19200	18700	19800	516	104	101
Total Oxidised Nitrogen	mg/l	1.37	<0.1	<0.1	<0.1	<0.1	0.911	0.593	0.278
Total Organic Carbon	mg/l	4.33	<3	<3	<3	<3	9.14	7.66	9.67
ortho-Phosphate (asP)	mg/l	0.0225	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sulphate	mg/l	38.2	2780	2500	2500	2760	104	55.8	88.4
Dissolved Oxygen	% sat	74	146	107	104	102	84	96	94

Table 7.1.2 Surface Water Monitoring Q2 2016

Tramore Landfill W0075-02 Quarter 2 2016 - Surface Water Results											
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW01**	**SW02**	**SW03**	**SW04**
Parameters	**Units**	**Date sampled**									
		26-Jun	27-Jun	26-Jun	26-Jun	26-Jun	26-Jun	27-Jun	26-Jun	26-Jun	26-Jun
Visual Inspection/Odour		Brown	clear	clear	clear	clear	clear	clear	dry	dry	seized manhole
Temp	oC	16.7	15.9	21.5	16.5	17.3	16.4	16.0			
pH	units	7.4	8.2	8.3	8.5	8.1	8.1	7.4			
Cond	uS/cm	1307	nm	nm	nm	nm	nm	820			
Salinity	%	nm	34.6	33.5	34.3	34.6	34.6	nm			
BOD	mg/l	7	<2	<2	<2	<2	<2	<5			
COD	mg/l	42.9	nm	nm	nm	nm	nm	16.4			
Sus Solids	mg/l	34.2	3.6	54.4	2.6	26.8	3.2	0.4			
Ammonia Total (as N)	mg/l	10.5	<0.2	0.263	<0.2	<0.2	35.5	<0.2			
Chloride(asCl)	mg/l	185	18300	17700	19400	18200	19600	92.5			
Sodium	mg/l	nm	nm	nm	nm	nm	nm	65.5			
Potassium	mg/l	nm	nm	nm	nm	nm	nm	<1			
Iron	mg/l	nm	nm	nm	nm	nm	nm	0.0603			
Total Organic Carbon	mg/l	9.78	<3	3.52	<3	<3	<3	7.27			
Dissolved Oxygen	% sat	44	130	107	151	103	97	55			
Total Coliforms	No/100mls	>100	nm	3	1	0	2	0			
E. coli	No/100mls	>100	nm	2	1	0	2	0			
			Full Tide								

Table 7.1.3 Tramore Landfill Surface Water Monitoring Q3 2016

Sampling Location		SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW01	SW02
Parameter	Units	Date sampled							
		30-Sep	30-Sep	02-Oct	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep
Visual Inspection/Odour		clear	No sample	clear	clear	clear	clear	clear	light brown
Temp	oC	14.3	nm	15.6	14.3	15.2	15.5	13.1	15.5
pH	units	7.0	nm	7.9	8.5	8.1	8.0	7.6	8.0
Cond	uS/cm	1551	nm	nm	nm	nm	nm	927	1377
Salinity	%	nm	nm	32	34.3	34.8	34.8	nm	nm
BOD	mg/l	6	nm	<5	1	<2	<2	<2	<2
COD	mg/l	27.1	nm	482	273	285	638	10.7	28.8
Sus Solids	mg/l	14.2	nm	16.8	4.6	14	10	1.2	13
Ammonia Total (as N)	mg/l	7.46	nm	<0.2	<0.2	<0.2	<0.2	<0.2	0.761
Chloride(asCl)	mg/l	196	nm	18700	19400	19700	19800	119	129
Total Organic Carbon	mg/l	8.6	nm	<3	<3	<3	<3	5.72	11.8
Dissolved Oxygen	% sat	15	nm	122	165	100	70	77	97
Total Coliforms	No/100mls	0	nm	52	31	0	0	0	0
E. coli	No/100mls	0	nm	31	31	0	0	0	0

Table 7.1.4 Tramore Landfill Surface Water Monitoring Q4 2016

Sampling Location		SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW01
Parameters	Units	Date sampled						
		21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov
Visual Inspection/Odour		clear	clear	clear	clear	clear	clear	clear
Temp	oC	7.0	5.2	5.3	7.4	7.8	7.9	4.9
Dissolved Oxygen	% sat	20	101.0	98	100	100	98	86
pH	units	7.3	8.2	8.2	8.2	8.1	8.2	8.2
Cond	uS/cm	1609	nm	nm	nm	nm	nm	987
Salinity	%	nm	34.0	34.2	34	354.6	34.6	nm
BOD	mg/l	4	1.0	2	1	<2	13	2
COD	mg/l	29.8	435.0	422	388	435	439	19.7
Sus Solids	mg/l	5.5	56.5	49.5	37.5	26.5	28.5	<2
Ammonia Total (as N)	mg/l	8.61	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chloride(asCl)	mg/l	206	20000.0	19200	19600	119900	19700	123
Total Coliforms	No/100mls	0	0	0	5	17	13	0
E. coli	No/100mls	0	0	0	5	12	13	0

7.2.2. Groundwater

7.2.1 INTRODUCTION

Samples were taken at sites BH2, BH5, BH8, BH9, RC4, RC6a, GW2, and GW5.

Borehole locations are shown on appendix 1. Drilling records, where available, for groundwater boreholes are shown on table and in the Hydrogeological Review Survey in Appendix I.

Table 7.2.1 . Drilling records for groundwater boreholes.

Name	BH2	BH5	BH8	BH9	BH10A	RC4	RC5
Nominal Type	GW	GW	GW	GW	GW	GW	GW
Total Depth (m)	4.2	3.95	7.7	8.7	13	15.3	25
Strata (m)	Made ground: hardcore fill (0-0.5) Made ground; loose mixture of gravel and rubble with fill (0.5-1.0) Made Ground: soft black sandy silt with domestic refuse (1.0-1.7) Soft/loose mixture of silt and gravel: (1.7-2.5) medium dense well graded silty gravel: (2.5-3.0) Frim brown gravelly silty clay: (3.0-4.2)	Made ground; clay and sand fill (0-0.8) Made ground: medium dense silty sand with black domestic refuse (0.8-1.8) Made ground: firm to stiff light brown gravelly clay with traces of reduse (1.8-2.9) Very stiff light brown gravelly clay (2.9-3.95)	topsoil: (0-0.3) Soft grey brown sandy silty clay: (0.3-1.2) Firm grey brown sandy clay with some gravel: (1.2-1.9) Stiff to very stiff brown silty sandy gravelly clay with cobbles and boulders: (1.9-7.7)	Made ground: grey silty clay with wood, paper and plastic (0-0.4) Firm grey brown sandy clay with some gravel (0.4-2.2 Stiff to very stiff brown silty sandy gravelly clay with cobbles and boulders (2.2-7.4 Hard brown silty laminated clay with frequent cobble and boulder size fragments of shale (7.4-8.7	Made ground : stiff brown silty gravelly clay with concrete, brick and cobbles (0-1.3) Made ground: brick, ash, wood, plastic, paper and steel (1.3-4.2) Soft grey very silty sandy clay with shells (4.2-10.2) Large limestone cobbles and boulders (11.8-13.0)	open hole (0-9.7 gravel (9.7-11.7 Siltstone (11.7-15.3	Overburden (0-20 Siltstone (20-25)
Response zone (m)	none given	not given	refers to installation sheet			12 to 14 m	21 to 24.5
Designation based on drill record				GW	GW	GW	GW

7.2.2 RESULTS

Results are presented in tables 7.2.2 to 7.2.5, and appendix D.

Groundwater monitoring results are compared with the Interim Guideline Values (IGVs) as outlined in the interim report by the environmental Protection agency, "*Towards Setting Guidelines for the Protection of Groundwater in Ireland*".

Elevated values for *Boron, Calcium, Chloride, Conductivity, Potassium and Sodium* reflect the impact of saline intrusion on borehole water characteristics. Additionally, the salinity of the samples can interfere with some of the tests, (*ammonia, arsenic, copper).* Accordingly interpretation of test results for some parameters must bear this in mind.

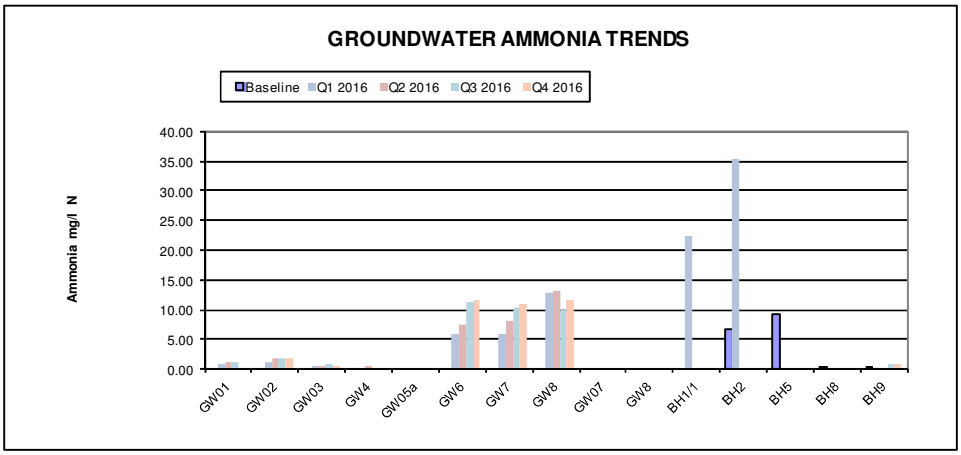
Conductivity values were elevated in many of the boreholes, reflecting significant saline intrusion at this estuarine site. A discussion of the extent of saline intrusion is beyond the scope of this environmental report, however detailed studies[2] of saline intrusion into these boreholes was carried out in 2002 and 2006.

Heavy metals, list I/II organics, phenols and coli form bacteria were low at all boreholes throughout the monitoring period.

[2] Waterford County Council, Investigation into the Occurrence of Salinity Intrusion at Tramore Landfill Site, MCOS, 2002 and RPS 2006.

AMMONIA

Ammonia occurs naturally in water bodies, including estuarine and marine waters, arising from the microbiological decomposition of nitrogenous organic matter. Fish and other aquatic organisms also excrete ammonia. Therefore unpolluted waters contain ammonia, usually < 0.1 mg/l N, although groundwaters in reducing conditions can contain higher levels.



Groundwater ammonia levels 2016

Ammonia levels were high (>5mg/l) in BH2, GW7, GW8 and RC5.

Results for 2015 were lower than baseline monitoring in most boreholes, though an increase at BH2 since baseline measurement was evident, likely due to waste degradation activity and concentration of leachate due to landfill capping.

7.2.3 DISCUSSION

The results of groundwater monitoring are in line with results from previous rounds of testing carried out since 1999. As indicated in previous reports, it appears that groundwater quality within the current working area is somewhat impacted by leachate from the landfill, as evidenced by elevated ammonia and iron levels at BH2, and RC4, though drilling records indicate that BH2 is characteristic of a leachate rather than groundwater borehole.

Heavy metals, List I/II Organics, and phenols were low at all boreholes throughout the monitoring period. As there are no groundwater abstractions in the area and given the very large dilution available in the receiving surface water estuarine environment, no significant environmental effects are expected.

Groundwater Threshold Values

Reference standard	Parameter	Groundwater Threshold Values
EC Environmental Objectives (Groundwater) Regulations , S.I. No. 9 of 2010	Ammonia(mg/l N)	0.175
	Chloride mg/l	800
	Potassium mg/l	5
	Sodium mg/l	150
	Total Oxidised Nitrogen mg/l N	8.5

Table 7.2.2 Tramore Landfill Groundwater Monitoring Q1 2016

Sampling Location	Units	BH 1/1	BH 8	BH9	GW01	GW02	GW03	GW04	GW05	GW06	GW07	GW08	BH 2
		Date sampled											
		28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar
Temp	oC	9.3	9.8	11.5	10.0	9.3	8.2	9.4	10.9	8.6	8.6	8.8	12.1
pH	units	6.8	7.3	7.0	7.5	7.3	7.1	6.9	7.2	7.0	7.0	7.1	6.82
Cond	uS/cm	3380	3980	1120	6460	10090	10060	1230	992	2190	1727	1881	19120
Salinity	%	nm	2.0	nm	3.4	5.6	5.5	nm	nm	nm	nm	nm	11.1
Ammonia Total (as N)	mg/l	22.5	<0.2	0.34	0.675	1.27	0.501	<0.2	<0.2	5.99	5.87	12.8	35.4
Chloride(asCl)	mg/l	730	1120	188	1800	2970	3080	152	118	322	206	236	5840
Total Oxidised Nitrogen	mg/l	<0.1	0.141	<0.1	0.136	<0.1	<0.1	0.404	0.978	0.136	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	8.38	109	<3	9.65	9.15	<3	<3	<3	9.27	7.61	10.4	12.4
Dissolved Oxygen	% sat	26	23	20	42	82	32	24	54	25	13	21	21
Iron	ug/l	5008	950	950	950	950	950	950	950	5003	3590	3008	6360
Potassium	mg/l	25.8	14.1	5.44	40.9	48.1	55.7	1.61	1.23	12.3	11.4	20	162
Sodium	mg/l	358	522	122	103	1430	1470	85.2	71.8	136	107	141	2820
Total Coliforms	No/100mls	26	18	12	>100	6	2	>100	17	0	0	1	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

Table 7.2.3 Tramore Landfill Groundwater Monitoring Q2 2016

Sampling Location	Units	BH 8	BH9	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
		Date sampled									
		27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun
Visual Inspection/Odour		rusty brown	muddy	light brown	sandy	brown grey	sl brown	muddy brown	cloudy grey	grey	gray pungent
Groundwater Level	m	7.1	5.7	4.2	5.2	1.4	3.0	6.8	2.6	6.6	3.7
Temp	oC	12.1	12.6	12.5	12.5	13.4	13.6	12.6	13.5	13.2	13.6
pH	units	7.2	7.2	6.9	7.2	6.9	7.0	7.2	6.9	7.0	7.2
Cond	uS/cm	5190	1060	nm	nm	nm	1186	985	1933	1817	1842
Salinity	%	2.7	nm	5.3	6.5	6.8	nm	nm	0.8	0.7	0.7
Ammonia Total (as N)	mg/l	0.312	0.588	1.27	1.92	0.448	0.393	<0.2	7.42	8.24	13.1
Chloride(asCl)	mg/l	1380	135	3560	3530	3690	94.2	106	233	196	196
Total Oxidised Nitrogen	mg/l	<0.1	<0.1	0.301	<0.1	<0.1	0.171	0.93	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	<3	<3	11.5	8.94	7.79	<3	<3	11.5	8.64	12.3
Dissolved Oxygen	% sat	23	17	65	50	34	51	27	16	15	14
Sodium	mg/l	691	115	1670	1620	1620	79.1	70.4	128	114	129
Potassium	mg/l	20.2	5.84	63.5	67.4	56.8	1.68	2.09	14.3	15.5	20.1
Iron	mg/l	950	2100	950	950	5820	950	950	8007	14300	8840
Total Coliforms	No/100mls	0	0	0	10	0	0	0	0	0	0
E. coli	No/100mls	0	0	0	10	0	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

Table 7.2.4 Tramore Landfill Groundwater monitoring Q3 2016

Sampling Location		BH 8	BH9	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
Parameter	Units	Date sampled									
		02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct
Visual Inspection/Odour		muddy brown	muddy brown	cloudy	light brown	sandy	muddy brown	muddy brown	cloudy grey	clear	grey
Groundwater Level	m	6.1	5.7	4.1	5.7	1.3	4.7	3.4	2.7	6.8	3.9
Temp	oC	12.9	12.4	13.2	14.5	14.7	14.2	13.9	14.2	14.3	14.5
pH	units	7.0	6.9	7.2	7.3	6.7	6.9	7.0	6.8	6.8	7.0
Cond	uS/cm	5100	2860	nm	nm	nm	1186	1006	2160	2020	1854
Salinity	%	2.6	1.3	5.6	7.7	11.7	nm	nm	nm	nm	nm
Ammonia Total (as N)	mg/l	<0.2	0.918	1.18	1.79	0.687	<0.2	<0.2	11.3	10.2	9.91
Chloride(asCl)	mg/l	1390	637	3160	420	6650	108	116	226	210	240
Total Oxidised Nitrogen	mg/l	<0.1	<0.1	0.379	<0.1	<0.1	<0.1	0.563	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	<3	<3	8.49	9.74	9.16	<3	<3	11	10.4	11.1
Dissolved Oxygen	% sat	26	15	52	93	16	41	29	12	14	15
Sodium	mg/l	759	340	1710	1900	3160	95.4	78.2	123	130	127
Potassium	mg/l	19.6	11.5	62.1	66.1	85.1	1.3	1.18	19.3	16.6	18.8
Iron	ug/l	<0.019	1.72	<0.19	<0.19	0.735	<0.019	<0.019	1.69	6.5	3.64
Total Coliforms	No/100mls	0	>100	78	25	12	>100	6	0	0	0
E. coli	No/100mls	0	0	78	25	7	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

Table 7.2.5 Tramore Landfill Groundwater monitoring Q4 2016

Sampling Location		BH 8	BH9	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
Parameters	Units	Date sampled									
		22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov
Visual Inspection/Odour		light brown	muddy brown	cloudy	cloudy	sandy	cloudy	muddy brown	cloudy grey	clear	grey
Groundwater Level	m	6.1	5.7	5.2	5.4	1.3	3.1	6.9	2.5	6.8	3.8
Temp	oC	10.7	10.8	11.8	10.8	10.4	11.3	11.6	11.5	11.2	11.0
Dissolved Oxygen	% sat	33	19	22	87	26	33	49	15	17	15
pH	units	7.4	7.0	7.2	7.4	7.0	7.2	7.4	6.9	6.8	7.2
Cond	uS/cm	4580	1397	nm	nm	nm	1102	1020	2180	2010	1919
Salinity	%	nm	nm	12.4	13.6	12.9	nm	nm	nm	nm	nm
Total Organic Carbon	mg/l	<3	3.56	8.34	11.2	12	<3	<3	12.3	10.9	12.5
Ammonia Total (as N)	mg/l	<0.2	0.68	<0.2	1.78	0.515	<0.2	<0.2	11.7	11	11.5
Chloride(asCl)	mg/l	1170	185	4700	4260	7100	8939	1153	227	207	221
Total Oxidised Nitrogen	mg/l	0.23	<0.1	<0.1	<0.1	<0.1	0.132	0.218	<0.1	<0.1	0.116
Sodium	mg/l	572	121	2170	2100	3830	77.9	78.6	132	128	154
Potassium	mg/l	14.8	7.07	67.3	66.3	97.7	<1	1.45	18.2	16.9	20.1
Iron	ug/l	<0.019	1.59	<0.19	<0.19	0.299	<0.019	<0.019	6.53	21.2	3.85
Arsenic	ug/l	0.848	4.83	3.88	3.87	2.85	0.63	2.1	216	17.9	7.09
Total Coliforms	No/100mls	13	11	77	26	15	>100	0	0	0	0
E. coli	No/100mls	0	11	77	16	15	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

7.3 LEACHATE

7.3.1 INTRODUCTION

Leachate boreholes, BH1, BH 7 and RC6 have been routinely sampled since Sept 2001. Supplementary boreholes LT 1-5 were constructed in late 2001, and sampled since 2002.

Borehole locations are shown on appendix 1. Drilling records, where available, for groundwater boreholes are shown on table.

Table 7.3.1. Leachate borehole drilling records

Name	BH1/1	BH7A	LT1	LT2	LT3a	LT4a	LT5a	RC6A
Nominal Type	GW + L	leachate	L	L	L	L	L	L
Total Depth (m)	4.5	6	8.4	4.8	6	6	6	9
Strata (m)	Made ground: fill/clay with traces of rubble (0-1.7) Made ground; domestic refuse (1.7-3.7) Made ground: firm brown clay with traces of rubbish (3.7-4.2) Firm brown sandy gravelly clay: (4.2-4.5)	Made ground; clay with cobbles (0-0.6) Made ground:waste, bricks and metal (0.6-6)	Made ground rubble and clay (0-2.3) Made ground: domestic refuse (2.3 - 3.3) Made ground black domestic refuse (3.3 - 7.2) Made ground; mixture of rubbish and black silty sand (7.2 - 7.8) Loose grey silty sand with shells (7.8 - 8.4)	Made ground clay with occasional cobbles (0-1.2) Made ground: domestic refuse (1.2 - 4.5) Made ground silty refuse (domestic) (4.5 - 4.8)	Clay with cobbles (0-6)	Made ground clay occasional cobbles (0-0.7) Made ground: clay/waste (0.7 - 6)	Made ground:clay with gravel and boulder obs (0-2) Made ground: clay (2 - 3) Made ground clay with traces of refuse (3 - 3.8) Made ground; domestic refuse (3.8 - 7.8) Made ground: mixture of	Made ground light brown clay with gravel, cobbles and concrete (0-1) Made ground: black silty clay with gravel and plastic (1-3.2) Firm light brown grey gravelly clay with cobbles (3.2-7) Light brown clay with gravel and abundant cobbles (7-8.3) Light brown clay with gravel and large cobbles (8.3-9)
Response zone (m)	0.80m to 4.0m	3.5m to 6.0m	1.8 to 7.2	1.3 to 4.6	1.5 to 5.6	1.5 to 5.2	2.8 to 6.35	3 to 9
Designation based on drill record	Leachate	Leachate	Leachate	Leachate	Leachate	Leachate	Leachate	Leachate

Results of analysis are presented in tables 7.3.2 to 7.3.5, and appendix E, and are compared with the median of "typical" landfill leachate, as published in the EPA document "*Landfill Operational Practices*", 1998.

7.3.2 RESULTS

Saline intrusion is evident in many of the leachate boreholes, reflected in the high concentrations of ions associated with seawater, such as *chloride, sodium, magnesium calcium and boron*, and subsequent interference in some of the tests normally used to characterise landfill leachate, as discussed in the introduction.

Heavy metal concentrations (c*admium, lead*) are generally low, being at about drinking water standard levels. There is a strong relationship between salinity and measured levels of zinc, copper, chromium and arsenic, which strongly indicate interference in tests due to salinity – see introduction.

Key Parameter – Ammonia

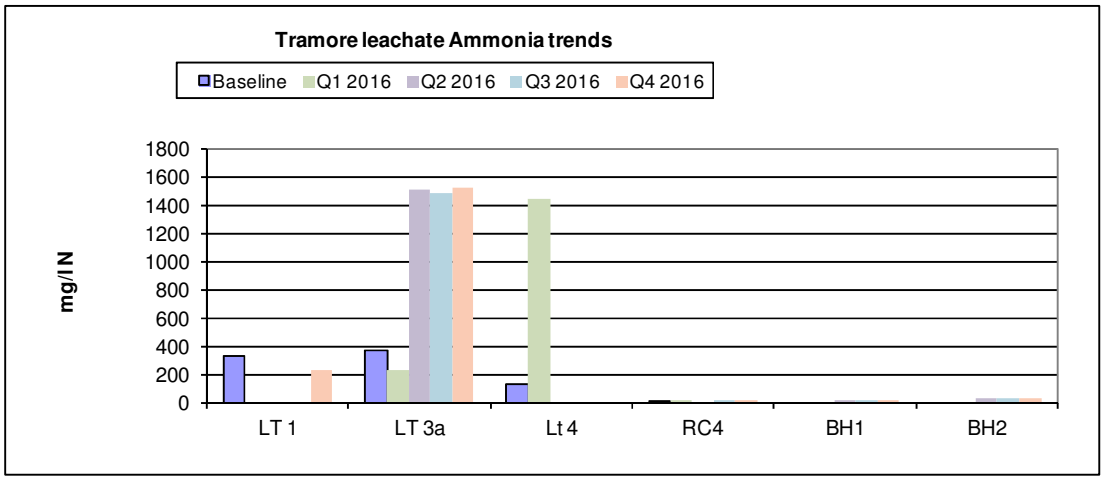


Fig 7.3.1 Leachate ammonia levels 2015

Many of the leachate boreholes were dry as a result of landfill capping and thus were not sampled in 2016.

Reference	**Parameter**	Typical Leachate Analysis (EPA, 1997)
EPA document "Landfill operational Practices", 1998	Ammonia mg/l N	453
	BOD mg/l O_2	270
	COD mg/l O_2	954
	Conductivity µS/cm	7180
	Iron µg/l	12100
	pH	7.1
	Potassium mg/l	492
	Sodium mg/l	688

Table 7.3.2 Tramore Landfill Leachate Monitoring Q1 2016

Sampling Location	Units	RC 4	LT 1	LT 3A
		Date sampled		
		28-Mar	28-Mar	28-Mar
Temp	oC	11.8	14.0	12.8
pH	units	7.2	6.9	7.5
Salinity	%	32.9	2.9	13.3
BOD	mg/l	32	133	99
COD	mg/l	808	490	1930
Ammonia Total (as N)	mg/l	5	237	1440
Chloride(asCl)	mg/l	17900	547	2680
Total Oxidised Nitrogen	mg/l	37	25.8	68
Iron	mg/l	950	1560	3390
Potassium	mg/l	338	173	925
Sodium	mg/l	8630	384	2130
Total Coliforms	No/100mls	0	0	0

Table 7.3.3 Tramore Landfill Leachate Monitoring Q2 2016

Sampling Location		LT1	LT3A	RC4	BH1/1	BH2
		Date sampled				
Parameter	Units	26-Jun	26-Jun	26-Jun	26-Jun	26-Jun
Visual Inspection/Odour		grey	black pungent	clear	clear	light brown
Groundwater Level	m	2.0	1.4	12.5	2.3	3.6
Temp	oC	14.9	15.4	13.5	13.1	14
pH	units	6.9	7.6	7.2	6.9	7.3
Cond	uS/cm	5550	nm	nm	3900	nm
Salinity	%	2.9	13.3	31.9	nm	10.7
BOD	mg/l	36	36	<5	8	<5
COD	mg/l	556	1970	404	41.8	179
Ammonia Total (as N)	mg/l	242	1510	12.4	24.4	39.1
Chloride(asCl)	mg/l	512	2530	17600	772	5770
Total Oxidised Nitrogen	mg/l	0	0.113	<0.1	<0.1	<0.1
Sodium	mg/l	367	2200	8080	392	2820
Potassium	mg/l	175	965	372	29.3	144
Iron	ug/l	21800	3004	950	3510	1340

Table 7.3.5 Tramore Landfill Leachate Monitoring Q3 2016

Sampling Location		LT3A	RC4	BH1/1	BH2
Parameters	Units	Date sampled			
		30-Sep	30-Sep	30-Sep	30-Sep
Visual Inspection/Odour		black pungent	clear	clear	clear
Taste					
Groundwater Level	m	1.6	11.7	2.6	3.7
Temp	oC	14.5	13.1	14.4	13.7
pH	units	7.5	7.2	6.9	7
Cond	uS/cm	nm	nm	2720	nm
Salinity	%	13.3	32.9	nm	11.6
BOD	mg/l	43	<5	6	3
COD	mg/l	1650	383	24.9	135
Ammonia Total (as N)	mg/l	1480	5.55	24.1	36.9
Chloride(asCl)	mg/l	2710	19100	466	6550
Total Oxidised Nitrogen	mg/l	<0.5	<0.1	<0.1	<0.1
Sodium	mg/l	2440	9730	267	3310
Potassium	mg/l	1050	357	24.9	157
Iron	ug/l	3.59	<0.19	<0.19	<0.19

Table 7.3.6 Tramore Landfill Leachate Monitoring Q4 2016

Sampling Location		LT1	LT3A	RC4	BH 1	BH 2
Parameters	Units	Date sampled				
		22-Nov	22-Nov	22-Nov	22-Nov	22-Nov
Visual Inspection/Odour		brownish	black pungen	clear	clear	black tinge
Taste						
Groundwater Level	m	2.1	3.4	6.4	2.4	4.8
Temp	oC	13.0	10.6	11.5	11.3	11.9
pH	units	6.9	7.6	7.1	6.9	6.9
Cond	uS/cm	5500	nm	nm	2130	nm
Salinity	%	nm	13.2	33	nm	12
BOD	mg/l	34	157	<5	8	40
COD	mg/l	389	1590	502	61.6	253
Ammonia Total (as N)	mg/l	239	1530	5.61	25.3	36.9
Chloride(asCl)	mg/l	514	2510	18300	442	6380
Sodium	mg/l	334	2040	8530	264	3360
Potassium	mg/l	160	1020	369	24.5	155
Iron	ug/l	13.50	3.35	0.134	5.07	29.3

7.4. Leachate Levels

7.4.1 Introduction

Leachate levels are determined weekly, by dip meter, at boreholes BH1/1, BH7, RC6, LT1, LT2, LT3, LT4, and LT5.

7.4.2 Results

Results of monitoring are presented in tables 4.1 to 4.4. There were minor fluctuations in levels in BH7, LT1, and LT2. LT 4 and LT5 were dry most of 2016.

7.4.3 Discussion

The variation in groundwater and leachate levels may be due to air pressure, changes in landfill water balance or tidal effects.

Tidal intrusion into the landfill boreholes was the subject of special reports in 2002 and 2006; Waterford County Council, *Investigation into the Occurrence of Salinity Intrusion at Tramore Landfill Site*, MCOS, 2002 and *Investigation into the possible occurrence of salinity intrusion at Tramore Landfill,* RPS 2006.

Table 4.1 Tramore Landfill Leachate & Groundwater Levels Q1 2016

Week	Date	Operator	BH 1/1	BH 2	BH4A	BH 5	BH 7b	BH 8	BH 9	GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6
1	05/01/2016	DR	2.01	1.77		0.60	1.77	1.32	0.97	1.52	1.59	1.34	0.86	0.74	1.37	2.29	2.02	2.86	2.50	4.17	Dry	Dry	2.30	0.60	2.35
2	14/01/2016	DR	2.01				1.77											2.86	2.5	4.17	Dry	Dry			2.35
3	20/01/2016	DR	1.91				1.57											2.86	2.5	4.17	Dry	Dry			2.45
4	26/01/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.35
5	04/02/2016	DR	2.11	1.77		0.60	1.57	1.32	0.97	1.52	1.59	1.54	0.86	0.74	1.27	2.29	1.92	2.86	2.50	4.17	Dry	Dry	1.90	0.60	2.35
6	08/02/2016	DR	1.81				1.47											2.86	2.5	4.17	Dry	Dry			2.45
7	15/02/2016	DR	1.81				1.57											2.86	2.5	4.17	Dry	Dry			2.35
8	23/02/2016	DR	1.81				1.57											2.86	2.5	4.17	Dry	Dry			2.35
9	29/02/2016	DR	1.91				1.37											2.86	2.5	4.17	Dry	Dry			2.35
10	04/03/2016	DR	2.01	1.77		0.60	1.77	1.32	0.87	1.52	1.59	1.44	0.86	0.74	1.37	2.29	1.92	2.86	2.50	4.17	Dry	Dry	1.90	0.60	2.35
11	14/03/2016	DR	1.81				1.57											2.86	2.50	4.17	Dry	Dry			2.35
12	22/03/2016	DR	1.91				1.67											2.86	2.50	4.17	Dry	Dry			2.35
13	29/03/2016	DR	1.71				1.57											2.86	2.50	4.17	Dry	Dry			2.55
Week	Date	Operator	BH 1/1	BH 2	BH4A	BH 5	BH 7b	BH 8	BH 9	GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6

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All levels refer to Ordnance Datum

Table 4.2 Tramore Landfill Leachate &Groundwater Levels Q2 2016

Week	Date	Operator	BH 1/1	BH 2	BH4A	BH 5	BH 7b	BH 8	BH 9	GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6
14	05/04/2016	DR	2.01	1.77		0.60	1.67	1.32	0.87	1.52	1.59	1.44	0.86	0.74	1.37	2.29	1.92	2.86	2.50	4.17	Dry	Dry	1.90	0.60	2.35
15	12/04/2016	DR	1.91				1.37											2.86	2.5	4.17	Dry	Dry			2.35
16	18/04/2016	DR	2.01				1.47											2.86	2.5	4.17	Dry	Dry			2.45
17	27/04/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.35
18	04/05/2016	DR	1.91	1.67		0.60	1.77	1.32	0.97	1.52	1.59	1.44	0.86	0.74	1.27	2.19	1.82	2.86	2.50	4.17	Dry	Dry	2.10	0.60	2.35
19	10/05/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.45
20	18/05/2016	DR	1.81				1.77											2.86	2.5	4.17	Dry	Dry			2.35
21	23/05/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.35
22	30/05/2016	DR	2.01				1.67											2.86	2.5	4.17	Dry	Dry			2.56
23	03/06/2016	DR	2.11	1.67		0.60	1.57	1.32	0.97	1.62	1.69	1.64	1.06	0.84	1.17	2.19	1.72	2.86	2.50	4.17	Dry	Dry	2.20	0.80	2.55
24	14/06/2016	DR	1.71				1.37											2.86	2.50	4.17	Dry	Dry			2.35
25	22/06/2016	DR	1.91				1.67											2.86	2.50	4.17	Dry	Dry			2.35
26	28/06/2016	DR	1.91				1.47											2.86	2.50	4.17	Dry	Dry			2.45
Week	**Date**	**Operator**	**BH 1/1**	**BH 2**	**BH4A**	**BH 5**	**BH 7b**	**BH 8**	**BH 9**	**GW 1**	**GW 2**	**GW 3**	**GW 4**	**GW 5**	**GW 6**	**GW 7**	**GW 8**	**LT1**	**LT2**	**LT3**	**LT4**	**LT5**	**RC4**	**RC5**	**RC6**

na No Access

All levels refer to Ordnance Datum

Table 4.3 Tramore Landfill Leachate & Groundwater Levels Q3 2016

Week	Date	Operator	BH 1/1	BH 2	BH4A	BH 5	BH 7b	BH 8	BH 9	GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6
27	05/07/2016	DR	2.01	1.67		0.60	1.47	1.32	1.17	1.52	1.59	1.54	1.06	0.94	0.87	2.19	1.92	2.86	2.40	4.17	Dry	Dry	2.30	0.70	2.35
28	12/07/2016	DR	2.01				1.77											2.86	2.5	4.17	Dry	Dry			2.35
29	20/07/2016	DR	2.01				1.77											2.86	2.5	4.17	Dry	Dry			2.45
30	25/07/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.45
31	29/07/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.45
32	05/08/2016	DR	2.01	1.77		0.70	1.57	1.32	1.17	1.52	1.59	1.54	1.06	0.94	0.87	2.19	1.92	2.86	2.40	4.17	Dry	Dry	2.30	0.70	2.35
33	15/08/2016	DR	1.91				1.57											2.86	2.5	4.17	Dry	Dry			2.45
34	23/08/2016	DR	2.01				1.77											2.86	2.5	4.17	Dry	Dry			2.35
35	30/08/2016	DR	2.01				1.57											2.86	2.5	4.17	Dry	Dry			2.45
36	06/09/2016	DR	2.01				1.67											2.86	2.5	4.17	Dry	Dry			2.56
37	12/09/2016	DR	2.01				1.47											2.86	2.50	4.17	Dry	Dry			2.35
38	22/09/2016	DR	2.01	1.77		0.70	1.57	1.32	1.17	1.52	1.59	1.54	1.06	0.94	0.87	2.19	1.92	2.86	2.40	4.17	Dry	Dry	2.30	0.70	2.35
39	26/09/2016	DR	1.71				1.37											2.86	2.50	4.17	Dry	Dry			2.25
Week	**Date**	**Operator**	**BH 1/1**	**BH 2**	**BH4A**	**BH 5**	**BH 7b**	**BH 8**	**BH 9**	**GW 1**	**GW 2**	**GW 3**	**GW 4**	**GW 5**	**GW 6**	**GW 7**	**GW 8**	**LT1**	**LT2**	**LT3**	**LT4**	**LT5**	**RC4**	**RC5**	**RC6**

na No Access

All levels refer to Ordnance Datum

Table 4.4 Tramore Landfill Leachate & Groundwater Levels Q4 2016

Week	Date	Operator	BH 1/1	BH 2	BH4A	BH 5	BH 7b	BH 8	BH 9	GW 1	GW 2	GW 3	GW 4	GW 5	GW 6	GW 7	GW 8	LT1	LT2	LT3	LT4	LT5
40	04/10/2016	JMcK	1.50				1.30											2.70	2.41	3.90	Dry	Dry
41	12/10/2016	JMcK	1.3				1.4											2.75	2.41	4.05	Dry	Dry
42	18/10/2016	JMcK	1.4				1.31											2.6	2.4	3.8	Dry	Dry
43	26/10/2016	JMcK	1.4	1.53		0.3	1.36	1.51	1.01	1.3	1.7	1.6	1.26	1.2	1.2	2.1	1.89	2.75	2.4	4.05	Dry	Dry
44	03/11/2016	JMcK	1.5				1.42											2.7	2.5	3.9	Dry	Dry
45	09/11/2016	JMcK	1.70				1.50											2.75	2.40	4.00	Dry	Dry
46	13/11/2016	DR	1.91				1.57											2.86	2.5	4.17	Dry	Dry
47	22/11/2016	JMcK	1.6				1.4											2.7	2.4	4.1	Dry	Dry
48	30/11/2016	JMcK	1.51	1.67		0.70	1.37	1.42	0.97	1.22	1.59	1.44	1.26	0.94	0.87	2.19	1.92	2.76	2.40	3.97	Dry	Dry
49	08/12/2016	JMcK	1.7				1.37											2.71	2.40	4.12	Dry	Dry
50	15/12/2016	LMCGM	2.01	1.97		0.10	1.37	1.67	1.27	1.82	2.19	1.84	1.26	1.54	1.67	2.99	2.62	2.76	2.50	4.27	Dry	Dry
51	19/12/2016	JMcK	1.86				1.35											2.70	2.41	4.04	Dry	Dry
52	30/12/2017	JMcK	1.63				1.42											2.68	2.40	4.02	Dry	Dry
Week	**Date**	**Operator**	**BH 1/1**	**BH 2**	**BH4A**	**BH 5**	**BH 7b**	**BH 8**	**BH 9**	**GW 1**	**GW 2**	**GW 3**	**GW 4**	**GW 5**	**GW 6**	**GW 7**	**GW 8**	**LT1**	**LT2**	**LT3**	**LT4**	**LT5**

7.5. Landfill Gas

7.5.1 Introduction

The main landfill gases, Methane and Carbon dioxide, as well as Oxygen, were measured in monitoring boreholes within [BH1/1, BH2, BH7, BH10, RC4, L1, L2, L3, L4, L5] and outside [BH8, BH9, RC5] the landfill area, and in the former civic amenity site area.

7.5.2 Results

Results are presented in tables 7.5.1 to 7.5.4 and figure 7.5.1.

Key parameter – methane

Methane is a product of the breakdown of biodegradable material in the landfill. The methane levels detected during 2014 are presented in figs. 7.5.1a and 7.5.1b below.

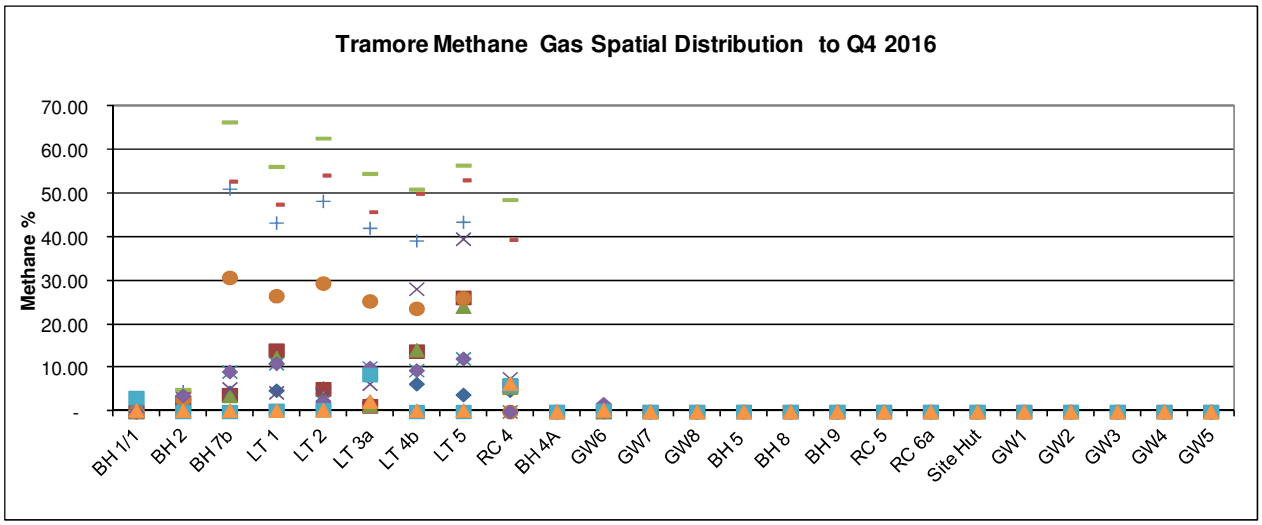


Fig 7.5.1a Methane spatial distribution 2016

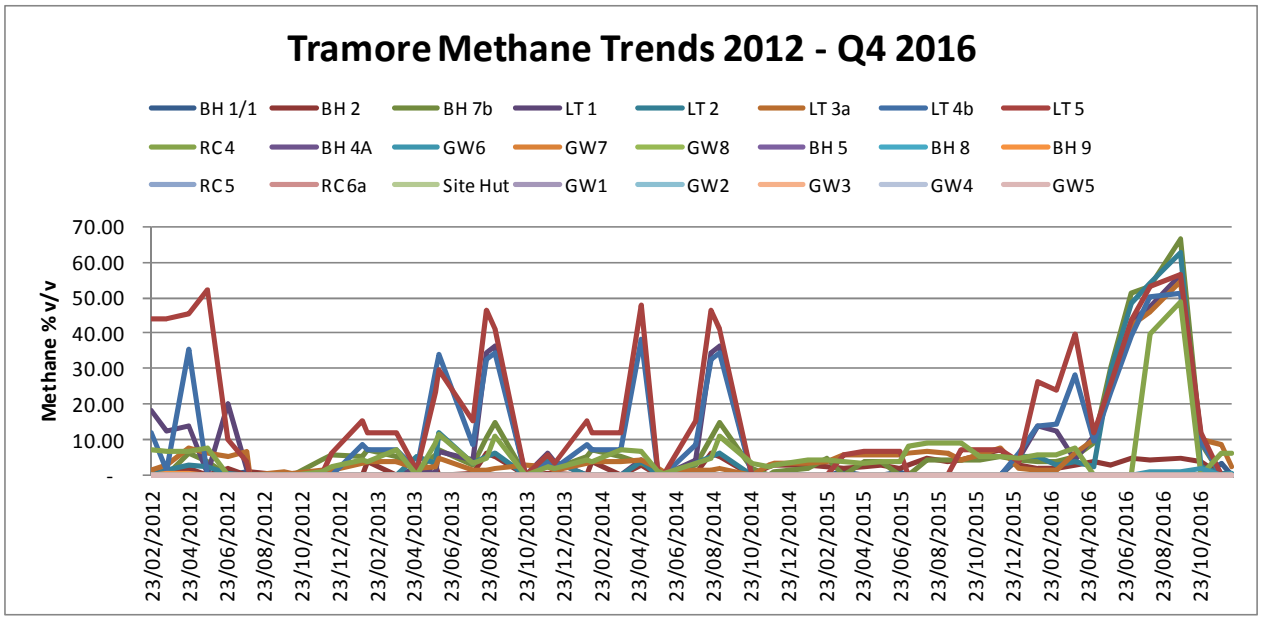


Fig 7.5.1b Methane temporal trends 2012 - 2016

7.5.3 Discussion

Spatial distribution (Fig 7.5.1a): Methane, consistent with the breakdown or organic waste, was present in some boreholes within the landfill area at levels up to 48% v/v (in LT5). There was no landfill gas detected in the site buildings (local area depot) or at boreholes outside the waste body area.

Temporal trends (fig 7.5.1b): In general, across the landfill, there is a trend of decreasing methane since 2007, and further monitoring will indicate ongoing trends.

Table 7.5.1 Gas Levels Q1 2016

Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A
1	04/01/2016	DR	CH_4	0.00	0.00	3.10	0.00	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	5.40	2.10	6.40	3.90	4.90	0.00	0.00
			CO_2	0.00	0.00	1.60	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10	2.20	1.20	4.40	2.90	2.20	0.00	0.00
			O_2	20.90	20.90	17.40	20.90	20.90	15.70	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	12.20	14.60	16.50	12.40	15.90	13.80	20.90	20.90
			Air Pressure	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016
2	14/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1001																							
3	20/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1008																							
4	26/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
5	04/02/2016	DR	CH_4	0.00	0.00	2.10	0.00	0.00	3.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.10	5.20	1.30	13.90	26.20	5.90	0.00	0.00
			CO_2	0.00	0.00	1.10	0.00	0.00	3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.10	2.10	1.20	2.30	16.90	2.70	0.00	0.00
			O_2	20.90	20.90	18.90	20.90	20.90	16.60	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	7.90	15.60	18.20	5.70	2.10	16.30	20.90	20.90
			Air Pressure	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024
6	08/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1002																							
7	15/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
8	23/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
9	29/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
10	04/03/2016	DR	CH_4	0.00	0.00	1.80	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.40	3.10	1.40	14.20	24.20	5.60	0.00	0.00
			CO_2	0.00	0.00	0.80	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	1.70	1.00	2.10	16.20	2.40	0.00	0.00
			O_2	20.90	20.90	18.60	20.90	20.90	16.40	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	8.60	17.60	17.10	3.60	2.40	16.90	20.90	20.90
			Air Pressure	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998
11	14/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1000																							
12	22/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1021																							
13	29/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A

Table 7.5.2 Gas Levels Q2 2016

Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A
1	04/01/2016	DR	CH_4	0.00	0.00	3.10	0.00	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	5.40	2.10	6.40	3.90	4.90	0.00	0.00
			CO_2	0.00	0.00	1.60	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10	2.20	1.20	4.40	2.90	2.20	0.00	0.00
			O_2	20.90	20.90	17.40	20.90	20.90	15.70	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	12.20	14.60	16.50	12.40	15.90	13.80	20.90	20.90
			Air Pressure	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016	1016
2	14/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1001																							
3	20/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1008																							
4	26/01/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
5	04/02/2016	DR	CH_4	0.00	0.00	2.10	0.00	0.00	3.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.10	5.20	1.30	13.90	26.20	5.90	0.00	0.00
			CO_2	0.00	0.00	1.10	0.00	0.00	3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.10	2.10	1.20	2.30	16.90	2.70	0.00	0.00
			O_2	20.90	20.90	18.90	20.90	20.90	16.60	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	7.90	15.60	18.20	5.70	2.10	16.30	20.90	20.90
			Air Pressure	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024
6	08/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1002																							
7	15/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
8	23/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
9	29/02/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
10	04/03/2016	DR	CH_4	0.00	0.00	1.80	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.40	3.10	1.40	14.20	24.20	5.60	0.00	0.00
			CO_2	0.00	0.00	0.80	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.40	1.70	1.00	2.10	16.20	2.40	0.00	0.00
			O_2	20.90	20.90	18.60	20.90	20.90	16.40	20.90	16.70	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	8.60	17.60	17.10	3.60	2.40	16.90	20.90	20.90
			Air Pressure	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998	998
11	14/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1000																							
12	22/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1021																							
13	29/03/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A

Table 7.5.3 Gas Levels Q3 2016

Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A
27	05/07/2016	DR	CH_4	0.00	0.00	4.70	0.00	0.00	51.20	0.00	0.00	0.00	0.00	0.00	0.25	0.00	11.20	0.00	0.00	43.40	48.40	42.20	39.30	43.60	0.00	0.00	0.00
			CO_2	0.00	0.00	2.40	0.00	0.00	26.10	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.75	0.00	0.00	0.00	0.00	21.50	0.00	14.20	18.30	15.20	0.00	0.00
			O_2	20.90	20.90	16.70	20.90	20.90	1.10	20.90	17.70	20.90	20.90	20.90	17.00	20.90	10.90	20.90	20.90	0.30	0.00	3.20	0.10	2.50	4.60	20.90	20.90
			Air Pressure	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003	1003
28	12/07/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1001																							
29	20/07/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1008																							
30	25/07/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
31	29/07/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1017																							
32	05/08/2016	DR	CH_4	0.00	0.00	5.10	0.00	0.00	66.50	0.00	1.10	0.00	0.00	0.00	0.30	0.00	14.60	0.00	0.00	56.30	62.80	54.70	51.10	56.60	48.70	0.00	0.00
			CO_2	0.00	0.00	2.80	0.00	0.00	39.00	0.00	0.90	0.00	0.00	0.00	2.20	0.00	1.10	0.00	0.00	33.50	32.20	31.20	21.20	27.30	22.60	0.00	0.00
			O_2	20.90	20.90	18.50	20.90	20.90	1.10	20.90	18.60	20.90	20.90	20.90	17.90	20.90	11.50	20.90	20.90	0.30	0.10	3.30	0.10	2.60	4.80	20.90	20.90
			Air Pressure	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018
33	15/08/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
34	23/08/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
35	30/08/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1019																							
36	06/09/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1017																							
37	12/09/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1000																							
38	22/09/2016	DR	CH_4	0.00	0.00	5.10	0.00	0.00	66.50	0.00	1.10	0.00	0.00	0.00	0.30	0.00	14.60	0.00	0.00	56.30	62.80	54.70	51.10	56.60	48.70	0.00	0.00
			CO_2	0.00	0.00	2.80	0.00	0.00	39.00	0.00	0.90	0.00	0.00	0.00	2.20	0.00	1.10	0.00	0.00	33.50	32.20	31.20	21.20	27.30	22.60	0.00	0.00
			O_2	20.90	20.90	18.50	20.90	20.90	1.10	20.90	18.60	20.90	20.90	20.90	17.90	20.90	11.50	20.90	20.90	0.30	0.10	3.30	0.10	2.60	4.80	20.90	20.90
			Air Pressure	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018
39	26/09/2016	DR	CH_4	0.00																							
			CO_2	0.00																							
			O_2	20.90																							
			Air Pressure	1015																							
Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A

Table 7.5.4 Gas Levels Q4 2016

Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A
40			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
41			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
42	20/10/2016		CH_4	0.00	0.00	3.70	0.00	0.00	9.20	0.00	0.00	0.00	0.00	0.00	0.20	0.00	6.80	0.00	0.00	11.10	2.30	10.10	9.50	12.20	0.00	0.00	0.00
			CO_2	0.00	0.00	1.90	0.00	0.00	8.70	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.70	0.00	0.00	4.70	4.90	3.70	5.20	6.40	0.00	0.00	0.00
			O_2	20.90	20.90	16.40	20.90	20.90	6.50	20.90	16.70	20.90	20.90	20.90	16.20	20.90	10.50	20.90	20.90	4.40	14.40	8.10	9.10	11.80	20.90	20.90	20.90
			Air Pressure	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017
43			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
44			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
45			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
46			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
47			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
48	30/11/2016		CH_4	0.00	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	8.50	0.00	0.00	6.10	0.00	0.00
			CO_2	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	4.20	0.00	0.00	6.30	0.00	0.00
			O_2	20.90	11.60	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	17.30	20.90	20.90	20.90	20.90	17.00	20.90	20.90	13.40	20.90	20.90
			Air Pressure	1035	1035	1035	1035	1035	1035	1035	1035	1034	1034	1034	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
49			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
50			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
51	15/12/2016		CH_4	32.60	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.40	0.30	0.30	0.40	2.40	0.30	0.30	6.50	0.30	na
			CO_2	28.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	2.80	0.00	na
			O_2	1.50	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	20.10	19.50	20.10	20.10	18.50	20.10	na
			Air Pressure	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
52			CH_4																								
			CO_2																								
			O_2																								
			Air Pressure																								
Week No	Date	Operator	Gas	Site Hut	BH1/1	BH2	BH4	BH5	BH7B	BH8	BH9	GW 1	GW 2	GW3	GW4	GW5	GW6	GW7	GW8	LT1	LT2	LT3	LT4	LT5	RC4	RC5	RC6A

7.6 NOISE

7.6.1 Introduction

Noise monitoring was not carried out during the reporting period as there was little or no activity on site throughout the year. The most recent results for the site are attached. Activity on the site has decreased significantly since this round of testing and the licensee will formally apply to the Agency to have the noise monitoring requirements of the licence reviewed.

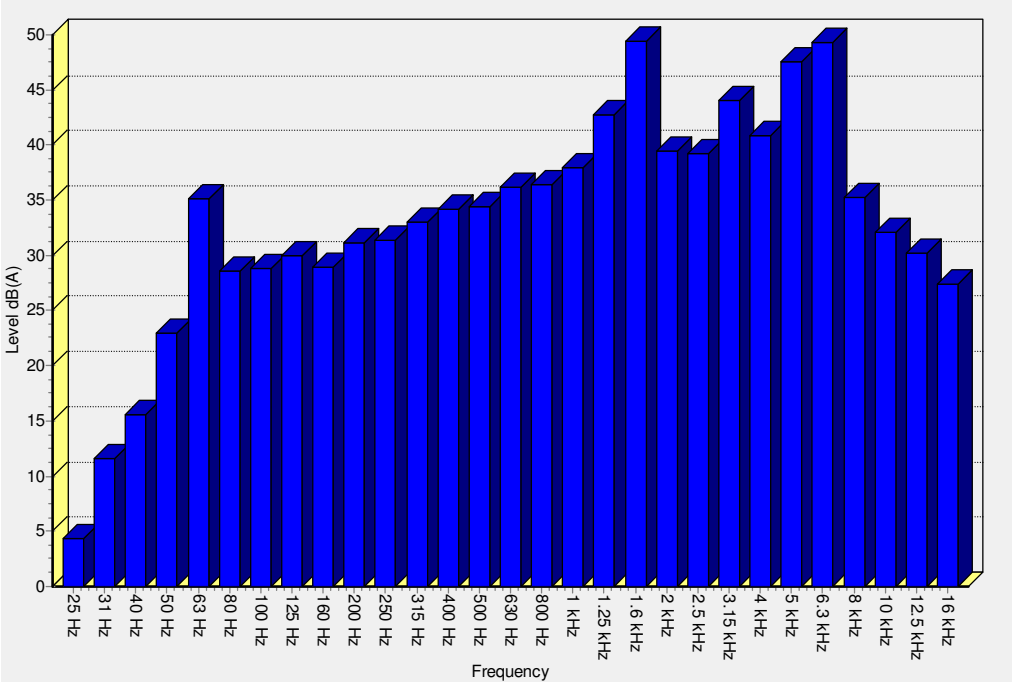
Daytime noise levels were recorded on 13/4/12 at two locations at Tramore Landfill Site, B1 and B2, as specified in the licence monitoring schedule D. These locations are shown in appendix 1. There are limits of 55 dB Leq(30) daytime, and 45 dB Leq(30) night-time imposed as a condition of the licence.
A Cirrus 800A Sound Level Meter was used. The meter was calibrated and checked with a 94 dB calibrator before and after each measurement. Broadband and Frequency Band analysis measurements were conducted at each location. A summary of 2012 results is presented in table 7.6.1, below. Noise monitoring at the landfill was not possible during 2016 due to extensive heavy machinery movements associated with rock armoury and car parking works on the adjoining stretch of beach and adjacent to the main entrance to the site.

7.6.2 Summary of 2014 Results / Discussion

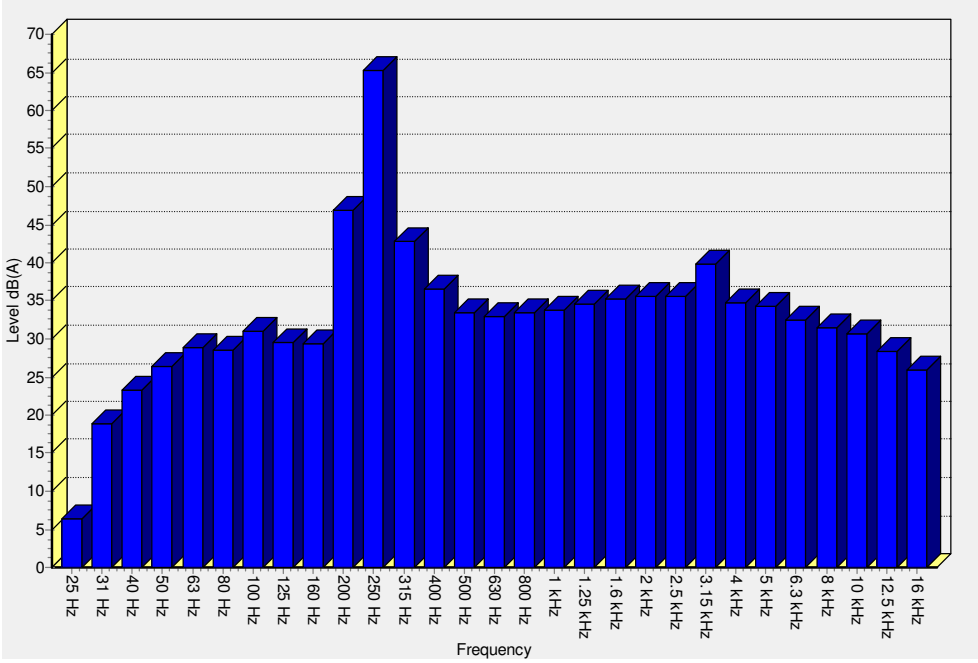
Site	*Date of Monitoring*	*Time of commencement of monitoring*	*L(A)eq[30mins]dB*
B1	28/5/14	13.13	57.5
B2	28/5/14	14.03	60.2

Table 7.6.1 Summary of noise measurements at Tramore landfill 28/5/14.

Average noise levels, LAEQ(30), at sites B1 and B2 were above the daytime limits of 55dB. As the landfill was not operating, this was deemed due to background and traffic noise. Night-time measurements were not made, as the landfill is not operational outside of daytime hours.



B1 1/3 Octave Noise Analysis, (A weighting) 28/5/14



B2 1/3 Octave Noise Analysis, (A weighting) 28/5/14

Frequency analysis at sites B1 and B2 indicated a broad range of frequencies, consistent with a variety of noise sources, such as wind and machinery and traffic. Some low frequency noise, of unknown origin but perhaps the noise from the seashore, at location B1 was evident. A single tone around 250hz at B2 was detected, source unknown.

7.7 ANALYSIS OF ESTUARINE BENTHIC MACROFAUNA

Sampling of estuarine macrofauna and sediment was not possible during 2014 due to adverse weather conditions during field surveys. Results from the December 2011 surveys are presented below.

7.7.1 CHEMICAL ANALYSIS

7.7.1.1 METHODS

Shellfish samples – cockles (*Ceracostaderma edule*) and mussels (*Mytilis edulis*) were taken from the backstrand, within 200 metres of the landfill, on 7/12/2011.

Approximately 50 adult individuals of each type were sampled along the sampling zone, figure 7.8.1. These individuals were mixed well and a subset of 15 individuals of each type was taken for processing and testing.

Shellfish were depurated overnight in clean aerated seawater, before de-shelling. The flesh was blotted dry, and dried at 60degC for 3 days. The dried flesh was ground to powder at Waterford County Council's laboratory and portions were analysed for metals at Environmental Laboratory Services, Cork. QUASIMEME[3] reference materials were processed with the samples. Only results which satisfied the QUASIMEME criteria for accuracy are included in this report.

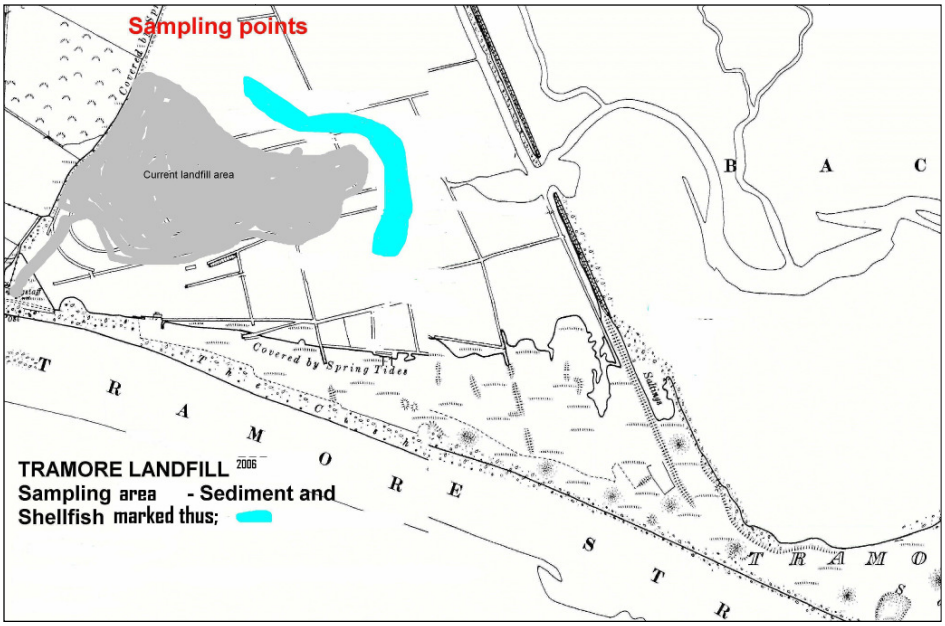


Fig 7.8.1. Tramore backstrand shellfish and sediment sampling areas

[3] Quality Assurance of Information in Maritime Environment Monitoring

7.7.1.2 RESULTS

Results of analysis are presented in table 1.

Table 7.8.1. Trace metal concentrations in shellfish samples from Tramore inner backstrand, December 2011 mg/Kg wet weight

PARAMETER **mg/Kg wet weight ***	**Cockle flesh** ***Cardium edule***	**Mussel flesh** ***Mytilis edulis***	**Shellfish Quality Standards ***	
	December 2011	**December 2011**	EU Regulation 221/2002/EC	SI No. 268 of 2006
Arsenic	2.8	4.4		5.6
Cadmium	0.098	0.279	1	0.93
Lead	0.294	0.465	1.5	1.4
Zinc	40.5	49.9		744

7.7.1.3 COMPARISON WITH STANDARDS

*EU Commission Regulation 466/2001/EC (as amended by Regulation 221/2002/EC) came into effect on 5th April 2002. This set maximum levels for mercury, cadmium and lead in bivalve molluscs of 0.5mg kg^{-1}, 1mg kg^{-1}, and 1.5mg kg^{-1} wet weight respectively.
The EC (Quality of shellfish waters) Regulations, SI No. 268 of 2006 contains guidelines values for heavy metals in shellfish flesh. These standards are specified as dry weight and corresponding wet weight values have been calculated for inclusion in table 7.8.1 above.

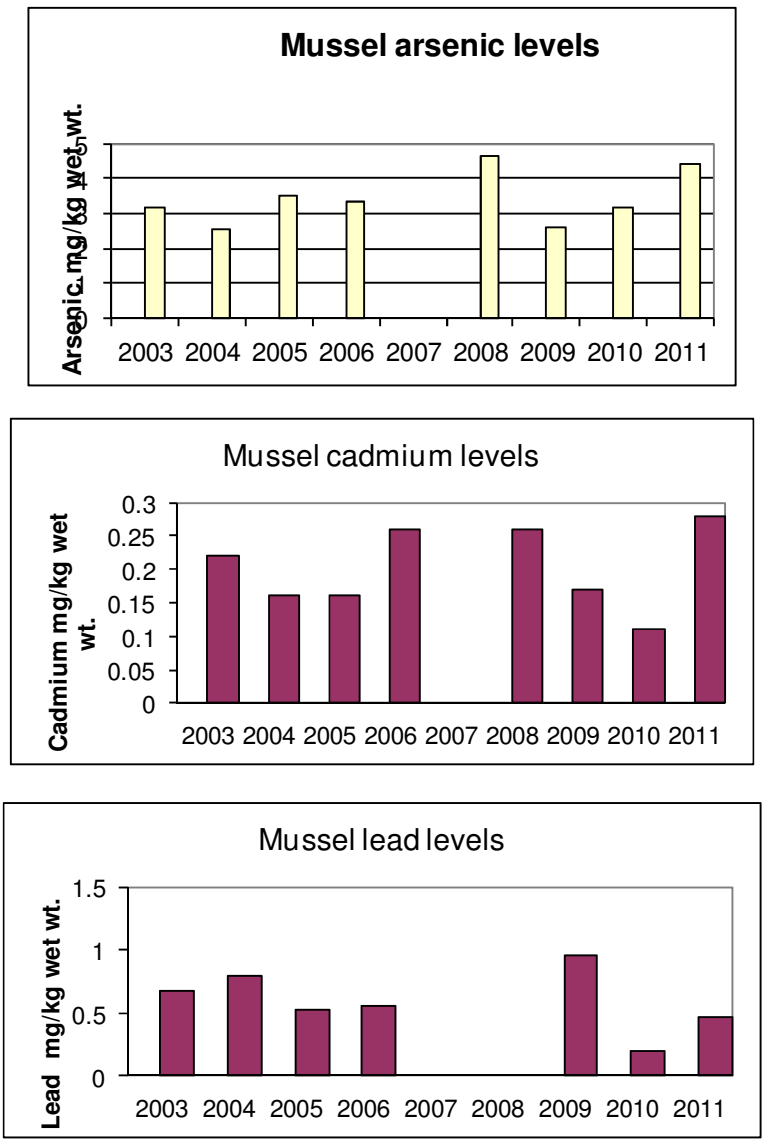
Discussion

The metals levels in mussel and cockle samples from Tramore backstrand in December 2011 complied with EU and national shellfish quality standards. There were no activities carried out on-on site which should cause a change in this status.

7.7.1.4 TRENDS AND COMPARISON WITH PREVIOUS RESULTS

The results obtained for mussels and cockles in the 2011 survey are presented in figure 7.7.2 below for comparison with previous results for this site.

Figure 7.7.2 Metal concentrations in mussels in Tramore backstrand for years 2003 to 2011



7.7.1.5 Discussion

Results for 2011 were similar to previous years. Some minor fluctuations from year to year are apparent, but there is no clear trend and the differences are likely due to natural variations. There were no activities carried out on-on site which should cause a change in this status.

7.7.1.6 COMPARISON WITH OTHER SITES

Trace metal concentrations in mussel samples from Tramore inner backstrand are compared in table 7.8.2 with levels found in the following surveys;

a) Marine Institute survey of 25 shellfish growing areas around the Irish coast, sampled 2004 and 2005.
b) EPA surveys of Waterford and Wexford Harbours, 2004 and 2005.

Table 7.7.2. Trace metal concentrations in mussels from Tramore backstrand, and at other estuarine and coastal sites

	Tramore inner backstrand	Wexford Harbour,	Waterford Harbour	Metals levels in mussel samples from 25 locations on the Irish coast, Marine Institute Surveys 2004 - 2005 Refs 1 and 2		
mg/kg wet weight		EPA survey, Ref 3	EPA survey, Ref 3			
		2004	2005			
	07 December 2011	Mean of 4 samples	Mean of 4 samples	Mean	90% ile	Max
Arsenic	4.43	3.6	2.6			
Cadmium	0.28	0.3	0.25	**0.15**	**0.2**	**0.35**
Chromium	0.93	4	1.4	**0.18**	**0.33**	**0.66**
Copper	NR	2.2	2.9	**1.39**	**1.57**	**1.97**
Lead	0.47	1.3	2.1	**0.23**	**0.52**	**0.85**
Zinc	49.98	15.6	25.4	**15.69**	**19.1**	**27**

7.7.1.7 Discussion

Metals levels recorded in Tramore backstrand mussels in December 2011 were similar to that found at other estuarine and coastal sites around the country. There were no activities carried out on-on site which should cause a change in this status.

7.7.2 MICROBIOLOGICAL ANALYSIS

7.7.2.1 Methods

Samples of cockles and mussels were collected as described in section 7.8.1.1 above. Testing of intervalvular fluids for faecal coliforms was carried out atWaterford County Council Adamstown Laboratory. Results are compared with EC (Quality of Shellfish Waters) Regulations No. 268 of 2006, schedule 4.

7.7.2.2 Results

Sample	Faecal coliforms per 100 mls	EC (Quality of Shellfish Waters) Regulations No. 268 of 2006
Tramore backstrand Cockles	<100	≤300 per 100 mls in intervalvular liquid
Tramore backstrand Mussels	<100	

7.7.2.3 Discussion

The faecal coliform counts in cockles and mussels intervalvular liquid were in compliance with regulatory guidelines. There were no activities carried out on-on site which should cause a change in this status.

7.8.2. Sediment.

7.8.2.1 Introduction

A composite sample of sediment (approx 2 kg) was taken on 7/12/11 at ten sampling points along a sampling zone adjacent to Tramore landfill, see fig 7.8.1 above. This was hand mixed on-site, and a portion (approx 200g) taken for analysis. The composite sample was dried at 105 deg for two days, and powdered with mortar and pestle in Waterford County Council's laboratory. Portions of the powdered samples were analysed for metals at Environmental Services Laboratory, Cork. QC and reference materials were processed with the samples.

7.8.2.2 Results

Parameter	Units	Tramore inner backstrand, December 2010	Sediment Quality Standards			
			Baseline *	Threshold **	ERL ***	Proposed Irish sediment guidance levels ****
Arsenic	mg/Kg dry wt.	5.8				
Cadmium	mg/Kg dry wt.	<0.5	0.5	1.5	5	1
Chromium	mg/Kg dry wt.	21.5	5	50	80	100
Copper	mg/Kg dry wt.	9.85	5	50	70	50
Iron	mg/Kg dry wt.	15,975				
Lead	mg/Kg dry wt.	13				50
Zinc	mg/Kg dry wt.	55.8	20	100	120	400

Table 4. Trace metal concentrations in sediment from Tramore inner backstrand, and comparison with environmental standards

7.8.2.3 Comparison with Standards.

Based on field investigations and literature data, Jeffrey et al (1995) ref 4, established baseline and threshold values for organic matter and heavy metals in estuarine sediments.

* The baseline concentration is defined as "that of the natural unpolluted estuary and corresponds to the authors views of the pre-industrial situation for sediments".

** The threshold is "the pollutant concentration beyond which deleterious environmental change is observable".

*** The National Oceanic and Atmospheric administration in USA (Long and Man, 1995) also established sediment quality guidelines. The guidelines are based on a review of numerous studies of the correlation between the toxicity of sediments and the content of pollutants. The ERL limits shown represent the concentration above which there may be a risk of deleterious impacts on fauna.

**** Proposed new Irish sediment guidance levels. Cronin et al, *Guidelines for the assessment of dredge material for disposal in Irish waters.* Marine Institute, 2006

Discussion

Chromium, Copper and Zinc at Tramore were above baseline levels. However, all values were below threshold and ERL limits, and proposed Irish standards for non-contaminated sediment, and were well below concentration where deleterious impacts on fauna can be expected. There were no activities carried out on-on site which should cause a change in this status.

7.8.2 .4 Comparison with previous surveys and other sites

Table 5. Trace metal concentration in sediment from Tramore inner backstrand and other estuarine and coastal sites

		Tramore Backstrand									Waterford Estuary ref 3	Wexford Hbr ref 3
Parameter	Units	2011	2010	2008	2006	2005	2004	2003	2002	1998	2001	2004
Arsenic	mg/kg dry wt	5.8	8.5	6.1	4.96	5.2	5.2	7.1	5.6		8	10
Cadmium	mg/kg dry wt	<0.5	0.2	<0.5	0.063	0.1	<0.44	<0.04	0.123	0.42	0.04	0.3
Chromium	mg/kg dry wt	21.5	27.5	16.4	16.4	14.3				65.6	35	31
Copper	mg/kg dry wt	9.85	2.1	10.6	6.98	8.1	10.7	8.6	5.4	11	9.8	13
Iron	mg/kg dry wt	15975	15245	13094	12,880	9721	13106	14048	15500		17466	24689
Lead	mg/kg dry wt	13	14.7	19.4	9.6	11.3	14.5	11	15.1		26	20
Manganese	mg/kg dry wt		258	242	225	215	263	398	270		622	385
Zinc	mg/kg dry wt	55.8	54.8	52.6	41.2	34	48.5	35	51.4	55.3	141	83

7.8.2.5 Discussion

December 2011 Tramore backstrand sediment metal levels were similar to levels found at that site in previous years. The majority of sediment metal levels at Tramore backstrand were lower than that found in samples from Waterford and Wexford Estuaries. There were no activities carried out on-on site which should cause a change in this status.

7.9 CONCLUSIONS – Impact of Tramore Landfill on Surrounding Environment

There is no indication of any effect from the landfill on ambient surface waters.

The results of groundwater monitoring are in line with results from previous rounds of testing carried out since 1999. As indicated in previous reports, it appears that groundwater quality within the current working area is impacted by leachate from the landfill, with elevated ammonia and iron. However heavy metals and organic concentrations are low at all boreholes. Groundwater outside the landfill site was generally satisfactory.

Leachate quality was as expected for a landfill accepting mainly domestic and inert waste. Heavy metal and organic content were low. Based on chemical analysis, and available dilution, no significant environmental effect from landfill leachate is expected. Leachate boreholes appear to be drying up, most likely as an effect of landfill capping.

The metal concentrations and microbial quality in shellfish from Tramore inner backstrand in December 2011 and previous years complied with relevant shellfish quality standards and were similar to that found at other estuarine and coastal sites around the country. Monitoring results indicate that the landfill is having no significant impact on adjacent sediment and shellfish. There were no activities carried out on-on site which should cause a change in this status.

The environmental monitoring carried out during 2016 indicates that the landfill had no detrimental impact on the surrounding environment.

7.10 Ecological Report and Survey

As there were little or no works carried out within the body of the landfill during the reporting period is was felt that it was not necessary to carry out annual biological/ecological assessments. The licensee will formally apply to the Agency to have the requirement to have biological/ecological assessments carried out on an annual basis changed.

8. Topographic Survey

As there were little or no works carried out within the body of the landfill during the reporting period is was felt that it was not necessary to carry out a further topographical survey from that previously submitted. The licensee will formally apply to the Agency to have the requirement to have a topographical survey carried out on an annual basis changed.

9. Slope Stability Assessment

As no significant works were carried out on the main landfill body during the reporting period there was no significant slope slippage in 2015. The licensee will formerly apply to the Agency to have the frequency at which the Slope Stability Assessment carried out reduced.

10. Proposed Development of the Facility and Timescales for such development

a) Landfill Capping and Restoration

A Closure Restoration and Aftercare Plan was sent to the EPA during 2009 and capping was completed in 2009.

b) Landfill Gas Management

Under condition 3.12.1 of the Waste Licence "infrastructure for the active collection and flaring of landfill gas has been installed at the facility. The flare compound is an enclosed type design". The gas collection system was installed in tandem with the final capping of the landfill. Gas wells were bored in 2006 and the quantity of gas in these boreholes was recorded. The permanent flare was installed in April 2009. Gas field balancing is now carried out at regular intervals and a telemetry system to alert the licensee of flare irregularities has also been installed. The licensee has now reached an agreement with the flare manufacturers Automatic Flare Systems Ltd to carry out monitoring of the flare unit in accordance with Condition 6.1 and Schedule C.1.2 of the licence.

Unfortunately there have been ongoing problems with analysis of gas levels throughout the reporting period due to the failure of the gas analyser within the flare network. Gas levels throughout the year have been assessed using the GA5000 hand held analyser. The licensee is

currently in the process of reviewing analysis options in this regard with the options being to either to replace the existing analyser or replace the entire flare with a lo-cal option. Flare servicing reports are included in Appendix H

11. Volume of leachate produced and volume of leachate transported / discharged offsite.

The annual volume of leachate generated was estimated for the Waste Licence Application in 1998 to be in the order of 14087m^3. A saline intrusion study was conducted on the Landfill in 2005 and submitted to the Agency. A leachate extraction system has been installed in tandem with the final capping of the landfill. Leachate extraction wells were bored in 2006 and wells were monitored. These wells are now connected and pumping trials began in early 2009. A leachate tank was installed which collects leachate pumped from these wells. This leachate will be transported to Tramore Waste Water Treatment Plant. Leachate levels, which were generally low appear to have been reduced further due to the capping works, which will keep rainwater from entering the landfill, also the pumping of the leachate wells will reduce the leachate head. Leachate will be brought to the Tramore Waste Water Treatment plant under agreement in accordance with Condition No. 5.8.1 of the facility licence.

There was an extremely low volume of leachate produced on site during the reporting period and the leachate storage tank was only emptied on one occasion. The removal records are included in Appendix J

12. Report on Development works undertaken during the Reporting Period

Remediation of Landfill

No significant works other than those covered by agreed equipment maintenance contracts were carried out on site during the reporting period.

13. Annual Water Balance Calculation and Interpretation

The annual water balance could not be determined as the site is subject to saline intrusion. Meteorological data from Johnstown Castle weather station is collected for the facility on a daily basis. (Appendix E).

14. Report on the progress towards achievement of the Environmental Objectives and Targets contained in the previous year's report. (*Pleases refer to the AER 2008 for the previous year's Objectives and Targets).*

1. All site infrastructures have been maintained to the standards outlined in Condition 3 of the Waste Licence.
2. The effect of environmental nuisances was kept to a minimum during the reporting period. There had been an increase in unauthorised dumping in and around the site boundaries since the closure of the Civic Amenity site but our litter wardens have remained on top of this and the occurrences have lessened as a result of the ongoing works on the adjacent relief road.
3. Monitoring sites within the landfill area, had none or only trace levels of methane and carbon dioxide (<1%).
4. The Monitoring Programme as outlined under condition 8 and Schedule D of the Waste Licence has been maintained during the reporting period and all reports have been submitted to the Agency.
5. There is a comprehensive set of records for 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,2014, 2015 and 2016 held at the Council Office.
6. No emergency or significant complaint occurred on site during the reporting period

15. Schedule of Environmental Objectives and Targets for the forthcoming year

Objective 1 – To maintain site infrastructure to the standards outlined in Condition 3 of the Waste Licence

Target 1.1 - Any defect to the existing infrastructure will be repaired / replaced as quickly as possible on an ongoing basis.

Objective 2 – To minimise the effect of environmental nuisances

Target 2.1 – To implement the procedures outlined in Condition 7 of the Waste Licence on an ongoing basis throughout the year. Waterford County Council have endeavoured to achieve compliance with this condition and have to date been successful.

Objective 3 – That no specified emissions from the facility, shall exceed the limit values, set out in Condition 6 and Schedule C of the Waste Licence.

Objective 4 – To maintain the Monitoring Programme as outlined in Condition 8 and Schedule D of the Waste Licence.

Target 4.1 – To carry out the monitoring programme as outlined in Condition 8 and Schedule D of the Waste Licence.

Target 4.2 – To submit Monitoring Reports to the Agency within the timescale as outlined in Schedule E of the Waste Licence.

Objective 5 – To establish good record keeping and that all records are held at the facility office to comply with Condition 10 of the Waste Licence.

Objective 6 – That no emergency situation occurs on the site.

Target 6.1 – Ensure the contingency arrangements as outlined in Condition 9 of the Waste Licence are implemented throughout the year and to follow the procedure set out in the Emergency Response Procedures.

Objective 7 – Ensure the there is sufficient funds available to comply with Condition 12 of the Waste Licence.

The gate fee was the only avenue available to Waterford County Council to raise funds to ensure financial stability of the facility. As the Civic Amenity Facility has now been enclosed indefinitely the licensee will endeavour to identify other means of funding the facility.

16. Reported Incidents and Complaints Summary

16.1 Incidents

With regard to Condition 11.3 of the issued licence no incidents took place during the reporting period.

16.2 Complaints

No complaints were received during the reporting period.

17. Reports on Financial Provisions

Waterford County Council is responsible for providing annual fees to the Agency for monitoring and inspection of the site. The annual fee for 2016 for landfill monitoring was €46,000 and €22,704. for the licence. With regard to the details of financial provisions required under Condition 12.2.1 which are to be set aside in relation to the prevention of environmental damage and in order to underwrite the costs for remedial actions following anticipated events or incidents the licensee will establish, through consultation with the Agency, a timeframe for the provision and value of the required fund.

18. Management and Staffing Structure of the Facility

This can be viewed in Appendix F – Management Structure of Waterford City and County Council.

19. Programme for Public Information

A record of all monitoring results and reports are maintained both at the facility office and within the Environment Section of Waterford City and County Council at the Civic Offices in Dungarvan Co. Waterford. As the site office has been removed from the site and the Tramore Area Office has closed, all records will be accessible in Dungarvan or Waterford City.

20. Reports on Training of Staff

Both the Facility Manager and Deputy Manager have completed the Fás Waste Management Training Course and Fás Safe Pass program along with the IOSS Safety Managers course.

21. Maintenance Program

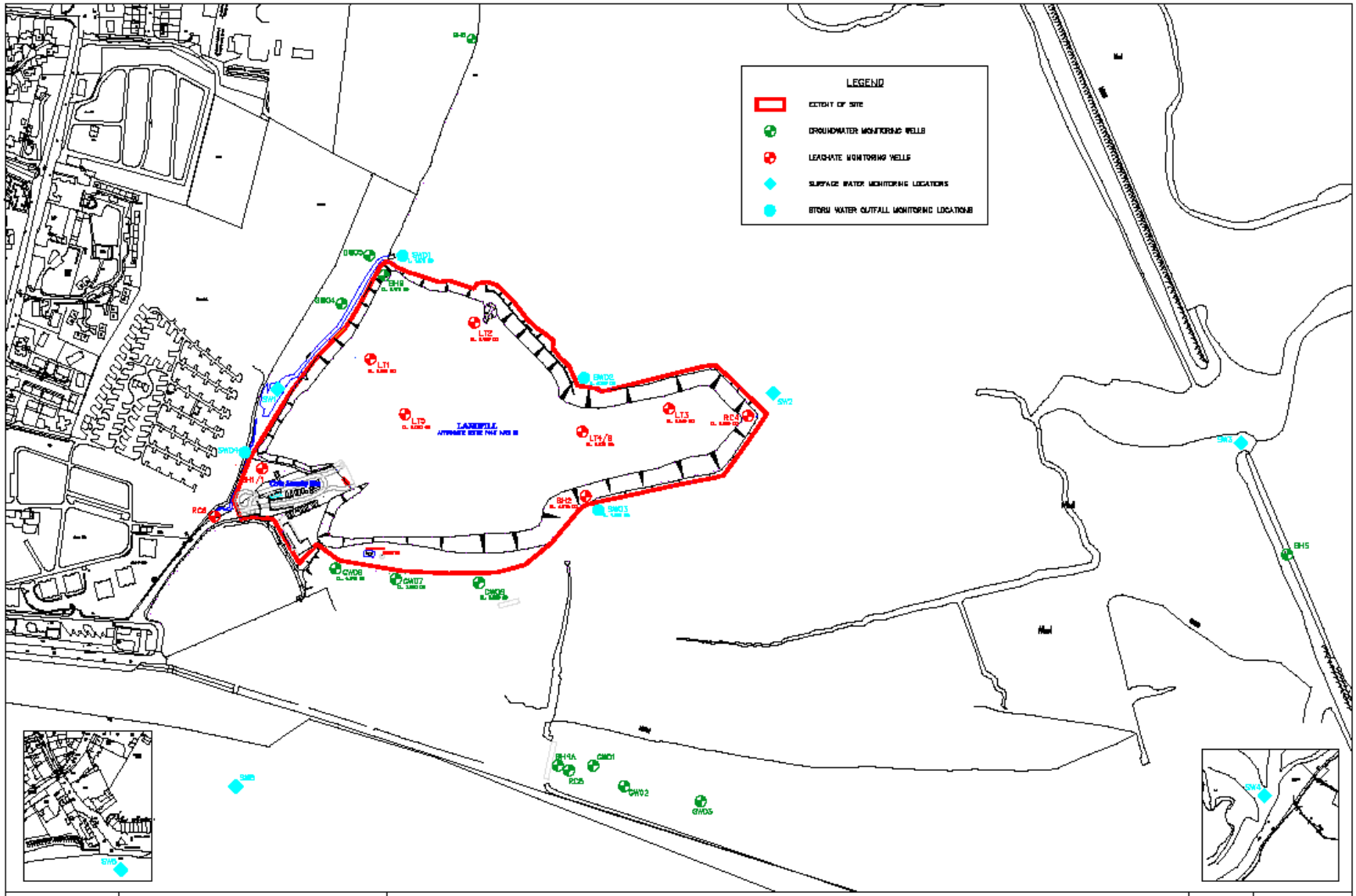
The licensee had adopted an electronic Preventative Maintenance Program (PEMAC by MJM Technologies).This Program covers all aspects of site maintenance and include monitoring and reporting, health and safety, maintenance and all training. All records and schedules are also maintained using the Project Vision maintenance system.

22. Statement of Financial Provisions in Relation to Prevention of Environmental Damage and Remedial Actions

A hydrogeological review survey is included in Appendix I

Appendix A

Monitoring Locations



WATERFORD COUNTY COUNCIL
Comhairle Chontae Phort Lairge
Civic Offices, Dmitt's Quay, Dungarvan
Tel: 058 22000
Fax: 058 45048

TRAMORE LANDFILL SURFACE WATER MONITORING AND GROUNDWATER/LEACHATE MONITORING WELL LOCATIONS

Drawn by	David Regan
Drawing No.	TLRM 1
Date	December 2010
Scale	Not to Scale

Appendix B
Surface Water Results

Jim McGarry, Brownstown, Kilkieran, Co. Kilkenny

Tel: 0874198557

Annual Monitoring Report

Waterford County Council

Facility: Tramore Landfill Site

Licence No. W0752-02

Report date: 21/05/2016

Date sampled: 28/03/2016

Date Completed: 07/04/2016

LABORATORY NUMBER		**2066**	**2067**	**2068**	**2069**	**2070**	**2071**	**2072**	**2074**	**2075**
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW03**	**SW01**	**SW02**	**SW04**
Date sampled	28/03/2016	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	29-Mar	28-Mar	28-Mar
Sampled by	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		16:40	11:50	11:15	10:00	10:30	14:50	17:15	15:45	15:55
Visual Inspection/Odour		clear	clear	clear	clear	clear	clear	clear	clear	nm
Taste										
Groundwater Level	m									
Temp	oC	8.9	9.5	8.5	7.7	8.6	9.2	8.5	9.3	
pH	units	7.4	8.4	8.2	8.2	8.1	7.6	7.9	7.7	
Cond	uS/cm	889	nm	nm	nm	nm	2620	1046	1193	
Salinity	%	nm	33.9	33.9	32.4	33.4	nm	nm	nm	
BOD	mg/l	4	3	2	3	2	3		2	
COD	mg/l	13.6	475	374	431	374	<14	24.7	32.7	
Sus Solids	mg/l	0.8	12.8	13	26.6	46.4	1.4	15.2	7	
Ammonia Total (as N)	mg/l	<0.2	0.207	<0.2	<0.3	<0.4	0.362	0.363	0.281	
Chloride(asCl)	mg/l	133	19400	19200	18700	19800	516	104	101	
Total Oxidised Nitrogen	mg/l	1.37	<0.1	<0.1	<0.1	<0.1	0.911	0.593	0.278	
Total Organic Carbon	mg/l	4.33	<3	<3	<3	<3	9.14	7.66	9.67	
ortho-Phosphate (asP)	mg/l	0.0225	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Sulphate	mg/l	38.2	2780	2500	2500	2760	104	55.8	88.4	
Dissolved Oxygen	% sat	74	146	107	104	102	84	96	94	
Alkalinity	mg/l	130	130	121	124	122	388	372	371	
Calcium	mg/l	74.1	353	341	350	353	170	150	149	
Cadmium	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Chromium	ug/l	<3	86.4	62.4	<3	<3	<3	<3	<3	
Copper	ug/l	<0.85	6.69	2.84	5.11	3.86	2.06	1.59	2.01	
Iron	ug/l	<0.019	0.265	<0.019	<0.019	<0.019	<0.019	0.0254	<0.019	
Lead	ug/l	0.089	1.14	1.62	2.06	1.1	0.078	0.031	0.038	
Magnesium	mg/l	13.6	1100	1080	1100	1110	43.4	18.2	17	
Manganese	ug/l	3.3	2.91	3.5	2.49	2.26	770	1330	1490	
Mercury	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Potassium	mg/l	4.99	374	369	371	378	15.9	4.58	3.53	
Sodium	mg/l	69.3	9610	9620	9040	9910	257	60.1	49.4	
Zinc	ug/l	18	12	2.2	8.2	5.96	1.08	0.931	0.939	
Total P	ug/l	43.4	<200	<200	<200	<200	<20	22.4	23.6	
Total Coliforms	No/100mls	29	2	5	24	14	16	>100	9	
E. coli	No/100mls	21	0	3	19	4	6	>100	6	
Clostridium Perfringens	No/100mls	nm	nm	nm	nm	nm	nm	nm	nm	

LABORATORY NUMBER		**2257**	**2258**	**2259**	**2260**	**2261**	**2262**	**2263**	**2264**	**2265**	**2266**
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW01**	**SW02**	**SW03**	**SW04**
Date sampled	26/06/2016	26-Jun	27-Jun	26-Jun	26-Jun	26-Jun	26-Jun	27-Jun	26-Jun	26-Jun	26-Jun
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		19:00	16:00	16:10	14:05	15:05	15:30	16:35	18:35	16:40	16:50
Visual Inspection/Odour		Brown	clear	clear	clear	clear	clear	clear	dry	dry	seized manhole
Temp	oC	16.7	15.9	21.5	16.5	17.3	16.4	16.0			
pH	units	7.4	8.2	8.3	8.5	8.1	8.1	7.4			
Cond	uS/cm	1307	nm	nm	nm	nm	nm	820			
Salinity	%	nm	34.6	33.5	34.3	34.6	34.6	nm			
BOD	mg/l	7	<2	<2	<2	<2	<2	<5			
COD	mg/l	42.9	nm	nm	nm	nm	nm	16.4			
Sus Solids	mg/l	34.2	3.6	54.4	2.6	26.8	3.2	0.4			
Ammonia Total (as N)	mg/l	10.5	<0.2	0.263	<0.2	<0.2	35.5	<0.2			
Chloride(asCl)	mg/l	185	18300	17700	19400	18200	19600	92.5			
Sodium	mg/l	nm	nm	nm	nm	nm	nm	65.5			
Potassium	mg/l	nm	nm	nm	nm	nm	nm	<1			
Iron	mg/l	nm	nm	nm	nm	nm	nm	0.0603			
Total Organic Carbon	mg/l	9.78	<3	3.52	<3	<3	<3	7.27			
Dissolved Oxygen	% sat	44	130	107	151	103	97	55			
Total Coliforms	No/100mls	>100	nm	3	1	0	2	0			
E. coli	No/100mls	>100	nm	2	1	0	2	0			
			Full Tide								

LABORATORY NUMBER		**2394**	**2395**	**2396**	**2397**	**2398**	**2399**	**2400**	**2401**	**2402**	**2403**
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW01**	**SW02**	**SW03**	**SW04**
Date sampled	30/09/2016	30-Sep	30-Sep	02-Oct	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		14:45	13:15	13:40	11:00	15:30	01:50	15:00	14:15	12:25	14:55
Visual Inspection/Odour		clear	No sample	clear	clear	clear	clear	clear	ght brow	no flow	seized manhole
Temp	oC	14.3	nm	15.6	14.3	15.2	15.5	13.1	15.5		
pH	units	7.0	nm	7.9	8.5	8.1	8.0	7.6	8.0		
Cond	uS/cm	1551	nm	nm	nm	nm	nm	927	1377		
Salinity	%	nm	nm	32	34.3	34.8	34.8	nm	nm		
BOD	mg/l	6	nm	<5	1	<2	<2	<2	<2		
COD	mg/l	27.1	nm	482	273	285	638	10.7	28.8		
Sus Solids	mg/l	14.2	nm	16.8	4.6	14	10	1.2	13		
Ammonia Total (as N)	mg/l	7.46	nm	<0.2	<0.2	<0.2	<0.2	<0.2	0.761		
Chloride(asCl)	mg/l	196	nm	18700	19400	19700	19800	119	129		
Total Organic Carbon	mg/l	8.6	nm	<3	<3	<3	<3	5.72	11.8		
Dissolved Oxygen	% sat	15	nm	122	165	100	70	77	97		
Total Coliforms	No/100mls	0	nm	52	31	0	0	0	0		
E. coli	No/100mls	0	nm	31	31	0	0	0	0		
			Tide out								

LABORATORY NUMBER		**2587**	**2588**	**2589**	**2590**	**2591**	**2592**	**2593**	**2594**	**2595**	**2596**
Sampling Location		**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW01**	**SW02**	**SW03**	**SW04**
Date sampled	21/11/2016	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov	21-Nov
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		13:45	13:05	12:35	11:55	14:15	14:00	13:25	13:20	12:55	13:45
Visual Inspection/Odour		clear	clear	clear	clear	clear	clear	clear	no flow	no flow	seized manhole
Temp	oC	7.0	5.2	5.3	7.4	7.8	7.9	4.9			
Dissolved Oxygen	% sat	20	101.0	98	100	100	98	86			
pH	units	7.3	8.2	8.2	8.2	8.1	8.2	8.2			
Cond	uS/cm	1609	nm	nm	nm	nm	nm	987			
Salinity	%	nm	34.0	34.2	34	354.6	34.6	nm			
BOD	mg/l	4	1.0	2	1	<2	13	2			
COD	mg/l	29.8	435.0	422	388	435	439	19.7			
Sus Solids	mg/l	5.5	56.5	49.5	37.5	26.5	28.5	<2			
Ammonia Total (as N)	mg/l	8.61	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2			
Chloride(asCl)	mg/l	206	20000.0	19200	19600	119900	19700	123			
Total Coliforms	No/100mls	0	0	0	5	17	13	0			
E. coli	No/100mls	0	0	0	5	12	13	0			
Comments:											

Appendix C
Ground Water Results

Jim McGarry, Brownstown, Kilkieran, Co. Kilkenny

Tel: 0874198557

Annual Monitoring Report

Waterford County Council

Facility: Tramore Landfill Site

Licence No. W0752-02

Report date: 21/05/2016

Date sampled: 28/03/2016

Date Completed: 07/04/2016

LABORATORY NUMBER		**2076**	**2077**	**2078**	**2079**	**2080**	**2081**	**2082**	**2083**	**2084**	**2085**	**2086**	**2094**
Sampling Location		**BH 1/1**	**BH 8**	**BH9**	**GW01**	**GW02**	**GW03**	**GW04**	**GW05**	**GW06**	**GW07**	**GW08**	**BH 2**
Date sampled	28/03/2016	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar
Sampled by	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		14:30	15:50	16:05	19:25	19:45	20:00	17:10	16:40	18:50	18:40	18:05	15:00
Visual Inspection/Odour Taste		clear	light brown	muddy	greyish	rusty brown	grey w/sed	light brown	muddy	muddy sandy	light brown	grey w/sed	sl rusty brown
Groundwater Level	m	1.4	6.0	5.8	5.7	5.7	1.8	2.3	6.0	3.0	7.2	3.2	1.8
Temp	oC	9.3	9.8	11.5	10.0	9.3	8.2	9.4	10.9	8.6	8.6	8.8	12.1
pH	units	6.8	7.3	7.0	7.5	7.3	7.1	6.9	7.2	7.0	7.0	7.1	6.82
Cond	uS/cm	3380	3980	1120	6460	10090	10060	1230	992	2190	1727	1881	19120
Salinity	%	nm	2.0	nm	3.4	5.6	5.5	nm	nm	nm	nm	nm	11.1
Ammonia Total (as N)	mg/l	22.5	<0.2	0.34	0.675	1.27	0.501	<0.2	<0.2	5.99	5.87	12.8	35.4
Chloride(asCl)	mg/l	730	1120	188	1800	2970	3080	152	118	322	206	236	5840
Total Oxidised Nitrogen	mg/l	<0.1	0.141	<0.1	0.136	<0.1	<0.1	0.404	0.978	0.136	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	8.38	109	<3	9.65	9.15	<3	<3	<3	9.27	7.61	10.4	12.4
ortho-Phosphate (asP)	mg/l	<0.2	<0.2	<0.2	0.421	0.0222	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.02
Sulphate	mg/l	<2	185	30	224	369	313	75.8	42.9	54.9	<2	<2	396
Dissolved Oxygen	% sat	26	23	20	42	82	32	24	54	25	13	21	21
Alkalinity	mg/l	695	300	150	540	588	755	434	311	570	581	837	1090
Boron	ug/l	373	191	56.9	414	563	421	<9.4	<9.4	58.7	125	249	1060
Calcium	mg/l	168	113	57.3	13.3	243	330	146	91.3	208	179	150	301
Cadmium	ug/l	<0.1	<0.1	<0.1	<0.1	0.105	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	ug/l	12.5	10.5	47.3	17.5	5.91	162	5.57	24	19.4	<3	66.5	10.4
Copper	ug/l	<0.85	0.992	<0.85	<0.85	<0.85	1.37	0.932	<0.85	<0.85	<0.85	<0.85	1.97
Iron	ug/l	5.08	<0.019	<0.019	<0.019	<0.19	<0.19	<0.019	<0.019	5.03	3.59	3.08	6.36
Lead	ug/l	0.192	<0.02	<0.02	0.298	1.02	0.154	0.079	0.064	0.327	<0.02	<0.02	0.028
Magnesium	mg/l	44	66.5	23.6	94.6	169	214	32.5	21.2	31.9	22.4	34.3	389
Manganese	ug/l	880	109	1370	596	571	109	737	420	2540	2020	2170	2260
Mercury	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	mg/l	25.8	14.1	5.44	40.9	48.1	55.7	1.61	1.23	12.3	11.4	20	162
Sodium	mg/l	358	522	122	103	1430	1470	85.2	71.8	136	107	141	2820
Zinc	ug/l	1.78	1.77	2.01	1.96	29.6	5.99	5.92	15.9	17.4	1.59	0.877	2.67
Total P	ug/l	366	146	1100	869	1000	9020	41.5	330	1910	366	1830	1620
Total Coliforms	No/100mls	26	18	12	>100	6	2	>100	17	0	0	1	0
E. coli	No/100mls	0	0	8	3	6	0	0	0	0	0	0	0
Clostridium Perfringens	No/100mls	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
VOC'S ****	mg/l												
Fluoride	mg/l F	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

**** ıal compounds are contained in the Certificate of Analysis, eı

LABORATORY NUMBER		**2267**	**2268**	**2269**	**2270**	**2271**	**2272**	**2273**	**2274**	**2275**	**2276**
Sampling Location		**BH 8**	**BH9**	**GW1**	**GW2**	**GW3**	**GW4**	**GW5**	**GW6**	**GW7**	**GW8**
Date sampled	27/06/2016	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun	27-Jun
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		16:50	11:50	14:25	14:10	13:45	15:55	12:30	14:50	15:20	15:30
Visual Inspection/Odour		rusty brown	muddy	light brown	sandy	brown grey	sl brown	muddy brown	cloudy grey	grey	gray pungent
Groundwater Level	m	7.1	5.7	4.2	5.2	1.4	3.0	6.8	2.6	6.6	3.7
Temp	oC	12.1	12.6	12.5	12.5	13.4	13.6	12.6	13.5	13.2	13.6
pH	units	7.2	7.2	6.9	7.2	6.9	7.0	7.2	6.9	7.0	7.2
Cond	uS/cm	5190	1060	nm	nm	nm	1186	985	1933	1817	1842
Salinity	%	2.7	nm	5.3	6.5	6.8	nm	nm	0.8	0.7	0.7
Ammonia Total (as N)	mg/l	0.312	0.588	1.27	1.92	0.448	0.393	<0.2	7.42	8.24	13.1
Chloride(asCl)	mg/l	1380	135	3560	3530	3690	94.2	106	233	196	196
Total Oxidised Nitrogen	mg/l	<0.1	<0.1	0.301	<0.1	<0.1	0.171	0.93	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	<3	<3	11.5	8.94	7.79	<3	<3	11.5	8.64	12.3
Dissolved Oxygen	% sat	23	17	65	50	34	51	27	16	15	14
Sodium	mg/l	691	115	1670	1620	1620	79.1	70.4	128	114	129
Potassium	mg/l	20.2	5.84	63.5	67.4	56.8	1.68	2.09	14.3	15.5	20.1
Iron	ug/l	<0.019	0.201	<0.19	<0.19	0.582	<0.019	<0.019	8.07	14.3	8.84
Total Coliforms	No/100mls	0	0	0	10	0	0	0	0	0	0
E. coli	No/100mls	0	0	0	10	0	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

LABORATORY NUMBER		**2404**	**2405**	**2406**	**2407**	**2408**	**2409**	**2410**	**2411**	**2412**	**2413**
Sampling Location		**BH 8**	**BH9**	**GW1**	**GW2**	**GW3**	**GW4**	**GW5**	**GW6**	**GW7**	**GW8**
Date sampled	02/10/2016	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct	02-Oct
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		10:35	11:00	14:40	14:30	14:00	11:40	11:20	12:15	12:30	13:00
Visual Inspection/Odour		muddy brown	muddy brown	cloudy	light brown	sandy	muddy brown	muddy brown	cloudy grey	clear	grey
Groundwater Level	m	6.1	5.7	4.1	5.7	1.3	4.7	3.4	2.7	6.8	3.9
Temp	oC	12.9	12.4	13.2	14.5	14.7	14.2	13.9	14.2	14.3	14.5
pH	units	7.0	6.9	7.2	7.3	6.7	6.9	7.0	6.8	6.8	7.0
Cond	uS/cm	5100	2860	nm	nm	nm	1186	1006	2160	2020	1854
Salinity	%	2.6	1.3	5.6	7.7	11.7	nm	nm	nm	nm	nm
Ammonia Total (as N)	mg/l	<0.2	0.918	1.18	1.79	0.687	<0.2	<0.2	11.3	10.2	9.91
Chloride(asCl)	mg/l	1390	637	3160	420	6650	108	116	226	210	240
Total Oxidised Nitrogen	mg/l	<0.1	<0.1	0.379	<0.1	<0.1	<0.1	0.563	<0.1	<0.1	<0.1
Total Organic Carbon	mg/l	<3	<3	8.49	9.74	9.16	<3	<3	11	10.4	11.1
Dissolved Oxygen	% sat	26	15	52	93	16	41	29	12	14	15
Sodium	mg/l	759	340	1710	1900	3160	95.4	78.2	123	130	127
Potassium	mg/l	19.6	11.5	62.1	66.1	85.1	1.3	1.18	19.3	16.6	18.8
Iron	ug/l	<0.019	1.72	<0.19	<0.19	0.735	<0.019	<0.019	1.69	6.5	3.64
Total Coliforms	No/100mls	0	>100	78	25	12	>100	6	0	0	0
E. coli	No/100mls	0	0	78	25	7	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

LABORATORY NUMBER		**2600**	**2601**	**2606**	**2607**	**2608**	**2609**	**2610**	**2611**	**2612**	**2613**
Sampling Location		**BH 8**	**BH9**	**GW1**	**GW2**	**GW3**	**GW4**	**GW5**	**GW6**	**GW7**	**GW8**
Date sampled	22/11/2016	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov	22-Nov
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		15:50	11:40	13:40	13:20	12:55	15:10	15:35	14:35	14:15	14:00
Visual Inspection/Odour		light brown	muddy brown	cloudy	cloudy	sandy	cloudy	muddy brown	cloudy grey	clear	grey
Groundwater Level	m	6.1	5.7	5.2	5.4	1.3	3.1	6.9	2.5	6.8	3.8
Temp	oC	10.7	10.8	11.8	10.8	10.4	11.3	11.6	11.5	11.2	11.0
Dissolved Oxygen	% sat	33	19	22	87	26	33	49	15	17	15
pH	units	7.4	7.0	7.2	7.4	7.0	7.2	7.4	6.9	6.8	7.2
Cond	uS/cm	4580	1397	nm	nm	nm	1102	1020	2180	2010	1919
Salinity	%	nm	nm	12.4	13.6	12.9	nm	nm	nm	nm	nm
Total Organic Carbon	mg/l	<3	3.56	8.34	11.2	12	<3	<3	12.3	10.9	12.5
Ammonia Total (as N)	mg/l	<0.2	0.68	<0.2	1.78	0.515	<0.2	<0.2	11.7	11	11.5
Chloride(asCl)	mg/l	1170	185	4700	4260	7100	8939	1153	227	207	221
Total Oxidised Nitrogen	mg/l	0.23	<0.1	<0.1	<0.1	<0.1	0.132	0.218	<0.1	<0.1	0.116
Sodium	mg/l	572	121	2170	2100	3830	77.9	78.6	132	128	154
Potassium	mg/l	14.8	7.07	67.3	66.3	97.7	<1	1.45	18.2	16.9	20.1
Iron	ug/l	<0.019	1.59	<0.19	<0.19	0.299	<0.019	<0.019	6.53	21.2	3.85
Arsenic	ug/l	0.848	4.83	3.88	3.87	2.85	0.63	2.1	216	17.9	7.09
Total Coliforms	No/100mls	13	11	77	26	15	>100	0	0	0	0
E. coli	No/100mls	0	11	77	16	15	0	0	0	0	0
Phenols (speciated)	ug/l	<0.025	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025	<0.025	<0.025

Appendix D

Leachate Results

Tel: 0874198337

Annual Monitoring Report

Waterford County Council

Facility: Tramore Landfill Site

Licence No. W0752-02

Report date: 21/05/2016

Date sampled: 28/03/2016

Date Completed: 07/04/2016

LABORATORY NUMBER		**2087**	**2088**	**2089**	**2090**	**2091**	**2092**	**2093**
Sampling Location		**RC 4**	**RC 6**	**LT 1**	**LT 2**	**LT 3A**	**LT 4B/B**	**LT 5A**
Date sampled	28/03/2016	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar	28-Mar
Sampled by	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		12.10	12.10	13.10	12.55	12.40	12.50	13.20
Visual Inspection/Odour		slightly brown	No sample	black	No sample	black	No sample	No sample
Taste								
Groundwater Level	m	12.9	missing	2.5	0.4	1.2	dry	dry
Temp	oC	11.8		14.0		12.8		
pH	units	7.2		6.9		7.5		
Cond	uS/cm	nm		5550		22500		
Salinity	%	32.9		2.9		13.3		
BOD	mg/l	32		133		99		
COD	mg/l	808		490		1930		
Ammonia Total (as N)	mg/l	5		237		1440		
Chloride(asCl)	mg/l	17900		547		2680		
Total Oxidised Nitrogen	mg/l	37		25.8		68		
ortho-Phosphate (asP)	mg/l	<0.02		<0.02		2		
Sulphate	mg/l	2420		<2		<2		
Boron	ug/l	1820		1970		3420		
Calcium	mg/l	416		215		34		
Cadmium	ug/l	<0.1		<0.1		0.103		
Chromium	ug/l	36.5		25.8		68.4		
Copper	ug/l	5.3		<0.85		4.1		
Iron	ug/l	<1.9		1.56		3.39		
Lead	ug/l	0.1		0.2		2.4		
Magnesium	mg/l	1020.0		88.2		238.0		
Manganese	ug/l	6840		833		50		
Mercury	ug/l	<0.01		<0.01		<0.01		
Potassium	mg/l	338		173		925		
Sodium	mg/l	8630		384		2130		
Zinc	ug/l	21.80		4.16		21.80		
Total Coliforms	No/100mls	0		0		0		
E. coli	No/100mls	0		0		0		
Clostridium Perfringens	No/100mls	nm		nm		nm		
Cyanide	mg/l	<0.5		<0.5		<0.5		
VOC'S	mg/l							
Fluoride	mg/l F	1.08		<0.5		2.02		
Total P	ug/l	<200		1840		8000		

Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		17:55	17:40	17:30	17:35	18:05	17:15	17:00	18:20	16:50
Visual Inspection/Odour Taste		grey	No sample	black pungen	well blocked	dry	clear	missing	clear	light brown
Groundwater Level	m	2.0	DRY	1.4		DRY	12.5		2.3	3.6
Temp	oC	14.9		15.4			13.5		13.1	14
pH	units	6.9		7.6			7.2		6.9	7.3
Cond	uS/cm	5550		nm			nm		3900	nm
Salinity	%	2.9		13.3			31.9		nm	10.7
BOD	mg/l	36		36			<5		8	<5
COD	mg/l	556		1970			404		41.8	179
Ammonia Total (as N)	mg/l	242		1510			12.4		24.4	39.1
Chloride(asCl)	mg/l	512		2530			17600		772	5770
Total Oxidised Nitrogen	mg/l	0		0.113			<0.1		<0.1	<0.1
Sodium	mg/l	367		2200			8080		392	2820
Potassium	mg/l	175		965			372		29.3	144
Iron	ug/l	21.80		3.04			<0.19		3.51	1.34

LABORATORY NUMBER		**2416**	**2417**	**2418**	**2419**	**2420**	**2421**	**2422**	**2414**	**2415**
Sampling Location		**LT1**	**LT2**	**LT3A**	**LT4B/B**	**LT5**	**RC4**	**RC6**	**BH1/1**	**BH2**
Date sampled	30/09/2016	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep	30-Sep
Sampled by	Jim McGarry	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG	JMcG
Time sampled		14:25	14:20	13:50	14:15	14:30	13:20	14:35	12:15	12:35
Visual Inspection/Odour Taste		dry	No sample	black pungen	well blocked	dry	clear	missing	clear	clear
Groundwater Level	m	5.3	DRY	1.6		DRY	11.7		2.6	3.7
Temp	oC	5.3		14.5			13.1		14.4	13.7
pH	units			7.5			7.2		6.9	7
Cond	uS/cm			nm			nm		2720	nm
Salinity	%	DRY		13.3			32.9		nm	11.6
BOD	mg/l			43			<5		6	3
COD	mg/l			1650			383		24.9	135
Ammonia Total (as N)	mg/l			1480			5.55		24.1	36.9
Chloride(asCl)	mg/l			2710			19100		466	6550
Total Oxidised Nitrogen	mg/l			<0.5			<0.1		<0.1	<0.1
Sodium	mg/l			2440			9730		267	3310
Potassium	mg/l			1050			357		24.9	157
Iron	ug/l			3.59			<0.19		<0.19	<0.19

Time sampled		12:00	11:20	11:10	11:15	12:15	11:05	12:30	12:40	10:40
Visual Inspection/Odour Taste		brownish	No sample	black pungen	well blocked	dry	clear	missing	clear	black tinge
Groundwater Level	m	2.1	DRY	3.4		DRY	6.4		2.4	4.8
Temp	oC	13.0		10.6			11.5		11.3	11.9
pH	units	6.9		7.6			7.1		6.9	6.9
Cond	uS/cm	5500		nm			nm		2130	nm
Salinity	%	nm		13.2			33		nm	12
BOD	mg/l	34		157			<5		8	40
COD	mg/l	389		1590			502		61.6	253
Ammonia Total (as N)	mg/l	239		1530			5.61		25.3	36.9
Chloride(asCl)	mg/l	514		2510			18300		442	6380
Sodium	mg/l	334		2040			8530		264	3360
Potassium	mg/l	160		1020			369		24.5	155
Iron	ug/l	13.50		3.35			0.134		5.07	29.3

Appendix E

Meteorological Data

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
rain: - Precipitation Amount (mm)
maxtp: - Maximum Air Temperature (C)
mintp: - Minimum Air Temperature (C)
gmin: - 09utc Grass Minimum Temperature (C)
soil: - Mean 10cm soil temperature (C)
cbl: - Mean CBL Pressure (hpa)
wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)

ddhm: - Wind Direction at max 10 min mean (deg)
hg: - Highest Gust (kt)
pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Jan-16	9.6	1.8	-4.2	10.7	996.2	15	25	130	39	5.931	0.6	0.8	0	-10	-10	45
02-Jan-16	10.1	4.3	5.9	1.7	988.2	8	17	110	26	8.432	0.3	0.4	0	-1.4	-10	124
03-Jan-16	10.1	4.3	1.6	9.8	979.9	10.8	24	140	35	7.783	0.1	0.2	0	-9.7	-10	304
04-Jan-16	9.4	5.6	4.8	1.2	969	6.2	11	220	16	7.272	0.2	0.3	0	-1	-10	239
05-Jan-16	8.2	5.3	2.5	1.2	978.4	10.6	17	300	24	6.862	0.4	0.5	0	-0.8	-10	267
06-Jan-16	10.1	2.5	-1.1	11.5	979	11.6	28	140	39	5.87	0.3	0.4	0	-10	-10	188
07-Jan-16	9.9	2.8	1.2	5.5	978.5	11.3	24	290	35	5.739	0.1	0.1	0	-5.4	-10	388
08-Jan-16	7.8	3.6	1.4	20.1	984.8	7.3	17	200	29	5.686	0.3	0.3	0	-10	-10	260
09-Jan-16	7.1	2.2	-0.7	14.3	975.3	5.6	12	300	18	5.203	0.3	0.5	0	-10	-10	83
10-Jan-16	5.6	1.9	-0.1	1.4	972.3	7.1	12	220	18	4.008	0.3	0.4	0	-1.1	-10	269
11-Jan-16	6.4	0.2	-4.1	0.2	979.7	8.6	19	300	30	3.559	0.2	0.3	0	0	-9.5	299
12-Jan-16	6	-0.2	-0.1	0	998.6	15.6	29	290	42	3.003	0.6	0.8	0.7	0.7	-8.4	413
13-Jan-16	6.1	0.3	-2.9	1.4	1003.2	8.3	13	250	19	2.57	0.5	0.6	0	-0.3	-8.9	137
14-Jan-16	5.3	-1.4	-4.4	0.2	1006	11	19	290	29	2.099	0.5	0.6	0.3	0.3	-8.2	401
15-Jan-16	5.4	0.8	-0.6	0	1018.2	11.7	21	290	28	1.921	0.7	0.8	0.9	0.9	-7.1	451
16-Jan-16	6.9	-0.3	-5.4	0	1021	4.7	10	300	13	2.514	0.3	0.4	1.2	1.2	-6.5	289
17-Jan-16	9.1	4.2	-1	4.9	1009.9	7.8	19	140	27	4.755	0.5	0.6	0	-3.3	-10	135
18-Jan-16	8.2	5.9	3	5.6	1002.1	7.9	18	150	28	6.287	0.4	0.5	0	-5.2	-10	84
19-Jan-16	9.1	3.1	2.1	0	1007.6	3.4	8	150	12	5.88	0.4	0.6	0.4	0.4	-9.1	265
20-Jan-16	7.4	2.1	-5.5	0.1	1007.9	7.6	16	140	23	3.377	0.6	0.7	0.9	0.9	-8.2	282
21-Jan-16	10.9	7.4	-1.8	10.4	1002.5	16.4	22	150	29	7.426	0.5	0.7	0	-9.1	-10	49
22-Jan-16	11.2	8.4	9.1	12.8	1004.5	13.4	18	170	29	8.872	0.3	0.5	0	-10	-10	409
23-Jan-16	11.3	8.6	6.8	6	1013.1	12.1	23	160	36	8.315	0.4	0.6	0	-5.6	-10	88
24-Jan-16	11.7	10.8	8.5	0.6	1009.2	14.5	18	190	29	10.07	0.4	0.6	0	-0.2	-9.7	100
25-Jan-16	11.7	6.1	10.3	0.5	1004.9	14.1	21	170	35	9.345	0.6	0.8	0.1	0.1	-9.2	277
26-Jan-16	11.3	9.2	3.1	13	999.3	20.3	26	210	45	9.185	0.6	1	0	-10	-10	60
27-Jan-16	11.4	2.1	9.9	2.8	999.1	14.9	23	200	37	8.724	0.4	0.6	0	-2.4	-10	329
28-Jan-16	10.7	2.4	0.2	0.6	1009.5	15.1	23	220	39	5.977	0.6	0.8	0	0	-9.5	141
29-Jan-16	10.6	6.8	6.5	0.5	1003.6	16.1	27	220	46	8.698	0.7	0.9	0.2	0.2	-8.9	399
30-Jan-16	7	2.5	0.5	0.1	1002.2	10.4	18	260	28	4.944	0.7	0.9	0.7	0.7	-7.9	419
31-Jan-16	13.2	4.2	2.2	5	998.9	13	19	250	30	7.753	0.7	0.9	0	-3.6	-10	264

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
rain: - Precipitation Amount (mm)
maxtp: - Maximum Air Temperature (C)
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pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Feb-16	11.6	6.6	9	0.4	1003.2	17.9	26	230	39	8.548	1.1	1.4	0.7	0.7	-8.8	536
02-Feb-16	7.7	1.2					18	230	30							
03-Feb-16	8.8	1.3					18		27							
04-Feb-16	12.5	8.2		0.1	1016.7	10.1	15	250	24	8.239	0.6	0.8	0.5	0.5	0.5	353
05-Feb-16	9.9	3	7.4	8.9	1004.6	13.2	20	200	36	7.588	0.5	0.7	0	-7.9	-7.9	104
06-Feb-16	9.5	3.9	-0.2	9	983.4	12.6	22	180	33	6.269	0.6	0.9	0	-8.4	-10	272
07-Feb-16	9.9	3.1	1.5	6.9	976.2	14.5	24	250	41	4.9	0.5	0.8	0	-6.4	-10	427
08-Feb-16	8.7	3.4	3.6	4.4	975.2	18.9	29	270	47	5.537	1	1.5	0	-3.4	-10	694
09-Feb-16	5.1	0.9	-0.7	2.1	983	13	21	290	34	3.324	0.6	0.9	0	-1.5	-10	528
10-Feb-16	7.9	1.6	-0.1	0.1	991.6	6.9	18	270	29	4.317	0.5	0.8	0.4	0.4	-9.1	1322
11-Feb-16	7.3	1.1	-3.8	1.5	991.3	2.4	8	350	13	4.056	0.3	0.6	0	-0.8	-9.8	855
12-Feb-16	7.5	2.7	-0.7	4.1	982.5	7.3	17	120	31	5.304	0.4	0.6	0	-3.7	-10	444
13-Feb-16	6.9	5	4.5	9.4	978	9.3	15	140	25	5.819	0.6	0.9	0	-8.8	-10	272
14-Feb-16	6.9	1.3	3.4	0.7	996.6	10.2	17	50	24	4.736	0.9	1.3	0.2	0.2	-9.3	727
15-Feb-16	6.7	-0.2	-1.8	0	1019.8	6.3	11	330	19	3.199	0.8	1.2	1	1	-8	1562
16-Feb-16	8.7	3	-3.2	19.5	1016.1	14.9	21	200	35	4.957	0.7	1.1	0	-10	-10	263
17-Feb-16	8.9	0.7	3.5	12.5	1005.3	7.2	20	190	32	6.095	0.5	0.8	0	-10	-10	949
18-Feb-16	7.9	0	-2.5	0.1	1007.3	7.1	11	250	17	3.589	0.9	1.3	0.8	0.8	-8.7	1485
19-Feb-16	9.8	1.9	-0.2	1	1003.9	10.3	16	200	26	5.767	0.6	0.9	0.3	0.3	-8.7	624
20-Feb-16	12	7.1	5.3	0.9	1000.7	12	18	240	28	7.55	0.8	1.2	0.3	0.3	-8.3	350
21-Feb-16	11.4	7	8.9	0.7	1000.3	15.9	25	240	38	9.42	0.7	1.1	0.3	0.3	-7.9	645
22-Feb-16	8	2.4	3.7	0	1004.5	6.3	12	290	18	6.911	0.9	1.3	1.2	1.2	-6.6	1385
23-Feb-16	7.8	1.2	-2.1	0.1	1011	7.1	11	50	17	4.989	1	1.6	2.1	2.1	-5.4	1848
24-Feb-16	7.9	-0.3	-2.4	0	1012.3	6.3	9	340	13	4.213	1.1	1.5	3.1	3.1	-4	1039
25-Feb-16	7.3	-0.8	-4	0.9	1007.5	4.6	7	320	11	3.65	0.7	1	2.9	2.9	-4	548
26-Feb-16	6.9	3.1	1.2	11.7	998.7	8.8	14	100	23	4.765	0.7	0.9	0	-8.1	-10	186
27-Feb-16	7	3.8	2.5	0.5	1004.5	8.4	12	40	21	5.008	1.2	1.6	0.7	0.7	-8.8	764
28-Feb-16	7.6	0.8	-0.8	0	1015.9	5.3	10	80	16	4.913	1	1.5	1.7	1.7	-7.3	1170
29-Feb-16	9.5	1.7	-4.5	8.4	1013.3	10	18	220	30	4.905	0.6	0.9	0	-6	-10	164

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
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maxtp: - Maximum Air Temperature (C)
mintp: - Minimum Air Temperature (C)
gmin: - 09utc Grass Minimum Temperature (C)
soil: - Mean 10cm soil temperature (C)
cbl: - Mean CBL Pressure (hpa)
wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)
ddhm: - Wind Direction at max 10 min mean (deg)
hg: - Highest Gust (kt)
pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Mar-16	12.4	2.8	4.2	7.3	1001.9	15.5	22	260	35	8.354	1	1.6	0	-6.3	-10	847
02-Mar-16	9.4	1.5	0.7	8.2	996.8	19	29	250	44	5.256	1.4	2.3	0	-6.8	-10	999
03-Mar-16	8.6	0.8	3.4	3.5	996	10.3	21	280	31	5.588	0.6	1	0	-2.9	-10	536
04-Mar-16	6.3	-0.1	-1.3	1.3	989.2	12.2	20	350	31	3.549	0.8	1.2	0	-0.5	-10	544
05-Mar-16	8.4	1.8	1.4	0	1000	10.6	16	320	26	4.681	1.5	2.1	1.5	1.5	-8	1199
06-Mar-16	5.5	-1.5	-4.9	0.8	1001.6	5.6	10	270	13	3.708	0.7	1	1.4	1.4	-7.7	651
07-Mar-16	9.4	1.2	-0.4	0.1	1005.7	8.2	15	290	24	4.73	1.1	1.6	2.4	2.4	-6.3	904
08-Mar-16	9.8	3.8	2.6	8.7	998.9	7.2	14	290	21	6.632	1	1.4	0	-5.3	-10	830
09-Mar-16	9.9	3.7	2.3	0.8	999.4	15.1	23	320	38	5.964	1.7	2.7	0.9	0.9	-8.6	1319
10-Mar-16	10.9	2.9	-0.7	0	1014	5.8	12	320	18	6.425	1.2	1.7	2.1	2.1	-6.9	1174
11-Mar-16	10.3	7.3	-0.5	0.5	1018.6	6.5	10	200	15	7.927	0.8	1.1	2.4	2.4	-6.3	443
12-Mar-16	12	8.5	8.3	0.1	1021.1	5.1	9	210	14	9.172	0.8	1.1	3.1	3.1	-5.3	525
13-Mar-16	10.9	6.6	7.3	0	1025.7	3.8	9	40	14	9.538	0.9	1.2	3.9	3.9	-4.2	756
14-Mar-16	8.8	5.4	1.6	0.2	1024.2	7.9	14	50	19	8.035	1.3	2	5	5	-2.9	1485
15-Mar-16	9.7	4.3	2.1	0	1023.6	8.2	12	50	18	7.301	1.5	2.1	6.4	6.4	-1.2	1232
16-Mar-16	9.4	5.5	2.9	0.1	1023.7	8.9	17	40	24	7.665	0.9	1.3	7.1	7.1	-0.4	656
17-Mar-16	8.1	1.4	1.2	0	1023.5	5.7	10	100	17	7.113	1.2	1.7	8.2	8.2	0.8	1251
18-Mar-16	7.9	1	-1.5	0	1021	8.8	15	20	24	6.736	1.1	1.9	9.2	9.2	1.9	1481
19-Mar-16	7.1	5.4	4.3	0	1020.7	9.4	14	30	21	7.138	1	1.4	10.2	10.2	2.9	333
20-Mar-16	7.7	2	4.7	0	1019.9	4.9	9	40	15	7.111	0.8	1.1	10.9	10.9	3.7	492
21-Mar-16	8.1	1.7	-1.9	0	1016.9	4.7	7	320	11	6.261	0.9	1.2	11.7	11.7	4.6	643
22-Mar-16	8	4.5	1.7	0	1012	2.9	5	330	7	7.089	0.8	1.1	12.4	12.4	5.4	361
23-Mar-16	10.6	5	4	0.1	1008.6	5.5	12	210	19	8.185	1.3	1.9	13.5	13.5	6.6	1000
24-Mar-16	11	5.6	4.2	3.1	1003.1	10.5	18	210	29	8.111	0.8	1.2	11.1	11.1	4.4	348
25-Mar-16	10.7	4	0.5	0	1000.8	12.2	21	200	35	7.758	1.4	2.3	12.4	12.4	5.8	1316
26-Mar-16	9.7	5.4	7.7	11.6	986.6	16	24	210	36	8.315	0.8	1.4	1.5	1.5	-5	477
27-Mar-16	9.5	3.5	2.4	4.5	979.7	12.9	23	220	40	7.066	1.4	2.3	0	-1.6	-7.8	1110
28-Mar-16	9.9	2.2	0.2	0	981.7	9.3	16	280	22	6.823	1.6	2.4	1.6	1.6	-5.8	1317
29-Mar-16	7.9	2.2	0.9	3.8	991.4	8.5	17	220	26	6.015	1.2	1.8	0	-1	-8.1	930
30-Mar-16	11.1	1.8	-1.5	0	1000.5	7.4	14	220	20	5.962	1.7	2.4	1.7	1.7	-6	1321
31-Mar-16	11.1	2.4	-0.1	0	1008.9	7.2	13	230	20	6.903	2	2.8	3.6	3.6	-3.8	1616

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pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Apr-16	9.1	6.7	0.8	12.4	1003.9	14.8	23	170	35	7.544	0.8	1.3	0	-8	-10	260
02-Apr-16	9.1	6.3	7.4	21.9	998.2	9.4	19	160	29	8.303	0.6	1	0	-10	-10	306
03-Apr-16	10.7	6.4	5.7	9	993.9	10	18	160	25	8.063	0.8	1.3	0	-8.2	-10	450
04-Apr-16	11.7	6.3	4.1	7.2	994.6	4.3	11	250	18	9.62	1.4	2	0	-5.8	-10	1187
05-Apr-16	11.5	3.2	0.2	0.6	1000.1	8.3	14	230	22	8.925	1.7	2.6	1.1	1.1	-8.4	1575
06-Apr-16	9.3	3.8	4	2.4	1000.1	14.4	24	310	38	8.355	1.4	2.6	0.1	0.1	-9	1636
07-Apr-16	12.3	3.6	2.5	0.1	1005.6	11.7	19	310	28	7.547	2	3.1	1.9	1.9	-6.7	1593
08-Apr-16	8.6	2.9	1	7.5	1002.7	8.7	17	300	25	7.117	0.8	1.3	0	-4.8	-10	579
09-Apr-16	7.9	1	-0.8	0	994.2	6.1	11	180	17	7.288	2	3	2	2	-7.5	2040
10-Apr-16	10.1	2.5	-3.5	6.5	993.3	13.2	21	100	37	6.434	1.3	1.9	0	-3.2	-10	425
11-Apr-16	9.9	5.9	5.3	0.8	997.4	6.4	12	90	19	8.413	0.9	1.2	0.1	0.1	-9.4	547
12-Apr-16	12	3	-1.7	0.1	998.5	4.8	11	190	14	9.789	2	3	2	2	-7	2014
13-Apr-16	12.1	2.7	0.8	3.4	1000.3	5.1	8	130	13	10.177	1.5	2.2	0.1	0.1	-8.5	1389
14-Apr-16	10.9	7.5	7	3.4	1000.1	9.5	16	40	24	10.658	1.7	2.7	0	-1.6	-9.8	1537
15-Apr-16	11.5	2.6	5.8	1.8	996.4	7.8	13	310	20	9.417	1.6	2.2	0	-0.2	-9.5	846
16-Apr-16	9.8	1.4	-0.4	0	1002.1	7.8	15	340	25	8.213	2.2	3.2	2.2	2.2	-6.9	1856
17-Apr-16	9.2	1.1	-1.5	0	1010.2	6.4	12	220	18	7.657	1.6	2.3	3.7	3.7	-5	1225
18-Apr-16	11.6	6.8	6	0	1015.9	8.2	15	230	22	8.94	1.8	2.5	5.4	5.4	-3	1006
19-Apr-16	11.3	5.2	1.3	0	1020.6	6.5	11	50	16	10.434	2.3	3.4	7.6	7.6	-0.5	2094
20-Apr-16	12.2	4.1	1.3	0	1020	9.3	17	40	26	10.809	2.4	3.8	9.8	9.8	1.9	2261
21-Apr-16	11.5	7.7	5.9	0	1015.9	9.9	14	50	20	9.917	1.9	2.7	11.6	11.6	3.8	938
22-Apr-16	9.9	5.7	7.8	0	1014.3	8.5	13	40	20	9.773	1.4	1.9	12.8	12.8	5.2	740
23-Apr-16	11.1	3.4	1.8	0	1016.2	5.4	10	350	17	9.696	2	2.9	14.6	14.6	7.2	1631
24-Apr-16	11.8	3.8	-0.6	0	1015.2	7.8	11	330	18	10.172	2	2.9	16.3	16.3	9.2	1442
25-Apr-16	13.9	3.7	5.1	0.1	1009.1	9.6	15	300	23	11.055	2.7	3.8	18.5	18.5	11.8	1558
26-Apr-16	10.1	2	-0.9	0.3	1008.2	10.5	19	320	32	9.692	2.8	4.3	20.5	20.5	14.2	2279
27-Apr-16	10	0.8	-1.6	0.2	1008.5	7.7	16	310	27	9.366	2.3	3.4	22.2	22.2	16.2	1908
28-Apr-16	12.2	1.6	-2.1	1.1	1005.1	12	22	250	31	8.182	2.1	3.1	22.7	22.7	17.1	1271
29-Apr-16	10.6	1.3	-0.6	0.2	1006.8	10.4	19	290	28	8.333	2.4	3.7	24.4	24.4	19.1	1812
30-Apr-16	11	2.1	-0.9	0	1014.4	8.4	15	210	23	8.482	1.8	2.6	25.8	25.8	20.7	1297

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date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-May-16	12.1	8.3	5.8	4	1013.7	11.6	16	220	24	10.183	1.1	1.7	22.6	22.6	17.7	677
02-May-16	13.2	5.1	8.5	3.9	1010.9	12.6	22	260	35	11.298	2.3	3.9	20.6	20.6	15.9	2026
03-May-16	12.1	4.4	2.1	0	1017.5	8.4	15	240	21	9.972	2.1	3.2	22.3	22.3	17.9	1568
04-May-16	11.9	7.5	3.4	0	1014.8	10.6	17	190	26	10.805	1.8	2.9	23.8	23.8	19.6	1387
05-May-16	14.3	7	6.1	1.8	1010.1	5.4	9	150	13	12.765	2.4	3.3	23.8	23.8	19.9	1782
06-May-16	14.5	7.2	3.3	0	1004.2	10.1	15	40	23	12.952	3.1	4.5	26.2	26.2	22.7	2111
07-May-16	12.8	8.3	7.9	8.3	998.1	8	13	50	20	11.78	1.4	1.9	19	19	15.6	684
08-May-16	16.9	10.2	10.4	0	996.6	6	12	50	18	14.052	2.5	3.5	21.1	21.1	18	1704
09-May-16	14.4	12.1	9.5	15.9	999.2	6.4	10	50	18	12.948	1.4	1.8	6.3	6.3	3.3	518
10-May-16	13.4	11.6	11.8	7.7	999.1	5.3	11	50	17	13.12	0.8	1.1	0	-0.7	-3.5	396
11-May-16	15.6	11.4	11.5	0.3	997.3	6.8	11	30	18	13.575	1.4	2	1.1	1.1	-2.3	785
12-May-16	18.2	11.5	10.8	0.9	999.1	10	15	40	23	15.12	3.1	4.6	3.3	3.3	0.1	2168
13-May-16	16.4	9.5	8.6	0	1005.8	9.1	13	50	21	15.665	3.4	5.1	6.6	6.6	3.5	2613
14-May-16	11	4.5	6.7	0	1013.4	7.8	14	50	20	15.138	2.6	4.2	9.1	9.1	6.1	2603
15-May-16	14.1	4.4	-0.8	0	1016.2	5	8	270	13	14.627	2.4	3.4	11.3	11.3	8.5	1796
16-May-16	14.9	9.1	9.5	0	1013.8	5.8	13	220	18	16.597	2.9	4.2	13.9	13.9	11.4	2365
17-May-16	13.1	9.8	7.8	1.4		10	17	210	26	14.003	1.1	1.8	13.5	13.5	11.1	787
18-May-16	15.6	8.1	6.5	3.2	998.3	7.1	15	320	22	14.057	2.8	4	12.7	12.7	10.7	1885
19-May-16	14.5	7.6	5.5	5.9	1001.7	9.4	15	230	25	12.72	1.5	2.3	8.1	8.1	6.3	1016
20-May-16	13.3	9.9	8.1	8.8	1000.4	10.5	17	200	27	12.653	1.4	2.2	0.6	0.6	-1.1	898
21-May-16	14.2	9	10.5	0.5	995.1	11.6	17	210	26	13.955	2.5	4.3	2.6	2.6	0.9	2313
22-May-16	14.7	6.7	1.6	6.2	1003.1	6.9	12	290	17	13.073	2.5	3.7	0	-1.1	-2.8	1912
23-May-16	13.9	6	3.7	0	1012.7	5.7	11	300	17	12.983	2.7	3.9	2.7	2.7	0.1	2063
24-May-16	14.1	5.7	0.9	0	1013.9	8.6	14	50	21	14.132	3.1	4.8	5.7	5.7	3.1	2779
25-May-16	11.7	8.4	5.9	0	1012.1	9.6	14	40	22	14.285	2.7	4.1	8.2	8.2	5.8	2085
26-May-16	13	7.3	7.5	0	1009.7	4.5	6	50	10	14.505	2.1	2.9	10.1	10.1	7.9	1448
27-May-16	13.9	7.2	3.3	1.3	1009.3	6.1	9	50	14	13.545	1.7	2.4	10.3	10.3	8.2	1169
28-May-16	16.8	8.5	5.8	0	1008.1	4.7	7	50	11	16.42	3.2	4.4	13.2	13.2	11.4	2398
29-May-16	17	9.6	6.2	0.2	1009.2	6	11	40	16	17.788	3.5	5	16.1	16.1	14.6	2653
30-May-16	17.9	10.3	7.2	0	1014.1	7	13	50	18	17.985	3.7	5.3	19.2	19.2	18.1	2629
31-May-16	18.8	11.3	7.8	0	1017.7	5.9	10	320	15	19.335	4.1	5.7	22.6	22.6	21.9	2863

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date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Jun-16	17.1	10.9	8.9	0	1019.4	10.4	17	50	27	19.158	3.7	5.8	25.5	25.5	25.1	2962
02-Jun-16	14.8	9.5	9.1	0	1015.8	9.5	15	50	22	18.368	3.8	5.9	28.5	28.5	28.4	3035
03-Jun-16	16.9	7.7	5.3	0	1011.4	4.8	8	0	11	18.79	3.6	5.1	31.2	31.2	31.4	2764
04-Jun-16	18.1	9.9	5.8	0	1011.4	5.6	9	50	14	19.818	3.8	5.2	33.9	33.9	34.3	2662
05-Jun-16	19.1	12.9	12.8	0	1012.7	3.5	7	70	11	20.7	3.1	4.1	36	36	36.7	1974
06-Jun-16	18.5	13	9.8	9.3	1013.2	4	10	150	13	19.105	2.1	2.8	28.1	28.1	28.9	1273
07-Jun-16	20.2	14.2	14	0.1	1015.8	6.4	11	220	16	19.275	3.5	4.8	30.6	30.6	31.6	2230
08-Jun-16	20.3	11.4	11.1	0	1017	4.1	9	250	13	20.673	3.4	4.6	33	33	34.3	2358
09-Jun-16	18	11.7	12.8	0.1	1012.3	3.5	7	180	11	20.01	2.3	3.1	34.6	34.6	35.9	1494
10-Jun-16	17.6	13.6	12.6	0.7	1005.9	3.3	10	0	21	19.003	1.9	2.5	35.2	35.2	36.7	1096
11-Jun-16	19	13.2	12.5	5.8	1001.1	6.1	14	200	21	19.545	2.8	3.8	31.3	31.3	32.9	1733
12-Jun-16	19	13	13.1	7.2	998.1	7.5	15	240	23	18.433	2.5	3.5	25.9	25.9	27.6	1490
13-Jun-16	18.8	11.8	11.6	4.8	994.9	6.8	13	220	19	17.52	2.3	3.2	22.8	22.8	24.7	1390
14-Jun-16	17.3	12.5	11.8	9.2	989.2	8.4	14	290	22	16.755	2.1	2.9	15.3	15.3	17.3	1108
15-Jun-16	17.5	11	11.7	3	990.8	4.6	10	0	15	17.632	2.7	3.8	14.6	14.6	16.8	1896
16-Jun-16	16.3	10.6	7.5	0.2	997.2	8.5	14	320	21	16.29	2.4	3.4	16.5	16.5	18.8	1511
17-Jun-16	16.3	10	8.3	0	1005.5	9.2	15	340	25	15.682	3	4.2	19	19	21.5	1789
18-Jun-16	16.4	9.9	7.6	0.8	1013.4	6.6	13	240	19	16.36	2.5	3.5	20.2	20.2	22.9	1700
19-Jun-16	15.7	13.1	12.9	8.3	1010	11.7	18	200	30	16.153	0.9	1.5	12.6	12.6	15.4	544
20-Jun-16	19.3	13.2	13.2	1.6	1004.7	7.8	15	290	26	17.68	3.4	4.8	14	14	17	2143
21-Jun-16	17.2	12.2	10.3	0	1007.5	8.2	15	210	24	17.485	2.9	4.3	16.6	16.6	19.7	1983
22-Jun-16	17.9	11.6	8.9	0.1	1008.7	8.4	14	190	20	18.15	3.3	5	19.3	19.3	22.6	2496
23-Jun-16	17.4	9.7	5.7	0	1009	8.9	15	230	24	18.202	3.2	4.9	21.9	21.9	25.4	2444
24-Jun-16	17.1	11.6	9.6	5.6	1009.4	8.5	15	240	24	16.81	2.5	3.7	18.4	18.4	21.9	1638
25-Jun-16	17.1	11.8	10.3	0.1	1012.5	9.4	15	290	26	15.89	2.5	3.5	20.3	20.3	24	1415
26-Jun-16	19.1	11.7	10	1.2	1011	8.3	17	290	25	16.167	2	2.7	20.8	20.8	24.5	998
27-Jun-16	17.1	11.4	9.7	0	1011.9	7.5	14	220	22	17.22	3.1	4.4	23.3	23.3	27.2	1944
28-Jun-16	16.3	10.5	7.8	19.8	1006	5.6	11	170	18	15.083	1.9	2.5	5	5	8.9	929
29-Jun-16	19.1	10.2	9.4	13.2	997.7	10.3	16	200	26	15.682	2.8	4.1	0	-5.6	-1.5	1673
30-Jun-16	13.9	9.2	7.3	2.4	999.1	7.9	14	230	24	14.14	1.2	1.8	0	-1.2	-2.6	736

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
rain: - Precipitation Amount (mm)
maxtp: - Maximum Air Temperature (C)
mintp: - Minimum Air Temperature (C)
gmin: - 09utc Grass Minimum Temperature (C)
soil: - Mean 10cm soil temperature (C)
cbl: - Mean CBL Pressure (hpa)
wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)
ddhm: - Wind Direction at max 10 min mean (deg)
hg: - Highest Gust (kt)
pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Jul-16	15.8	9.1	8.6	3	1000.4	9.3	17	240	27	15.35	2.9	4.4	0	-0.1	-2.5	2180
02-Jul-16	16.6	8.7	6.5	0.4	1005.2	9.2	16	250	25	15.19	3.1	4.7	2.7	2.7	0.3	2275
03-Jul-16	16.9	9.9	6.2	0	1010.1	7.6	12	220	18	16.938	3.6	5.2	6.2	6.2	3.9	2575
04-Jul-16	16.2	10.7	7.2	0.5	1007.8	9.8	20	220	31	16.25	2	3.2	7.6	7.6	5.4	1550
05-Jul-16	16.4	9.3	5.6	0	1012.5	6.7	11	320	18	16.595	2.5	3.5	9.9	9.9	7.9	1601
06-Jul-16	15.4	11.8	10.3	0.5	1012.9	7.9	12	200	20	16.505	1.3	2	10.6	10.6	8.7	862
07-Jul-16	17.6	13.9	13.8	4.3	1008.1	9.3	15	220	24	17.698	2	3.1	8.2	8.2	6.5	1448
08-Jul-16	19.3	13.4	13	0.7	1007.1	10.1	14	220	24	17.812	2.4	3.6	9.7	9.7	8.2	1481
09-Jul-16	16.3	14.4	14.6	12.9	1003.9	12.4	17	200	30	16.98	0.9	1.4	0	-2.4	-3.9	536
10-Jul-16	16.2	13.4	13.3	0.7	995.7	13.1	18	220	32	16.425	1.5	2.4	0.8	0.8	-2.9	926
11-Jul-16	17.4	12.5	12.6	0	999.2	9.6	14	250	23	16.228	2.4	3.3	3.1	3.1	-0.4	1252
12-Jul-16	16.7	10.1	7.8	0.9	1007.6	7	14	230	20	16.003	2.5	3.5	4.7	4.7	1.3	1553
13-Jul-16	17.8	9.7	7.5	0	1014.1	8.7	15	300	21	16.622	3	4.3	7.6	7.6	4.3	1826
14-Jul-16	17.1	8.6	4.4	0.8	1018.5	7.2	13	300	19	17.47	2.9	4.2	9.5	9.5	6.4	2060
15-Jul-16	16.2	12.1	10.8	3.7	1016.9	12.1	16	220	24	16.988	1.4	2.3	7.1	7.1	4.1	1031
16-Jul-16	18.5	14.1	14.1	0	1016	7.4	14	230	21	17.943	2	2.8	8.9	8.9	6.1	1304
17-Jul-16	21.3	14.4	13.1	0	1015.1	5.7	11	220	15	20.263	2.9	4	11.6	11.6	9	1884
18-Jul-16	21.4	13.2	11.5	0	1013.1	4.6	8	160	13	22.147	3.9	5.4	15.1	15.1	12.9	2758
19-Jul-16	22.4	14.3	11	0.1	1006.4	5.8	10	210	15	23.057	3.8	5.3	18.3	18.3	16.5	2563
20-Jul-16	20.8	14.8	14.7	0.3	1003.5	7.9	12	240	18	21.833	2.9	3.9	20.3	20.3	18.9	1627
21-Jul-16	19.3	14.8	13	2.5	1007.4	8.9	14	190	23	20.89	2.5	3.6	19.8	19.8	18.6	1549
22-Jul-16	20	15.1	15.3	3.4	1010.6	5.6	10	170	16	20.693	3	4	18.9	18.9	17.9	1793
23-Jul-16	17.5	13.8	12.2	0.6	1012.3	5.7	11	220	18	19.142	1.7	2.3	19.7	19.7	18.8	1017
24-Jul-16	19.4	12.8	10.5	2.4	1009.5	6.6	16	220	23	18.998	2.5	3.5	19.3	19.3	18.7	1598
25-Jul-16	17.8	11	7.5	0	1012.2	5.7	11	230	16	18.005	2	2.8	21	21	20.6	1188
26-Jul-16	17.1	13.8	11	1.1	1010.3	9.4	14	210	24	18.36	1.6	2.4	21.2	21.2	20.9	943
27-Jul-16	18.5	13.7	13.6	0.7	1008.8	6.7	12	320	17	18.958	2.4	3.3	22.4	22.4	22.3	1417
28-Jul-16	20.2	14.5	13.5	1.4	1005.5	8.8	14	230	22	20.052	2.9	4.3	23.3	23.3	23.5	1960
29-Jul-16	16.5	13	12.7	3.2	1005.1	5.1	11	270	16	18.345	1.2	1.7	21.1	21.1	21.4	651
30-Jul-16	18.3	12.5	11.2	0	1008.7	5	9	300	13	18.025	2.3	3	23	23	23.4	1243
31-Jul-16	17.4	11.6	9	0	1011.3	6.1	12	280	18	18.465	2.6	3.6	25	25	25.6	1644

Station Name: JohnstownII
Station Height: 62 M
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soil: - Mean 10cm soil temperature (C)
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wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)

ddhm: - Wind Direction at max 10 min mean (deg)
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pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Aug-16	16.4	12.4	11.2	12.6	1006	5.5	12	150	17	17.478	1	1.3	13.2	13.2	13.9	418
02-Aug-16	19.6	14.9	15	0.4	999.2	8.3	16	220	23	18.88	2.1	3.1	14.6	14.6	15.5	1420
03-Aug-16	18.4	13.7	12.6	0.1	996.6	13.3	20	210	34	18.095	2.5	4	16.7	16.7	17.8	1824
04-Aug-16	19.3	13.6	12.2	0.3	1003.8	9.2	14	250	20	18.142	2.5	3.5	18.5	18.5	19.8	1431
05-Aug-16	18.4	13.3	12	0	1013	7.9	15	230	22	19.505	3	4.4	21.1	21.1	22.5	2198
06-Aug-16	18.5	11.7	7.4	0.7	1016.5	9.3	15	220	27	19.013	1.9	2.9	21.9	21.9	23.4	1457
07-Aug-16	18.5	12.1	12	0.1	1013.9	11.7	20	230	31	19.475	3	4.7	24.2	24.2	26	2286
08-Aug-16	18.8	10.9	8.3	0	1017.6	7.7	13	320	21	17.685	3.2	4.4	26.7	26.7	28.6	1893
09-Aug-16	17.5	9.3	3.2	0	1022	7.7	14	320	19	16.845	2.7	3.7	28.7	28.7	30.8	1508
10-Aug-16	16.8	10.9	8	0	1019.8	8	16	270	24	16.388	1.8	2.4	30	30	32.3	860
11-Aug-16	22.9	11.5	8.5	0	1017	8.3	18	270	24	17.812	3.4	4.6	32.5	32.5	34.9	1995
12-Aug-16	18.1	10.6	6.1	0	1015	11.1	20	220	33	17.177	1.8	2.7	33.7	33.7	36.2	1156
13-Aug-16	18	11.7	8.6	0	1015.7	6.8	14	240	21	17.538	1.9	2.6	35	35	37.6	1155
14-Aug-16	17.5	11.2	12	0	1018.8	3.6	8	300	12	17.638	1.8	2.4	36.3	36.3	38.9	1021
15-Aug-16	21.3	10.6	5.5	0.1	1015	6.1	13	150	17	18.093	3.2	4.5	38.3	38.3	41.1	2339
16-Aug-16	20.6	12.8	7.1	0.2	1009.1	6	13	140	18	18.833	3	4.2	40.1	40.1	43	2099
17-Aug-16	17.3	15	11	2.4	1005.1	4.7	9	120	15	17.728	1.3	1.7	38.5	38.5	41.4	578
18-Aug-16	19.6	14	13.8	0.4	1001.3	4.5	8	160	13	18.443	2.4	3.2	39.6	39.6	42.7	1487
19-Aug-16	19	13.2	12.7	20	992.3	14.2	21	140	30	17.54	1.8	3	20.8	20.8	23.9	1395
20-Aug-16	18.1	14.3	13.7	4.7	993.7	15.3	21	220	37	16.442	1.9	3	17.7	17.7	20.8	1108
21-Aug-16	16.1	12.7	10.5	2	1005.8	12.1	18	220	30	15.562	1.1	1.7	16.6	16.6	19.8	540
22-Aug-16	20	13.9	15.2	11.3	1011	9	18	220	26	17.44	2	3	7.1	7.1	10.4	1437
23-Aug-16	18.5	13.8	13.7	1.1	1012.8	5	10	180	15	17.465	1.5	2	7.3	7.3	10.8	843
24-Aug-16	19.2	10.4	5.1	0	1013.3	3.7	7	110	12	17.562	2.9	3.9	10	10	13.6	2175
25-Aug-16	18.5	10.7	7.6	0	1009.6	5	9	240	14	16.968	2.1	2.8	11.9	11.9	15.7	1280
26-Aug-16	18.3	11.4	8	0.2	1009.8	7.9	14	220	22	16.53	2.3	3.4	13.8	13.8	17.7	1801
27-Aug-16	17.4	11.9	7.3	0.2	1007	5.9	11	40	18	16.948	1.9	2.7	15.3	15.3	19.2	1448
28-Aug-16	19.6	13.6	11.5	0	1007.6	4.6	9	350	15	17.675	2.1	2.8	17.1	17.1	21.1	1305
29-Aug-16	19.4	10.9	6.5	0	1014.8	6.6	13	210	19	17.568	2.5	3.5	19.1	19.1	23.3	1927
30-Aug-16	18.6	15.2	13.6	0	1013.2	9.3	15	190	22	17.722	1.8	2.4	20.6	20.6	24.8	935
31-Aug-16	18.4	11.5	9	5.1	1012.3	7	11	190	19	17.13	1.8	2.6	17	17	21.3	1228

Station Name: JohnstownII
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smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
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glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Sep-16	16.6	9.1	5.7	3.6	1012.7	9.4	16	190	26	15.51	1.3	2.1	14.5	14.5	18.8	1037
02-Sep-16	18.2	13.3	12.7	0.1	1009.1	7.4	14	210	23	16.5	1.9	2.7	16	16	20.4	1337
03-Sep-16	17.2	13.7	11.2	30.9	1002.9	11.2	19	230	31	15.743	0.8	1.2	0	-10	-9.8	382
04-Sep-16	17.4	13.1	12.3	5.2	1003.5	8.1	15	150	22	15.907	1.5	2.1	0	-3.7	-10	844
05-Sep-16	18.1	14.4	13	0.9	1007.8	10.6	17	220	25	16.905	1.1	1.8	0.2	0.2	-9.3	842
06-Sep-16	19.6	16	16	0.6	1013.2	6.9	12	180	19	17.472	1.1	1.6	0.7	0.7	-8.3	634
07-Sep-16	20.2	15.1	15.7	1.6	1005.7	7.7	15	140	21	17.903	1.5	2.1	0.6	0.6	-8	905
08-Sep-16	16.9	13.7	12.9	4.4	999.8	11.3	16	180	28	16.695	1.5	2.3	0	-2.3	-10	1066
09-Sep-16	16.9	11.3	12.3	15.6	998.4	11.6	21	190	34	15.855	0.8	1.2	0	-10	-10	367
10-Sep-16	16.9	10.3	9.4	0	1004.8	5.8	11	220	19	15.257	1.9	2.6	1.9	1.9	-7.6	1318
11-Sep-16	17.4	11.8	9.4	1.6	1001.9	13.3	21	180	35	15.262	1.7	2.8	2	2	-7.1	1457
12-Sep-16	17.9	15.4	14.7	10.2	997.2	12.3	20	170	32	16.455	0.6	0.9	0	-7.6	-10	314
13-Sep-16	16.4	12.2	11.9	2.2	1003.3	7.3	12	340	18	16.108	1.1	1.5	0	-1.1	-10	600
14-Sep-16	20.7	13.1	12.8	0.4	1003.9	8	14	50	23	16.64	2.2	3.1	1.8	1.8	-7.7	1504
15-Sep-16	18.2	12.5	10.6	0.1	1005.5	5.9	14	290	19	16.875	1.7	2.3	3.4	3.4	-5.7	1250
16-Sep-16	17.4	10.3	9.1	0	1012	8.5	14	290	22	15.575	2	2.7	5.3	5.3	-3.5	1266
17-Sep-16	16.9	10	9.3	0	1016.8	4.7	11	290	16	15.425	1.6	2.2	6.8	6.8	-1.7	1125
18-Sep-16	15.7	10.2	8.2	2.5	1014.2	6.3	12	210	21	15.075	0.7	1	5	5	-3.4	432
19-Sep-16	15.2	9.9	9.9	0.1	1017.2	6.5	12	350	19	14.783	1.5	2.1	6.3	6.3	-1.8	975
20-Sep-16	16	10.5	9.3	0	1013.2	3.4	7	120	12	14.845	1.6	2.2	7.8	7.8	-0.1	940
21-Sep-16	16.1	9.4	5.9	11.7	1007.3	8.2	15	190	23	14.195	1.2	1.7	0	-2.7	-10	636
22-Sep-16	15.9	6.4	1.9	0.1	1010.5	7.5	14	200	22	13.1	1.6	2.3	1.5	1.5	-8	1263
23-Sep-16	16.6	8.5	3.3	0.2	1009	11.5	20	200	33	13.347	1.2	2	2.5	2.5	-6.6	1146
24-Sep-16	16.5	13	12.2	6.8	1000.3	14.6	20	180	32	14.797	0.9	1.2	0	-3.4	-10	160
25-Sep-16	15.1	9.8	7	0	1003	9.5	18	230	29	13.483	1.8	2.6	1.8	1.8	-7.7	1479
26-Sep-16	15.3	11.2	8.6	10.1	1007.7	6.8	16	140	24	14.02	1	1.4	0	-7.4	-10	729
27-Sep-16	18.9	12.8	13.7	0.6	1010.8	9.4	14	260	22	15.257	1.7	2.5	1.1	1.1	-8.4	1299
28-Sep-16	16.2	12.6	11.2	0.9	1011.3	14.3	20	220	33	15.062	0.7	1.2	1	1	-8.1	400
29-Sep-16	16.2	9.1	10	0.1	1005.8	9.4	17	270	24	14.212	1.3	2	2.1	2.1	-6.5	1255
30-Sep-16	14.3	8.7	5.6	1.1	1001.1	6	11	230	17	12.845	1.4	1.9	2.4	2.4	-5.9	1091

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smd_wd:- Soil Moisture Deficits(mm) well drained
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smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Oct-16	13.9	8.5	4.8	9.3	1001.3	7.9	15	320	24	12.903	1.4	2	0	-5.5	-10	1030
02-Oct-16	15.4	6.5	3.5	0.1	1010.2	6.7	11	160	18	12.505	1.4	2	1.3	1.3	-8.2	1271
03-Oct-16	16.8	13.4	8.8	0	1015.3	14.3	22	150	31	13.548	1.9	2.6	3.2	3.2	-5.9	1092
04-Oct-16	16.1	13.1	11	0	1018.1	10.1	16	140	22	13.745	1.2	1.6	4.4	4.4	-4.3	554
05-Oct-16	15.9	11.6	10.4	0	1019	8.7	14	110	21	13.682	1.5	2	5.9	5.9	-2.6	827
06-Oct-16	13.5	10.7	6.2	0	1016.7	9.4	15	110	24	12.55	1.7	2.3	7.5	7.5	-0.7	1071
07-Oct-16	13.3	9.5	5.4	5.2	1015.2	6.4	11	110	18	12.25	0.8	1.1	3.1	3.1	-5	310
08-Oct-16	15.9	11.4	10.3	0.1	1020.1	2.7	5	70	8	13.493	0.9	1.2	3.9	3.9	-4	712
09-Oct-16	15	8.7	9.9	0	1022.7	4.8	9	60	12	13.73	1	1.4	4.9	4.9	-2.8	868
10-Oct-16	14.1	7.9	3.9	0	1019.9	5.2	9	60	14	12.863	1.1	1.6	5.9	5.9	-1.5	939
11-Oct-16	12.4	10.2	4.5	0	1015.5	7.8	13	90	19	11.898	1.2	1.6	7.1	7.1	-0.2	741
12-Oct-16	14.1	10.3	6.6	0	1013.5	7.8	11	60	18	12.22	1.1	1.4	8.1	8.1	0.9	619
13-Oct-16	12.9	7.2	7	1.5	1006.3	5.4	11	50	17	11.94	0.9	1.2	7.4	7.4	0.3	515
14-Oct-16	13.4	6.9	0.9	22.7	996.9	6.6	14	120	24	11.22	0.9	1.2	0	-10	-10	716
15-Oct-16	13.5	7.8	3.9	20	993.8	5.4	17	140	25	11.307	0.8	1.1	0	-10	-10	643
16-Oct-16	14.3	10	5.9	11	995.1	13.9	23	140	33	11.608	1.3	1.8	0	-9.7	-10	790
17-Oct-16	14.6	8.9	5.6	0.2	1005.1	9.3	15	220	25	11.493	1.1	1.5	0.9	0.9	-8.6	861
18-Oct-16	13.1	6	4.7	0	1014.2	8.5	15	270	23	10.753	1	1.4	1.9	1.9	-7.2	804
19-Oct-16	12.6	6.5	2.2	0	1018.6	7.5	11	280	17	10.25	1	1.4	2.9	2.9	-5.8	838
20-Oct-16	13.7	7	4.9	0.1	1017.2	5.8	8	340	13	10.56	0.9	1.2	3.6	3.6	-4.7	898
21-Oct-16	13.3	5.6	1.8	0.2	1013.6	3.3	7	320	8	10.323	0.6	0.9	4	4	-4.1	575
22-Oct-16	12.4	8.6	1.9	0	1009	6.1	11	90	18	10.507	0.8	1.2	4.8	4.8	-3	776
23-Oct-16	11.8	9.4	6.8	0	1004.4	11.1	15	60	26	10.247	1.3	1.6	6.1	6.1	-1.6	625
24-Oct-16	11.4	10.2	8.3	1.6	1006.6	9.9	15	50	23	10.227	1	1.2	5.4	5.4	-2.1	192
25-Oct-16	14.2	10.2	9.2	0.3	1013	4.8	9	170	13	11.24	0.6	0.7	5.7	5.7	-1.7	243
26-Oct-16	15.1	10.8	8.7	0	1018.9	6.4	10	210	16	12.09	0.7	1	6.3	6.3	-1	677
27-Oct-16	14.8	11.2	7.2	0.1	1021.7	11	18	220	30	12.208	0.9	1.1	7	7	-0.1	473
28-Oct-16	16.2	12.1	9.8	0	1025.2	6.4	10	250	16	12.51	0.8	1	7.8	7.8	0.7	457
29-Oct-16	12.5	11.1	8.6	0	1025.1	5.1	8	180	13	12.13	0.7	0.9	8.5	8.5	1.4	171
30-Oct-16	13.2	11	9.8	0	1021.1	3	7	200	11	12.023	0.6	0.7	9	9	2	145
31-Oct-16	14	10.4	4.9	0.2	1018.4	6.8	11	50	17	11.948	0.5	0.7	9.3	9.3	2.3	454

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
rain: - Precipitation Amount (mm)
maxtp: - Maximum Air Temperature (C)
mintp: - Minimum Air Temperature (C)
gmin: - 09utc Grass Minimum Temperature (C)
soil: - Mean 10cm soil temperature (C)
cbl: - Mean CBL Pressure (hpa)
wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)

ddhm: - Wind Direction at max 10 min mean (deg)
hg: - Highest Gust (kt)
pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Nov-16	12	5.3	7.2	0	1019.3	10.6	16	20	26	10.86	0.8	1	9.9	9.9	3	405
02-Nov-16	10.5	3.5	0.8	0	1019.1	5.5	9	330	15	8.865	0.6	0.9	10.5	10.5	3.7	662
03-Nov-16	10.8	4.4	-1.5	0	1012	4.4	11	250	16	8.827	0.6	0.8	11.1	11.1	4.2	344
04-Nov-16	10.5	4.6	1	0.1	1003.7	6.3	10	270	15	8.562	0.6	0.8	11.5	11.5	4.7	544
05-Nov-16	8.5	3.9	-0.9	0	1004.3	10.1	15	340	23	7.712	0.8	1	12.2	12.2	5.5	719
06-Nov-16	8.4	3	0	0	1007.8	11.5	17	330	28	6.639	1	1.2	13.1	13.1	6.5	698
07-Nov-16	8.3	2.1	-0.1	0	1011	9	13	320	21	6.151	0.7	0.9	13.7	13.7	7.2	699
08-Nov-16	11.1	4.7	0	16.9	999.3	8.9	20	320	32	7.181	0.7	0.9	0	-2.6	-9	95
09-Nov-16	10.2	4.2	1.8	0.9	996.2	9.3	16	270	25	7.29	0.6	0.8	0	-0.3	-8.8	513
10-Nov-16	10.3	3.4	2.3	0.4	1005.4	8.5	15	300	21	7.574	0.5	0.7	0.1	0.1	-8.2	386
11-Nov-16	12.2	2	-3	9.3	1006.9	9.1	19	180	30	6.98	0.4	0.5	0	-8.8	-10	189
12-Nov-16	13.1	6.8	4.6	3.6	1009	6.7	14	190	23	9.672	0.2	0.4	0	-3.4	-10	478
13-Nov-16	11.7	6.6	1.3	0	1020	6.1	13	300	18	8.825	0.4	0.6	0.4	0.4	-9.1	192
14-Nov-16	13.1	11	8.4	0.1	1020.7	9.1	13	230	20	10.565	0.3	0.5	0.7	0.7	-8.4	223
15-Nov-16	14.3	7.6	11.1	0.1	1016	6.2	12	230	18	11.37	0.3	0.5	0.9	0.9	-7.7	237
16-Nov-16	11.3	5.9	1.9	0.2	1007.1	10	17	270	30	9.427	0.7	0.8	1.4	1.4	-6.9	371
17-Nov-16	9.9	2.3	1.6	2.4	992.8	12.2	22	250	33	7.459	0.7	0.9	0	-0.4	-8.3	387
18-Nov-16	5.1	0.6	-1.8	0	988.7	10.8	17	250	24	5.302	0.5	0.7	0.5	0.5	-7.3	334
19-Nov-16	5.8	2.1	-1.4	2.3	987.4	6.9	15	270	21	5.116	0.5	0.6	0	-1.3	-8.8	266
20-Nov-16	5.8	1.2	-0.8	0	983.6	8.7	13	320	19	5.1	0.5	0.6	0.5	0.5	-7.9	508
21-Nov-16	7.4	1.2	-1.1	7.6	985	14.1	24	40	39	4.809	0.9	1.2	0	-6.3	-10	53
22-Nov-16	7.8	3.1	2.6	0.1	996.7	13.5	19	330	32	5.22	0.9	1.1	0.8	0.8	-8.7	424
23-Nov-16	9	1.8	-0.1	0	1012	9.7	14	40	22	5.007	0.5	0.7	1.4	1.4	-7.7	225
24-Nov-16	8.8	6.6	1.6	0	1017.5	12.1	16	60	24	6.41	0.7	0.8	2.1	2.1	-6.6	413
25-Nov-16	8.4	5.5	2.7	0	1017.1	10.1	15	40	23	6.396	0.5	0.6	2.6	2.6	-5.7	340
26-Nov-16	8.9	3.7	1.1	0.2	1014.5	8	12	40	19	5.913	0.3	0.4	2.7	2.7	-5.3	349
27-Nov-16	9.5	4.2	0.5	0.1	1017.7	6.9	11	100	20	6.291	0.5	0.7	3.1	3.1	-4.6	154
28-Nov-16	8.1	5.5	4.9	0	1022.2	6.2	10	100	17	6.622	0.9	1.1	4	4	-3.5	153
29-Nov-16	7.7	-0.3	-5.7	0	1025.9	4.1	7	330	9	5.082	0.2	0.3	4.1	4.1	-3.2	454
30-Nov-16	9.9	0.8	-4.1	0	1027.4	5.2	9	320	11	4.134	0.3	0.4	4.5	4.5	-2.7	440

Station Name: JohnstownII
Station Height: 62 M
Latitude:52.292

date: - 00 to 00 utc
rain: - Precipitation Amount (mm)
maxtp: - Maximum Air Temperature (C)
mintp: - Minimum Air Temperature (C)
gmin: - 09utc Grass Minimum Temperature (C)
soil: - Mean 10cm soil temperature (C)
cbl: - Mean CBL Pressure (hpa)
wdsp: - Mean Wind Speed (kt)
hm: - Highest ten minute mean wind speed (kt)

ddhm: - Wind Direction at max 10 min mean (deg)
hg: - Highest Gust (kt)
pe: - Potential Evapotranspiration (mm)
evap: - Evaporation (mm)
smd_wd:- Soil Moisture Deficits(mm) well drained
smd_md:- Soil Moisture Deficits(mm) moderately drained
smd_pd:- Soil Moisture Deficits(mm) poorly drained
glorad:- Global Radiation (J/cm sq.)
ind: - Indicator (i)

date	maxtp	mintp	gmin	rain	cbl	wdsp	hm	ddhm	hg	soil	pe	evap	smd_wd	smd_md	smd_pd	glorad
01-Dec-16	9	0.9	-4.2	0	1024.2	3.8	8	320	10	4.143	0	0.1	4.5	4.5	-2.5	438
02-Dec-16	8.1	3.7	-0.8	0	1019.6	4.9	9	110	14	5.376	0.5	0.7	5	5	-1.8	35
03-Dec-16	8.2	6	4.8	0	1016	6.8	11	100	18	6.135	0.8	0.9	5.8	5.8	-1	122
04-Dec-16	6.9	4.7	0.9	0	1013.6	7.9	13	120	21	5.326	0.9	1	6.6	6.6	0	195
05-Dec-16	10	5.4	-0.5	0.7	1013.5	5.7	9	100	13	6.066	0.5	0.6	6.3	6.3	-0.3	70
06-Dec-16	12.2	9.7	6.1	0.6	1013	10.1	16	180	28	8.043	0.4	0.6	6.1	6.1	-0.4	51
07-Dec-16	12.6	11.5	10.3	7.4	1011	13	17	210	29	9.802	0.3	0.5	0	-0.9	-7.5	38
08-Dec-16	12.2	10.3	8.6	14.8	1011.8	7	14	180	22	10.217	0.1	0.1	0	-10	-10	263
09-Dec-16	12.2	10.9	10.3	5.4	1010.7	11.1	16	200	27	10.592	0.3	0.4	0	-5.1	-10	97
10-Dec-16	11.2	6	6.5	0.1	1013.7	6.2	12	220	18	9.783	0.4	0.5	0.3	0.3	-9.2	99
11-Dec-16	11	5.4	0.6	0.3	1015.9	5.6	12	250	16	7.99	0	0	0	0	-9.1	423
12-Dec-16	11.2	6.4	-1.4	7.6	1010.8	6.7	12	220	18	8.447	0.2	0.3	0	-7.4	-10	148
13-Dec-16	12	8.8	7.9	14.8	1005.1	10	17	170	28	9.807	0.3	0.4	0	-10	-10	127
14-Dec-16	12.5	5.9	7.9	25.4	1004.9	10.6	20	170	31	9.887	0.5	0.7	0	-10	-10	30
15-Dec-16	11.1	5.2	0.1	5.6	1004.2	9.3	17	140	27	8.925	0.1	0.1	0	-5.5	-10	293
16-Dec-16	10.7	4.3	6.7	18.6	1014.8	8.7	15	150	24	8.935	0.3	0.4	0	-10	-10	114
17-Dec-16	8.5	1.8	-3.9	0.1	1028.3	4.2	8	320	12	6.727	0.1	0.2	0	0	-9.5	282
18-Dec-16	9.2	7.6	-0.2	0	1026.7	7	12	210	19	7.351	0.6	0.7	0.6	0.6	-8.4	163
19-Dec-16	10.3	4.7	3.1	0	1020.1	5.8	11	340	18	7.964	0.3	0.4	1	1	-7.7	148
20-Dec-16	9.4	3.8	-0.7	5.6	1009.5	7.9	14	200	26	7.298	0.2	0.3	0	-4.4	-10	204
21-Dec-16	9.8	3.7	-0.5	1.1	1009.1	6.9	15	240	25	7.189	0.4	0.4	0	-0.7	-10	251
22-Dec-16	8.9	5.5	-3.4	0	1016.9	7.7	12	210	18	6.236	0.4	0.4	0.4	0.4	-9.1	309
23-Dec-16	11.6	5.1	0.3	5.8	1010.8	15	24	210	40	7.255	0.6	0.8	0	-4.9	-10	93
24-Dec-16	11	5.4	1.1	0	1015.3	14.6	22	220	33	6.833	0.6	0.8	0.6	0.6	-8.9	209
25-Dec-16	12.1	6.4	5.3	1.6	1012.3	15.2	23	220	34	9	0.6	0.9	0	-0.3	-9.4	106
26-Dec-16	7.9	2.2	-0.8	0	1024.4	7.3	15	240	22	6.576	0.4	0.4	0.4	0.4	-8.5	373
27-Dec-16	8.8	2.1	-4.2	0.1	1033.3	5.1	11	160	15	5.889	0.5	0.6	0.7	0.7	-7.7	116
28-Dec-16	9.9	6.7	2.5	0	1030.1	5.6	9	160	15	6.705	0.4	0.5	1.2	1.2	-6.9	215
29-Dec-16	10.2	5.1	-2.4	0	1026.5	5	10	210	16	7.138	0.4	0.5	1.6	1.6	-6.2	69
30-Dec-16	11	9.7	3.5	0	1025.8	7.7	13	230	19	8.448	0.4	0.5	1.9	1.9	-5.5	106
31-Dec-16	10.4	8.6	5.9	0.4	1018	8.9	14	240	24	8.82	0.2	0.3	1.7	1.7	-5.4	227

Appendix F

Management Structure

Management Structure of Waterford City and County Council

Chief Executive Michael Walsh

Director of Services

Environment & Planning Mr. Fergus Galvin

Senior Executive Engineer Mr. Niall Kane

Executive Engineer Mr. John McKeown

Executive Scientific Officer	**Assistant Engineer** (Deputy Manager)	**Environmental Consultants**
Mr. Paul Carroll	Mr. Ted Cunningham	

Landfill Manager

Mr. David Regan

Appendix G

Pollutant Release Transfer Register

Environmental Protection Agency

Guidance to completing the PRTR workbook

PRTR Returns Workbook

Version 1.1.19

REFERENCE YEAR	2016

1. FACILITY IDENTIFICATION

Parent Company Name	Waterford City & County Council
Facility Name	Tramore Waste Disposal Site
PRTR Identification Number	W0075
Licence Number	W0075-02

Classes of Activity

No.	**class_name**
-	Refer to PRTR class activities below

Address 1	Tramore Intake & Tramore Burrows
Address 2	Tramore
Address 3	
Address 4	
	Waterford
Country	Ireland
Coordinates of Location	-7.13286 52.1616
River Basin District	IESE
NACE Code	3821
Main Economic Activity	Treatment and disposal of non-hazardous waste
AER Returns Contact Name	David Regan
AER Returns Contact Email Address	dregan@waterfordcouncil.ie
AER Returns Contact Position	Executive Techncian
AER Returns Contact Telephone Number	058 22112
AER Returns Contact Mobile Phone Number	086 8307065
AER Returns Contact Fax Number	058 45606
Production Volume	0.0
Production Volume Units	
Number of Installations	0
Number of Operating Hours in Year	0
Number of Employees	1
User Feedback/Comments	
Web Address	www.waterfordcouncil.ie

2. PRTR CLASS ACTIVITIES

Activity Number	**Activity Name**
50.1	General
50.1	General

3. SOLVENTS REGULATIONS (S.I. No. 543 of 2002)

Is it applicable?	No
Have you been granted an exemption ?	
If applicable which activity class applies (as per Schedule 2 of the regulations) ?	
Is the reduction scheme compliance route being used ?	

4. WASTE IMPORTED/ACCEPTED ONTO SITE Guidance on waste imported/accepted onto site

Do you import/accept waste onto your site for on-site treatment (either recovery or disposal activities) ?	No

SECTION A : SECTOR SPECIFIC PRTR POLLUTANTS

RELEASES TO AIR					Please enter all quantities in this section in KGs			
POLLUTANT		METHOD			ADD EMISSION POINT	QUANTITY		
			Method Used					
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
					0.0	0.0	0.0	0.0

ADD NEW ROW | DELETE ROW * * Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

SECTION B : REMAINING PRTR POLLUTANTS

RELEASES TO AIR					Please enter all quantities in this section in KGs			
POLLUTANT		METHOD			ADD EMISSION POINT	QUANTITY		
			Method Used					
No. Annex II	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
01	Methane (CH4)	E	OTH	USEPA LANDGEM model and trend model	54000.0	54000.0	0.0	0.0
03	Carbon dioxide (CO2)	E	OTH	USEPA LANDGEM model and trend model	1200000.0	1200000.0	0.0	0.0
07	**Non-methane volatile organic compounds (NMVOC)**	E	OTH	USEPA LANDGEM model and trend model	16000.0	16000.0	0.0	0.0

ADD NEW ROW | DELETE ROW * * Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

EMISSIONS (As required in your Licence)

RELEASES TO AIR					Please enter all quantities in this section in KGs			
POLLUTANT		METHOD			ADD EMISSION POINT	QUANTITY		
			Method Used					
Pollutant No.	Name	M/C/E	Method Code	Designation or Description	Emission Point 1	T (Total) KG/Year	A (Accidental) KG/Year	F (Fugitive) KG/Year
					0.0	0.0	0.0	0.0

ADD NEW ROW | DELETE ROW * * Select a row by double-clicking on the Pollutant Name (Column B) then click the delete button

Additional Data Requested from Landfill operators

For the purposes of the National Inventory on Greenhouse Gases, landfill operators are requested to provide summary data on landfill gas (Methane) flared or utilised on their facilities to accompany the figures for total methane generated. Operators should only report their Net methane (CH4) emission to the environment under T(total) KG/yr for Section A: Sector specific PRTR pollutants above. Please complete the table below:

Landfill: Tramore Waste Disposal Site

Please enter summary data on the quantities of methane flared and / or utilised	T (Total) kg/Year	M/C/E	Method Used: Method Code	Method Used: Designation or Description	Facility Total Capacity m3 per hour	
Total estimated methane generation (as per site model)	330000.0	E	OTH	Landgem	N/A	
Methane flared	270000.0	E	OTH	Landgem	0.0	(Total Flaring Capacity)
Methane utilised in engine/s	0.0				0.0	(Total Utilising Capacity)
Net methane emission (as reported in Section A above)	54000.0	E	OTH	Landgem	N/A	

Please enter all quantities on this sheet in Tonnes

Transfer Destination	European Waste Code	Hazardous	Quantity (Tonnes per Year)	Description of Waste	Waste Treatment Operation	Method Used		Location of Treatment	Haz Waste : Name and Licence/Permit No of Next Destination Facility Non Haz Waste: Name and Licence/Permit No of Recover/Disposer	Haz Waste : Address of Next Destination Facility Non Haz Waste: Address of Recover/Disposer	Name and License / Permit No. and Address of Final Recoverer / Disposer (HAZARDOUS WASTE ONLY)	Actual Address of Final Destination i.e. Final Recovery / Disposal Site (HAZARDOUS WASTE ONLY)
						M/C/E	Method Used					
Within the Country	20 03 03	No	81.37	street-cleaning residues	D8	C	Volume Calculation	Offsite in Ireland	Born Na Mona,W0201-01	Drehid Landfill,Kilnagh Upper,Carbury,Co. Kildare,Ireland		
Within the Country	19 07 03	No	38.0	landfill leachate other than those mentioned in 19 07 02	D15	M	Volume Calculation	Offsite in Ireland	Irish Water,D0015-01	Waste Water Treatment Plant,Crobally Upper,Tramore,Waterford,Ireland		

Appendix H

Landfill Gas Survey and Flare Service Reports

Environmental Protection Agency

A survey of landfill sites to determine the quantity of methane flared and or recovered in utilisation plants for 2016

Please choose from the drop down menu the license number for your site	W0075
Please choose from the drop down menu the name of the landfill site	Tramore
Please enter the number of flares operational at your site in 2016	1
Please enter the number of engines operational at your site in 2016	0
Total methane flared	52,628 kg/year
Total methane utilised in engines	0 kg/year

Please note that the closing date for reciept of completed surveys is 31/03/2017

Introduction

The Office of Environmental Sustainability (OES) of the Environmental Protection Agency acts as the inventory agency in Ireland with responsibility for compiling and reporting national greenhouse gas inventories to the European Commission and the United Nations Framework Convention on Climate Change. In addition to meeting international commitments Ireland's national greenhouse gas inventory informs national agencies and Government departments as they face the challenge to curb emissions and meet Ireland's emission reduction targets under the Effort Sharing Decision (No. 406/2009/EC). The national inventory also informs data suppliers, making them aware of the importance of their contributions to the inventory process and a means of identifying areas where input data may be improved.

It is on this basis that the Environmental Protection Agency is asking landfill operators to partake in this survey so that the most uptodate information on methane flaring and recovery in utilisation plants at landfills sites is used in calculating the contribution of the landfill sector to national greenhouse gas emissions

The Environmental Protection Agency wishes to thank you for partaking in this survey. If you have any questions about the survey and how to complete it please view the "Help sheet" worksheet. If however, your query is not answered by viewing the "Help sheet" worksheet please contact:
LFGProject@epa.ie

Once completed please send the completed file as an attachment clearly stating the name and or license number of the landfill site (e.g. W000 Xanadu landfill_2015) to:
LFGProject@epa.ie

	to be filled in by licensee		calculated by spreadsheet	

Flare No. 1

Flare type ?	Other	**If "other" enter flare description here**	
Is the flare an open or enclosed flare ?	Enclosed	**Rated flare capacity ?**	250 **m3/hr**
Month /year comissioned ?	April	2009	
Month decomissioned if decomissioned in 2016 ?	Select		
What is the function of the flare ?	Extraction from capped area	**If "other" enter flare function here**	

Monthly	Method M/C/E	Runtime days/month	Runtime hrs/day	Downtime hrs	Total runtime hrs/month	Average Inlet Pressure (mbg)	Average Inlet Temp ◦C	Average Flow Rate (m^3/hr)	Average CH_4 %v/v	Average CO_2 %v/v	Average O_2 %v/v	Combustion efficiency (%)	Total CH_4 m^3	Total CH_4 kgs
January	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
February	E	27	10.0	0.0	270	-21	10	75	30.00	22.40	3.00	98.0	5,954	4,025
March	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
April	E	29	10.0	0.0	290	-21	10	75	30.00	22.40	3.00	98.0	6,395	4,324
May	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
June	E	29	10.0	0.0	290	-21	10	75	30.00	22.40	3.00	98.0	6,395	4,324
July	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
August	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
September	E	29	10.0	0.0	290	-21	10	75	30.00	22.40	3.00	98.0	6,395	4,324
October	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
November	E	29	10.0	0.0	290	-21	10	75	30.00	22.40	3.00	98.0	6,395	4,324
December	E	30	10.0	0.0	300	-21	10	75	30.00	22.40	3.00	98.0	6,615	4,473
Total					3,530								77,837	52,628

Please note: Only fill the "Yearly" table if data is not availabe or cannot be calculated nor estimated on a monthly basis

Yearly	Method M/C/E	Runtime days/year	Runtime hrs/day	Downtime hrs	Total runtime hrs/year	Average Inlet Pressure (mbg)	Average Inlet Temp ◦C	Average Flow Rate m^3/hr	Average CH_4 %v/v	Average CO_2 %v/v	Average O_2 %v/v	Combustion efficiency (%)	Total CH_4 m^3	Total CH_4 kgs
2016					0		10					98.0	0	0

SERVICE SHEET

Page No 1

JOB NO
Tramore

Automatic Flare Systems Ltd
Unit 8, Ensign Business Centre
Coventry CV4 8JA
United Kingdom
Tel: +44 (0)24 7647 4877
Fax: +44 (0)24 7647 4834
www.afs-group.co.uk

SITE: Tramore, Co Waterford

DATE: 02-11-2016

HEALTH AND SAFETY NOTICE

WEAR A HEAD HAT AND REFLECTIVE VEST OR JACKET ON OPERATIVE SITES

WEAR A PROTECTIVE FACE MASK WHEN WORKING IN AN AREA WHERE THERE IS ANY POSSIBILITY OF BREATHING IN CERAMIC INSULAING DUST

TO BE COMPLETED FOR ALL HIRE INSTALLATION, SERVICE AND REPAIR VISITS

1. RECORD ALL INSTRUMENT READINGS AND VALVE SETTINGS ON ARRIVAL
2. RECORD ALL CHANGES AND REPAIRS MADE
3. RECORD ALL PARTS, MATERIALS & COMPONENTS FITTED OR USED
4. CHECK THAT PRESSURE AND VACUUM GAUGES ARE ZEROED
5. RECORD ALL INSTRUMENT READINGS AND VALVE SETTINGS ON DEPARTURE
6. LEAVE SITE CLEAN AND TIDY
7. NOTE FUTURE REMEDIAL ACTION NEEDED AND SEE THAT IT IS CARRIED OUT

FLARE AUTO TIMER SETTINGS

DAY	START	STOP
SUNDAY		
MONDAY		
TUESDAY		
WEDNESDAY		
THURSDAY		
FRIDAY		
SATURDAY		

ENGINEERS NAME	Steve Hindle	Uni- flare

ARRIVAL: **Flare off high condensate alarm**

HOURS RUN	BOOSTER	23242	CH4	52.7 %	CO2	30.8 %	
	FLARE	23211	O2	1.2 %	PRESSURE	8.3	mbar

INLET VALVE SETTING % OPEN

NO 1	100%	NO 2	N/A	NO 3	N/A	NO 4	N/A	NO 5	N/A	NO 6	N/A

MAIN CONTROL VALVE SETTING % OPEN	100%

INLET VACUUM GAUGE READINGS STARING SIDE NEAREST KNOCKOUT POT (mbarg)

NO 1	-2.0	NO 2	N/A	NO 3	N/A	NO4	N/A	NO 5	N/A	NO 6	N/A

INLET TEMP	12 °C	INLET VACUUM PRIOR TO KO POT FILTER	-2.0 MBAR
VACUUM AFTER KO POT FILTER	-2.0 MBAR	VACUUM AFTER INLET FLAME ARRESTER	N/A MBAR
OUTLET PRESSURE AFTER GAS BOOSTER	10 MBAR	OUTLET GAS TEMP	22 °C
PRESSURE AFTER SLAM SHUT	Gauge stuck MBAR	PRESSURE AFTER OUTLET FLAME ARRESTER	0 gauge sticking
TOTAL FLOW	N/A m^3	BLOWER SPEED	20 %
DAMPER POSTION	N/A %		
FLOW RATE	75 m^3/hr	MEASURING INSTRUMENT	OPFM
FLAME TEMP	1010 °C	MOTOR TEMP (drive bearing)	25 °C
FLAME QUALITY	OK	AMBIENT TEMP	N/A °C
MANOMETER LIQUID LEVEL WITH RIG SHUT DOWN		AMBIENT PRESSURE	N/A MBAR

TYPE OF LIQUID: PERFLOW

RED SG - 0.8		EMISSIONS ANALYSER CO CELL	N/A	EMISSIONS ANALYSER NOX CELL	N/A

SERVICE SHEET Page No 2	Job No Tramore	**Automatic Flare Systems Ltd** Unit 8, Ensign Business Centre Coventry CV4 8JA United Kingdom Tel: +44 (0)24 7647 4877 Fax: +44 (0)24 7647 4834

CHECK FOR LEAKS WITH GAS DETECTOR		None	
CONDENSATE DRAIN SYSTEM CHECK		Yes	
DRAINS CORRECTLY	Yes	KNOCKOUT POT FILTER CLEAN	N/A
COMMENTS			
BOOSTER MODEL AND SERIAL NO	Transatr Vac TAV4471		
MOTOR & FAN SEAL GREASED	N/A	BOOSTER CORRECT ROTATION	Yes
NOTE: USE SHELL ALVANIA 3, GREASE EVERY SERVICE **IMPORTANT DO NOT OVERGREASE**			
BOOSTER OIL CHANGED (EVERY 5000 HOURS, USE 20W50 ENGINE OIL IN DONKIN V50			N/A

BOOSTER FLEXIBLE CONNECTORS	OK	MOUNTINGS	OK	BEARING NOISE	OK
BOLTS TIGHT	Yes	SLAMSHUT SPRING	OK	GAUGES ZEROED	Yes
FLAME ARRESTER INLET	N/A	OUTLET	OK	PILOT	Fault
PILOT LIGHT FUNCTION	Cleaned & set	UV SENSOR FUNCTION	Cleaned	CONDITION OF THERMOCOUPLER	OK
DAMPER OPERATION	OK	CONDITION OF BURNER CUPS	OK	CONDITION OF FLARE LINING	OK
LOUVERS CONDITION	OK	INTERIOR LIGHT	OK	EXTERIOR LIGHT	N/A
ALL INDICATOR BULBS FUNCTION		Yes	ELECTRICAL CONNECTIONS CHECKED FOR TIGHTNESS		Yes
HINGES & VALVES LUBRICATED		Yes			

PRESSURE SWITCH FUNCTION

SUCTION	N/A	SETTING	N/A	VENT	N/A	SETTING	N/A
BOOSTER	Yes	SETTING	1.0 mbar	OTHER (specify)	N/A	SETTING	N/A
BURNER	N/A	SETTING	N/A			SETTING	

COMMENTS

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CHECK SIGNAL, CONTROL AND TELEMETRY FUNCTION	N/A
SIGNAL, CONTROL & TELEMETRY REPORT FILLED OUT AS APPROPRIATE	N/A
REPORT ALL & ANY CHANGES MADE TO TELEMETRY SYSTEM	None
REPORT ALL & ANY CHANGES MADE TO CONTROL PROGRAMME	None
CH4 ANALYSER OPERATION	Fault
O2 ANALYSER OPERATION	Fault
C02 ANALYSER OPERATION	Fault
CO EMISSION ANALYSER	Fault
REPORT ALL & ANY REPAIRS	None
REPORT ALL & ANY PARTS REPLACED OR NEW PARTS FITTED INCLUDING PART NOS & SUFFICIENT DETAIL FOR THEM TO BE INVOICED	

	COMMENTS	NEW PARTS FITTED
	Flare was off on arrival due a high condensate alarm with the gas collection system flooded. Drained water from KOP filter & main gas pressure line.	
	Pilot light solenoid valve was stuck closed, Removed, cleaned, freed and refit.	
	Gas Data analyser not working investigated and found the Lambda DPP50-15 240 VAC > 15VDC transformer has failed and requires a new one.	
	Drained Flare's compressor	

GAS ANALYSER CALIBRATION REPORT:

GAS USED: 1954 Compressed Gas.		Methane (CH4) 50 % concentration		Carbon Dioxide: Remaining Balance	
Before Calibration:	CH4	N/A %	CO2	N/A %	
After Calibration:	CH4	N/A %	CO2	N/A %	
Comments:	None				

GAS USED: 1954 Compressed Gas.		Oxygen (O_2) 20.9% Concentration	Nitrogen: Remaining Balance
Before Calibration:	O_2	N/A %	
After Calibration:	O_2	N/A %	
Comments:	None		

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REPORT ANY FURTHER REPAIRS OR ACTION NEEDED:
Requires replacement of 3 x ¼' BSP valves and suction gauge. Old ones seized, blocked and not working.
Requires replacement of 3 x ¼' BSP valves and pressure gauge. Old ones seized, blocked or sticking, not working.
Gas Data analyser not working investigated and found the Lambda DPP50-15 240 VAC > 15VDC transformer has failed and requires a new one.
Pilot light solenoid valve was stuck closed, Removed, cleaned, freed and refit. Requires new 1"bsp 240V solenoid valve.
Ignitor and carriage badly corroded. Requires new carriage and new ignitor.

DEPARTURE REPORT:							
FLARE HOURS RUN: 23256		RUN RIG FOR 30 MINUTES BEFORE TAKING READINGS					
CH4	55.8 %	CO2	28.5 %	O2	1.1 %	CO	N/A

INLET VALVE SETTING % OPEN											
NO 1	100%	NO 2	N/A	NO 3	N/A	NO 4	N/A	NO 5	N/A	NO 6	N/A

MAIN CONTROL VALVE SETTING % OPEN	100%

INLET VACUUM GAUGE READINGS STARTING SIDE NEAREST KNOCKOUT POT										(mbar)	
NO 1	- 1.0	NO 2	N/A	NO 3	N/A	NO4	N/A	NO 5	N/A	NO 6	N/A

INLET TEMP	12 °C	INLET VACUUM PRIOR TO KO POT FILTER	-1.0 MBAR
VACUUM AFTER KO POT FILTER	-1.0 MBAR	VACUUM AFTER INLET FLAME ARRESTER	N/A MBAR
OUTLET PRESSURE AFTER GAS BOOSTER	8.0 MBAR	OUTLET GAS TEMP	20 °C
PRESSURE AFTER SLAM SHUT	Gauge Stuck	PRESSURE AFTER OUTLET FLAME ARRESTER	Gauge Sticking
OTHER		BLOWER SPEED %	20 %
DAMPER POSITION	N/A % m3/hr	MANOMETER READING	75 m^3hr
FLOW RATE	75 m^3hr	FLAME QUALITY	OK
FLAME TEMP	1005 °C	HAS RIG & COMPOUND BEEN LEFT CLEAN	Yes

NAMES OF ALL AFS & SUB CONTRACTOR STAFF CARRYING OUT WORK			
Steve Hindle			
REPORT WRITER	Steve Hindle		
SIGNATURE			

SERVICE SHEET

Page No 1

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Tramore

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www.afs-group.co.uk

SITE: Tramore, Co Waterford | DATE: 04-05-2017

HEALTH AND SAFETY NOTICE

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WEAR A PROTECTIVE FACE MASK WHEN WORKING IN AN AREA WHERE THERE IS ANY POSSIBILITY OF BREATHING IN CERAMIC INSULAING DUST

TO BE COMPLETED FOR ALL HIRE INSTALLATION, SERVICE AND REPAIR VISITS
1. RECORD ALL INSTRUMENT READINGS AND VALVE SETTINGS ON ARRIVAL
2. RECORD ALL CHANGES AND REPAIRS MADE
3. RECORD ALL PARTS, MATERIALS & COMPONENTS FITTED OR USED
4. CHECK THAT PRESSURE AND VACUUM GAUGES ARE ZEROED
5. RECORD ALL INSTRUMENT READINGS AND VALVE SETTINGS ON DEPARTURE
6. LEAVE SITE CLEAN AND TIDY
7. NOTE FUTURE REMEDIAL ACTION NEEDED AND SEE THAT IT IS CARRIED OUT

FLARE AUTO TIMER SETTINGS

DAY	START	STOP
SUNDAY		
MONDAY		
TUESDAY		
WEDNESDAY		
THURSDAY		
FRIDAY		
SATURDAY		

ENGINEERS NAME	Steve Hindle	UF10-250

ARRIVAL: **Flare running**

HOURS RUN	BOOSTER	27456	CH4	32.4 %	CO2	20.4 %	
37819 hrs clock	FLARE	27412	O2	1.4 %	PRESSURE	2.0	mbar

INLET VALVE SETTING % OPEN

NO 1	100%	NO 2	N/A	NO 3	N/A	NO 4	N/A	NO 5	N/A	NO 6	N/A

MAIN CONTROL VALVE SETTING % OPEN: 100%

INLET VACUUM GAUGE READINGS STARING SIDE NEAREST KNOCKOUT POT: (mbarg)

NO 1	-19.0	NO 2	N/A	NO 3	N/A	NO4	N/A	NO 5	N/A	NO 6	N/A

INLET TEMP	12.0 °C	INLET VACUUM PRIOR TO KO POT FILTER	-20.0 MBAR
VACUUM AFTER KO POT FILTER	-20.0 MBAR	VACUUM AFTER INLET FLAME ARRESTER	N/A MBAR
OUTLET PRESSURE AFTER GAS BOOSTER	2.0 MBAR	OUTLET GAS TEMP	19 °C
PRESSURE AFTER SLAM SHUT	Gauge stuck MBAR	PRESSURE AFTER OUTLET FLAME ARRESTER	0 gauge sticking
TOTAL FLOW	N/A m^3	BLOWER SPEED	15.5 %
DAMPER POSTION	N/A %		
FLOW RATE	40 m^3/hr	MEASURING INSTRUMENT	OPFM
FLAME TEMP	999 °C	MOTOR TEMP (drive bearing)	24 °C
FLAME QUALITY	OK	AMBIENT TEMP	N/A °C
MANOMETER LIQUID LEVEL WITH RIG SHUT DOWN		AMBIENT PRESSURE	N/A MBAR

TYPE OF LIQUID: PERFLOW

RED SG - 0.8		EMISSIONS ANALYSER CO CELL	N/A	EMISSIONS ANALYSER NOX CELL	N/A

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CHECK FOR LEAKS WITH GAS DETECTOR		None	
CONDENSATE DRAIN SYSTEM CHECK		Yes	
DRAINS CORRECTLY	Yes	KNOCKOUT POT FILTER CLEAN	N/A
COMMENTS			
BOOSTER MODEL AND SERIAL NO	Transatr Vac TAV4471		
MOTOR & FAN SEAL GREASED	N/A	BOOSTER CORRECT ROTATION	Yes
NOTE: USE SHELL ALVANIA 3, GREASE EVERY SERVICE **IMPORTANT DO NOT OVERGREASE**			
BOOSTER OIL CHANGED (EVERY 5000 HOURS, USE 20W50 ENGINE OIL IN DONKIN V50			N/A

BOOSTER FLEXIBLE CONNECTORS	OK	MOUNTINGS	OK	BEARING NOISE	OK
BOLTS TIGHT	Yes	SLAMSHUT SPRING	OK	GAUGES ZEROED	Yes
FLAME ARRESTER INLET	N/A	OUTLET	OK	PILOT	Fault
PILOT LIGHT FUNCTION	Cleaned & set	UV SENSOR FUNCTION	Cleaned	CONDITION OF THERMOCOUPLER	OK
DAMPER OPERATION	OK	CONDITION OF BURNER CUPS	N/A	CONDITION OF FLARE LINING	N/A
LOUVERS CONDITION	OK	INTERIOR LIGHT	OK	EXTERIOR LIGHT	N/A
ALL INDICATOR BULBS FUNCTION	Yes	ELECTRICAL CONNECTIONS CHECKED FOR TIGHTNESS			Yes
HINGES & VALVES LUBRICATED	Yes				

PRESSURE SWITCH FUNCTION							
SUCTION	N/A	SETTING	N/A	VENT	N/A	SETTING	N/A
BOOSTER	Yes	SETTING	1.0 mbar	OTHER (specify)	N/A	SETTING	N/A
BURNER	N/A	SETTING	N/A			SETTING	
COMMENTS							

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CHECK SIGNAL, CONTROL AND TELEMETRY FUNCTION	N/A
SIGNAL, CONTROL & TELEMETRY REPORT FILLED OUT AS APPROPRIATE	N/A
REPORT ALL & ANY CHANGES MADE TO TELEMETRY SYSTEM	None
REPORT ALL & ANY CHANGES MADE TO CONTROL PROGRAMME	None
CH4 ANALYSER OPERATION	Fault
O2 ANALYSER OPERATION	Fault
C02 ANALYSER OPERATION	Fault
CO EMISSION ANALYSER	Fault
REPORT ALL & ANY REPAIRS	None
REPORT ALL & ANY PARTS REPLACED OR NEW PARTS FITTED INCLUDING PART NOS & SUFFICIENT DETAIL FOR THEM TO BE INVOICED	

	COMMENTS	NEW PARTS FITTED
	Gas Data analyser not working investigated and found the Lambda DPP50-15 240 VAC > 15VDC transformer has failed and requires a new one.	
	Drained Flare's compressor	
	Container very badly rusting, holes are now appearing in the sides	
	Would recommend a replacement or welding of new panels to close the	
	Holes. This is only going to get worse with time!!!!	

GAS ANALYSER CALIBRATION REPORT:

GAS USED: 1954 Compressed Gas.		Methane (CH4) 50 % concentration		Carbon Dioxide: Remaining Balance	
Before Calibration:	CH4	N/A %	CO2	N/A %	
After Calibration:	CH4	N/A %	CO2	N/A %	
Comments:	None				

GAS USED: 1954 Compressed Gas.		Oxygen (O_2) 20.9% Concentration		Nitrogen: Remaining Balance
Before Calibration:	O_2	N/A %		
After Calibration:	O_2	N/A %		
Comments:	None			

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REPORT ANY FURTHER REPAIRS OR ACTION NEEDED:

Requires replacement of 3 x ¼' BSP valves and suction gauge. Old ones seized, blocked and not working.

Requires replacement of 3 x ¼' BSP valves and pressure gauge. Old ones seized, blocked or sticking, not working.

Gas Data analyser not working investigated and found the Lambda DPP50-15 240 VAC > 15VDC transformer has failed and requires a new one.

Ignitor and carriage badly corroded. Requires new carriage and new ignitor.

To maintain the quality of gas the flow was reduced at the flare from 40m^3hr to 30m^3hr.

The production & quality of gas from the gas field has reduced to the level that the Flare has reached its minimum Flow rate to maintain a flare stack temperature of 1000C.

Recommend – Replace the Flare with a Low-cal flare or install a timer on existing flare and run part time.

DEPARTURE REPORT:

FLARE HOURS RUN: 37819		RUN RIG FOR 30 MINUTES BEFORE TAKING READINGS					
CH4	33.0 %	CO2	25.7 %	O2	2.8 %	CO	N/A

INLET VALVE SETTING % OPEN											
NO 1	100%	NO 2	N/A	NO 3	N/A	NO 4	N/A	NO 5	N/A	NO 6	N/A

MAIN CONTROL VALVE SETTING % OPEN	100%

INLET VACUUM GAUGE READINGS STARTING SIDE NEAREST KNOCKOUT POT										(mbar)	
NO 1	- 14.0	NO 2	N/A	NO 3	N/A	NO4	N/A	NO 5	N/A	NO 6	N/A

INLET TEMP	8 °C	INLET VACUUM PRIOR TO KO POT FILTER	-14.0 MBAR
VACUUM AFTER KO POT FILTER	-14.0 MBAR	VACUUM AFTER INLET FLAME ARRESTER	N/A MBAR
OUTLET PRESSURE AFTER GAS BOOSTER	2.0 MBAR	OUTLET GAS TEMP	18 °C
PRESSURE AFTER SLAM SHUT	Gauge Stuck	PRESSURE AFTER OUTLET FLAME ARRESTER	Gauge Sticking
OTHER		BLOWER SPEED %	14.5 %
DAMPER POSITION	N/A % m3/hr	MANOMETER READING	30 m^3hr
FLOW RATE	30 m^3hr	FLAME QUALITY	OK
FLAME TEMP	1003 °C	HAS RIG & COMPOUND BEEN LEFT CLEAN	Yes

NAMES OF ALL AFS & SUB CONTRACTOR STAFF CARRYING OUT WORK			
Steve Hindle			
REPORT WRITER	Steve Hindle		
SIGNATURE			

GAS FIELD BALANCING SHEET

Site:	**Tramore**	**Total Flare Hrs**	37773
Date:	02/05/2017	**Flare Automatic Operating Hrs Settings**	Flare running
Name:	Steve Hindle	**Flare Temperature ^{0}C**	1006
Equipment Used :	GA5000	**Blower motor setting**	18% reduced to 15.5.%
Serial No :	G500854	**Flow Arrival m^3hr**	50m^3hr
Last Calibration Date :		**Flow after balance m^3hr**	40m^3hr
Calibration Due Date :		**Flow Leaving m^3hr**	40m^3hr

1	2	3	4	5	6	9	10	12	13	14	15	16
ID	Date/Time	CH4 %	CO2 %	O2 %	BALANCE %	RESIDUAL NITROGEN %	CO ppm	H2S ppm	SUCTION PRESSURE mb	COMMENTS	START VALVE POSITION %	FINISH VALVE POSITION %
TM_FLARE	02/05/2017 15:13	25.2	22.1	2.3	50.4	41.71	0	0	-16.38		100	100
TMGE2-01	02/05/2017 15:33	20.7	22.3	0.8	56.2	53.18	0	0	-14.24		10	0
TMGE2-02	02/05/2017 15:36	0	0.5	20.2	79.3	2.94	0	0	-0.88		0	0
TMGE2-03	02/05/2017 15:38	29	22.1	4.4	44.5	27.87	0	0	-1.56		0	0
TMGE2-04	02/05/2017 15:41	29.5	25.4	0.5	44.6	42.71	0	2	-1.81		0	5
TMGE2-05	02/05/2017 15:43	0	4.7	15.5	79.8	21.21	0	0	-11.34		0	0
TMGE2-06	02/05/2017 15:44	0.1	7.2	13.7	79	27.21	0	0	0.08		0	0
TMGE2-07	02/05/2017 15:47	0	2	18.8	79.2	8.14	0	0	-1.07		0	0
TMGE2-08	02/05/2017 15:49	0.4	3.3	15.5	80.8	22.21	0	0	0.19		0	0
TMGE1-01	02/05/2017 15:59	0.9	17.7	1	80.4	76.62	0	0	-2.4		0	0
TMGE1-02	02/05/2017 16:01	0	0.2	20.4	79.4	2.29	0	0	-0.07		0	0
TMGE1-03	02/05/2017 16:04	1.2	18.3	0.3	80.2	79.07	0	0	-3.92		0	0
TMGE1-04	02/05/2017 16:06	0	0.3	20.2	79.5	3.14	0	0	0.26		0	0
TMGE1-05	02/05/2017 16:07	2.1	2.8	18.3	76.8	7.63	0	0	-16.33		0	0
TMGE1-06	02/05/2017 16:09	0.8	3	17.8	78.4	11.12	0	0	-10.9		0	0
TMGE1-07	02/05/2017 16:11	12.2	20.2	1.6	66	59.95	0	1	-0.88		0	0
TMGE1-08	02/05/2017 16:14	17.9	21.9	0.3	59.9	58.77	0	3	-0.71		0	0
TMGE1-09	02/05/2017 16:17	14.5	19.9	0.9	64.7	61.3	0	0	-0.85		0	0
TMGE4-01	02/05/2017 16:22	33	21.7	3.8	41.5	27.14	0	1	-16.48		20	20
TMGE4-02	02/05/2017 16:23	54.4	30.1	1.5	14	8.33	0	0	-16.13		20	100
TMGE4-03	02/05/2017 16:25	8.4	4.8	17.2	69.6	4.58	2	0	0.44		0	0
TMGE4-04	02/05/2017 16:27	33.6	25.8	1.3	39.3	34.39	2	1	-16.1		40	20
TMGE4-05	02/05/2017 16:29	23.5	11.6	12.1	52.8	7.06	0	2	-14.24		0	0
TMGE4-06	02/05/2017 16:31	39.8	26.1	2.9	31.2	20.24	1	0	-15.76		60	20
TMGE4-07	02/05/2017 16:33	0	0.1	20.4	79.5	2.39	0	0	0.16		0	0
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TMGE4-09	02/05/2017 16:37	0.2	10.7	9.5	79.6	43.69	0	0	-15.35		0	0
TMGE4-10	02/05/2017 16:40	2.2	4.9	16	76.9	16.42	0	0	0.26		0	0
TMGE3-01	02/05/2017 16:45	29.6	23.9	0.4	46.1	44.59	1	3	-16.29		10	10
TMGE3-02	02/05/2017 16:46	33.5	25.4	0.4	40.7	39.19	1	9	-2.92		10	10
TMGE3-03	02/05/2017 16:47	43.8	27.7	0.1	28.4	28.02	2	16	-17.54		60	60
TMGE3-04	02/05/2017 16:49	8.9	6	16.2	68.9	7.66	4	1	-0.57		0	0
TMGE3-05	02/05/2017 16:51	22.7	19.7	1.9	55.7	48.52	2	10	-0.83		0	0
TMGE3-06	02/05/2017 16:58	25.4	23.2	1	50.4	46.62	1	0	0.33		0	0
TMGE3-07	02/05/2017 17:01	25.3	22.7	0.1	51.9	51.52	1	8	-0.68		0	0
TMGE3-08	02/05/2017 17:02	33.1	20.9	0.2	45.8	45.04	1	41	-15.36		0	0
TMGE3-09	02/05/2017 17:03	19.8	22	0.2	58	57.24	2	18	-3.03		10	0
TMGE3-10	02/05/2017 17:08	26.4	15	7.7	50.9	21.79	3	1	0.08		0	0
TM_FLARE	02/05/2017 17:13	34.6	24.3	1.3	39.8	34.89	3	6	-20.59		100	100

Appendix I

Hydrogeological Review

Document Control Sheet

Client:	Waterford City & County Council
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TRAMORE LANDFILL HYDROGEOLOGICAL REVIEW

INTRODUCTION

This hydrogeological review / technical assessment has been prepared in response to Technical Amendment A issued by the EPA on the 15th of January 2013 with respect to Waste Licence W0075-02.
Condition 6.23 specified "*Within eighteen months of the date of this technical amendment, the licensee shall carry out a risk screening and where necessary a technical assessment in accordance with the Guidance on the Authorisation of Discharges to Groundwater, published by the Environmental Protection Agency. A report on the outcome of the screening and where relevant the recommendations of the technical assessment in relation to the setting of groundwater compliance points and values, shall be included in the next AER. Any actions required to demonstrate compliance with the European Communities Environmental Objectives (Groundwater) Regulations 2010, as amended shall be agreed by the Agency and implemented before 22nd December 2015. Groundwater monitoring results shall be submitted annually or as required in the Schedules to this licence*".

Further correspondence was received from the Agency on the 31/07/14, in the form of a notification of a non compliance, outlining that the report was due to be submitted no later than the 31/03/2015 with the Annual Environmental Report for 2014.

This report has been prepared in accordance with the fee proposal issued to Waterford City and County Council on the 26th of February 2015. The scope of proposed works outlined to Waterford City and County Council was as follows:

- Desk study to establish the baseline geological and hydrogeological conditions at the site;
- Review type and nature of current and past site activities to assess the potential impact on the hydrogeological regime;
- Risk screening to determine the degree of risk posed by the landfill on the groundwater and surface water quality and receptors based on source-pathway-receptor model;
- Generic Quantitative Risk Assessment;
- Assessment of whether the hydrogeological impacts are compliant with the discharge limits;
- Remedial strategy required to ensure objectives of groundwater regulations will be met;
- Review of compliance values and monitoring regime and identification of additional mitigation measures if required.

The Groundwater Risk Assessment has been carried out in accordance with the EPA Document "*Guidance On the Authorisation of Discharges To Groundwater* (EPA, 2011). This guidance document covers point source discharges such as the escape of leachate from landfills (beyond engineered and/or geological barriers) and outlines the technical assessments that are required to permit discharges to groundwater in accordance with the European Communities Environmental Objectives (Groundwater) Regulations, 2010 (SI No. 9 of 2010) (Groundwater Regulations).

eNVIRONMENTAL sITE SETTING

The town of Tramore is located 13km south of Waterford City. The Tramore Landfill site is located on the south eastern outskirts of the town to the north east of the Strand Road and the Promenade. The landfill site is located adjacent to the western end of the Tramore Backstrand which is a shingle embankment and dune system. Tramore Backstrand dries out completely during low tide and includes c500 ha of intertidal sand and mud flats. It is connected to the open sea by a channel known as Rinnashark.
The landuse in the immediate vicinity of the site is mainly recreational activities. The promenade and Tramore Beach are located to the south of the site and separated from the site by a car parking area. There is a caravan park and camping grounds located to the north west and west of the landfill site, off the Riverstown Road, within 100m of the facility boundary. The Riverstown Business Park, Tramore Waste Water Treatment Plant and St. Declan's Cemetery are located to the north west of the site. The closest permanent residential properties are located at Beach Grove approximately 200m to the north west of the western site boundary (Drawing DG0112, Appendix A).
The site occupies an area of 39 acres. The site is unlined and the landfilling of waste took place on top of the original ground surface. The northern most 18 acres is owned by Waterford City and County Council while the southern most 21 acres is leased by the local authority from Tramore Leisure Parks Ltd. The landfilling of waste within the existing facility boundary took place from circa 1939 to 2005. The deposition of waste has taken place above the original ground level resulting in the creation of a waste mound. The 2009 topographic survey indicates the ground elevation at the site ranges from approximately 0.50m above ordnance datum (mOD) at the base of the rock mound to 10.50mOD on the top of the waste mound. In general the elevation on top perimeter of the waste mound ranges from 6mOD to 8mOD.
The site is operated by Waterford City and County Council. A Waste Licence was first granted on the 25th September 2001 (Ref 75-1) for the continued operation of the existing unlined landfill and civic waste facility. A revised licence (W0075-02) was issued for the site on the 31st July 2007 and the site is currently operated under this licence. The waste body is composed of domestic and commercial waste including construction and demolition waste.
The landfill site ceased accepting waste on the 31st December 2005. The civic waste facility has been closed since the 20th November 2009. The site is currently being used by Waterford City and County Council as a storage compound for the Tramore Area Office.
The landfilling of waste also took place in the area of land immediately south of the landfill site outside of the facility boundary. This area of land is in the ownership of Tramore Leisure Parks Ltd. A site investigation programme was undertaken on behalf of Tramore Leisure Parks Ltd. in this area in late 2005 and early 2006. 5 no. groundwater monitoring wells were installed (BH1 – BH5) in the adjacent site. The investigations indicated elevated ammoniacal nitrogen, total and faecal coliforms, total dissolved solids and alkalinity in the groundwater at BH4.
The engineering works associated with the final restoration of Tramore Landfill Site took place between 2006 and 2009. A summary of the restoration works completed since the closure of the site in 2005 is provided in Table 2.1.

Element	Commencement	Completion
Gas Abstraction Wells	2006	2009
Permanent Gas Flare		2009
Leachate Extraction Wells	2006	2009
Leachate Storage Tank		2009
Final Capping	2008	2009

Table 0.1: Summary of Phasing of Restoration and Remedial Works Completed To Date

The gas abstraction system was installed in 2006 and is composed of 36 no. extraction wells, collection network, manifolds and condensate pots. An enclosed flare has been operational at the site since 2009 and operates on a continuous basis.

The leachate management system includes 12 no. leachate abstraction wells, collection pipework and an above ground leachate storage tank (40m^3 capacity) with the provision for moving pumps to other wells over

time if required. The layout of the leachate abstraction wells is shown on Drawing DG0114 Leachate Extraction System (Appendix A). The extraction wells were installed in 2006 and following the completion of the pumping trials in 2009 the leachate storage tank was commissioned. A review of the efficiency of the leachate extraction system was undertaken in 2010 (Leachate Behaviour Assessment Report, RPS 2010) and a maintenance service and check of the extraction system. The system was assessed to be operating correctly.

The system is pneumatic and uses pressurised airlines to drive pneumatic pumps in the wells discharging via 32mm leachate rising mains into 160mm gravity collector pipework. The wells operate automatically if the wells contain approximately 1m or more of leachate. Each pump is set 0.3m above the bottom of the well. The well depths were designed to collect and pump leachate but to avoid saline water intrusion. The leachate then gravitates to the 40m^3 leachate storage tank. The leachate is collected on site and removed by tanker as required to the Tramore Wastewater Treatment Plant. The data for 2014 AER indicates that no leachate was transported off site for disposal during 2014. To date no leachate has been removed off site in 2015.

The specified engineering works included the installation of the final cap over the waste mound during 2008 and 2009. The surface of the final cap has been completely vegetated over since it was reseeded and the grass cover has become established. The final capping was composed of a five layer composite system as follows:

- Top soil – 150 – 300mm;
- Subsoil such that thickness of topsoil and subsoil is at least 1m thick;
- Surface Water geocomposite layer;
- 1mm LLDPE geomembrane;
- Geocomposite gas collection layer.

It was agreed that a surface water drainage layer would not be required on the side slopes adjacent to the seashore as the existing gradient was adequate. Geogrid was placed on the side slopes adjacent to the seashore in areas that had a steep gradient in addition to the rock armour has been placed to provide erosion protection.
A Closure Restoration and Aftercare Plan was submitted to the EPA in 2009. The remediation of the landfill has been completed in accordance with this plan. Access to the site is provided to the general public and the site is currently being used for walking and running.
In 2011 a constructed wetlands was developed on the western edge of the landfill to improve the water quality in the environs of the landfill site and to intercept the emergency overflow from the pumping station on the Tramore agglomeration.

There are several designated sites located down gradient of the site. The landfill site is located adjacent to Tramore Dunes and Backstrand which include designated sites for ecological conservation interest. The Tramore Dunes and Backstrand is a candidate Special Area of Conservation (cSAC) under the EU habitats directive. The Tramore Backstrand is a designated Special protection Area (SPA) under the EU Birds Directive. The Tramore Dunes and Backstrand is also designated as a proposed Natural Heritage Area (pNHA). The locations of these sites are shown on Figure 2.1.

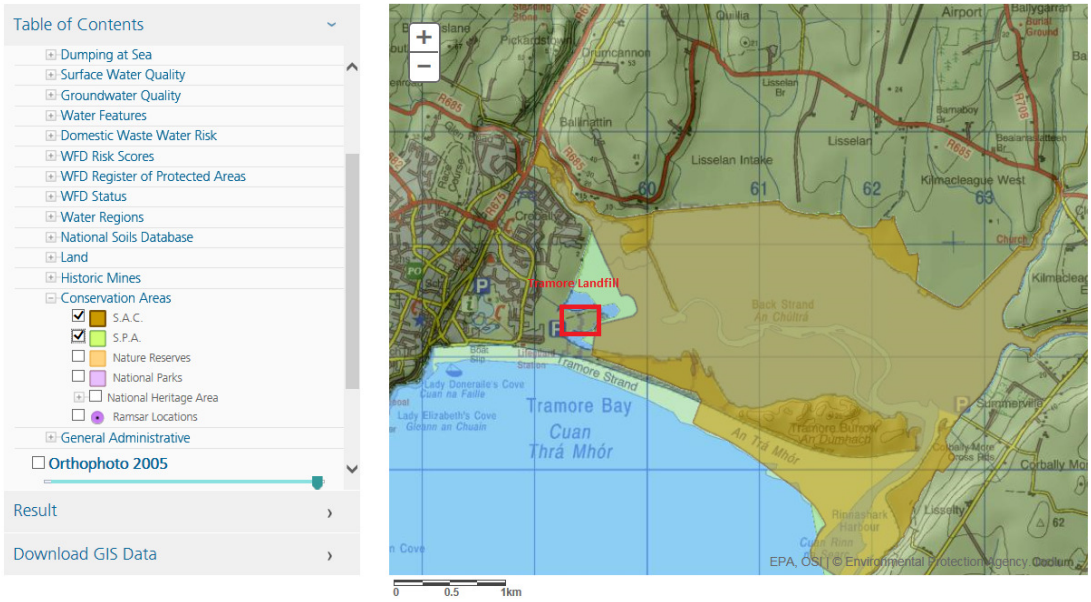


Figure 0.1: Proximity of Tramore Landfill to Designated Conservation Areas (Source EPA Maps)

In addition there is a designated Bathing Water Area at Tramore Beach located down gradient of the site. The surface water and groundwater in the area is also designated under recreational waters by the EPA for Surface Water in Bathing Location at Tramore Bay and Groundwater in Bathing Locations for the Dunmore East Groundwater Body.

A monitoring programme is in place at the site to monitoring the leachate composition and the groundwater and surface water quality in the vicinity of the landfill. The locations of the monitoring points are illustrated on Drawing DG0112 Designated Monitoring Points (Appendix A).

In order to complete the assessment of the site the following reports have been consulted to obtain information on the site:

- Annual Environmental Reports 2008 – 2014;
- Environmental Liability Risk Assessment (MDR0349Rp0013, RPS, January 2010);
- Previous site investigations reports (Appendix B);
- Environmental monitoring data – results of groundwater, surface water and leachate monitoring 2008 – Quarter 1 2015.

regional Geology

The bedrock geology of the Tramore area is composed of rocks of Ordovician age. Information on the geology has been obtained from the Geological Survey of Ireland (GSI) 1:100,000 series bedrock geology map (Sheet 23 geology of South Wexford, GSI, 1994). The bedrock geology map indicates that the site is underlain by the Tramore Shale Formation (TM) which is composed of dark grey shales and siltstones. The Tramore Shale Formation is part of the Duncannon Group and is Ordovician in age.

To the east of the landfill site, at the eastern end of the Tramore Burrows, the Booley Bay Formation (BB) forms the underlying bedrock. This formation is composed of grey to black mudstones and siltstone of Cambrian age.

The structural geology of the area is characterised by approximate north to south trending faults. The main structural features in the area is the Tramore Enniscorthy fault which is mapped on the northeastern margin of the Tramore Backstrand but is not mapped in the immediate vicinity of the site due to the presence of significant overburden deposits.

The Campile Formation (CA) forms the bedrock on the higher ground to the west of the Promenade. This formation is typically composed of rhyolitic volcanics, grey and brown slates and felsic volcanics and is Ordovician in age.
Information on the overburden deposits has been obtained from the Teagasc Subsoil map. The map indicates made ground as a result of the development of the landfill site in addition to the urban area to the west. The natural ground in the area is composed of glacial and fluvio glacial deposits. The landfill site was developed on an area of marine estuarine silts and clays (Mesc). To the east the overburden is composed of windblown sands (Wsd) while to the south along the seashore the overburden is classed as beach sands and gravels (Mbs). Further to the north and north west outside of the site the overburden is classed as till.

regional hydrogeology

Information on the aquifer classification has been obtained from the GSI online mapping (www.gsi.ie). The Tramore Landfill Site and the surrounding area is underlain by a Poor Aquifer (Pl) which is generally unproductive except in local zones.
The bedrock has no primary permeability and the groundwater flow is controlled by secondary permeability as a result of the development of fractures. The site is located within the Dunmore East Groundwater Body.
Information on the regional hydrogeological properties has been obtained from the GSI groundwater body description. Estimated transmissivities are reported to be in the range of 1 – 10m^2/d in the Dunmore East Groundwater Body. Short groundwater flow paths are typical with most of the groundwater flow is expected to be taking place in the upper zone of the bedrock profile (top 25m). Groundwater discharges locally to streams and rivers crossing the aquifer. At the landfill site but the main groundwater discharge is to the tidal waters. There are no springs indicated in the area on the historic maps. The regional groundwater flow direction is expected to be in a southerly direction based on the surface water drainage and topography.
While the available site investigation information indicates the presence of significant thickness of overburden deposits beneath the landfill site and in the surrounding area there are no regionally or locally important sand and gravel aquifers classified by the GSI in the area.
The GSI vulnerability map for the area indicates a moderate vulnerability classification for the landfill site.
The area is served by the public mains water supply. Information on the location of potential private wells in the area has been obtained from the GSI well database. There are no private wells located down gradient of the site. The area down gradient is undeveloped and would be subject to saline intrusion due to the proximity to the coast. There are no Source Protection Zones indicated on the GSI website in the area.
Information on the EPA website indicates the Water Framework Directive (WFD) status 2007 – 2012 for the Dunmore East Groundwater Body is “Good Status”. The WFD Risk Score for the Dunmore East Groundwater Body Risk Score is category 2a “expected to achieve good status”.

surface water features

The landfill site is located in the catchment of the Brickey-Colligan-Dalligan-Mahon-Tay-Coastal (River Catchment Code IE17-01). The regional surface water drainage is in a southerly direction towards the coast.
The Tramore Backstrand is located adjacent to the landfill site. There are several streams flowing in a north to south direction that discharge to Tramore Backstrand to north of the site (including the Monloum _010). These streams discharge to the Backstrand at distances of between 1km and 3km from the site.
There is a surface water drain located along the north western boundary of the site (Drawing DG0103, Appendix A). This drain receives surface water runoff from the land to the north west of the site in addition to surface water runoff from the landfill site itself. This surface water drain flows in a north westerly direction along the western side of the landfill around the northern most point prior to discharging to the tidal area of the Backstrand. This surface water drain then discharges to a south easterly flowing stream which flows along the northern and eastern boundary of the adjacent caravan park. The combined flow then discharges to the Backstrand close to the northern most point of the landfill site having passed through the area of constructed wetlands prior to discharging to the Back Strand.
Details of the surface water management system at the site are illustrated on DG0103 (Appendix A) including the perimeters drains and outfalls.
The Coastal Waterbody Status 2010 – 2012 for Tramore Backstrand is “High” while Tramore Bay is “Good”.
There is a Designated Bathing Water Area at Tramore Beach located down gradient of the site. The beach is designated as a Blue Flag Beach. The Bathing Water Status for 2014 and 2015 is classed as excellent. The EPA classification for 2013 was good, sufficient in 2012 and 2011 and classed as good in 2010.

site geology

The site investigation information from the landfill site and surrounding area has been examined. The original borehole logs for the monitoring boreholes within the landfill site are not available but summary details on the strata encountered and information on the monitoring intervals was provided by Waterford City and County Council and is presented in Table B.1 of Appendix B.
A cross section through the waste body is presented on Figure 3.1 to illustrate the conceptual site model. The section line has been selected through the site to transect the waste body and intercept the available site investigation boreholes. The location of the section line is shown in Drawing DG0112 Designated Monitoring Points (Appendix A). The available site investigation data has been used in the development of the conceptual site model (CSM).
The site investigation data from within the facility boundary confirms the waste material ranged in thickness from 0.40m (BH9) to 8.0m (BH7B). In the centre of the site the confirmed thickness of made ground is approximately 8m at LT1, LT5 and BH7B. The made ground / waste is underlain by brown or grey soft to firm silty sandy gravely CLAY with cobbles and boulders overlying hard brown silty laminated CLAY. There are also pockets of silty sand with shells and minor intervals of gravel.
In general the overburden at the landfill site appears to be composed of sandy gravely CLAY with cobbles and boulders to a depth of 3.6m to 8.30m bgl. This is underlain by grey sandy SILT to a depth of 15m to 20mbgl. In some areas the grey sandy SILT is located beneath the waste body (i.e. at GW06 and GW07).
Bedrock does not outcrop in the vicinity of the landfill site due to the thickness of the overburden deposits present. The site investigation within the landfill site encountered siltstone bedrock at -6m above ordnance datum (mOD) at RC4 and-17.20mOD at RC5. The boreholes encountered siltstone bedrock which correlates with the mapped bedrock geology map.
To the west of the site in the Tramore town area outcrops of shale rock and volcanic rocks have been identified by the GSI but this is outside of the area of interest.
A site investigation report (E.G. Pettit & Co., 2006) was available for the area of land immediately south of the landfill (30 acres) to determine the nature, extent and characteristics of any waste material at the site. The investigation included: excavation of 28 no. trial pits; analysis of 20 no. soil samples; gas monitoring; installation of 5 no. gas monitoring wells; groundwater analysis and determination of groundwater flow direction. The trial pits indicated soft to firm slightly sandy SILT / CLAY with occasional shell fragments with strong seepages of groundwater encountered at 2.4mbgl to 2.7mbgl.
This data has been used in the development of the Conceptual Site Model also. These investigations confirmed a layer of fill material ranging in depth from 0.4mbgl to > 3.3mbgl. Below the fill material natural deposits of beach sand and silts were investigated to a maximum depth of 3.4mbgl during the excavation of the trial pits. Boreholes were also installed and confirmed an interval of silty clay to depths of between 8.5m and 17.5m underlying the beach sands. The site investigation indicated that the natural ground beneath the waste included: dark brown sandy silt, grey / black alluvial silt and grey sandy silt. Bedrock was not encountered during this site investigation. The site investigation in the Tramore Leisure Parks Ltd Site did not encounter bedrock indicating that bedrock occurs at depths greater than 17.5mbgl (-14.50mOD) in the area immediately south of the landfill.

site hydrogeology

Information on the site specific hydrogeology has been obtained from a review of the available site investigation information. A summary of the results of the site investigation boreholes is provided in Table B.1, Appendix B.

Groundwater Flow Zones

The main water bearing horizons are (1) the groundwater in the overburden deposits composed of sandy gravely clay with cobbles and boulders with strong seepages encountered between 0.50m to 1.0mOD (2) the groundwater in the bedrock aquifer (top 25m). The static water levels measured in RC4 and RC5 indicate confined conditions for the groundwater in the bedrock aquifer due to the presence of the overlying overburden deposits.
There are no sand and gravel aquifers delineated by the GSI in the area. The aquifer of interest is the bedrock aquifer. Based on the site specific data the aquifer vulnerability for the bedrock aquifer would be classed as moderate.
The site is located within the Dunmore East Groundwater Body which is classed as having Good Status under the Water Framework Directive and the groundwater body risk score is classed as 2a expected to achieve good status.
A number of the groundwater monitoring wells are affected by tidal influence as shown on DG0119 Extent of Saline Intrusion (Appendix A).

Groundwater Flow Direction

Weekly monitoring of leachate levels and monthly monitoring of groundwater levels is undertaken at the landfill site by Waterford City and County Council. Surveying of the top of the monitoring boreholes was undertaken by Waterford City and County Council on the 3/11/15 to confirm the elevations of the top of casing. A round of

water level monitoring was undertaken at all of the boreholes on the same date. The data is presented in Table 2.2. The water level monitoring data for 2014 has been converted to meters above ordnance datum (mOD) and is presented for the different monitoring regimes to demonstrate the seasonal variation in levels.

Table 0.2: Groundwater & Leachate Levels November 2015

Monitoring Locations	Monitoring Zone	Elevation Top of Casing (mOD)	Groundwater Level Measured from Top of Casing 03/11/15	Groundwater Level (mOD) 03/11/15
RC4	Groundwater Bedrock	5.70	3.60	2.10 mOD
RC5	Groundwater Bedrock	2.80	2.30	0.50 mOD
GW01	Groundwater Overburden	2.72	0.60	2.12 mOD
GW02	Groundwater Overburden	2.69	0.70	1.99 mOD
GW03	Groundwater Overburden	2.74	1.10	1.64 mOD
GW04	Groundwater Overburden	2.26	1.20	1.06 mOD
GW05A	Groundwater Overburden	2.14	1.00	1.14 mOD
BH8	Groundwater Overburden	2.28	1.00	1.28 mOD
BH9	Groundwater Overburden	2.47	1.30	1.17 mOD
BH5	Groundwater Overburden & Possible Leachate	No level		
GW6	Groundwater Overburden & Possible Leachate	3.37	2.20	1.17 mOD
GW7	Groundwater Overburden & Possible Leachate	3.99	1.00	2.99 mOD
GW8	Groundwater Overburden & Leachate	3.52	1.20	2.32 mOD
BH1/1	Leachate	3.51	1.20	2.31 mOD
BH2	Leachate	4.97	3.10	1.87 mOD
BH7B	Leachate	8.47	7.10	1.37 mOD
RC6A	Leachate	3.45	0.60	2.85 mOD
LT1	Leachate	7.96	5.20	2.76 mOD
LT2	Leachate	8.40	6.00	2.40 mOD
LT3A	Leachate	9.37	5.30	4.07 mOD
LT4B	Leachate	10.14	Dry	
LT5	Leachate	9.02	Dry	

The monitoring of groundwater levels in the bedrock aquifer is currently only being undertaken at two locations, RC4 and RC5 (Drawing DG0112 Designated Monitoring Points, Appendix A). A third monitoring borehole is required to confirm the groundwater flow direction and hydraulic gradient in the bedrock aquifer. None of the boreholes drilled in the Tramore Leisure Parks Ltd. site encountered bedrock therefore there is no groundwater level monitoring data from the bedrock aquifer from the adjacent site. The limited data suggests a southerly

component to groundwater flow in the bedrock aquifer corresponding with the expected regional groundwater flow direction. The monitoring of groundwater levels in the bedrock aquifer indicates a seasonal variation in RC4 of the order of 0.4m with no variation seen in RC5

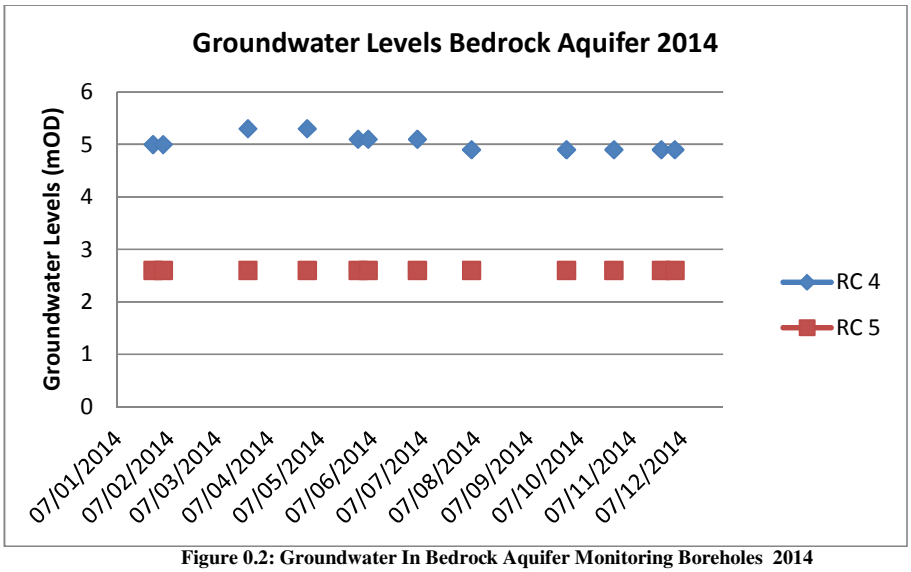


Figure 0.2: Groundwater In Bedrock Aquifer Monitoring Boreholes 2014

The monitoring of groundwater levels in the overburden deposits is carried out at boreholes GW01, GW02, GW03, GW05A, BH9 and BH8. There was no data in 2014 for monitoring location GW04. The levels for the shallow groundwater measured in the overburden deposits on the 03/11/2015 are illustrated on DG0112 Designated Monitoring Points (Appendix A). The shallow groundwater in the overburden deposits is influenced by the tidal water in Tramore Backstrand and in the area south of Tramore Beach.
The monitoring indicates a south easterly groundwater flow direction along the southern portion of the landfill. Within the northern portion of the landfill site the groundwater levels indicate the groundwater flow direction is towards the tidal area to the north of the waste body.
Previous investigations have indicated that the site is subject to saline intrusion only on the edges of the waste body (Investigation In to Possible Occurrence of Salinity Intrusion At Tramore Landfill, RPS February 2006). Both RC4 and BH2 are affected by tidal variation confirming that the area south of GW07, BH2 and RC4 is affected by saline intrusion. The site investigations in the adjacent Tramore Leisure Parks Ltd. Site also indicated a south easterly groundwater flow direction in the overburden deposits. All of the boreholes indicate very little variation in measured water levels in the groundwater in the overburden deposits. A seasonal variation of 0.10m to 0.20m is demonstrated Figure 2.3.

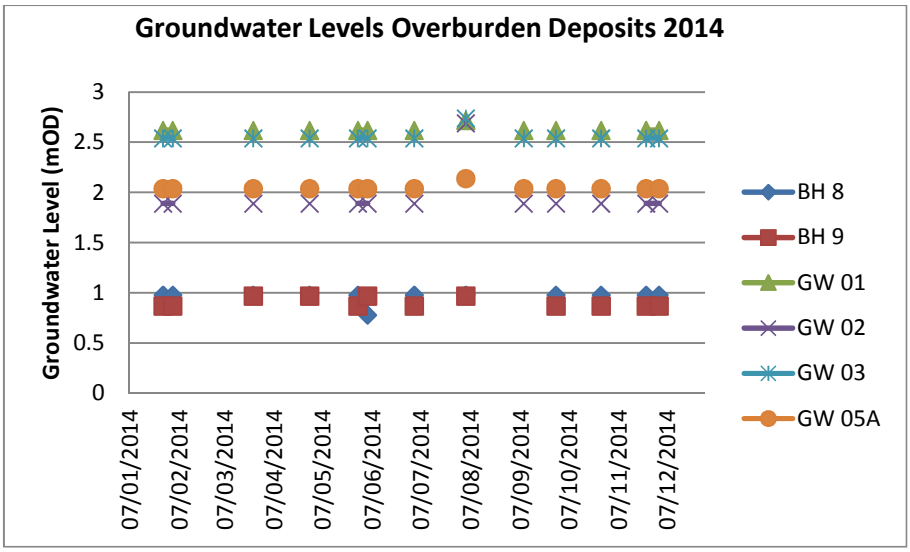


Figure 0.3: Groundwater Levels Shallow Groundwater Monitoring Boreholes 2014

Leachate Management

The weekly monitoring of leachate levels for 2014 is presented in Figure 2.4. The leachate levels have been converted to mOD based on the top of casing levels provided by Waterford City and County Council (surveyed 03/11/2015).

The results indicate very little seasonal variation in the leachate levels at the site. The highest leachate levels are seen along the northern boundary of the site at LT2 and LT3A. In the centre of the site the boreholes are LT5 and LT4B were dry in 2014. Data from the previous Annual Environmental Reports for the landfill site indicates LT4 has been dry for most of period 2008 to 2014. While LT5 has been dry for most of 2009 – 2014. The 2014 leachate level monitoring data indicates a seasonal variation of the order of 0.10m at LT2 and LT1 while LT3a has a variation of 0.20m. Leachate monitoring boreholes RC6a, BH2 and BH1/1, which are also are located at the southern end of the waste body, also indicate the same level of seasonal variation (0.10m to 0.20m) as shown on Figure 2.4.

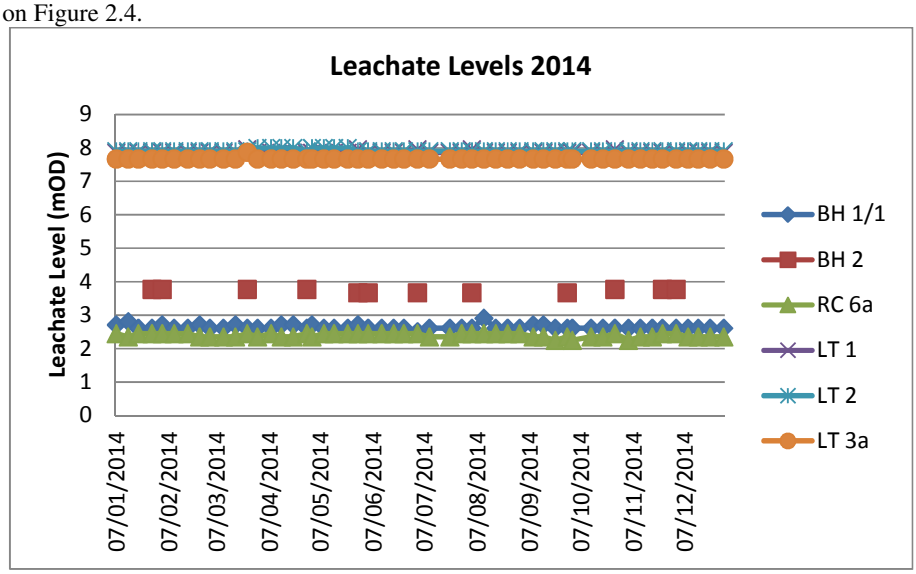


Figure 0.4: Leachate Monitoring Boreholes 2014 (levels mOD)

The monitoring data indicates leachate elevations are higher than groundwater elevations in the north west (LT1 & LT2) and east of site (LT3A) indicating the potential for migration of leachate to the shallow groundwater. The leachate monitoring boreholes in the centre of the site (LT5 and LT4B/B) are dry / cross check against 2014 AER / indicating little potential for discharge of leachate to the shallow groundwater in this area.

The Investigation In To The Possible Occurrence of Salinity Intrusion At Tramore Landfill (RPS, February 2006) identified the extent of the area affected by saline intrusion (Appendix A, DG0119 Extent of Saline Intrusion). The investigation assessed the relationship between the levels in the leachate boreholes recorded by data logger every half hour between July and September 2005 and the tidal variation in the backstrand. The report concluded that there was no apparent correlation between the leachate levels in the boreholes located in the centre of the site and in the north of the landfill. A clear correlation was noted in the wells located at the edge of the landfill adjacent to the seashore. The report concluded that the saline intrusion was possible along the margins of the landfill. This results in the potential for flushing of leachate from the waste body at the edge of the site due to tidal variation at the site.

The leachate management system has been designed to take saline intrusion into account to avoid the pumping of saline water into the leachate abstraction system. The leachate extraction wells were installed in 2006. Pumping trials were undertaken in 2009 to determine the most suitable pumping regime. The 2014 AER indicates that there was an extremely low volume of leachate produced and the leachate storage tank was not filled therefore no leachate was removed from site.

Prior to the installation of the final capping layer (2008 – 2009) rainfall would have been percolating through the waste body and discharging to the groundwater beneath the site and ultimately discharging to the sea. The installation of the engineered cap has significantly reduced the quantity of rainfall percolating through the waste body and consequently reduced the volume of leachate being generated as seen in the reduction of leachate levels at LT4 and LT5 since the capping was installed.

Hydraulic Parameters

There is no site specific information available on the hydraulic parameters from the previous site investigations undertaken at the site as it has not been possible to locate the original borehole logs from the site.

Geological Units of Interest

The main geologic units of interest with respect to groundwater flow and contaminant transport at the site are considered to be (i) upper overburden layer with main groundwater interval 0.5m to 1.0mOD (ii) the top 25m of bedrock.

The landfill site is unlined and leachate from the waste body is discharging to the shallow groundwater in the overburden deposits and potentially deep groundwater in the bedrock aquifer beneath the site. Both the shallow groundwater and deep groundwater are discharging to the sea in the vicinity of the site. The proximity of the landfill to the open sea and the Tramore Backstrand results in the margins of the landfill site being subject to saline intrusion.

The shale and siltstone bedrock beneath the site is classed as a poor aquifer. The main groundwater movement in the bedrock is expected to be concentrated at the top of rock with groundwater flow concentrated in the top 25m. There are no significant structural features indicated on the regional bedrock geology map which are likely to indicated zones for preferential groundwater movement on a regional basis. There are no springs or hydrogeological features of interest shown on the historic maps for the area which could represent additional preferential flow zones.

The available site investigation information indicates 15m to 20m of overburden present. Based on the guidelines published by the Department of Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland in the 1999 publication Groundwater Protection Schemes the site specific vulnerability for the bedrock aquifer is classed as moderate which agrees with the GSI map.

CONCEPTUAL SITE MODEL

A cross section has been prepared to graphically illustrate the conceptual site model for the Tramore Landfill Site and is presented as Figure 3.1. The section line was selected to intersect the waste mound and the available borehole locations in an approximate north west to south east direction.

Potential Source Areas

2.3.1 Landfill Source Area

The landfill site at Tramore operated from 1939 to 2005. A Waste Licence was granted for the site on 25th September 2001. The landfill ceased accepting waste for disposal in 2005. The intake of waste prior to 1995 is unknown as there was no weighbridge at the site. Since 1995 the volume of waste landfilled was approximately 450,000tonnes / 930,000 m3. The total volume of waste landfilled is estimated to be 1,050,000m^3. Can WCC provide any details on the total estimated volume of waste .

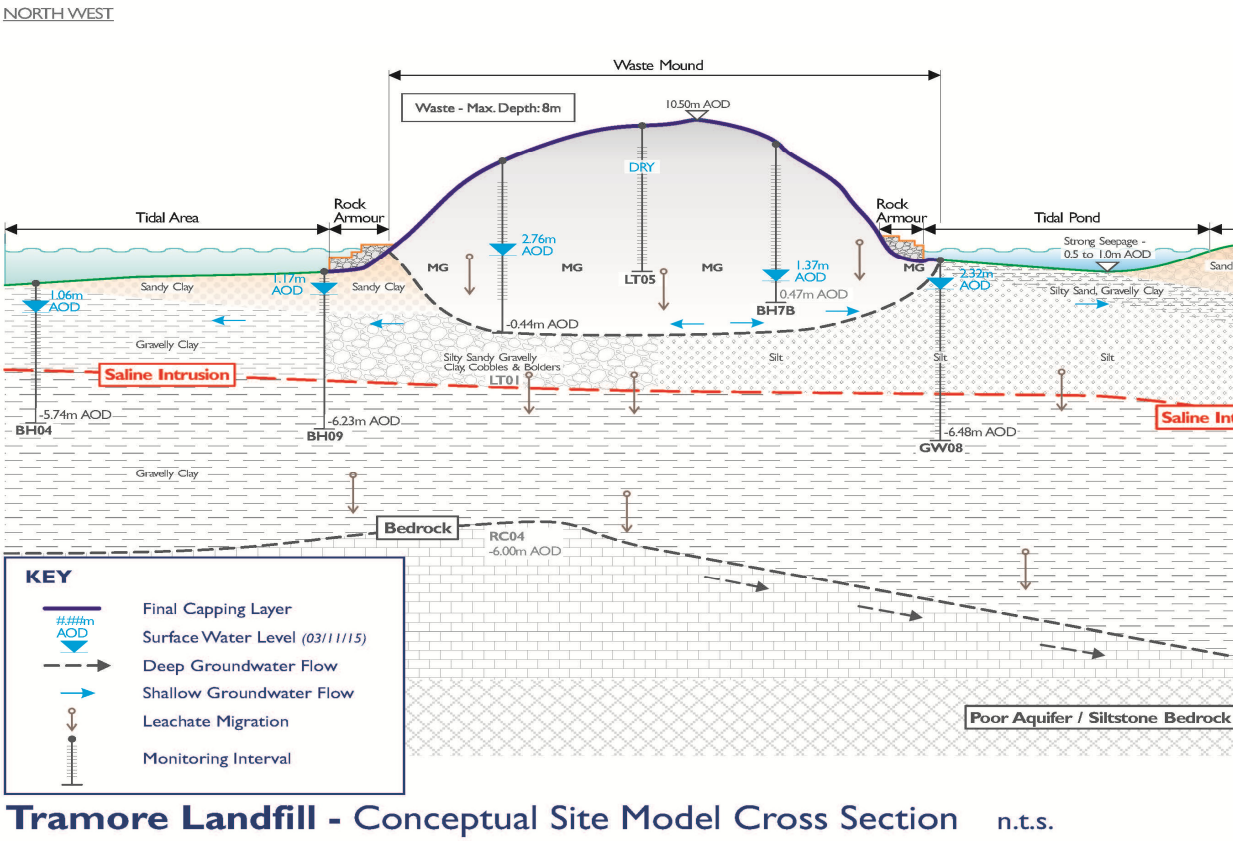
The landfill site is unlined and covers an area of approximately 12 hectares. The extent of the waste body for the licensed site is shown on Drawing DG0101 Site Location & Site Layout Plan (Appendix A). The facility accepted household, non hazardous, commercial, industrial and construction and demolition waste. The site is located on a formerly reclaimed estuarine site on the inner reaches of Tramore Backstrand. The site is located in a high amenity area approximately 100m north of Tramore Beach and bounded on the landward side by a caravan park and the seaward site by the Tramore Backstrand.

The source for potential groundwater contamination at the site is the leachate being generated from the degradation of the landfilled material and the percolation of rainfall through the waste mound which results in the generation of leachate.

Since the waste licence was granted for the site in 2001 a number of specified engineering works have taken place at the site to reduce the potential for leachate generation including the installation of the surface water management system, leachate abstraction and collection system and final engineered capping layer in accordance with the licence conditions for the site.

Site Investigations on the adjacent site (Tramore Leisure Parks Ltd. Site) indicate the presence of domestic refuse in the area immediately south of the landfill site.

Figure 0.1: Tramore Landfill Conceptual Site Model



2.3.2 Leachate Composition

The leachate monitoring data for the period 2014 has been reviewed to determine what the contaminants of potential concern (COPC) at the site are. Monitoring of leachate composition typically takes place at BH1/1, BH7, RC6a, LT1, LT2, LT3, LT4 and LT5. The monitoring includes weekly monitoring of the leachate levels. Quarterly and annual chemical analysis of the leachate is undertaken. During 2014 the data for the site was limited to leachate monitoring location BH1/1 as LT2, LT3a, LT4B/B, LT5 and LT1 were dry on the sampling dates. This is due to the reduction in leachate levels since the capping was installed.
The data for BH1/1 is presented in Appendix E where the leachate composition has been compared to the Environmental Objectives Groundwater Regulations (SI No. 9 of 2010) threshold values and the typical leachate compositions (Landfill Site Design Manual, Table 7.2, EPA 2000). The data indicates the leachate composition is at the lower end of the range reported for methanogenic leachate (Landfill Site Design Manual, EPA 2000). The elevated parameters include electrical conductivity, chloride, potassium, sodium, ammonia, iron, magnesium, manganese and coliforms. No List I / II substances were detected at concentrations above the detection limit. 1,2,4-Trimethylbenzene was detected at the detection limit of 0.5 ug/l and Ethylbenzene was also detected at the detection limit of 0.5 ug/l. No hazardous substances were detected in 2014 at concentrations above the screening values.

2.3.3 Leachate Volume

Information on the annual volumes of leachate removed from the site for 2008 to 2014 are presented in Table 3.1. As part of the original Waste Licence Application it had been estimated that 14,087m^3 per annum of leachate was being produced. The Leachate behaviour Assessment Report, RPS 201) indicated that the predicted leachate generation in the area not subject to tidal influence is estimated at 87.85m^3/month (1,054m^3/annum).

The 2009 AER states that the leachate levels which were generally low prior to the installation of the capping were reduced further by the capping works. An assessment was carried out in March 2010 due to concerns that very little leachate was being pumped. It was concluded that the leachate extraction system was correctly set up and functioning but that the installation of the capping has reduced the leachate generation to a minimum and due to the low leachate levels (dry boreholes) the pumped system is not required to operate very often.

Table 0.1: Leachate Removal Volumes

Year	Leachate Volume Removed (m^3)
2008	None removed
2009	6.75m^3
2010	None removed
2011	24.5m^3
2012	139.3m^3
2013	106.3m^3
2014	None removed

pathways

The Tramore Landfill site is an unlined site. The deposition of waste took place on top of the original ground surface in an area of reclaimed estuarine land. The waste body is separated from the underlying bedrock aquifer by 12m to 20m of overburden deposits.
The main pathway for the discharge of leachate from the site is expected to be to be via the shallow groundwater in the overburden deposits and the deeper groundwater in the bedrock aquifer to the tidal waters adjacent to the landfill site. The site investigation data indicate that the main pathways for the preferential migration of leachate off site as shown on Figure 3.1 are:

- Leachate vertically migrating to the shallow groundwater in the sandy and gravely clay layer within the overburden deposits (some of the monitoring standpipe are screened over both the waste body and overburden deposits);
- Leachate in the shallow groundwater vertically migrating to the deeper groundwater in the upper bedrock interval (top 25m) ;
- Shallow groundwater in the overburden deposits horizontally migrating to the surface water / coastal waters.
- Deeper groundwater in the bedrock aquifer horizontally migrating to the coastal waters.

The available site investigation data and groundwater monitoring programme indicate confined groundwater conditions for the bedrock aquifer due to the thickness of the overburden deposits. The vulnerability of the groundwater in the bedrock aquifer beneath the landfill, as per the GSI vulnerability classification scheme, is moderate.

receptors

The following receptors have been assessed:

- Drinking Water Supplies;
- Recreational Waters (Bathing Water & Blue Flag beach);
- Designated sites (cSAC & SPA).

Drinking Water Supplies

The landfill site is located within the Dunmore East Groundwater Body which is classed as a Poor Aquifer. In addition to the current groundwater usage in the area the future resource potential needs to be considered as the groundwater body is classed under the WFD Register of Protected Areas as Groundwater for Drinking Water. The study area is served by a public mains water supply and no private well users have been identified down gradient of the site. There are no properties located down gradient of the site and no private wells have been identified down gradient of the landfill. The closest residential properties to the site are located to the west and north west of the site. Based on the groundwater flow direction these properties are located up gradient of the landfill.

Due to the proximity of sea and the likelihood of saline intrusion in the areas down gradient of the landfill it is not considered likely that private wells will be developed.

Recreational Waters

There are three recreational waters located down gradient of the site; (a) Bathing Water Area at Tramore beach; (b) Surface Water in Bathing Location at Tramore Bay and (c) Groundwater in Bathing Location. Based on the groundwater flow direction there is potential for the discharge of both shallow groundwater from the site to these three recreational waters.

Designated Sites

The landfill site is located adjacent to an area of wetlands the Tramore Backstrand which is designated for ecological conservation interest due to the presence of saltmarsh and a large saltwater lagoon. The Tramore Dunes and Backstrand is a candidate Special Area of Conservation (cSAC) under the EU habitats directive. The Tramore Backstrand is also a designated Special Protection Area (SPA) under the EU Birds Directive. The Tramore Dunes and Backstrand is also designated as a proposed Natural Heritage Area (pNHA). There is potential for the discharge of groundwater and surface water from the landfill to these designated sites.

spr linkages - Risk Screening

The risk screening process is based on the Source – Pathway – Receptor model. This requires the assessment of whether the source (waste body) and receptors are linked by one or more pathways as summarised in **Table 3.2.** The assessment of risk as low, medium or high has been carried out by examining the link between each risk factor and a review of the site specific water quality monitoring data.

Table 0.2: Risk Assessment

Source	Pathway	Receptor	Risk
Waste body composed of domestic, commercial and construction and demolition waste. The site is unlined but the waste body is capped. The main contaminants of concern are ammonia, iron and manganese.	Leachate vertically migrating to shallow groundwater	**Drinking Water Supplies** No potential groundwater users have been identified for the shallow groundwater down gradient of site.	The site is unlined and waste is directly located on overburden deposits. Evidence from groundwater quality monitoring in the overburden indicates that leachate is discharging to shallow groundwater. No potential shallow groundwater users have been identified due to coastal location and likelihood for saline intrusion. **No risk identified**.
	Leachate vertically migrating to deeper groundwater in bedrock aquifer (top 25m)	**Drinking Water Supplies** No potential groundwater users have been identified for the deeper groundwater down gradient of site.	The site is unlined and the waste is separated from the deeper groundwater by the 12m to 20m of overburden deposits. The groundwater quality monitoring from RC4 and RC5 for 2012 indicates elevated concentrations of the identified contaminants of potential concern in the leachate. It is recommended that monitoring of groundwater composition at RC4 and RC5 be continued as these are the only two down gradient monitoring locations in the bedrock aquifer. **No risk identified**
	Leachate vertically migrating to shallow groundwater	**Recreational Waters** There is potential for shallow groundwater from beneath the site to discharge to the Tramore Beach Bathing Water which is located down gradient of the landfill site.	The volume of leachate being produced is low in terms of the dilution available within Tramore Bay. Since the installation of the final capping there has been a significant reduction in the leachate levels at the site. The surface water quality data indicates no issue with elevated concentrations of contaminants of potential concern. The most recent Bathing Water Status for 2015 is classed as excellent. **The risk is**

Source	Pathway	Receptor	Risk
			classed as Low Risk.
	Leachate vertically migrating to deeper groundwater in bedrock aquifer (top 25m)	**Recreational Waters** There is potential for the deeper groundwater from beneath the site to discharge to the Tramore Beach Bathing Water which is located down gradient of the landfill site.	The volume of leachate being produced is low in terms of the dilution available within Tramore Bay. Since the installation of the final capping there has been a significant reduction in the leachate levels at the site. The surface water quality data indicates no issue with elevated concentrations of contaminants of potential concern. The most recent Bathing Water Status for 2015 is classed as excellent. **The risk is classed as Low Risk.**
	Leachate vertically migrating to shallow groundwater	**Designated Sites** There is potential for the shallow groundwater from beneath the site to discharge to the Tramore Backstrand which is located down gradient of the landfill site. There is potential for landfill to impact on surface water quality due to elevated concentrations (i.e. elevated ammonia) and on the aquatic habitats.	The monitoring data indicates no issues with surface water quality. The ecological monitoring at the site which included both sediment sampling and shellfish analysis indicated contaminants were within typical levels in south east Ireland. Due to the tidal nature of the water within the Tramore Backstrand there is significant dilution available. **The risk is classed as Low Risk.**
	Leachate vertically migrating to deeper groundwater in bedrock aquifer (top 25m).	**Designated Sites** There is potential for the deeper groundwater from beneath the site to discharge to the Tramore Backstrand which is located down gradient of the landfill site. There is potential for landfill to impact on surface water quality due to elevated concentrations (i.e. elevated ammonia) and on the aquatic habitats.	The monitoring data indicates no issues with surface water quality. The ecological monitoring at the site which included both sediment sampling and shellfish analysis indicated contaminants were within typical levels in south east Ireland. Due to the tidal nature of the water within the Tramore Backstrand there is significant dilution available. **The risk is classed as Low Risk.**

appropriate tier of assessment

The Source Pathway Receptor methodology has been followed. The EPA "Hydrogeological Review / Technical Assessment Report Template" outlines that a tiered approach is recommended in assessing potential impacts on groundwater and other potential receptors.

conclusion

The monitoring data indicates the contaminants of concern in the leachate include: electrical conductivity; chloride; potassium; sodium; ammonia; iron; magnesium; manganese and coliforms. With the exception of ammonia, iron and manganese all of the parameters are naturally elevated in the coastal waters down gradient of the landfill site.
Prior to the completion of this report a Generic Quantitative Risk Assessment (GQRA) had not been prepared for this site. Generally all landfills are required undertake a Tier 3 assessment, which is considered to be analogous to a DQRA unless there is clear evidence that the risk to groundwater is low.
The risk screening indicates that the site represents a low risk to the identified receptors , based on the available monitoring data, the low levels of leachate being generated at the site and the presence of saline waters down gradient of the site.
The results of the risk screening indicate low risk to the all of the identified receptors at the site. A detailed quantitative risk assessment has not been undertaken at the site. Based on the identified low risks at the site and the results of the groundwater and surface water monitoring the undertaking of a Detailed Quantitative Risk Assessment (DQRA) is not considered necessary. The existing monitoring programme (existing surface water and groundwater) is considered to be adequate to monitor changing groundwater composition.

It is recommended that the current environmental monitoring programme be continued as it includes monitoring of the down gradient bedrock monitoring locations (RC4 & RC5) and monitoring of the shallow groundwater at monitoring locations BH8, BH9, GW01, GW02, GW03, GW04 and GW05A.

ASSESSMENT OF GROUNDWATER IMPACTS & compliance with groundwater regulations

The EPA guidance document outlines the technical assessments that are required to permit discharges to groundwater in accordance with the European Communities Environmental Objectives (Groundwater) Regulations, 2010 (SI No. 9 of 2010) (Groundwater Regulations).
The objectives of the groundwater regulations are to:-

1. Prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater.
2. Protect, enhance and restore all bodies of groundwater to achieve good groundwater quantitative status and good groundwater chemical status by 22nd December, 2015.
3. Reverse any significant sustained upward trend in concentration of any pollutant to reduce pollution of groundwater.
4. Achieve compliance with any standards and objectives established for groundwater dependent protected area.

The technical assessment has included a review of the following data:-

- All previous relevant reports for the Tramore Landfill including Annual Environmental Reports (2008 – 2014).
- All relevant historical groundwater levels and quality data and relevant surface water data.
- Relevant site investigation data.

4.1 EXTENT of Plume and Trends

The results of the groundwater monitoring for 2014 and Quarter 1 2015 have been compared to the limits specified in the following regulations and guidance in order to identify the contaminants of potential concern:

- European Communities Environmental Objectives (Groundwater) Regulations, 2010 (SI No. 9 of 2010);
- Towards Setting Guideline Values For the Protection of Groundwater In Ireland (EPA / GSI, 2003);
- Drinking Water Regulations (SI No. 122 of 2014).

The monitoring of the composition of the shallow groundwater in the overburden deposits is carried out at GW1, GW2, GW3, GW4, GW6, BH8 and BH9. While the monitoring of the deeper groundwater in the bedrock aquifer down gradient of the site is undertaken at RC4 and RC5. Monitoring locations RC4 and RC5 were not monitored during 2014. RC4 was monitored in 2013. The last year in which both RC4 and RC5 were monitored was in 2012 and this data has been used in the assessment of the Tramore Landfill.
The site investigation borehole logs indicate the potential for leachate bearing zones being penetrated by a number of the shallow groundwater monitoring boreholes including BH2, GW6, GW7 and GW8. The locations of the groundwater monitoring boreholes are illustrated on the Drawing DG0112 Designated Monitoring Points (Appendix A).
The screening values which have been used for the identification of the contaminants of potential concern are summarised in Table 4.1 below. The IGV values have been taken as the screening levels (GAC). Where an IGV has not been specified the Drinking Water Limit has been taken as the screening value (GAC).

Table 0.1: Screening Values Used To Identify Contaminants of Potential Concern

Parameter	EPA / GSI IGV Limits	Drinking Water Regulations S.I. No. 122 of 2014	S.I. 9 2010 GW Regs Limits Column 2 Adverse Impact on SW Bodies	S.I. 9 2010 GW Regs Limits Column 3 Drinking Water Protected Area	S.I. 9 2010 GW Regs Limits Column 4 Ability to Support Human Uses
Ammonia (mg/l)	0.15	0.30	0.065	0.175	0.175
Chloride (mg/l)	30	250		187.5	
Electrical Conductivity (us/cm)	1,000	2,500		1,875	
Iron (ug/l)	200	200			
Manganese (ug/l)	50	50			
Dissolved Oxygen	No Abnormal Change				
Sodium (mg/l)	150	200		150	
Potassium (mg/l)	5				
Total Organic Carbon (mg/l)	No Abnormal Change	No Abnormal Change			
Total Oxidised Nitrogen (mg/l)	No Abnormal Change				
Boron (ug/l)	1,000	1,000		750	750
Calcium (mg/l)	200	200			
Arsenic (ug/l)	10	10			7.5
Iron (ug/l)	200	200			
Lead (ug/l)	100	100			18.75
Magnesium (mg/l)	50	50			
Manganese (ug/l)	50	50			
Nickel (ug/l)	20	20			15
Potassium (mg/l)	5	12			
Selenium (ug/l)		10			
Phenols (ug/l)	0.5				
T Coli (Cfu/100ml)	0	0			
E Coli (CFu/100ml)	0	0			

The results of the groundwater monitoring for 2014 and Quarter 1 2015 are presented in Appendix D. The assessment of the groundwater monitoring results to the screening values is presented in Table 4.2 below. Based on the available monitoring results there is evidence that the shallow and deep groundwater at the site is contaminated.

Table 0.2: Summary of Quarterly Groundwater Monitoring 2014 - Quarter 1 2015

BH Code	Interpretation of Monitoring Results 2014 & Q1 2015	Monitoring Interval
BH2	Ammonia range 49 to 95 mg/l > 100 GAC and threshold values. Iron and manganese elevated. Iron 2,500 ug/l to 4,300 ug/l above IGV of 200 ug/l. Manganese 1,100 ug/l above IGV of 50 ug/l. Total Coliforms 310 – 5,700 cfu / 100ml. F. Coliforms < 10 to 2500 cfu/100ml. This area is subject to saline intrusion. Boron	Located in south eastern edge of waste mound down gradient of waste body. Total depth 4.20m log indicates monitoring overburden. Groundwater monitoring zone not reported in site investigation summary details. The borehole went through 1.70m of made ground including domestic refuse and may be sampling leachate as well as shallow groundwater.

BH Code	Interpretation of Monitoring Results 2014 & Q1 2015	Monitoring Interval
	1,300 ug/l above IGV of 1,000 ug/l but likely to be affected by saline influence. Boron present in seawater at concentrations up to 5,000 ug/l. Elevated boron, magnesium, potassium, sodium, sulphate and chloride are related to saline influence. List I / II substances not detected.	
GW1	While the ammonia concentration is above IGV it is < 100 times GAC. Higher ammonia in Q1 2015 4.5 mg/l. In 2014 ranged from 0.16 to 0.69 mg/l. The 2013 results indicate ammonia ranging from 0.41mg/l to 2.2 mg/l. Iron and manganese elevated. Iron in 2014 150 to 9,300 mg/l a lot of variation during reporting period but above 200 ug/l IGV. Manganese 560 to 590 ug/l above IGV of 50 ug/l. Elevated boron, magnesium, potassium, sodium, sulphate and chloride are related to saline influence. Expect saline conditions based on proximity to sea and previous saline intrusion study. List I / II substances not detected.	This borehole is monitoring the shallow groundwater down gradient of the landfill site and is located within area affected by saline intrusion. This borehole is located south of landfill site and located south east of Tramore Leisure Parks Ltd Site. Monitoring interval 9.0m to 10.0m in sand interval with pockets of silty clay. No waste reported.
GW2	Ammonia concentration 0.27 mg/l in Q4 2014 and 1.5 mg/l in Q1 2015 which is lower than GW1 which is adjacent and monitoring similar interval. Very limited results available for 2014. F Coli < 10 cfu/100ml to 280 cfu/100 ml. Iron elevated Q4 2014 8,810 ug/l and 37 ug/l in Q1 2015. List I / II substances not analysed in 2014.	Down gradient borehole shallow groundwater in overburden deposits. Located south of landfill and south east of Tramore Leisure Parks Ltd Site. Monitoring interval 9.0m to 10.0m in sand. No waste reported.
GW3	Ammonia 0.26 to 0.35 mg/l is only slightly above IGV and generally less than drinking water limit of 0.3 mg/l. The iron (1,600 to 7,300 ug/l), magnesium and manganese (180 – 290 ug/l) are higher than IGV but < 100 times GAC. Expect saline conditions. F Coli < 10 to 52 cfu/100ml. List I / II substances not detected except for 0.6 ug/l toluene which is < IGV of 10 ug/l.	Down gradient shallow groundwater monitoring borehole. Located south of landfill and south east of Tramore Leisure Parks Ltd Site. Monitoring interval reported as 2.0m to 10.0m in silty sandy gravely clay and sand with occasional pockets of silty clay.
GW4	Low ammonia < 0.02 to 0.048 ug/l less than IGV. Iron and manganese are still elevated. The chloride (121 to 132 mg/l) is elevated but this area is outside of saline intrusion area. The iron and manganese are elevated up gradient of the site. Iron 1200 – 1700 ug/l compared to 200 ug/l IGV. Manganese 430	Up gradient monitoring borehole in shallow groundwater. This borehole is most representative of up gradient shallow groundwater composition and indicates ammonia is not an issue up gradient of the site. Located in northern corner of the landfill. Monitoring interval 1.0m to 8.0m in gravely clay with cobbles and boulders. No waste reported.

BH Code	Interpretation of Monitoring Results 2014 & Q1 2015	Monitoring Interval
	to 550 ug/l compared to 50 ug/l IGV. The dissolved oxygen is low (18 to 43.8 % sat). F Coliforms < 10 – 20 cfu/100ml. List I / II substances not detected.	Iron and manganese are elevated due to reducing conditions.
GW5	Low ammonia < 0.02 to 0.08 mg/l. Chloride 112 to 132 mg/l. Close proximity to extent of saline intrusion. Iron (83 to 2,800 ug/l) and manganese (200 – 620 ug/l) are elevated. Considered to be up gradient of the waste body. Consider this representative of background concentrations. Dissolved oxygen low (15.9 to 33.1 % sat). F Coli < 10 cfu/100ml. List I / II substances not detected.	Up gradient shallow groundwater monitoring borehole. Located in northern corner of landfill. Monitoring interval 1.0m to 4.10m in gravely clay. No waste reported. F. Coliforms down gradient of site issue in terms of bathing water. Iron and manganese elevated due to reducing conditions.
GW6	Limited data for 2014 only one result available. Ammonia (2.6 mg/l) and chloride (246 mg/l) elevated but < 100 times IGV. Arsenic (520 ug/l), iron (1,100 ug/l) and manganese (1,300 ug/l) also elevated. F Coli 41 cfu/100ml. List I / II substances not detected.	Down gradient shallow groundwater monitoring borehole. Located along to south of southern boundary of site close to facility boundary and down gradient of civic amenity. Monitoring interval 1.0m to 10.50m. In made ground to 2.0mbgl underlain by sandy silt. No mention of waste. Affected by saline intrusion.
GW7	Ammonia elevated (0.37 to 9.7 mg/l) but < 100 times IGV. Chloride elevated 207 to 236 mg/l. Arsenic (5.1 to 18 ug/l) above IGV. Iron and manganese are elevated. Iron concentration 4,800 to 30,500 ug/l are higher than up gradient points BH2, GW4 and GW5. Manganese 2,100 to 2,300 ug/l. F Coli < 10 to 41 cfu/100ml. List I / II substances not detected.	This is a down gradient borehole monitoring shallow groundwater. It may also be intercepting leachate. Located to south of southern boundary of site close to facility boundary. Monitoring interval 1.0m to 11m. In made ground to 3.6mbgl underlain by sandy silt. Affected by saline intrusion.
GW8	Ammonia 0.45 to 13 mg/l elevated but less than 100 times IGV. Chloride 267 to 599 mg/l elevated. Arsenic 12 to 46 ug/l above 10 ug/l IGV. Iron, 3,100 to 19,300 ug/l above IGV 200 ug/l. Manganese, 2,000 to 2,200 ug/l above IGV 50 ug/l. Potassium and sodium elevated. This area likely to be saline. F Coli < 10 to 41 cfu/100ml. List I / II substances not detected.	Down gradient shallow groundwater monitoring borehole. Located to south of southern boundary of site close to facility boundary. Monitoring overburden and waste material. This area affected by saline intrusion and borehole possibly contains leachate.
BH8	Up gradient shallow groundwater monitoring borehole. Would expect this area to be saline based on location and measured salinity, chloride, magnesium, potassium and sodium. The ammonia concentration is low 0.04 to 0.24 mg/l. Iron < 10 to 1,900 ug/l and manganese 360 to 3,400 ug/l are elevated. F Coli < 10 to 120 cfu/100ml. List I / II substances not detected.	Up gradient shallow groundwater monitoring borehole. Not influenced by landfilling operations. No info on exact monitoring interval. Monitoring groundwater in overburden. Affected by saline conditions.
BH9	Ammonia ranged from 0.25 to 0.34 mg/l	Up gradient shallow groundwater monitoring

BH Code	Interpretation of Monitoring Results 2014 & Q1 2015	Monitoring Interval
	while higher than BH8 is close to the drinking water limit. Iron and manganese elevated. Iron 94 to 3,400 ug/l above IGV 200 ug/l. Manganese 940 to 2,000 ug/l above IGV 50 ug/l. F Coli < 10 to 190 cfu/100ml. List I / II substances not detected.	borehole. Located in northern most corner of site. Exact monitoring interval not known. Monitoring in overburden. Made ground to 0.40m. Affected by saline conditions.
RC4	Not sampled in 2014. Data from 2012 has been reviewed. Affected by saline conditions. Ammonia elevated 4.1 to 5.1 mg/l above IGV of 0.15 mg/l but less than 100 times IGV. Iron available results 2,600 to 3,100 ug/l above IGV 200 ug/l. Iron (2,600 to 3,100 ug/l) and manganese (6,100 ug/l) are elevated. Arsenic 85 ug/l was above IGV of 10 ug/l. F Coli below detection limit. List I / II organics not detected.	Down gradient monitoring borehole monitoring bedrock interval. Located on eastern most tip of landfill site. Considered to be representative of conditions in bedrock groundwater down gradient of the licensed landfill site. In absence of recent data assuming similar impact in 2012 to present.
RC5	Not sampled in 2014 or 2013. Data from 2012 has been reviewed. Location saline influence influencing standard parameters. Ammonia concentration in RC5 significantly higher than RC4. Note RC5 is also down gradient of the area of historic waste in the adjacent lands owned by Tramore Leisure Parks Ltd. RC5 ammonia 33 to 35 mg/l in 2012. Iron elevated 1,800 to 5,400 ug/l compared to IGV 200 ug/l. Arsenic 73 ug/l above IGV 10 ug/l. Iron 1800 to 5400 ug/l and manganese 850 ug/l elevated.	Down gradient monitoring borehole monitoring bedrock interval. Located at greater distance from landfill than RC4 but is down gradient of areas of waste landfilled outside of facility boundary. In absence of recent data assuming similar impact in 2013 to present.

The assessment of the groundwater monitoring data for 2014 and Quarter 1 2015 confirms that the following parameters are present at concentrations above the screening levels: arsenic, ammonia, coliforms, iron and manganese. Of these parameters only arsenic is listed as hazardous in the EPA publication "Classification of Hazardous and Non Hazardous Substances In Groundwater" (EPA, December 2010). These parameters have been identified as the contaminants of potential concern.

Arsenic

The monitoring data (Appendix D) indicates the concentration of arsenic is slightly higher than the IGV of 10 ug/l at GW1, GW3, GW7 with higher concentrations reported at GW8 (21-46 ug/l), GW6 (520 ug/l), RC4 (85 ug/l) and RC5 (73 ug/l).

Waterford City and County Council have previously outlined that the test method used to determine metals concentrations is ICP-MS which can be affected by elements present in seawater. This can result in falsely high results for metals where saline intrusion is occurring. Investigations undertaken by WCC in 2006 indicated there was a direct and strong correlation between salinity and measured metal concentrations for arsenic, chromium, copper and zinc. The study concluded the results for metals analyses are unreliable where electrical conductivity is > 5,000 us/cm. The reported salinity values and electrical conductivity values indicate that the monitoring locations are affected by saline conditions and therefore the reported arsenic values are not considered reliable.

Due to the unreliability of the arsenic data is not possible to determine the arsenic concentrations in the groundwater down gradient of the landfill to determine if the prevent objective is being met. It is recommended that Waterford City and County Council examine the options for undertaking the analysis of arsenic using an alternative method that would not be subject to interference effects from saline conditions. If a more reliable analysis method can be used it is recommended that the frequency of monitoring for arsenic be increased to quarterly.

Ammonia

Ammonia is classed as a non hazardous substance. The monitoring data for ammonia for the period 2008 to Q1 2015 is presented on Figure 4.1. Monitoring of ammonia concentrations up gradient of the landfill indicate levels slightly above the groundwater threshold value range.

There is evidence of elevated ammonia concentrations in the shallow groundwater in a number of the groundwater monitoring boreholes located down gradient of the waste body (GW06, GW07, GW08). The borehole records indicate the presence of waste in these boreholes with the monitoring standpipes open over the waste interval. The ammonia concentrations in the shallow groundwater in the overburden deposits further down gradient of the site at GW1, GW2 and GW3 indicate significantly reduced concentrations to those seen at GW6, GW7 and GW8. This is considered to be due to natural attenuation and effects of saline intrusion. The concentrations at the furthest down gradient shallow groundwater monitoring boreholes are above the thresholds (0.065 – 0.175 mg/l) specified in the Groundwater Regulations. A review of the 2014 data and Q1 2015 indicates the following values: GW1 range 0.16 to 4.5 mg/l; GW2 0.27 mg/l to 1.5 mg/l; GW3 0.26 – 0.28 mg/l.

The highest ammonia concentrations are seen in BH2 where a significant variation in concentration is evident (Figure 4.1). Monitoring location BH2 is considered to be monitoring leachate also based on the site investigation records. The records indicate 1.70m of made ground / refuse. There is no information on the exact monitoring interval for the standpipe but it is considered likely to be intercepting leachate. This monitoring location is affected by saline intrusion.

The next highest ammonia concentrations are found at RC5 which monitors the groundwater composition in the bedrock down gradient of both the landfill site and Tramore Leisure Parks Ltd Site close to Tramore Beach. There is no recent data for monitoring location RC5 but the data from 2012 indicated very high concentrations of ammonia (33 to 35 mg/l). No details on the monitoring zone are provided in the site investigation summary data. There is no detail provided on the overburden encountered and whether there was any waste in this area. The ammonia concentration in RC5 is frequently significantly higher than the concentration in RC4. Due to the presence of waste material in the area south of the landfill site there is potential for RC5 to be impacted by the material deposited in the adjacent site also.

The data for RC4 for 2014 included two sampling dates with concentrations of 6.06 mg/l in Q2 and 0.87 mg/l in Q3. The average concentration at RC4 for 2012 to 2014 monitoring period was 4mg/l.

The concentration of ammonia is currently monitored on a quarterly basis in accordance with the Waste Licence and it is recommended that this monitoring frequency be maintained.

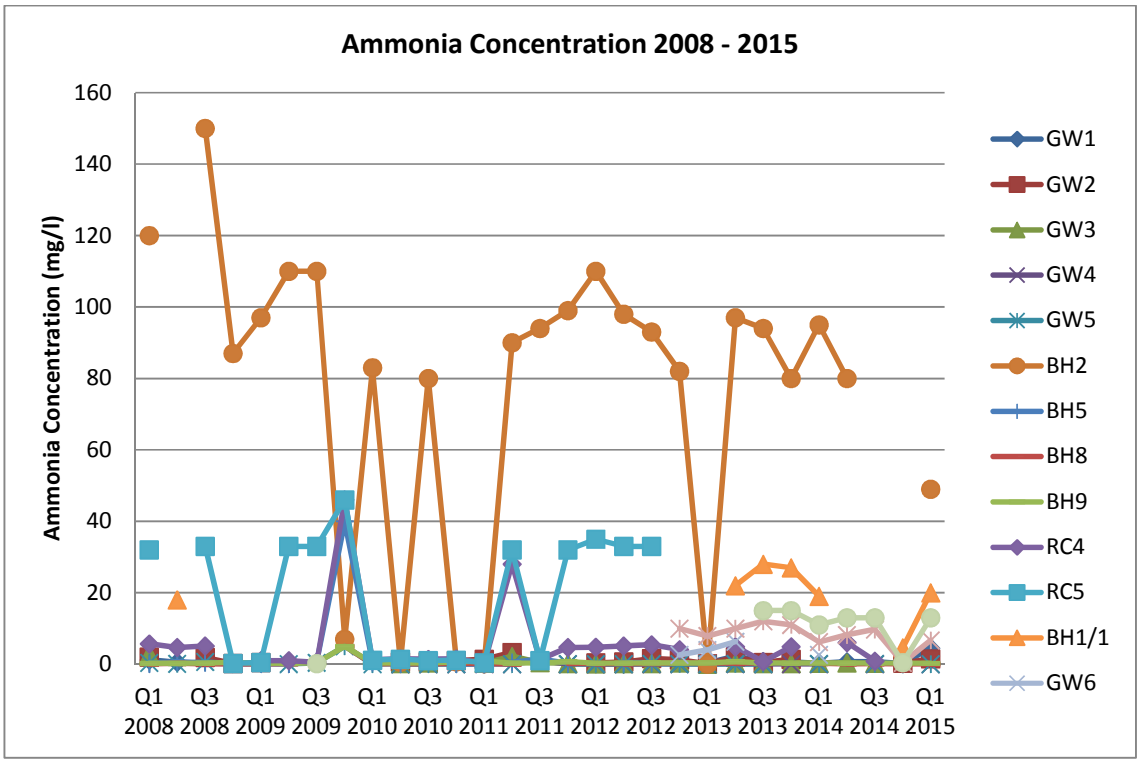


Figure 0.1: Ammonia Concentration 2008 to Quarter 1 2015

Coliforms

T.Coliforms and F. Coliform were detected in all of the shallow groundwater (overburden) monitoring locations in 2014. No results are available for the deeper groundwater (bedrock aquifer) for 2014. No threshold values are specified for coliforms in the Groundwater Regulations. The IGV for both T. Coliforms and E. Coliforms is 0 cfu/100ml.

Low to moderate levels of E. Coliforms were detected in the groundwater samples at the landfill site during 2014. All of the results were less than the limits specified for E. Coliforms in Schedule 4 of the Bathing Water Regulations for Coastal Waters and Transitional Water with the exception of Quarter 1 sample from BH2. Based on the site investigation data BH2 is likely to be sampling leachate in addition to groundwater. The Bathing Water Quality Data for 2014 and 2015 indicates excellent status. There is no evidence of an impact on the Bathing Water Status at Tramore as a result of the landfill site.

Iron

There are no groundwater threshold values specified for iron in the Groundwater Regulations. Iron is not classed as a hazardous substance in the EPA publication "Classification of Hazardous and Non Hazardous Substances In Groundwater" (EPA, December 2010). The IGV for iron is 200 ug/l.

The 2014 data indicates the iron concentrations are above the IGV on occasions at all of the groundwater monitoring locations. The iron concentrations for the period 2008 to Q1 2015 were examined and are presented on Figure 4.2. Significantly higher iron concentrations were seen at all monitoring locations during Q3 / Q4 2012 and Q1 / Q2 2013 with the highest concentrations seen at GW3 and GW6.

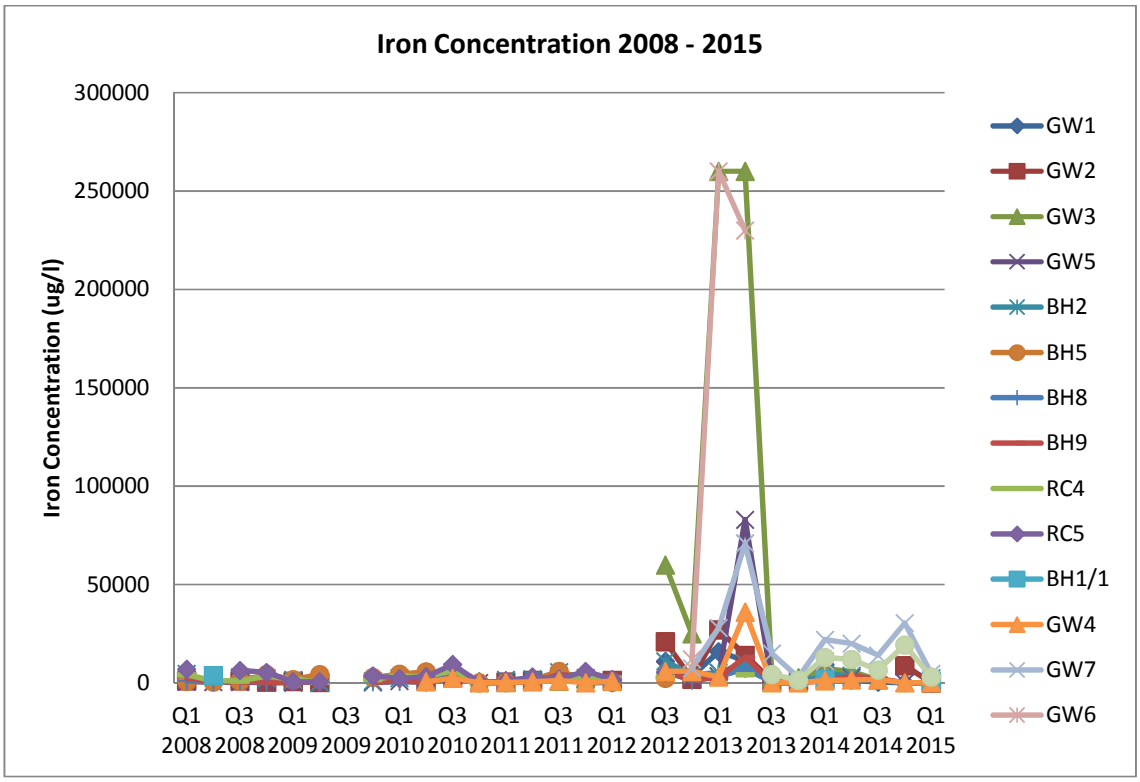


Figure 0.2: **Iron Concentrations 2008 – Quarter 1 2015**

The more recent data, 2013 to 2015, indicates higher concentrations of iron at GW6, GW7 and GW8 at the southern end of the landfill site than further down gradient at GW1, GW2 and GW3 which are immediately north of the Tramore Beach. The more elevated iron concentrations in proximity to the waste body are considered to be due to natural attenuation processes taking place in the shallow groundwater in this area.

The iron concentrations in the deeper groundwater in the bedrock aquifer have been plotted on Figure 4.3 and indicate a similar pattern of fluctuation at the two monitoring locations which may be related to tidal effects.

The concentration of iron is currently monitored on a quarterly basis in accordance with the Waste Licence and it is recommended that this monitoring frequency be maintained.

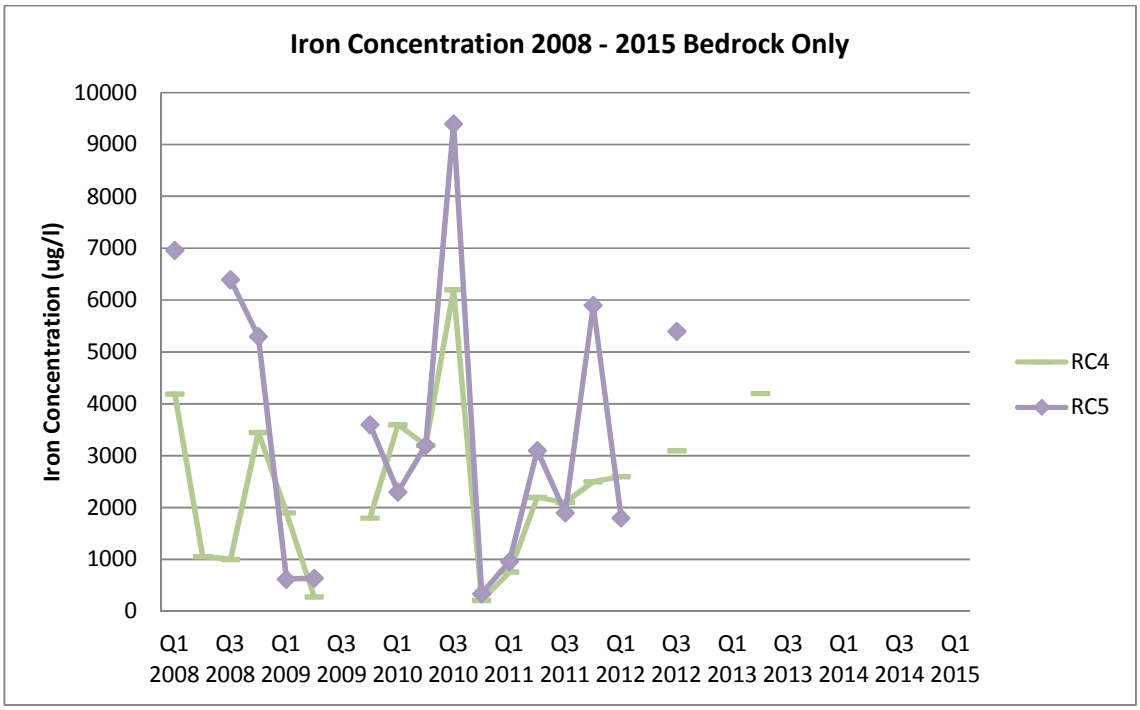


Figure 0.3: Iron Concentrations Deeper Groundwater 2008 – Quarter 1 2015

Manganese

There are no groundwater threshold values specified for manganese in the Groundwater Regulations. Manganese is not classed as a hazardous substance in the EPA publication "Classification of Hazardous and Non Hazardous Substances In Groundwater" (EPA, December 2010). The IGV for manganese is 50 ug/l.

The 2014 data indicates the manganese concentrations are above the IGV on all occasions at all of the groundwater monitoring locations. The available data for the period Q1 2008 to Q1 2015 is presented on Figure 4.4. The highest manganese concentrations have historically been seen at RC4 and RC5 which monitors the deeper groundwater in the bedrock aquifer but there is no data for manganese for these monitoring locations since 2011. BH8 is located up gradient of the landfill and typically has manganese concentrations higher than the shallow groundwater monitoring boreholes indicating that the manganese concentration is being affected by activities up gradient of the site.

The Waste Licence for the site requires annual monitoring of manganese. It is recommended that the compliance monitoring include quarterly monitoring of manganese for monitoring of trends.

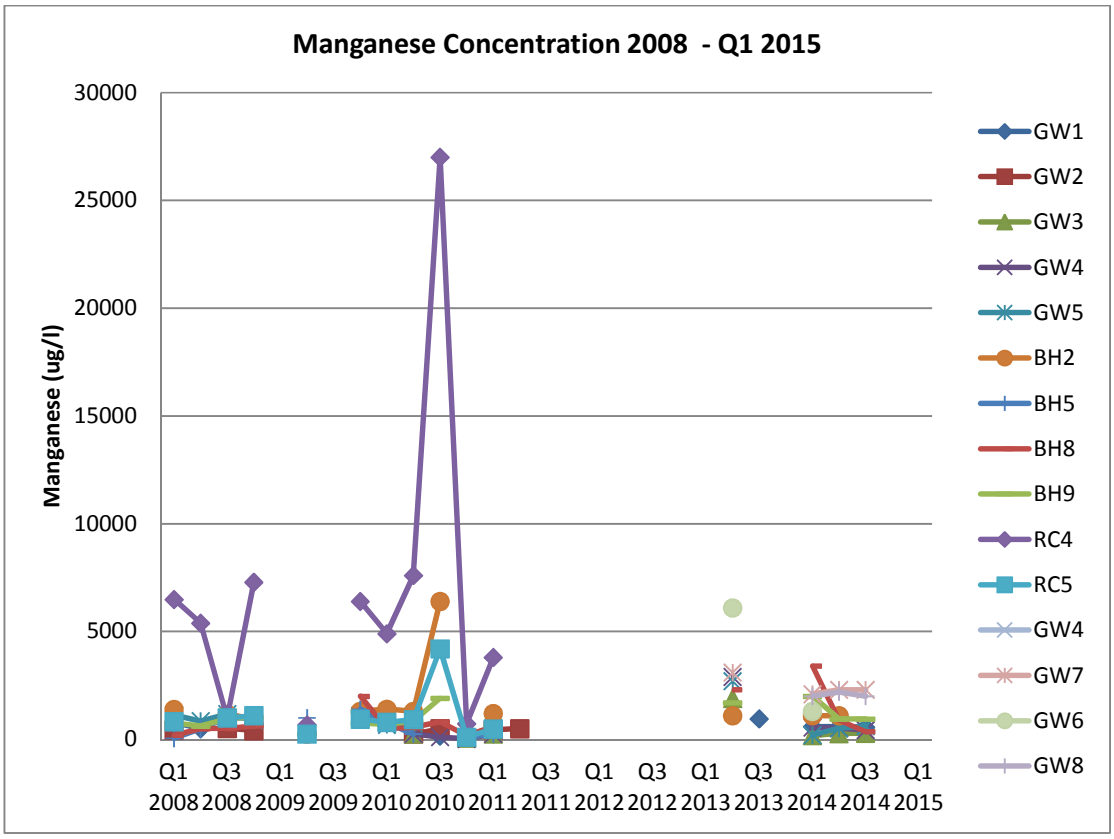


Figure 0.4: Iron Concentrations Deeper Groundwater 2008 – Quarter 1 2015

Conclusion

The installation of the final capping has significantly reduced the volume of leachate being generated with dry conditions being reported in a number of the monitoring boreholes within the waste body. On this basis the site is considered to be meeting the limit objective with respect to the discharge of non hazardous substances (ammonia, iron, manganese, iron, coliforms) pollutants to groundwater.

The concentrations of ammonia, iron and manganese in the shallow groundwater indicate natural attenuation is taking place at the site.

No list I / II substances have been detected at concentrations above the detection limits. Arsenic is the only hazardous substance identified to exceed the screening values at the site. Due to issues with saline interference there are issues over the reliability of the laboratory results due to the potential for false high readings. It is not possible to confirm that the limit objective is being met with respect to the discharge of arsenic (hazardous substance). It is recommended that an alternative analysis method be investigated to provide more reliable results.

There is no evidence of an upward trend in contaminant concentrations at the site or an expanding plume of contamination. Investigations into the extent of saline intrusion at the site have determined the extent of saline intrusion at the site as shown on DG0119. This indicates that the majority of the groundwater monitoring points

are located within area subject to saline intrusion. The contamination plume is limited to the area in the immediate vicinity of the waste body as the groundwater and leachate is discharging to the adjacent tidal waters where significant dilution is available.

Impact On Receptors

Prior to the preparation of this hydrogeological review a Generic Quantitative Risk Assessment had not been undertaken at the site. As part of this report the results of the historic groundwater monitoring at the site have been reviewed and compared to screening values as part of the risk assessment process. The results indicate there is potential for impact on groundwater quality down gradient of the site.

The landfill site is unlined and the results of the groundwater monitoring at the site indicate that the groundwater beneath the site is contaminated based on the results from the current groundwater monitoring boreholes. The contaminants of potential concern have been identified as arsenic; ammonia; coliforms; iron and manganese.

There are no identified drinking water sources down gradient of the site. Due to the coastal location of the site and the saline conditions encountered on the perimeter of the site groundwater resources there is no potential for the development of groundwater resources for drinking water purposes down gradient of the landfill site.

There is potential for impact on the surface water bodies down gradient of the site due to the discharge of groundwater to the surface water bodies. Tramore Beach is located approximately 200m hydraulically down gradient of the landfill site and a portion of the beach is designated as a Bathing Water Area. The Bathing Water Quality In Ireland Report (EPA, 2015) indicates the Tramore Beach Bathing Water Area has an overall status assessment of excellent (2011 – 2014). There is no evidence of the landfill impacting on the Bathing Water Quality.

The Tramore Backstrand is located immediately adjacent and down gradient of the landfill site. The Backstrand is subject to three separate designations: candidate Special Area of Conservation (cSAC) under the EU habitats directive; Special Protection Area (SPA) under the EU Birds Directive and a proposed Natural Heritage Area (pNHA). Tramore Backstrand is an intertidal area (approximately 500 hectares) that dries out completely during low tide. The backstrand is connected to the open sea by a channel known as Rinnashark.

Surface water quality monitoring is undertaken by WCC at 5 no. locations as shown on Drawing DG0112 Designated Monitoring Points (Appendix A).

- SW1 – western perimeter of site brackish water impacted by up stream activities landfill not considered to be a factor.
- SW2 – eastern perimeter of site saline water
- SW3 – saline water at gap between sand spits.
- SW4 – saline at discharge point east of Burrows
- SW5 – possibly at boat slip

The two key monitoring points in terms of potential impact from the landfill site are SW1 and SW2 as these are located immediately adjacent to the site. The other surface water monitoring locations are located further away from the site and would be impacted by other activities in the surface water catchment apart from the landfill site and would also be impacted by significant dilution due to the coastal nature of the site.

The surface water results have been compared to a number of limits for screening purposes:

- EQS for surface water based on the EPA / GSI 2003 publication Towards Setting Guideline Values for the Protection of Groundwater In Ireland;
- Category A1 limits, i.e. least treatment, set by the European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989;
- European Union (Drinking Water) Regulations 2014 (SI No. 122 of 2014).
- S.I. No. 272 of 2009 European Communities Environmental Objectives (Surface Waters) Regulations 2009 (Table 10 physico-chemcial conditions supporting the biological elements).

Monitoring of the quarterly surface water composition includes the analysis of: ammonia, BOD, COD, chloride, dissolved oxygen, electrical conductivity, pH, total suspended solids and temperature. The results of the quarterly monitoring for 2014 are presented in Tables C.1 to C.4 in Appendix C.

Surface water monitoring locations SW2, SW3, SW4 and SW5 are impacted by saline conditions while SW1 is affected by brackish conditions. This results in naturally elevated concentrations of chloride, sodium, sulphate, magnesium, calcium, potassium, boron and strontium.

The review of the groundwater monitoring data indicated that ammonia is one of the main potential contaminants of concern. A review of the surface water quality monitoring data indicates there is no evidence of elevated ammonia concentrations within the Tramore Backstrand.

In Quarter 2, 2014 there was elevated concentration of ammonia at SW1 which was reported to have been linked to stormwater overflow from the Tramore Agglomeration. Two constructed wetland wells were installed in 2011 to improve water quality in environs of the landfill site to intercept existing overflow from the Tramore CWW pumping station. Monitoring points SW1 is located in this area. The concentration of iron and manganese is also elevated at SW1 but is not elevated at the other surface water monitoring locations within Tramore Backstrand.

The 2014 AER indicates that sampling of estuarine macrofauna and sediment was not possible during 2014 due to adverse weather conditions. The most recent data is from December 2011 which indicated that the metals levels in mussel and cockle samples from Tramore Backstrand complied with EU and national shellfish quality standards. The metal concentrations in shellfish between 2003 to 2011 indicated similar concentrations and were reported to be similar to that found at other estuarine and coastal sites around the country. The microbiological analysis also indicated compliance with regulatory guidelines. The analysis of metal concentrations in sediments samples indicated the concentrations of chromium, copper and zinc at Tramore were above baseline levels but all values were below threshold and levels at which there may be an impact on fauna.
The EPA surface water quality monitoring data 2010 – 2012 for both Tramore Backstrand and Tramore Bay is classed as “Unpolluted”.
Due to the dilution available within the Tramore Backstrand, the saline nature of the surface water and a review of the surface water monitoring data for 2014 the potential for the landfill to impact on the designated site has been ranked as low
Chemical Status of Groundwater Body

2.3.4 Direct Discharges to Groundwater

Tramore Landfill site was developed as an unlined landfill site. Monitoring of the leachate composition at the site indicates a number of contaminants are above the groundwater threshold values. The site is unlined and leachate is discharging to the shallow and deep groundwater beneath the site. There is a significant thickness of overburden deposits present above the bedrock aquifer. The overburden deposits are not classed as constituting an aquifer on the GSI online mapping. On this basis there are no direct discharges to groundwater. There are indirect discharges of pollutants to groundwater after percolation through the overburden deposits.

2.3.5 Impact on Surface Water Bodies

Of the parameters of potential concern only ammonia is indicated as having a limit specified for groundwater in terms of its potential impact on the surface water quality standards. The ammonia concentration in both the shallow and deep groundwater is contributing to the coastal water at concentrations that are significantly higher than the river water standard for good status (0.065 mg/l). There are no standards specified for ammonia concentration in coastal waters. The results of surface water quality monitoring within Tramore Backstrand and Tramore Bay indicate no impact on the down gradient surface water quality.
The Coastal Waterbody Status 2010 – 2012 for Tramore Backstrand is “High” while Tramore Bay is “Good”.
The WFD Risk Score for Tramore Backstrand is classed as 1a “At risk of not achieving good status” but the current status report indicates that this is not related to the landfill site. The full report for the Tramore

Backstrand indicates that the waterbody is classed as 1a at risk for "Overall morphological risk – worst case" and "Coastal Risk Overall – Worst Case (2008)".
The WFD Risk score for Tramore Bay is classed as 1a "At risk of not achieving good status". The full report for Tramore Bay indicates that the waterbody is classed as 1a at risk due to "Worst Case of Point and Marine Direct Impacts Overall (2008)"; "Coastal Risk Overall – Worst Case (2008)" and "WWTPs (2008)". None of which relate to the landfill site.

2.3.6 Impact on Surface Groundwater Bodies

The WFD status 2007 – 2012 for the Dunmore East Groundwater body is an overall Poor Status based on its Poor Chemical Status. The groundwater body is classed under the WFD Register of Protected Areas as Groundwater for Drinking Water however due to the proximity of the site to the coast and the likelihood of saline conditions this area is not expected to be developed for groundwater supply down gradient of the landfill site.
None of the parameters monitored on an annual basis have been measured at concentrations > 100 times the GAC.
The concentration of ammonia in BH2, GW7, GW8 and RC5 has been measured at concentrations > 100 times the GAC. The down gradient monitoring boreholes in the shallower groundwater indicate that the ammonia concentrations at GW01, GW02 and GW03 are significantly lower and tend to be less than 10 times screening value of 0.15 mg/l. There is no recent data for monitoring locations RC4 and RC5 but the historic data (2012 / 2013) indicates that the concentration of ammonia in the deeper groundwater in the bedrock aquifer is > 100 times the screening value.
Due to the coastal location of the site both the shallow groundwater in the overburden deposits and the deeper groundwater in the bedrock aquifer will be discharging to the coastal waters. This results in significant dilution of the groundwater. This limits the extent of the groundwater contamination to the groundwater in the immediate vicinity of the site outside of the area of saline intrusion.

REMEDIAL STRATEGY

The purpose of this report is to demonstrate compliance with the Groundwater Regulations (S.I. No. 9 of 2010). The aim of the Groundwater Regulations is to ensure the objectives for groundwater set by the Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC) are achieved. There are currently no authorised discharges of groundwater at the site.

The risk screening has determined a low level of risk at the site to potential receptors. The groundwater from beneath the landfill site is discharging to saline coastal waters. There is no evidence of a risk to the surface water quality down gradient of the site or to the designated sites.

The site is considered to be compliant in terms of the limit objective of the groundwater regulations. The installation of the engineered final cap has significantly reduced the volume of leachate being generated at the site.

Due to an issue with the reliability of the results of the analysis of the concentration of arsenic it is not possible to determine if the prevent objective of the groundwater regulations is being met. Arsenic is classed as a hazardous substance. It is recommended that an alternative method, unaffected by saline conditions, be considered for the analysis of arsenic to confirm that the concentrations of arsenic in the surface water and groundwater affected by saline intrusion are not an issue at the site.

GROUNDWATER COMPLIANCE MONITORING

The current environmental monitoring points are considered to be suitable for compliance monitoring. The proposed compliance monitoring points are to include (1) monitoring of the down gradient bedrock monitoring locations (RC4 & RC5) and (2) monitoring of the shallow groundwater at monitoring locations BH8, BH9, GW01, GW02, GW03, GW04 and GW05A.
The existing monitoring network is considered adequate to monitor temporal and spatial trends in the contaminants of potential concern as the existing monitoring boreholes target the key potential migration pathways.
The proposed monitoring frequencies and the proposed parameters for compliance monitoring for groundwater analysis are outlined in **Table 6.1**. Details of the current groundwater monitoring programme are also included in **Table 6.1** for information purposes. The COPC have been identified as arsenic, ammonia, coliforms, iron and manganese.

Table 0.1: Compliance Monitoring

Parameter	Recommended Compliance Groundwater Monitoring	Current Groundwater Monitoring as per Licence W0075-02
Borehole Locations	Deep Groundwater: RC4 & RC5. Shallow groundwater: BH8, BH9, GW01, GW02, GW03, GW04 & GW05A.	BH1, BH2, BH5, BH8, BH9, BH10, RC4, RC5, RC6 plus 3 no. additional boreholes as per Condition 3.21.
Visual Inspection / Odour		Quarterly
Groundwater Level		Monthly
Ammonia	Quarterly	Quarterly
Arsenic	Quarterly	Bi-annually
Boron		Annually
Cadmium		Annually
Calcium		Annually
Chloride		Quarterly
Chromium		Annually
Copper		Annually
Cyanide (total)		Annually
Dissolved Oxygen		Quarterly
Electrical Conductivity		Quarterly
Iron	Quarterly	Quarterly
Lead		Annually
Magnesium		Annually
Manganese	Quarterly	Annually
Mercury		Annually
Ortho-phosphate		Annually
pH		Quarterly
Phenols		Quarterly
Potassium		Quarterly
Sodium		Quarterly
Sulphate		Annually
Temperature		Monthly
Total Organic Carbon		Quarterly
Total Oxidised Nitrogen		Quarterly
Zinc		Annually
List I / II Organic substances		Annually

Parameter	Recommended Compliance Groundwater Monitoring	Current Groundwater Monitoring as per Licence W0075-02
Residue on Evaporation		Annually
Faecal Coliforms	Quarterly	Quarterly
Total Coliforms	Quarterly	Quarterly

The EPA online mapping indicates that the landfill site is located in the catchment of Brickey_Colligan_Dalligan_Mahon_Tay_Coastal catchment (IE17_01). The portion of this catchment from which water discharges to the Tramore Backstrand is calculated as 51.33km^2.
The GSI online mapping indicates the effective rainfall in the area is 595mm per annum. There is no flow data available for the surface water discharges to the Tramore Backstrand however based on the area of the contributing catchment and the effective rainfall the overall estimate of water being discharged to the Tramore Backstrand is estimated to be of the order of 30,541,350m^3 per annum. The leachate generation rate is estimated at 1,054m^3/annum following the installation of the engineered final cap. This excludes the area affected by saline intrusion. This indicates a dilution of 1:29,000 is available within Tramore Backstrand excluding the effects of the tidal movements.
The standards which have been considered in the setting of compliance values for the groundwater include the following:

- European Communities (Drinking Water) Regulations 2014 (S.I. No. 144 of 2014);
- European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010) (groundwater threshold values for assessment of whether groundwater intended for human consumption in drinking water protected areas is impacted by pollutants and / or is showing a significant and sustained rise in pollutant levels);
- European Communities Environmental Objectives (Surface Waters) Regulation 2009 (S.I. No. 272 of 2009);
- Bathing Water Quality Regulations S.I. No. 79 of 2008.

On this basis the compliance values outlined in **Table 6.2** have been set for groundwater. The use of these compliance values will ensure the Environmental Quality Standards for Surface Water are also met based on the available dilution in the down gradient surface water body.

Table 0.2: Compliance Values for Contaminants of Potential Concern

Parameter	Standard To be Achieved In Surface Water	Proposed Compliance Value
Ammonia	There is no specific standard set for ammonia in S.I. No. 272 of 2009 Surface Water Regulations. The 65 ug/l (0.065 mg/l) threshold value for assessment of adverse impacts of chemical inputs from groundwater on associated surface water bodies has been used as a more conservative measure.	1,885 mg/l
Arsenic	There limit for arsenic is in surface water is 20ug/l (0.02 mg/l) based on annual average environmental quality standard, Table 10 S.I. 272 of 2009 for Other Surface Waters.	580 mg/l
Iron	There is no specific standard set for iron in S.I. No. 272 of 2009 Surface Water Regulations. There is no threshold specified for iron in S.I. No. 9 of 2010 Groundwater Regulations. The GSI / EPA publication Towards Setting indicated an EQS of 1.0mg/l for iron in surface water.	29,000 mg/l
Manganese	There is no specific standard set for manganese in S.I. No. 272 of 2009 Surface Water Regulations. There is no threshold specified for manganese in S.I. No. 9 of 2010 Groundwater Regulations. The GSI / EPA	8,700mg/l

Parameter	Standard To be Achieved In Surface Water	Proposed Compliance Value
	publication Towards Setting indicated an EQS of 0.3mg/l for manganese in surface water.	
E Coliforms	There is no specific standard set for coliforms in S.I. No. 9 of 2010 Groundwater Regulations. There are limits specified Bathing Water Quality Regulations S.I. No. 79 of 2008. Limit 250 cfu/100ml for excellent status, 500 cfu/100ml for good status and 500 cfu/100ml for sufficient status.	500 cfu/100ml

The dilution factor of 29,000 has been taken in to account in the back calculations of the compliance values for the contaminants of potential concern. This indicates compliance values are significantly higher than the current concentrations in the groundwater. On this basis the current groundwater quality is considered to be compliant with the proposed compliance values.

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

The conceptual site model has been presented in Chapter 3 of this report and is illustrated on **Figure 3.1**. There is considered to be sufficient site investigation data available for the development of the conceptual site model and the identification of the groundwater flow intervals.
No recent groundwater monitoring results were available for RC4 and RC5 which monitor the deep groundwater in the bedrock aquifer. Groundwater sampling in these boreholes is required to monitor changing trends in groundwater composition down gradient of the site.
The limit objective under the Groundwater Regulations requires that all necessary measures should be taken to limit inputs of non hazardous substances to groundwater to ensure that such inputs do not cause pollution, deterioration in status of groundwater bodies or cause sustained upward trends in groundwater concentrations. The site is considered to be compliant with the limit objective of the Water Framework Directive and Groundwater Directive.
The prevent objective of the Groundwater Regulations requires that hazardous substances should not be permitted to enter the groundwater. Due to issues with the analysis method for arsenic it is not possible to confirm if the prevent objective is being met. It is proposed that an alternative method for the analysis of the arsenic concentrations at the site be agreed with the EPA.
Remedial measures have been undertaken at the site between 2002 and 2012 which have included the installation of a leachate abstraction system, surface water management system and engineered final cap. The purpose of these remedial works has been to prevent or limit the input of pollutants into groundwater beneath the site and surface water down gradient of the site. The installation of the engineered cap has reduced the volume of leachate being generated at the site and monitoring of leachate levels at the site indicates a reduction in leachate levels at LT4 and LT5.
The groundwater monitoring data for the Quarter 1 to 4 2014 and Q1 2015 has been reviewed to identify the potential contaminants of concern. The potential contaminants of concern include: arsenic; ammonia; E. Coliforms; iron and manganese. It is recommended that monitoring of COPC be undertaken at the frequencies outlined in Table 6.1 and at the proposed compliance monitoring locations in addition to the monitoring specified by the waste licence.
There is no evidence of an upward trend in contaminant concentrations at the site or an expanding plume of contamination. As the site is located in an estuarine location and is subject to saline intrusion the area affected by the plume is limited to the immediate vicinity of the waste body as the groundwater and leachate is discharging to the adjacent tidal waters where significant dilution is available (1:29,000). There is no estimate of the seepage rates from beneath the landfill site due to the tidal effects.
There is no evidence of the existing surface water quality being impacted from leachate discharges from the landfill site. The monitoring of the ammonia concentration in the surface water monitoring points within the tidal areas indicate the ammonia concentration is less than the EQS of 0.02 mg/l specified for surface water in GSI / EPA Publication “Towards Setting Guideline Values For The protection of Groundwater In Ireland”. The WFD Coastal Waterbody Status (2010 – 2012) for the Tramore Backstrand is “High” while Tramore Bay is classed as having “Good Status”. The Bathing Water Area at Tramore Beach is classed as having “Excellent” status for both 2014 and 2015 and the beach is designated as a Blue Flag Beach. Based on the surface water monitoring data the risk to the down gradient Tramore Beach Bathing Water Area has been classed as low.
No existing down gradient groundwater users have been identified and based on the proximity of the coast (approximately 100m) and the known extent of saline intrusion in the area groundwater is not expected to be developed down gradient of the site.
The results of the surface water quality monitoring and the most recent ecological monitoring (2011) indicate no impact as a result of the landfill operations. The risk to the ecologically designated sites has been classed as low.

APPENDIX A

DRAWINGS

1. DG0101 Site Location & Site Layout Plan.
2. DG0112 Designated Monitoring Points.
3. DG0103 Surface Water Management.
4. DG0114 Leachate Extraction System.
5. DG0119 Extent of saline Intrusion.

APPENDIX B
SITE INVESTIGATION DATA

Table B.1 : Summary Details of Site Investigation Boreholes Tramore Landfill

Borehole Code	Total Depth	Elevation Top Of Casing	Comment	Groundwater Monitoring Interval	Strata Encountered
BH1/1 Leachate	4.5m	3.51mOD		0.80m to 4.0m in leachate	GL to 1.70m Made ground – fill / clay with traces of rubble. 1.70m to 3.70m Made Ground – domestic refuse. 3.70m to 4.20m Made Ground – firm brown clay with traces of rubbish. 4.20m to 4.50m Firm brown sandy gravely clay.
BH2 Groundwater Overburden + Possible leachate	4.2	4.97mOD	May be monitoring leachate also	None given	GL to 0.50m Made ground: hardcore fill. 0.50m to 1.0m Made ground; loose mixture of gravel and rubble with fill. 1.0m to 1.70m Made Ground: soft black sandy silt with domestic refuse. 1.70m to 2.50m Soft/loose mixture of silt and gravel. 2.50m to 4.20m? medium dense well graded silty gravel.
BH8 Groundwater Overburden	7.7	2.83mOD		Not known	GL to 0.30m Topsoil. 0.30m to 1.20m Soft grey brown sandy silty clay. 1.20m to 1.90m Firm grey brown sandy clay with some gravel. 1.90m to 7.70m Stiff to very stiff brown silty sandy gravelly clay with cobbles and boulders.
BH5 Groundwater + Possible Leachate	3.95		May be monitoring leachate also	Not known	GL to 0.80m Made ground; clay and sand fill. 0.80m to 1.80m Made ground: medium dense silty sand with black domestic refuse. 1.80m to 2.90m Made ground: firm to stiff light brown gravelly clay with traces of refuse. 2.90m to 3.95m Very stiff light brown gravelly

Borehole Code	Total Depth	Elevation Top Of Casing	Comment	Groundwater Monitoring Interval	Strata Encountered
					clay.
BH9 Groundwater Overburden	8.7	2.47mOD		Not known	GL to 0.40m Made ground: grey silty clay with wood, paper and plastic. 0.40m to 2.20m Firm grey brown sandy clay with some gravel. 2.2m to 7.4m Stiff to very stiff brown silty sandy gravelly clay with cobbles and boulders. 7.40m to 8.7m? Hard brown silty laminated clay with frequent cobbles.
10A Groundwater + Possible Leachate	13m		May be intercepting leachate also	Not known	GL to 1.30m Made ground: stiff brown silty gravelly clay with concrete, brick and cobbles. 1.30m to 4.20m Made ground: brick, ash, wood, plastic, paper and steel. 4.20m to 10.20m Soft grey very silty sandy clay with shells. 11.80m to 13.00m Large limestone cobbles and boulders.
RC4 Groundwater Bedrock	15.3	5.70mOD		12m to 14m	GL to 9.70m open hole drilling. GL to 11.70m gravel. 11.70m to 15.30m Siltstone.
RC5 Groundwater Bedrock	25	2.80mOD		21m to 24.5m	GL to 20.0m Overburden. 20.0m to 25.0m Siltstone.
RC6A Leachate	9	3.45mOD		3m to 9m	GL to 1.0m Made ground light brown clay with gravel, cobbles and concrete. 1.0m to 3.20m Made ground: black silty clay with gravel and plastic. 3.2m to 7.0m Firm light brown grey gravelly clay with cobbles. 7.0m to 8.30m Light brown clay with gravel and abundant cobbles. 8.30 – 9.00m Light brown clay with gravel

Borehole Code	Total Depth	Elevation Top Of Casing	Comment	Groundwater Monitoring Interval	Strata Encountered
					and large cobbles.
LT01 Leachate	5.30m	7.96mOD		1.0m to 5.30m	GL to 1.50m Made ground: Gravelly clay with cobbles. 1.50m to 5.0m Fill / Made ground; Landfill. 5.0m to 5.30m Made ground: Obstruction on wood and cobbles.
LT04B Leachate	6.7	10.14mOD		2.0m – 6.7m	GL to 1.60m Made ground: Gravelly clay with cobbles / Fill 1.60m to 6.70m Made ground; Landfill.
GW01 Groundwater overburden	10m	2.72mOD		9.0m to 10.0m	GL to 1.0m Sand and Gravel. 1.0m to 2.50m silty sandy gravelly clay. 2.50m to 10.0m Sand with pockets of silty clay and shells.
BH7B Leachate	8m	8.47mOD		5.4m to 8.0m	GL to 1.60m Made ground; gravelly clay with cobbles and boulders. 1.60m to 8.0m Made ground: Landfill.
GW02 Groundwater overburden	10m	2.69mOD		9.0m to 10.0m	GL to 1.0m Sand and gravel. 1.0m to 2.50m Silty sandy gravelly clay. 2.50m to 10.0m Sand with occasional pockets of silty clay and shells.
GW03 Groundwater overburden	10m	2.74mOD		2.0m to 10.0m	GL to 1.0m Sand and gravel. 1.0m to 1.50m Silty sandy gravelly Clay. 2.50m to 10.0m Sand with occasional pockets of silty clay and shells.
GW04 Groundwater overburden	8m	2.26mOD		1.0m to 8.0m	GL to 7.90m Gravelly clay with cobbles and boulders. 7.90m to 8.0m obstruction.
GW05A Groundwater overburden	4.1m	2.14mOD		1.0m to 4.10m	GL to 4.10m Gravelly Clay with cobbles and boulders.
GW06 Groundwater + Possible	10.5m	3.37mOD	May be intercepting leachate also	1.0m to 10.50m	GL to 0.10m Made Ground: Turf over topsoil. 0.10m to 2.0m Made Ground: Grey clay with

Borehole Code	Total Depth	Elevation Top Of Casing	Comment	Groundwater Monitoring Interval	Strata Encountered
Leachate					cobbles. 4.0m to 10.50m Grey sandy silt.
GW07 Groundwater + Possible Leachate	11m	3.99mOD	May be intercepting leachate also	1.0m to 11.0m	GL to 0.10m Made ground: Turf over topsoil. 0.10m to 0.60m Made ground: Brown clay with cobbles. 0.60m to 2.50m Made Ground: Grey clay with cobbles. 2.50m to 3.60m Made Ground: Landfill. 3.60m to 11.0 grey Sandy silt.
GW08 Groundwater + Possible Leachate	10m	3.52mOD	May be intercepting leachate also	1.0m to 10.0m	GL to 0.10m Made ground turf over topsoil. 0.10m to 1.40m Made ground: Brown clay with cobbles. 2.0m to 3.60m Made ground: Landfill. 3.60m to 8.80m Grey sandy silt. 8.80m to 10.0m Brown gravely clay.
LT1 Leachate	8.4m	7.96mOD		1.8m to 7.2m	GL to 2.30m Made ground: rubble and clay. 2.30m to 3.30m Made ground: domestic refuse. 3.30m to 7.20m Made ground: black domestic refuse. 7.20m to 7.80m Made ground: mixture of rubbish and black silty sandy. 7.80m to 8.4m loose grey silty sand with shells.
LT2 Leachate	4.8m	8.40mOD		1.3m to 4.6m	GL to 1.20m Made ground: clay with occasional cobbles. 1.2m to 4.5m Made ground: domestic refuse. 4.5m to 4.8m Made ground silty refuse (domestic).
LT3a Leachate	6.0m	9.37mOD		1.5m to 5.6m	GL to 6.0m Clay with cobbles
LT4a Leachate	6.0m	10.14mOD		1.5m to 5.2m	GL to 0.7m Made ground: clay occasional cobbles.

Borehole Code	Total Depth	Elevation Top Of Casing	Comment	Groundwater Monitoring Interval	Strata Encountered
					0.7m to 6.0m Made ground: clay / waste.
LT5a Leachate	7.80m	9.02mOD		2.8m to 6.35m	Gl to 2.0m Made ground: clay with gravel and boulders. 2.0m to 3.0m Made ground: clay 3.0m to 3.80m Made ground: clay with traces of refuse. 3.8m to 7.8 Made ground: domestic refuse.

APPENDIX C

SURFACE WATER QUALITY MONITORING DATA

Table C.1 Quarterly Parameters SW1

	SW1 Q1	SW1 Q2			EQS EPA / GSI	Cat A1 SI 294 of 1989
Sample Date	10/03/2014	09/06/2014				
Ammonia (mg/l)	< 0.02	6.6			0.02	0.2
BOD (mg/l)	1.9	3				5
COD (mg/l)	23					
Chloride (mg/l)	254	265			250	250
Conductivity (us/cm)	1,335	166			1,000	1,000
Dissolved Oxygen (% saturation)	162	15				> 60%
pH (PH units)	8.3	6.9				5.5 – 8.5
Suspended Solids (mg/l)	< 8	28				50
Temperature (deg C)	12.8	15.6				25

Table C.2 Quarterly Parameters SW3

		SW3 Q1	SW3 Q2	SW3 Q3	SW3 Q4	EQS EPA / GSI	Cat A1 SI 294 of 1989
Sample Date		10/03/2014	09/06/2014				
Ammonia (mg/l)		0.031	< 0.02	< 0.02	< 0.02	0.02	0.2
BOD (mg/l)		< 1.0	2	3.1	3		5
COD (mg/l)		NT					
Chloride (mg/l)		NT	NT	NT	NR	250	250
Conductivity (us/cm)		NT	NT	NT	NM	1,000	1,000
Dissolved Oxygen (% saturation)		115	100	125	102		> 60%
pH (PH units)		8.2	8.2	8.4	8.1		5.5 – 8.5
Suspended Solids (mg/l)		8	20	51	143		50
Temperature (deg C)		12.5	17.7	18.5	11.2		25

Table C.3 Quarterly Parameters SW4

		SW4 Q1	SW4 Q2	SW4 Q3	SW4 Q4	EQS EPA / GSI	Cat A1 SI 294 of 1989
Sample Date		10/03/2014	09/06/2014	11/08/2014			
Ammonia (mg/l)		< 0.02	< 0.02	< 0.02	< 0.02	0.02	0.2
BOD (mg/l)		< 1.0	2	3.1	< 1.0		5
COD (mg/l)		NT					
Chloride (mg/l)		NT	NT	NT	NR	250	250
Conductivity (us/cm)		NT	NT	NT	NM	1,000	1,000
Dissolved Oxygen (% saturation)		125	150	125	103		> 60%
pH (PH units)		8.4	8.2	8.4	8.0		5.5 – 8.5
Suspended Solids (mg/l)		< 8	< 8	51	48		50
Temperature (deg C)		10.4	19.1	18.5	11.7		25

Table C.4 Quarterly Parameters SW5

		SW5 Q1	SW5 Q2	SW5 Q3	SW5 Q4	EQS EPA / GSI	Cat A1 SI 294 of 1989
Sample Date		10/03/2014	09/06/2014	11/08/2014			
Ammonia (mg/l)		0.021	< 0.02	< 0.02	< 0.02	0.02	0.2
BOD (mg/l)		< 1.0	< 1.0	< 1.0	< 1.0		5
COD (mg/l)		NT					
Chloride (mg/l)		NT	NT	NT	NR	250	250
Conductivity (us/cm)		NT	NT	NT	NM	1,000	1,000
Dissolved Oxygen (% saturation)		96	98	100	100		> 60%
pH (PH units)		8.1	8.1	8.1	8.0		5.5 – 8.5
Suspended Solids (mg/l)		12	14	25	99		50
Temperature (deg C)		11.1	15.5	16.1	12.2		25

Table C.5: Surface Water Quality Monitoring 2014 Annual Parameters

Parameter	Units	EQS Surface Waters	Cat A1 SI 294 of 1989 Limits	SI No. 122 of 2014 Drinking Water Limits	SI No. 272 of 2009 AA-EQS Inland Surface Waters	SI No. 272 of 2009 AA-EQS Other Surface Waters	SI No. 272 of 2009 MAC EQS Inland Surface Waters	SI No. 272 of 2009 MAC EQS Other Surface Waters	SW1	SW3	SW4	SW4	SW5
Sampling Date									09/06/14	09/06/14	09/06/14	11/08/14	09/06/14
Ortho-Phosphate	mg/l P		0.22						0.16	< 0.01	< 0.01		< 0.01
Total Oxidised Nitrogen	mg/l N								< 0.20	< 0.20	< 0.20		< 0.20
Fluoride	mg/l	5	1	0.8 / 1.5	0.5	1.5				< 25			< 25
Sulphate	mg/l SO4	200	200	250					29	2400	2500		2700
Arsenic	ug/l	25	50	10	25	20			< 5	< 10	< 10	NR	< 5
Beryllium	ug/l								< 5	< 5	< 5	< 1.0	< 5
Boron	ug/l	2,000	2,000	1,000					230	3,800	4,000	3,900	4,000
Alkalinity-total	mg/l CaCO3		-										
Sodium	mg/l		-	200					150	9,400	9,700	7,700	> 10000
Magnesium	mg/l		-						29	> 1,000	> 1,000	910	> 1,000
Potassium	mg/l		-						9.8	330	340	320	350
Calcium	mg/l		-						120	360	380	350	400
Antimony	µg/l			5					< 5	< 5	< 5		< 5
Chromium	µg/l	30	50	50	4.7 Cr III. 3.4 Cr VI		32 Cr III.	32 Cr VI	< 5	< 5	< 5		< 5
Iron	µg/l	1,000	200 A1	200					1,600	490	< 50		390

Parameter	Units	EQS Surface Waters	Cat A1 SI 294 of 1989 Limits	SI No. 122 of 2014 Drinking Water Limits	SI No. 272 of 2009 AA-EQS Inland Surface Waters	SI No. 272 of 2009 AA-EQS Other Surface Waters	SI No. 272 of 2009 MAC EQS Inland Surface Waters	SI No. 272 of 2009 MAC EQS Other Surface Waters	SW1	SW3	SW4	SW4	SW5
			2,000 A2 / A3									100	
Manganese	µg/l	300	50 A1 300 A2 1000 A3	50					770	42	< 25	27	< 25
Nickel	µg/l	50	-	20	8 / 50 /100	40			< 5	< 5	< 5	< 10	< 5
Copper	µg/l	30	50	2,000	5 or 30	5			< 5	< 5	< 5		< 5
Zinc	µg/l	100	3,000		8 / 50 / 100				13	14	12		11
Cadmium	µg/l	5	5	5					< 0.1	< 0.1	< 0.1	0.02	< 0.1
Cobalt	µg /l								< 5	< 5	< 5	< 1.0	< 5
Selenium	µg/l		10	10					< 5	< 10	< 10	NR	< 5
Strontium	µg/l								540	7,300	7,300	6,700	7,700
Thallium	µg/l								< 5	< 5	< 5	< 1.0	< 5
Uranium	µg/l	20							< 5	< 5	< 5	2.7	< 5
Vanadium	µg/l								< 5	< 50	< 100	NR	< 10
Mercury	µg/l	1 µg/l	1 µg/l	1 µg/l					< 0.50	< 0.50	< 0.50		< 0.50
Lead	µg/l	10	50	10					< 5	< 5	< 5	< 1.0	< 5

APPENDIX D

GROUNDWATER QUALITY MONITORING DATA

Table D.1: Additional Annual Parameters 2014

Range	Units	BH2	GW02	GW03	GW04	GW05	GW07	GW08	BH8	BH9	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
List I / II Organics	ug/l	BLD	No sample 12/06/14	0.6 toluene rest BDL	BLD	BLD	BLD	BLD	BLD	BLD		
Orthophosphate	Mg/l	0.099	0.09	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Mercury	ug/l	< 0.50		< 0.05	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.75	1
Fluoride	mg/l	< 2.5	< 5	< 6.25	< 0.5	< 0.25	< 0.5	< 1.25	< 2.5	< 0.5		1
Sulphate	mg/l	30	600	920	59	43	11	22	320	37	187.5	250
Antimony	ug/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5		5
Chromium	ug/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5.4	37.5	50
Copper	ug/l	6.1	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	1,500	2,000
Molybdenum	ug/l	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5		
Zinc	ug/l	36	24	23	32	25	24	14	31	25		5,000

Table D.3: Summary of Groundwater Composition BH2

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
				No sample	No sample				
Date		11/03/14	12/06/14	11/08/14	20/11/14				
Temp	^{0}C	12.1	14.2			12.0			
Dissolved Oxygen % sat		57.6	70			66.4			
pH	pH units	7.0	7.0			7.0	6.5 – 9.5		6.5 to 9.5
EC	Us/cm						1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	2.4	3.4			9.7			
Ammonia	mg/l	95	80			49	0.15mg/l	65 – 175 ug/l	0.30 mg/l
Chloride	mg/l	661	1280			>2500	30	24 – 187.5	250
TON	mg/l	< 0.20	< 0.20			0.47			No abnormal change
TOC	mg/l	99.4	100.4			82.0			
T Coli	Cfu/100	4400	5700			310	0		0
F Coli	Cfu/100	2500	< 10			< 10	0		0
Arsenic	ug/l	1.8	< 5			< 1.0	10	7.5	10
Beryllium	ug/l	< 1.0	< 5						
Boron	ug/l	1300	1300				1,000	750	1,000
Cadmium	ug/l	< 0.02	< 0.1				5	3.75	5
Calcium	mg/l	280	250				200		200
Cobalt	ug/l	1.3	< 5						

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Iron	ug/l l	4300	3700			2500	200		200
Lead	ug/l	3.7	< 5				100	18.75	100
Magnesium	mg/l	130	150				50		50
Manganese	ug/l	1100	1100				50		50
Nickel	ug/l	1.5	< 5				20	15	20
Potassium	mg/l	97	86			140	5		12
Selenium	ug/l	1.5	< 5						10
Sodium	mg/l	390	720			8200	150	150	150
Strontium	ug/l	1200	1400						
Thallium	ug/l	< 1.0	< 5						
Uranium	ug/l	< 1.0	< 5				9		
Vanadium	ug/l	1.3	5.2						
Phenol	ug/l	BLD	BLD				0.5		

Note BH2 likely to be intercepting leachate

Table D.4: Summary of Groundwater Composition GW01

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	10.2	15.0	14.8	11.0	10.1			
Dissolved Oxygen % sat		50	70	42	43	63.9			
pH	pH units	7.2	7.2	7.2	7.1	7.2	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	NM	NM	NM	NM	NM	1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	8.4	8.2	6.7	10.6	7.7			
Ammonia	mg/l	0.26	0.69	0.69	0.16	4.5	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	NR	NR	NR	NR	>2500	30	24 – 187.5	250
TON	mg/l	0.29	0.4	< 0.20	< 0.20	< 0.20			No abnormal change
TOC	mg/l	6.6	7.1	10.4	10.1	14.1			
T Coli	Cfu/100	4900	10	560	>24000	5500	0		0
F Coli	Cfu/100	20	10	< 10	280	< 10	0		0
Arsenic	ug/l	13	6.1	< 10		13	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	1,000	480	770			1,000	750	1,000
Cadmium	ug/l	0.09	< 0.1	< 0.02			5	3.75	5
Calcium	mg/l	320	540	340			200		200
Cobalt	ug/l	13	5.7	2.8					
Iron	ug/l l	9,300	1400	440	150	18	200		200
Lead	ug/l	11	< 5	< 1.0			100	18.75	100
Magnesium	mg/l	330	280	210			50		50
Manganese	ug/l	590	590	560			50		50
Nickel	ug/l	23	7.9	4.2			20	15	20
Potassium	mg/l	100	60	59	7.9	59	5		12
Selenium	ug/l	4.2	< 5	< 10					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	2300	2000	1800	3400	2600	150	150	150
Strontium	ug/l	3100	4800	3200					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	1.9	< 5	1.7			9		
Vanadium	ug/l	19	7.3	NR					
Phenols	ug/l	BLD	BLD	0.06	NT		0.5		

Table D.5: Summary of Groundwater Composition GW02

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
		No access	No access	No access					
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C				11.0	9.6			
Dissolved Oxygen % sat					60	53.9			
pH	pH units				7.2	7.1	6.5 – 9.5		6.5 to 9.5
EC	Us/cm				NM	NM	1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$				10.2	10.9			
Ammonia	mg/l				0.27	1.5	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l				NR	>2500	30	24 – 187.5	250
TON	mg/l				0.25	0.83			No abnormal change
TOC	mg/l				12.3	18.0			
T Coli	Cfu/100				150	85	0		0
F Coli	Cfu/100				< 10	< 10	0		0
Arsenic	ug/l					< 1.0	10	7.5	10
Beryllium	ug/l								
Boron	ug/l						1,000	750	1,000
Cadmium	ug/l						5	3.75	5
Calcium	mg/l						200		200
Cobalt	ug/l								
Iron	ug/l l				8810	37	200		200
Lead	ug/l						100	18.75	100
Magnesium	mg/l						50		50
Manganese	ug/l						50		50
Nickel	ug/l						20	15	20
Potassium	mg/l				10	85	5		12

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Selenium	ug/l								10
Sodium	mg/l				2800	3000	150	150	150
Strontium	ug/l								
Thallium	ug/l								
Uranium	ug/l						9		
Vanadium	ug/l								
Phenols	ug/l				NT		0.5		

Table D.6: Summary of Groundwater Composition GW03

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	No sample			
Temp	^{0}C	9.3	14.9	16.4					
Dissolved Oxygen % sat		59	38	52					
pH	pH units	7.2	6.9	6.8			6.5 – 9.5		6.5 to 9.5
EC	Us/cm	NM	NM	NM			1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	6.4	11.9	13.5					
Ammonia	mg/l	0.26	0.35	0.28			0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	NR	NR	NR			30	24 – 187.5	250
TON	mg/l	< 0.20	< 0.20	< 0.20					No abnormal change
TOC	mg/l	6.0	10.6	9.7					
T Coli	Cfu/100	290	< 10	680			0		0
F Coli	Cfu/100	52	< 10	20			0		0
Arsenic	ug/l	14	7.7	< 10			10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	650	520	820			1,000	750	1,000
Cadmium	ug/l	< 0.02	< 0.1	< 0.02			5	3.75	5
Calcium	mg/l	400	720	720			200		200
Cobalt	ug/l	1.1	< 5	2.3					
Iron	ug/l l	7300	5800	1600			200		200
Lead	ug/l	< 1.0	< 5	< 1.0			100	18.75	100
Magnesium	mg/l	280	390	430			50		50
Manganese	ug/l	180	270	290			50		50
Nickel	ug/l	1.6	< 5	< 10			20	15	20
Potassium	mg/l	67	71	84			5		12
Selenium	ug/l	2	< 5	< 10					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	1800	3000	3400			150	150	150
Strontium	ug/l	3000	6300	6500					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	1	< 5	1.2			9		
Vanadium	ug/l	3.7	5.5	NR					
Phenols	ug/l	BLD	BLD	BLD			0.5		

Table D.7: Summary of Groundwater Composition GW04

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	14/08/14	20/11/14	17/02/15			
Temp	^{0}C	9.1	13.0	15.5	12.6	9.1			
Dissolved Oxygen % sat		25.6	18	27	22	43.8			
pH	pH units	7.3	7	7.0	7.0	7.4	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	1074	1142	1117	1129	1190	1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	0.3		NM	NM				
Ammonia	mg/l	0.048	< 0.02	0.028	< 0.02	0.028	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	128	132	127	121	125	30	24 – 187.5	250
TON	mg/l	< 0.20	0.69	2	1.1	< 0.20			No abnormal change
TOC	mg/l	1.3	2.8	1.6	3.6	2.3			
T Coli	Cfu/100	170	460	330	2700	350	0		0
F Coli	Cfu/100	< 10	< 10	20	< 10	< 10	0		0
Arsenic	ug/l	1.2	< 5	< 1.0		< 1.0	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	46	< 50	59			1,000	750	1,000
Cadmium	ug/l	0.04	< 0.1	0.05			5	3.75	5
Calcium	mg/l	98	100	99			200		200
Cobalt	ug/l	1.2	< 5	1.4					
Iron	ug/l l	1200	1600	1700	85	110	200		200
Lead	ug/l	1.2	< 5	2.4			100	18.75	100
Magnesium	mg/l	21	22	22			50		50
Manganese	ug/l	550	520	430			50		50
Nickel	ug/l	2.7	< 5	2.5			20	15	20
Potassium	mg/l	1.7	1.4	1.8	< 0.25	1.1	5		12
Selenium	ug/l	< 1.0	< 5	< 1.0					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	87	78	86	8.3	90	150	150	150
Strontium	ug/l	180	210	190					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	1.9	< 5	2.2			9		
Vanadium	ug/l	3.6	6	3.5					
Phenol	ug/l	BLD	BLD	BLD	NT		0.5		

Table D.8: Summary of Groundwater Composition GW05

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	9.9	13.4	13.8	12.7	9.3			
Dissolved Oxygen % sat		15.9	21.0	22.0	23.0	33.1			
pH	pH units	7.2	7.0	7.0	7.1	7.5	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	970	997	1005	982	995	1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	NM	NM	NM	NM				
Ammonia	mg/l	0.081	< 0.02	0.08	< 0.02	< 0.02	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	116	119	132	112	114	30	24 – 187.5	250
TON	mg/l	1.1	1	0.55	1.3	0.95			No abnormal change
TOC	mg/l	1.4	1.7	1.4	2.1	1.2			
T Coli	Cfu/100	990	170	20	150	20	0		0
F Coli	Cfu/100	< 10	< 10	10	< 10	< 10	0		0
Arsenic	ug/l	1.3	< 5	1.2		< 1.0	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	33	< 50	31			1,000	750	1,000
Cadmium	ug/l	0.08	0.11	0.08			5	3.75	5
Calcium	mg/l	93	88	89			200		200
Cobalt	ug/l	< 1.0	< 5	< 1.0					
Iron	ug/l l	2500	2800	1600	92	83	200		200
Lead	ug/l	2.5	< 5	1.7			100	18.75	100
Magnesium	mg/l	21	21	22			50		50
Manganese	ug/l	200	520	620			50		50
Nickel	ug/l	3	< 5	2.1			20	15	20
Potassium	mg/l	2.3	2.2	2	< 0.25	1.3	5		12

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Selenium	ug/l	< 1.0	< 5	< 1.0					10
Sodium	mg/l	72	64	75	7.3	76	150	150	150
Strontium	ug/l	140	160	140					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	2.4	< 5	2.7			9		
Vanadium	ug/l	6.3	10	4.3					
Phenols	ug/l	BLD	BLD	BLD	NT		0.5		

Table D.9: Summary of Groundwater Composition GW06

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	No sample too sandy			
Temp	^{0}C	9.1	No sample too much sand in bh	No sample too much sand in bh	No sample too much sand in bh				
Dissolved Oxygen % sat		19.0							
pH	pH units	7.0					6.5 – 9.5		6.5 to 9.5
EC	Us/cm	1676					1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	0.6							
Ammonia	mg/l	2.6					0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	246					30	24 – 187.5	250
TON	mg/l	< 0.20							No abnormal change
TOC	mg/l	11.9							
T Coli	Cfu/100	>6100					0		0
F Coli	Cfu/100	41					0		0
Arsenic	ug/l	520					10	7.5	10
Beryllium	ug/l	<1.0							
Boron	ug/l	60					1,000	750	1,000
Cadmium	ug/l	0.21					5	3.75	5
Calcium	mg/l	190					200		200
Cobalt	ug/l	<1.0							
Iron	ug/l l	1100					200		200
Lead	ug/l	4.9					100	18.75	100

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Magnesium	mg/l	24					50		50
Manganese	ug/l	1300					50		50
Nickel	ug/l	2.5					20	15	20
Potassium	mg/l	7.3					5		12
Selenium	ug/l	<1.0							10
Sodium	mg/l	120					150	150	150
Strontium	ug/l	600							
Thallium	ug/l	<1.0							
Uranium	ug/l	3.3					9		
Vanadium	ug/l	2.6							
Phenols	ug/l	BLD					0.5		

Note GW6 likely to be intercepting leachate

Table D.10: Summary of Groundwater Composition GW07

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	9.6	12.5	16.4	10.3	8.1			
Dissolved Oxygen % sat		30.7	20	20.0	19.0	19.6			
pH	pH units	7.0	6.8	6.7	6.9	7.1	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	1624	1812	1854	1824	1832	1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	0.6			0.7				
Ammonia	mg/l	6.2	8.2	9.7	0.37	6.7	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	207	216	213	236	224	30	24 – 187.5	250
TON	mg/l	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20			No abnormal change
TOC	mg/l	5.6	8.5	9.4	9.3	7.7			
T Coli	Cfu/100	< 10	< 10	1500	260	20	0		0
F Coli	Cfu/100	< 10	< 10	41	< 10	< 10	0		0
Arsenic	ug/l	18	16	13		5.1	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	150	200	260			1,000	750	1,000
Cadmium	ug/l	< 0.02	< 0.1	< 0.02			5	3.75	5
Calcium	mg/l	180	190	200			200		200
Cobalt	ug/l	< 1.0	< 5	< 1.0					
Iron	ug/l l	22000	20000	14000	30500	4800	200		200
Lead	**ug/l**	**1.9**	**< 5**	**< 1.0**			**100**	**18.75**	**100**
Magnesium	mg/l	25	28	27			50		50
Manganese	ug/l	2100	2300	2300			50		50
Nickel	ug/l	< 1.0	< 5	< 10			20	15	20
Potassium	mg/l	12	13	16	1.5	13	5		12
Selenium	ug/l	< 1.0	< 5	< 1.0					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	100	110	110	11	100	150	150	150
Strontium	ug/l	820	970	970					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	< 1.0	< 5	< 1.0			9		
Vanadium	ug/l	1.7	8	2.2					
Phenols	ug/l	BLD	BLD	BLD	NT		0.5		

Note GW7 likely to be intercepting leachate

TableD.11: Summary of Groundwater Composition GW08

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	9.5	12.7	14.7	12.1	8.5			
Dissolved Oxygen % sat		19.0	13.0	12.0	14.0	15.5			
pH	pH units	7.2	7.0	7.1	7.1	7.2	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	3030	2100	2060	2070	2010	1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	1.4	0.9	0.9	0.9				
Ammonia	mg/l	11	13	13	0.45	13	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	599	293	309	319	267	30	24 – 187.5	250
TON	mg/l	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20			No abnormal change
TOC	mg/l	10.7	10.3	12.9	11.2	11.5			
T Coli	Cfu/100	41	86	>24196	460	< 10	0		0
F Coli	Cfu/100	< 10	< 10	41	< 10	< 10	0		0
Arsenic	ug/l	25	46	21		12	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	290	330	400			1,000	750	1,000
Cadmium	ug/l	< 0.02	< 0.1	< 0.02			5	3.75	5
Calcium	mg/l	180	160	160			200		200
Cobalt	ug/l	< 1.0	< 5	< 1.0					
Iron	ug/l l	13000	12000	6600	19300	3100	200		200
Lead	ug/l	< 1.0	< 5	< 1.0			100	18.75	100
Magnesium	mg/l	47	34	34			50		50
Manganese	ug/l	2000	2200	2000			50		50
Nickel	ug/l	1.9	< 5	< 10			20	15	20
Potassium	mg/l	22	19	22	1.8	21	5		12
Selenium	ug/l	< 1.0	< 5	< 1.0					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	350	160	180	20	160	150	150	150
Strontium	ug/l	920	950	890					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	< 1.0	< 5	< 1.0			9		
Vanadium	ug/l	1.6	5.8	1.6					
Phenols	ug/l	BLD	BLD	BLD	BLD		0.5		

Note – No site investigation details but may be intercepting leachate

Table D.12: Summary of Groundwater Composition BH8

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	9.6	12.6	13.7	10.9	9.8			
Dissolved Oxygen % sat		25	33	28	19.0	28			
pH	pH units	7.1	7.4	6.9	7.1	7.2	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	NM	6990	NM	NM	NM	1,000	800 - 1875	1,500
Salinity	$^{0}/_{00}$	8.4	3.8	3.4	5.5	3.2			
Ammonia	mg/l	0.24	0.075	0.1	0.04	0.031	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	NR	2060	NR	995	1730	30	24 – 187.5	250
TON	mg/l	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20			No abnormal change
TOC	mg/l	2.0	2.3	1.9	2.7	2.0			
T Coli	Cfu/100	< 10	10	120	< 10	< 10	0		0
F Coli	Cfu/100	< 10	< 10	< 10	< 10	< 10	0		0
Arsenic	ug/l	< 1.0	< 5	1.5		1.1	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	710	290	320			1,000	750	1,000
Cadmium	ug/l	0.24	0.16	0.06			5	3.75	5
Calcium	mg/l	370	180	160			200		200
Cobalt	ug/l	1.8	< 5	1.2					
Iron	ug/l l	1600	1900	1700	80	< 10.0	200		200
Lead	ug/l	< 1.0	< 5	1.6			100	18.75	100
Magnesium	mg/l	330	110	110			50		50
Manganese	ug/l	3400	890	360			50		50
Nickel	ug/l	4.3	< 5	1.6			20	15	20
Potassium	mg/l	49	18	21	2.9	18	5		12
Selenium	ug/l	2.1	< 5	1.1					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	2500	960	890	1600	810	150	150	150
Strontium	ug/l	1900	930	780					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	5.2	< 5	4.2			9		
Vanadium	ug/l	< 1.0	< 5	1.3					
Phenols	ug/l	BLD	BLD	BLD	NT		0.5		

Table D.13: Summary of Groundwater Composition BH9

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		11/03/14	12/06/14	11/08/14	20/11/14	17/02/15			
Temp	^{0}C	10.7	12.2	12.4	11.6	11.1			
Dissolved Oxygen % sat		21.0	14.0	13.0	17.0	15.0			
pH	pH units	7.1	7.0	6.9	7.1	7.4	6.5 – 9.5		6.5 to 9.5
EC	Us/cm	3240	1217	1126	1041	1058	1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	1.5			NM				
Ammonia	mg/l	0.34	0.29	0.30	0.26	0.25	0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	792	199	182	140	145	30	24 – 187.5	250
TON	mg/l	<0.20	< 0.20	< 0.20	< 0.20	< 0.20			No abnormal change
TOC	mg/l	1.2	1.8	1.0	1.5	1.1			
T Coli	Cfu/100	1200		41	2100	< 10	0		0
F Coli	Cfu/100	120		< 10	190	< 10	0		0
Arsenic	ug/l	1	< 5	2.3		1.3	10	7.5	10
Beryllium	ug/l	< 1.0	< 5	< 1.0					
Boron	ug/l	160	74	78			1,000	750	1,000
Cadmium	ug/l	0.05	< 0.1	0.04			5	3.75	5
Calcium	mg/l	91	55	53			200		200
Cobalt	ug/l	1.7	< 5	1.5					
Iron	ug/l l	1000	3400	2100	110	94	200		200
Lead	ug/l	1.1	< 5	2.2			100	18.75	100
Magnesium	mg/l	65	27	25			50		50
Manganese	ug/l	2000	940	940			50		50
Nickel	ug/l	1.6	< 5	2.2			20	15	20
Potassium	mg/l	14	6.4	6.1	0.57	5.4	5		12
Selenium	ug/l	< 1.0	< 5	< 1.0					10

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	450	130	130	13	110	150	150	150
Strontium	ug/l	410	180	160					
Thallium	ug/l	< 1.0	< 5	< 1.0					
Uranium	ug/l	< 1.0	< 5	< 1.0			9		
Vanadium	ug/l	< 1.0	9.2	4.3					
Phenols	ug/l	BLD	BLD	BLD	NT		0.5		

Table D.14: Summary of Groundwater Composition RC4

Range	Units	Q1 2012	Q2 2012	Q3 2012	Q4 2012		IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		07/02/12	14/05/12		12/11/2012				
Temp	^{0}C	11.5	12.5	14	12.6				
Dissolved Oxygen % sat		57	50.5	52	NT				
pH	pH units	7.1	7.1	7.1	7.1		6.5 – 9.5		6.5 to 9.5
EC	Us/cm	NT	NT	NT	5110		1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	33.1	33.1	33	NT				
Ammonia	mg/l	4.8	5.1		4.1		0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	NT	NT	NT	8221		30	24 – 187.5	250
TON	mg/l	NT	BLD	BLD	BLD				No abnormal change
TOC	mg/l	NT	3	3.8	NT				
T Coli	Cfu/100	BLD	BLD	BLD	NT		0		0
F Coli	Cfu/100	BLD	BLD	BLD	NT		0		0
Arsenic	ug/l	85					10	7.5	10
Beryllium	ug/l	< 5							
Boron	ug/l						1,000	750	1,000
Cadmium	ug/l	< 5					5	3.75	5
Calcium	mg/l	610					200		200
Cobalt	ug/l	8.4							
Iron	ug/l l	2,600	NT	3,100	NT		200		200
Lead	ug/l	< 5					100	18.75	100
Magnesium	mg/l	1300					50		50
Manganese	ug/l	6100					50		50
Nickel	ug/l	9.4					20	15	20
Potassium	mg/l	470	NT	290	NT		5		12
Selenium	ug/l	300							10

Range	Units	Q1 2012	Q2 2012	Q3 2012	Q4 2012		IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	12,000	NT	4900	NT		150	150	150
Strontium	ug/l								
Thallium	ug/l	< 5							
Uranium	ug/l	8.1					9		
Vanadium	ug/l	97							
Phenols	ug/l	BLD	NT	BLD	NT		0.5		
List I / II organics	Ug/l	BLD							

Table D.15: Summary of Groundwater Composition RC5

Range	Units	Q1 2012	Q2 2012	Q3 2012	Q4 2012		IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Date		06/02/12	14/05/12		No sample				
Temp	^{0}C	12.1	12.5	13.8					
Dissolved Oxygen % sat		37	26.2	33					
pH	pH units	6.9	7	7			6.5 – 9.5		6.5 to 9.5
EC	Us/cm	NT	NT	NT			1,000	800 - 1875	1,500
Salinity	$^0/_{00}$	31.4	31	31					
Ammonia	mg/l	35	33	33			0.15mg/l	65 – 175 ug/l	0.30
Chloride	mg/l	NT	NT	NT			30	24 – 187.5	250
TON	mg/l	NT	BLD	BLD					No abnormal change
TOC	mg/l	5.6	5.5	6.7					
T Coli	Cfu/100	BLD	BLD	10			0		0
F Coli	Cfu/100	BLD	BLD	< 5			0		0
Arsenic	ug/l	73					10	7.5	10
Beryllium	ug/l	< 5							
Boron	ug/l						1,000	750	1,000
Cadmium	ug/l	< 5					5	3.75	5
Calcium	mg/l	590					200		200
Cobalt	ug/l	12							
Iron	ug/l l	1800	NT	5400			200		200
Lead	ug/l	< 5					100	18.75	100
Magnesium	mg/l	1200					50		50
Manganese	ug/l	850					50		50
Nickel	ug/l	10					20	15	20
Potassium	mg/l	250	NT	140			5		12
Selenium	ug/l	270							10

Range	Units	Q1 2012	Q2 2012	Q3 2012	Q4 2012		IGV	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit
Sodium	mg/l	11,000	NT	6200			150	150	150
Strontium	ug/l								
Thallium	ug/l	< 5							
Uranium	ug/l	6.1					9		
Vanadium	ug/l	82							
Phenols	ug/l	BLD	NT	BLD			0.5		
List I / II organics		BLD							

APPENDIX E

LEACHATE MONITORING DATA

Table E.1: Summary of Leachate Composition BH1/1

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2015	Q1 2015	Interim Guideline Value for Groundwater GSI / EPA	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit	Methanogenic Leachate Landfill Site Design Manual (EPA, 2000 Table 7.2)
Date		11/03/14	11/06/14	11/08/14	21/11/14	17/02/15				
Temp	^{0}C					9.0				
pH	pH units	6.9	6.8		6.8	7.0			6.5 to 9.5	6.8 to 8.2
EC	Us/cm	2,920	4,810		1,697	4,160		800 - 1875	1,500	5,990 to 19,300
TON	mg/l	< 0.20	< 0.20		< 0.20	< 0.20			No abnormal change	
Chloride	mg/l	564	1130		143	926		24 – 187.5	250	570 to 4,710
Potassium	mg/l	23	31		1.1	35			12	100 to 1,580
Sodium	mg/l	300	590		8.9	530		150	150	474 to 3,650
Ammonia	mg/l	19	23		4.6	20		0.065 to 0.175	0.30	283 to 2,040 ammoniacal nitrogen-N
Alkalinity	mg/l						No abnormal change			3,000 to 9,130
Iron	ug/l l	18000	18000		680	1,000			200	1.6 to 160 mg/l
Boron	ug/l	450	680				1000	750	1,000	
Cadmium	ug/l	< 0.02	< 0.1				5	3.75	5	< 0.01 to 0.08 mg/l
Calcium	mg/l	200	180				200		200	23 to 501
Chromium	ug/l		< 5				30	37.5	50	< 0.03 to 0.56 mg/l
Copper	ug/l		22				30	1,500	2,000	< 0.02 to 0.62

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2015	Q1 2015	Interim Guideline Value for Groundwater GSI / EPA	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit	Methanogenic Leachate Landfill Site Design Manual (EPA, 2000 Table 7.2)
										mg/l
Cyanide	ug/l				37.5		10	37.5	50	
Fluoride	mg/l		< 2.5				1.0		1,000	
Lead	ug/l	< 1.0	< 5					18.75	100	< 0.04 to 1.9 mg/l.
Magnesium	mg/l	45	83				50		50	40 to 1,580
Mercury	ug/l		< 0.50				1	0.75	1	< 0.0001 to 0.0008 mg/l
Sulphate	mg/l		< 25				200	187.5	250	< 5 to 322
Zinc	ug/l		68				100		5,000	0.03 to 6.7
F Coli	Cfu/100	< 10	< 10		63	< 10	0		0	
T Coli	Cfu/100	1100	370		6100	52	0		0	
Molybdenum	ug/l		< 5							
Arsenic	ug/l	2.4	< 5			1.9		7.5	10	< 0.001 to 0.485mg/l
Beryllium	ug/l	< 1.0	< 5							
Cobalt	ug/l	< 1.0	< 5							
Manganese	ug/l	1,000	1,000				20		50	0.04 to 3.59 mg/l
Nickel	ug/l	< 1.0	< 5					15	20	< 0.03 to 0.6 mg/l
Selenium	ug/l	< 1.0	< 5						10	
Strontium	ug/l	930	1,100							
Thallium	ug/l	< 1.0	< 5							
Vanadium	ug/l	< 1.0	< 5							
Antimony	ug/l	< 1.0	< 5						5	
TOC	mg/l	8.8			8.2	9.4				

Range	Units	Q1 2014	Q2 2014	Q3 2014	Q4 2015	Q1 2015	Interim Guideline Value for Groundwater GSI / EPA	Environmental Objectives Groundwater Regulations SI No. 9 of 2010 Threshold Range	Drinking Water Limit	Methanogenic Leachate Landfill Site Design Manual (EPA, 2000 Table 7.2)
List I / II organics		< LOD								

Appendix I

Leachate Removal Records

Leachate Removal Record - Tramore Landfill

Compliance with Conditions 8.2, 11.9 and 11.10 of Licence W0075-02

Date of Removal	Time of Removal	Amount Removed			Name and Address of Approved Carrier	Carrier Permit Number	Vehicle Reg	Final Destination of Leachate	Spillages during Removal/
		Tonnes	Cubic Meters	Gallons					
02/03/2016	10:00:00	38	35.8758	7972.4	Power Waste Disposal, Curraghduff, Carrick on Suir, Co. Waterford	WCP-KK-10-127-02	N/A	Tramore Waste Water Treatment Plant, Crobally Upper, Tramore, Co. Waterford	No