From:	Peters, Anne
To:	Magnus Amajirionwu
Cc:	Eve O''Sullivan; James O''Neill; Bernie Guinan; McKenna, Kieran
Subject:	RE: [External] Tipperary Closed Landfill
Date:	28 September 2018 17:11:08
Attachments:	image001.png image003.png image004.png P0563_RPT_Addendum to Tier 3_0.pdf

---

Dear Magnus,

Please find attached revised Tier 3 Risk Assessment for the Closed Landfill at Tipperary Town.

Slán,
Anne Peters,
Acting Senior Executive Engineer,
Environment Section,
Tipperary County Council,
County Hall,
Clonmel,
Co. Tipperary.
Phone number 0761065000

Environment

From: Peters, Anne
Sent: 27 August 2018 13:24
To: 'Magnus Amajirionwu'
Cc: Eve O'Sullivan; James O'Neill; Bernie Guinan; McKenna, Kieran
Subject: RE: [External] Tipperary Closed Landfill

Magnus,

As requested in your email below Tipperary County Council will submit an updated tier 3 risk assessment.

Slán,
Anne Peters,
Acting Senior Executive Engineer,
Environment Section,
Tipperary County Council,
County Hall,
Clonmel,

Co. Tipperary.
Phone number 0761065000

From: Magnus Amajirionwu [mailto:M.Amajirionwu@epa.ie]
Sent: 14 August 2018 10:16
To: Peters, Anne
Cc: Eve O'Sullivan
Subject: RE: [External] Tipperary Closed Landfill

Dear Anne,

Thanks for the response. The AA screening report would be assessed in due course.

Meanwhile, can you please forward the following to the Agency:

- Updated copy of Tier 3 risk assessment for the site including results of all monitoring events carried out from 2011 to date.
- Documentation in respect of the Qualified Person's **professional body**, having regard to the Code of Practice.

Kind regards

Magnus

From: Peters, Anne [mailto:anne.peters@tipperarycoco.ie]
Sent: 10 August 2018 16:40
To: Magnus Amajirionwu
Cc: McKenna, Kieran; Bernie Guinan; James O'Neill
Subject: RE: [External] Tipperary Closed Landfill

Dear Magnus,

In reply to your email below:

I have prepared a new AA for the proposed development. Please find attached. On reviewing the AA that was prepared in 2011 the stream flow direction was misreported and did not represent the actual stream flow on the ground. This AA was based on just one round of environmental monitoring. The new AA attached is based on environmental monitoring carried out over a number of years and the correct direction of stream flow.

I request that that you review the AA attached and that the recommendations from the review of the previous AA submitted be set aside. This AA was based on information that was not factually correct.

I have also attached the documentation in respect of the Qualified Person, James O'Neill , having regard to the Code of Practice.

Hard copy to follow in the post.

Slán,
Anne Peters,
Acting Senior Executive Engineer,
Environment Section,
Tipperary County Council,
County Hall,
Clonmel,
Co. Tipperary.
Phone number 0761065000

From: Magnus Amajirionwu [mailto:M.Amajirionwu@epa.ie]
Sent: 28 June 2018 16:04
To: O'Neill, Marion
Cc: Peters, Anne
Subject: [External] Tipperary Closed Landfill

Dear Marion,

I refer to your letter of 4th April 2018.

You had indicated in the later to contact the Agency again at the end of April with an update.

Can you please forward an update on the following:

- A full Natura Impact Statement to be prepared and submitted to the Agency.
- Reviewed copy of Tier 1, 2 and 3 risk assessment for the site.
- Documentation in respect of the Qualified Person, Chris Cronin, having regard to the Code of Practice.

Thanks and kind regards

Magnus

Dr. Magnus U. Amajirionwu
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Office of Environmental Sustainability
Environmental Protection Agency,
Johnstown Castle, Wexford, Ireland

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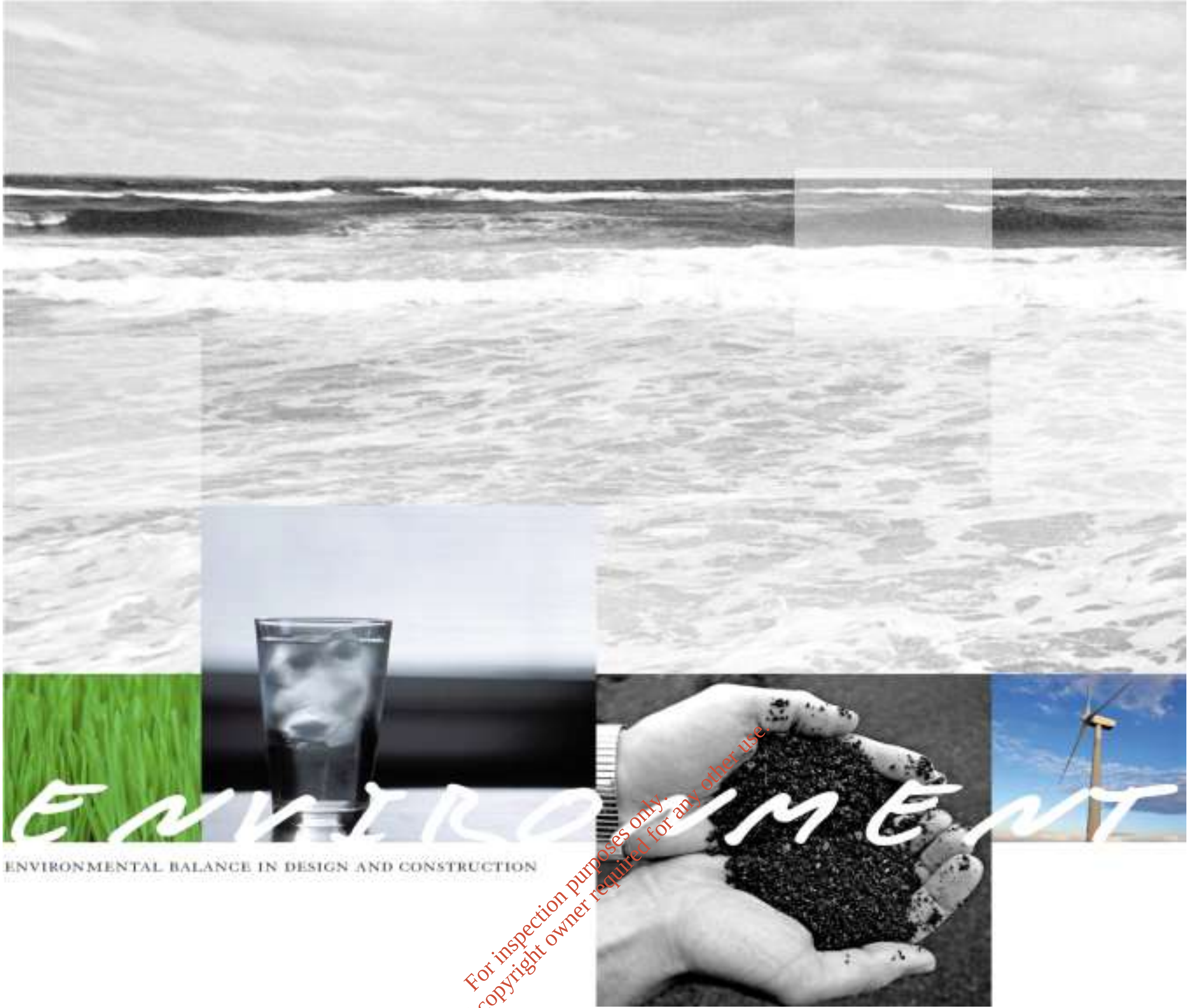
www.tipperarycoco.ie



ADDENDUM TO THE TIER 3 ENVIRONMENTAL RISK ASSESSMENT: TIPPERARY TOWN HISTORIC LANDFILL

TIPPERARY COUNCTY COUNCIL

SEPTEMBER 2018

Comhairle Contae Thiobraid Árann
Tipperary County Council

FEHILY TIMONEY & COMPANY

ADDENDUM TO THE TIER 3 ENVIRONMENTAL RISK ASSESSMENT: TIPPERARY TOWN HISTORIC LANDFILL

TIPPERARY COUNTY COUNCIL

User is Responsible for Checking the Revision Status of This Document

Rev. Nr.	Description of Changes	Prepared by:	Checked by:	Approved by:	Date:
00	Issue to Client	AB/CF	JON	BG	26/09/2018

Client: **Tipperary County Council**

Keywords: Addendum, Tier 3, Environmental Risk Assessment, Historic Landfill, Groundwater, Surface Water

Abstract: This document is presented as an addendum to the Tier 3 Environmental Risk Assessment of Tipperary Town Historic Landfill undertaken by O'Callaghan Moran & Associates in 2011. The Tier 3 risk assessment has been reviewed and updated by Fehily Timoney to account for additional monitoring data collected between 2011 and 2015 by Tipperary County Council and the EPA.

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1 INTRODUCTION

1.1 Background & Scope

A Tier 3 Environmental Risk Assessment (ERA) on Tipperary Town Historic Landfill was undertaken by O'Callaghan Moran & Associates (OCM) in October 2011, the ERA included an Appropriate Assessment (AA) Screening Report.

In August 2018, the EPA requested that the ERA be revised to take account of additional environmental monitoring that was undertaken since the submission of the ERA and 2015

This document is prepared as an addendum to the Tier 3 ERA prepared by OCM, to include for the TCC/EPA monitoring data results, an updated ERA and an assessment of the classification of the site.

2 TIER 3 ENVIRONMENTAL RISK ASSESSMENT SUMMARY

A Tier 3 Environmental risk assessment was undertaken by OCM in October 2011 in accordance with the EPA Code of Practice for Unregulated Waste Disposal sites and is attached in Appendix 1.

The OCM ERA relied upon the following works completed by OCM and TCC:

- Desk Study (Tier 1 Desk Study undertaken by TCC)
- Site Investigations (as part of Tier 2 undertaken by OCM)
  - Trial Pitting and trenching to determine extents of waste
  - Installation of groundwater monitoring wells
  - Installation of leachate monitoring well
  - Geophysical Survey
- Environmental Monitoring
- Quantitative Risk Assessments

2.1 Desk Study and Site investigations

The desk study and site investigations undertaken confirm the previous use of the site as an historic landfill. The site was classified High Risk (Class A) due to the risk posed to surface water, as surface water drains are within 50m of the site. Impact on surface water was considered low, however it was determined leachate migration into the wetland surrounding the site and land drains is possible.

The impact on groundwater was also considered low. Very stiff clay was observed during the installation of monitoring wells; hence it was assumed that this clay layer above the bedrock inhibits the vertical migration of leachate to bedrock. Significant dilution of leachate was noted between the landfill and groundwater, based on the substantial reduction in manganese, chloride and ammonia concentrations measured between the leachate wells in the waste and the monitoring wells located beyond of the waste body. Water quality was monitored at the public groundwater abstraction located 1.4km down gradient of the landfill site and was considered good.

It was recommended from the Tier 2 produced by OCM that landfill gas, surface water quality and groundwater quality be monitored over a longer time period to establish the extent of remediation required.

2.2 OCM Tier 3 Environmental Monitoring (2010)

Site monitoring undertaken by OCM comprised of the following:

- Two rounds of surface water monitoring (SW1 – SW3), on July 13th 2010 and August 17th 2010;
- Two rounds of leachate monitoring (MH1 – MH3), on July 13th 2010 and August 17th 2010. The second round was analysed for a reduced list of parameters;
- Two rounds of groundwater monitoring (MH4 – MH8), on July 13th 2010 and August 17th 2010. The second round was analysed for a reduced list of parameters.
- Gas monitoring was conducted by TCC staff in March, April and May 2010 and by OCM in September 2010.
- Assessment of surface water flow directions

It was noted that SW2 and SW3 were not sampled on August 17th 2010 as the drain was dry.

2.2.1 Surface Water Monitoring Results

Elevated levels of ammonia, iron, manganese and chromium were recorded in the surface water monitoring results. The elevated levels of iron, manganese and chromium were mostly like due do elevated background concentrations as these parameters had similar levels recorded in the upstream monitoring location.

2.2.2 Leachate Monitoring Results

Multiple parameters within the leachate monitoring results of the Tier 3 exceeded the EPA Interim Guideline Values (IGVs) for Groundwater. OCM reported that these results confirmed the presence of an aged Stage IV leachate in the monitoring wells.

2.2.3 Groundwater Monitoring Results

The following parameters were noted to exceed the EPA IGVs. These are not statutory limit values but are useful to determine impacts on groundwater quality in the context of the EU Water Framework Directive.

Parameters exceeding IGVs July 13th 2010:

- MW4: Aluminium, barium, conductivity, iron, manganese, chloride
- MW5: Aluminium, barium, conductivity, iron, manganese, lead, sodium, chloride
- MW6: Aluminium, barium, conductivity, iron, manganese, ortho-phosphate
- MW8: Aluminium, barium, conductivity, iron, manganese, ortho-phosphate, sodium, chloride

Parameters exceeding IGVs August 17th 2010:

- MW4: Ammonia, conductivity, chloride
- MW6: Ammonia, conductivity, chloride
- MW7: Conductivity, chloride
- MW8: Conductivity, chloride

2.3 Tier 3 Quantitative Risk Assessment

OCM presented a revised risk assessment in the Tier 3 report, modified from the Tier 2 Assessment based on the Tier 3 findings and feedback from the EPA. The site was classified as High risk, as shown in Figure 2.1 below. The high-risk classification was associated with leachate and landfill gas risk. Leachate was designated a high risk due to potential leachate impacts on surface water because of the pathway present in the form of the drain at the south east of the site. The landfill gas risk was due to the building present on site, although out of use.

The risk rating is shown in Figure 2.1.

Note: The table below represents the Tier II Risk rating for this site. SPR1 to 9 represent the leachate risk scores. SPR10 & 11 represent Landfill Gas Risk. The migration pathways are colour coded as follows:

Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical

	Calculator	SPR Values	Maximum Score	Normalised Score
SPR1	1a x (2a + 2b + 2c) x 3e	189	300	63.00%
SPR2	1a x (2a + 2b + 2c) x 3b	63	300	21.00%
SPR3	1a x (2a + 2b) x 3a	98	240	40.83%
SPR4	1a x (2a + 2b) x 3b	49	240	20.42%
SPR5	1a x (2a + 2b) x 3c	245	400	61.25%
SPR6	1a x (2a + 2b) x 3d	147	560	26.25%
SPR7	1a x (2a + 2b) x 3e	147	240	61.25%
SPR8	1a x 2c x 3e	42	60	70.00%
SPR9	1a x 2c x 3b	14	60	23.33%
SPR10	1b x 2d x 3f	105	150	70.00%
SPR11	1b x 2e x 3f	175	250	70.00%
Overall Risk Score		245		70.00%
				A

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	Greater than or equal to 70% for any individual SPR linkage
Moderate Risk (Class B)	Between 40-70% for any individual SPR linkage
Lowest Risk (Class C)	Less than or equal to 40% for any individual SPR linkage

Risk Classification	HIGHEST

Figure 2-1: OCM Tier 3 Risk Rating

2.4 OCM Tier 3 Conclusions & Recommendations

The OCM Tier 3 report presented the following conclusions on surface water, groundwater and landfill gas. The report also included recommendations for remediation measures. The proposed recommendations and remediation measures are outlined below.

2.4.1 Surface Water

The OCM Tier 3 concluded that the impact of leachate on SW quality in the drain leaving the wetland is limited as only elevated Ammonia recorded. Elevated levels of iron, manganese and chromium were also detected in the surface water samples; however, it was concluded that this was mostly like due do elevated background concentrations as these parameters had similar levels recorded in the upstream monitoring location.

Remedial measures recommended to minimise risk to surface water included:

- Installation of a low permeability cap over the waste to reduce rainwater infiltration and hence decrease the leachate head generated within the waste;
- Investigation of the source of contamination in drain entering site from the west (upstream monitoring point);
- Further observations to determine surface water flow in drain entering the site from the south and monitor water quality to establish its status. (This drain was noted as dry during the Tier 3 assessment.)

2.4.2 Groundwater

The OCM Tier 3 concluded that there were some leachate impacts detected in shallow groundwater and due to the thickness of the subsoil above the bedrock aquifer, the risk posed to the bedrock aquifer was considered Low. Lateral leachate migration away from the margins of the landfill were considered insignificant due to the direction of GW flow and vertically because of hard low permeability clay underlying the site.

It was recommended the groundwater be monitored biannually following capping of the landfill.

2.4.3 Landfill Gas

The OCM Tier 3 concluded that methane and carbon dioxide were still being generated at significant levels within the waste body. No significant migration of gas away from landfill area was detected.

OCM Tier 3 recommended the following works to reduce the risk of landfill gas:

- Maintain existing gas wells and install additional landfill gas ventilation wells installed across the site to minimise the risk of build-up of landfill gas and minimise the risk of landfill gas migration;
- Install a landfill gas cut-off trench along the southern boundary of the capped fill area;
- Monitor all gas monitoring wells at least annually.

3 UPDATED ENVIRONMENTAL RISK ASSESSMENT

An update to the Tier 3 Environmental Risk Assessment undertaken by OCM is presented in the following subsections. The Tier 3 is being updated following a Stage 1 AA Screening undertaken by FT in June 2018 which analysed and presented monitoring data collected by TCC and the EPA between 2011 and 2015 at Tipperary Town Historic Landfill.

3.1 Appropriate Assessment

FT was retained by TCC to undertake a Stage 1 Appropriate Assessment (AA) Screening in May2018 to evaluate the potential impact(s) of the proposed Tipperary Town historic landfill remediation on the European sites located within a 15km radius. The surface water flow regime was observed on site and monitoring results collected by the EPA and TCC between 2011 and 2015 for surface water and leachate were presented in the Appropriate Assessment.

The results of this analysis are presented in Section 3.2.

3.2 Environmental Monitoring 2011- 2015 & Results

Surface water, leachate and groundwater were sampled between 2011 and 2015 by the EPA and TCC as per the monitoring locations presented in the Tier 3 report. Figure 3.1 shows the environmental monitoring locations at the site.

The surface water monitoring locations are SW1, SW2 and SW3.

SW3 is upstream of the landfill, located along the Fidaghta watercourse/drain where it enters the marsh to the west of the landfill. SW2 is located at the outflow of the marsh on the eastern side, at the beginning of the Spital-land watercourse/land drain. SW1 is located downstream of this point to the south, downstream of the Carrownreddy Road underpass.

Three leachate monitoring wells MW1, MW2 and MW3 are located within the landfill. The groundwater monitoring wells MW5, MW6, MW7 and MW8 are located around the south perimeter of the site and MW4 is located adjacent to SW1.

Monitoring results were not available for some monitoring locations due to low water levels on the day of sampling. The list of parameters analysed by the EPA and TCC varied between monitoring events.

The complete surface water, leachate and groundwater quality monitoring results are presented Appendix 2 to this document. A review of the results is presented below.

3.2.1 Surface Water

Surface water quality sampling was undertaken by TCC and the EPA across the 2011 to 2015 period.

The results reviewed for this revised ERA were taken on the following dates; 17/08/10; quarterly between December 2011 and May 2014; 23/07/14; 01/10/14 and 21/09/15. Results from all monitoring periods listed above are included in Appendix 2.

Overall the results of surface water monitoring presented were considered inconclusive in determining the impact of the landfill on surrounding water bodies. The results suggest that while there is some evidence of contamination at locations downstream of the landfill, there is also evidence to suggest that run-off from the surrounding agricultural land is impacting on water quality at monitoring locations upstream and downstream of the landfill.

The potential for indirect impacts due to the transport of emissions in the form of leachate and/or suspended solids along the hydrological corridor identified (via the Spital-Land, Ara, and Aherlow) to the Lower River Suir SAC requires consideration. In considering this potential for impacts to occur upon the Lower River Suir SAC, the in-stream distance between the landfill site and the Lower River Suir SAC (18.2 km) and given the small size and low capacity of the Spital-Land watercourse means any such impacts are extremely unlikely.

3.2.2 Leachate

The following leachate monitoring results carried out by TCC/EPA in the period 2011 -2015 are available; monitoring at MW1 and MW2 only on 23/07/14, monitoring at locations MW2 and MW3 on 17/08/10 (chloride only), monitoring at MW2 and MW3 on 01/10/14, monitoring at locations MW1 and MW2 in 21/09/15.

All rounds of leachate monitoring are included in Appendix 2.

While small variations are noted, the results obtained in these sampling rounds are generally below the minimum overall range of methanogenic leachate composition as outlined in Table 7.2 of the EPA's Landfill Operational Practice Guidance Manual, 1997. These results indicate that leachate quality is typical of weak leachate sampled from large landfills, as outlined in the Landfill Operational Practices Guidance Manual, EPA 1997 and EPA Manual on Landfill Site Design (2000).

3.2.3 Groundwater

Groundwater was sampled by TCC/EPA at MW4 and MW8 on 23/07/14, at MW4 and MW6 on 01/10/14 and at MW4, MW5 and MW6 on 21/09/15. The results of the sampling are included in Appendix 2.

The results of the groundwater monitoring in 2014 and 2015 were compared to the EPA IGVs as per the OCM Tier 3 report, as discussed in Section 2.3.2.

The following parameters were in exceedance of the IGVs:

Parameters exceeding IGVs July 23rd 2014:

- MW4: Chloride, aluminium, barium, iron, manganese
- MW8: conductivity, ammonia, chloride, ortho-phosphate, arsenic, barium, iron, manganese, mercury

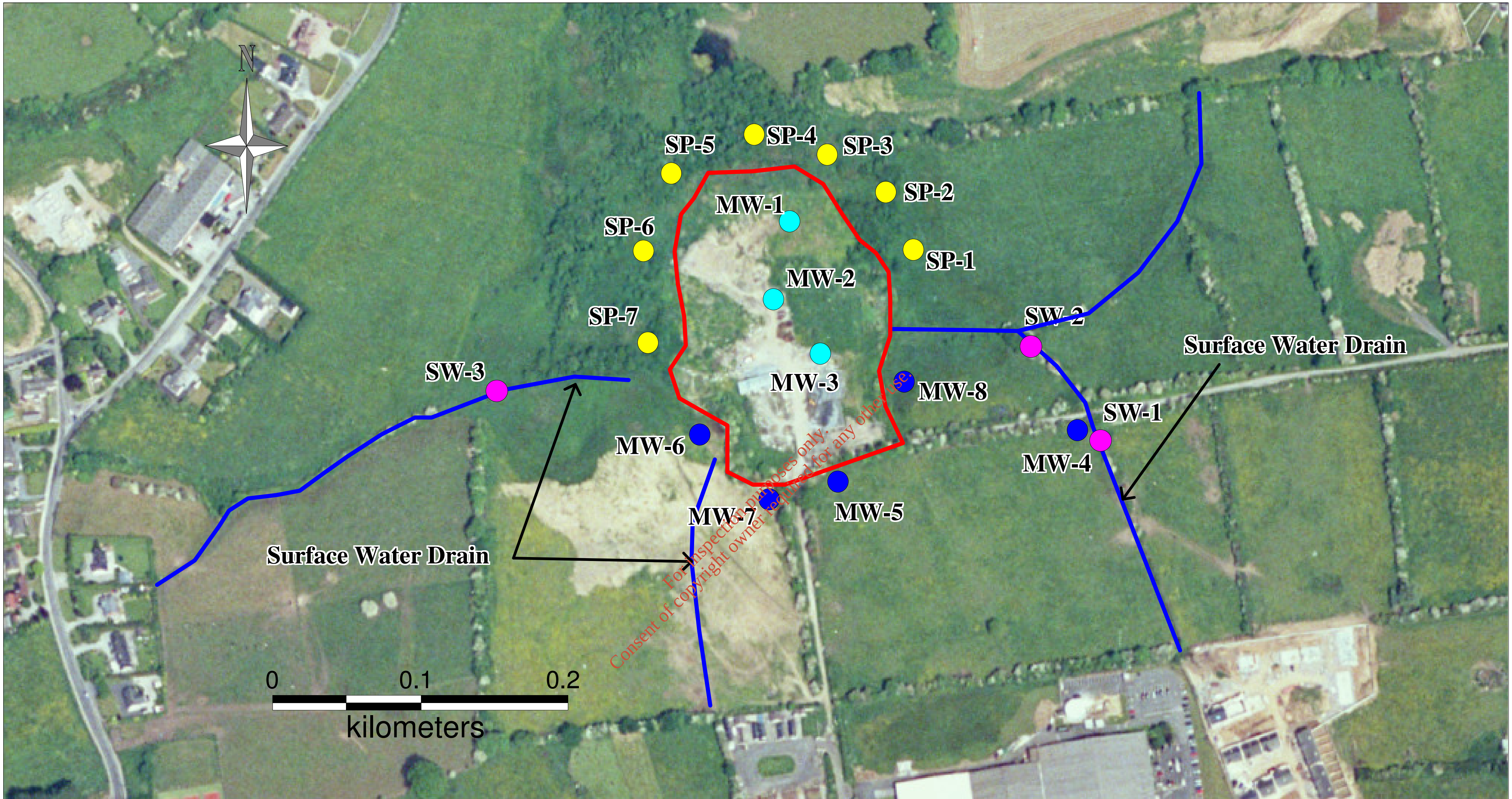
Parameters exceeding IGVs October 1st 2014:

- MW4: Conductivity
- MW6: Chloride

Parameters exceeding IGVs September 21st 2014:

- MW4: no exceedance
- MW5: Conductivity, chloride, calcium, sodium
- MW6: Conductivity, chloride, aluminium, calcium, manganese, potassium

All parameters that exceeded the IGVs in the 2014/2015 monitoring were also recorded in exceedance in the OCM Tier 3 monitoring results, with the addition of arsenic, mercury and potassium.



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email : info@ocallaghanmoran.com

environmental management for business

CLIENT

South Tipperary County Council

TITLE

Groundwater Landfill Gas Well Locations

Legend

- Groundwater Well
- Gas Well
- Surface Water Location
- Spike Probe Location

FIGURE No.

2.1

SCALE

3.2.4 Confirmation of Flow Regime

The flow regime presented in the 2011 OCM Tier 3 report was confirmed by FT during a site walkover on the 3rd May 2018 and is indicated in Figure 3.2 and 3.3. It was observed that the wetland surrounding the landfill mound drains from the south-western side into the Spital-Land watercourse, which flows south towards Tipperary town for c. 265 m before being channelled underground at the northern boundary of Rosanna Close housing estate. Due to the surrounding topography, the channel is assumed to continue underneath Tipperary town to join the Ara, which in turn joins the Aherlow, which flows into the Lower River Suir SAC c. 18.2 km downstream of the historical landfill site. The drain identified in the Tier 3 entering the site from the south was confirmed to flow from south to north and drain into the wetland area surrounding the landfill site.

This flow regime observed is in contradiction with the EPA watercourse mapping, which depicts the Fidaghta stream flowing from the west of the site, to continue east beyond the eastern side of the wetland, being joined by the Spital-Land stream, which is depicted flowing north from the town. The steams meet to continue to flow south east, eventually joining the River Suir. This is not the case as the actual onsite surface water flow regime was determined during the site visit. Large volumes of spoil have been deposited on the site, raising the land level, which may have altered the course of these streams. The headwaters of the Fidaghta are not located at the north-eastern corner of the wetland as indicated by the EPA, due to either a mapping error, or the deposition of spoil historically which may have altered to course of stream in this area (see flow mapping in Figures 3.2 & 3.3).

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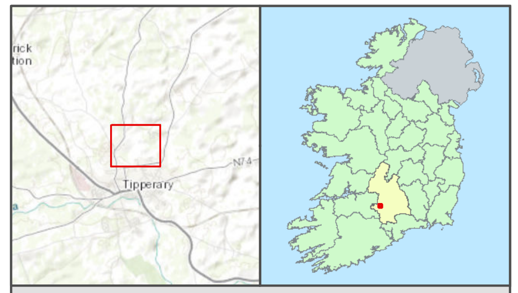

Co. Tipperary

Legend

- Landfill Boundary
- Indicative Footprint of Remedial Works
- WL1/WL2: Hedgerows / Treelines
- FW2: Depositing/Lowland Rivers
- FW4: Drainage Ditches
- BL3: Buildings and Artificial
- ED2/ED3/WS1: Spoil and Bare Ground / Recolonising Bare Ground / Scrub
- ED2/ED3: Spoil and Bare Ground / Recolonising Bare Ground
- ED2: Spoil and Bare Ground
- FS1: Reed and Large Sedge Swamps
- GA1/ED3: Improved Agricultural Grassland / Recolonising Bare Ground
- GA1: Improved Agricultural
- GS2: Dry Meadows and Grassy Verges
- GS4: Wet Grassland
- WD1: (Mixed) Broadleaved
- WN6: Wet Willow-Alder-Ash
- WS1: Scrub

Figure Title
Habitats

Figure No. 3.1

Project
Tipperary Town Historical Landfill Remediation

Client
Tipperary County Council

Scale 1:3,500 **Page Size** A3

Revision A **Date** 14/06/2018

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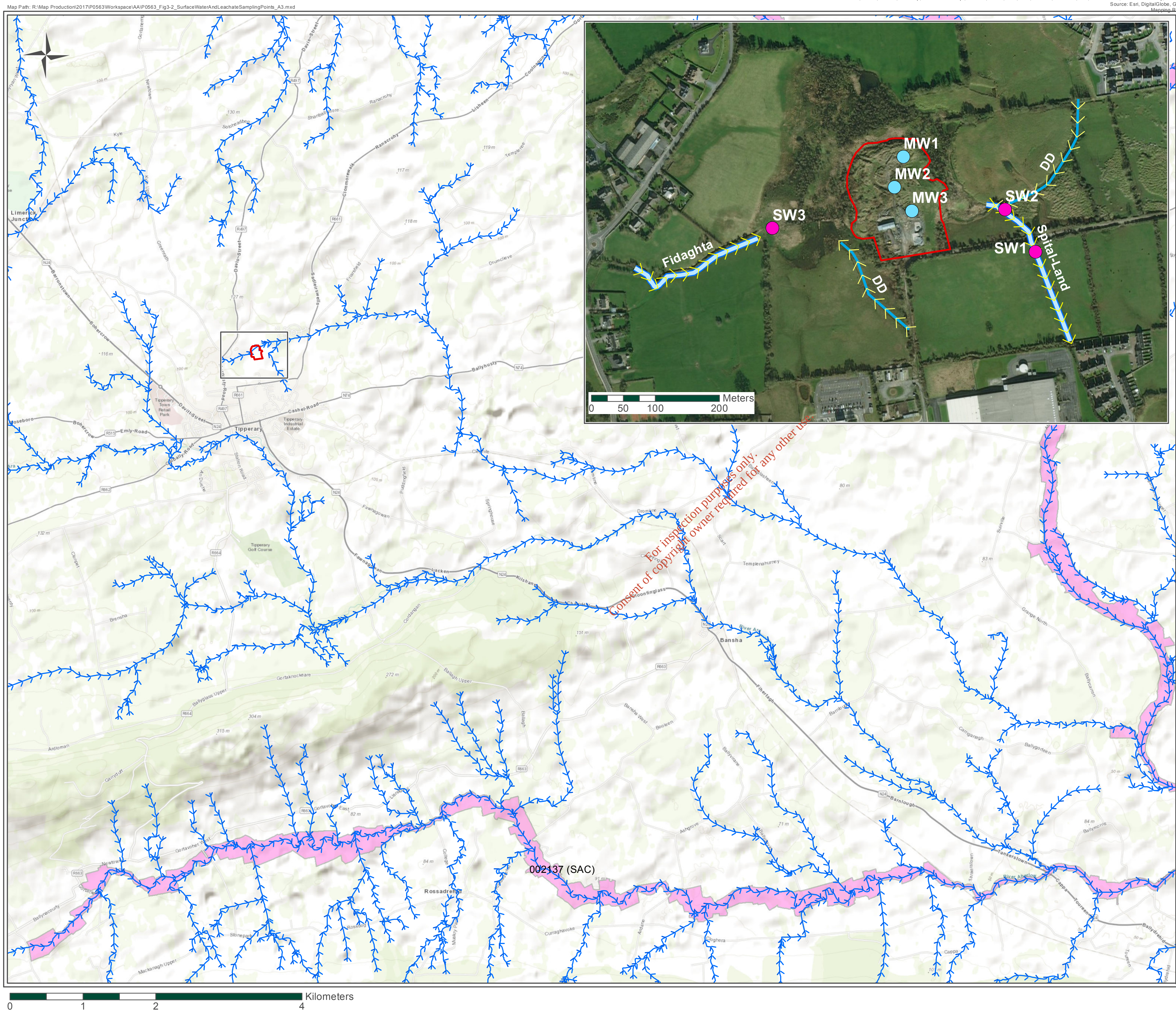
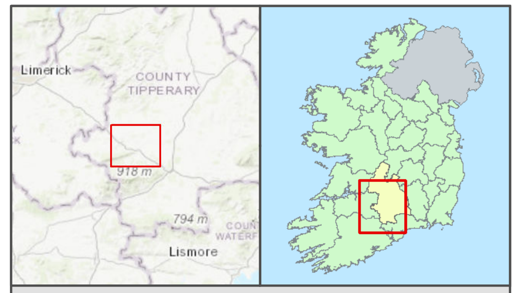
Map Path: R:\Map Production\2017\P0563\Workspace\AA\P0563_Fig3-2_SurfaceWaterAndLeachateSamplingPoints_A3.mxd





Co. Tipperary

Legend

- Landfill Boundary
- Leachate Sampling
- Surface Water Sampling
- Rivers
- Depositing/Lowland
- Drainage Ditches
- Special Area of Conservation

Figure Title	Surface Water and Leachate Sampling Points
Figure No.	3.2
Project	Tipperary Town Historical Landfill Remediation
Client	Tipperary County Council
Scale 1:50,000	**Page Size** A3
Revision A	**Date** 24/07/2018

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3.3 Updated Risk Assessment

The risk assessment rating presented in the OCM Tier 3 is updated in Table 3.1 and Table 3.2 below. The ERA is updated based on the results of the additional surface water, groundwater and leachate monitoring undertaken in the period 2011 -2015 since the original OCM.

The risk assessment is undertaken in accordance with the EPA CoP.

Table 3.1: Risk Classification Calculation

EPA Ref	Risk	Points	Rationale
1a	Leachate; source/hazard scoring matrix, based on waste footprint.	7	Based on an estimated waste footprint of >1 and ≤5 ha and a site that accepted domestic and industrial waste.
1b	Landfill gas; source/hazard scoring matrix, based on waste footprint.	7	Based on an estimated waste footprint of >1 and ≤5 ha and a site that accepted domestic and industrial waste.
2a	Leachate migration: Pathway (Vertical)	2	GSI describes the groundwater vulnerability as High across the entire site.
2b	Leachate migration: Pathway (Horizontal)	5	The bedrock is classified by the GSI as a Regionally Important Karstified (Rkd) aquifer.
2c	Leachate migration: Pathway (Surface water drainage)	2	Direct connection between the waste body and surface water stream.
2d	Landfill gas: Pathway (Lateral migration potential)	3	No residences within 250m of site; Karst bedrock, made ground
2e	Landfill gas: Pathway (Upwards migration potential)	3	No buildings above waste body; Made ground

EPA Ref	Risk	Points	Rationale
3a	Leachate migration: Receptor (Human presence)	2	Dwellings present greater than 50m but less than 250m of the waste body. Note: All houses can be served by public water
3b	Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/ groundwater dependent terrestrial ecosystems)	1	The nearest SAC/pNHA is located greater than 1 km from the waste body. The marsh has been considered as an undesignated GWDTE based on the precautionary approach
3c	Leachate migration: Receptor (Aquifer category – Resource potential)	5	The bedrock is classified by the GSI as a Regionally Important Karstified (Rkd) aquifer.
3d	Leachate migration: Receptor (Public water supplies – other than private wells)	3	Public water supply is greater than 1km away (Tipperary Co-op) Karst bedrock – but different geological formation
3e	Leachate migration: Receptor (Surface water bodies)	3	Surface water drain within 50m of site boundary
3f	Landfill Gas: Receptor (Human presence)	5	Empty building on site.

Table 3.2: Normalised Score of S-P-R Linkage

Calculator		S-P-R Values	Maximum Score	Linkage	Normalised Score
Leachate migration through combined groundwater and surface water pathways					
SPR1	1a x (2a + 2b + 2c) x 3e	7 x (2+5+2) x 3 = **189**	300	Leachate => surface water	63%
SPR2	1a x (2a + 2b + 2c) x 3b	7 x (2+5+2) x 1 = **63**	300	Leachate => SWDTE	21%
Leachate migration through groundwater pathway					
SPR3	1a x (2a + 2b) x 3a	7 x (2+5) x 2 = 9**8**	240	Leachate => human presence	41%
SPR4	1a x (2a + 2b) x 3b	7 x (2+5) x 1 = **49**	240	Leachate => GWDTE	20%
SPR5	1a x (2a + 2b) x 3c	7 x (2+5) x 5 = **245**	400	Leachate => Aquifer	61%
SPR6	1a x (2a + 2b) x 3d	7 x (2+5) x 3 = **147**	560	Leachate => Surface Water	26%
SPR7	1a x (2a + 2b) x 3e	7 x (2+5) x 3 = 105	240	Leachate => SWDTE	61%
Leachate migration through surface water pathway					
SPR8	1a x 2c x 3e	7 x 2 x 3 = **42**	60	Leachate => Surface Water	**70%**
SPR9	1a x 2c x 3b	7 x 2 x 1 = **14**	60	Leachate => SWDTE	20%
Landfill gas migration pathway (lateral & vertical)					
SPR10	1b x 2d x 3f	7 x 3 x 5 = **105**	150	Landfill Gas => Human Presence	**70%**
SPR11	1b x 2e x 3f	7 x 5 x 5 = **175**	250	Landfill Gas => Human Presence	**70%**
Site maximum S-P-R Score					**70%**
Risk Classification					**A - Highest**

Table 3.2 shows the maximum S-P-R scoring for the site is **70%.**

The following are the risk classifications applied:

- Highest Risk (Class A) — Greater than 70 for any individual SPR linkage
- Moderate Risk (Class B) — 41-69 for any individual SPR linkage
- Lowest Risk (Class C) — Less than 40 for any individual SPR linkage

Based on this, the site can be classified as a **high-risk classification (Class A)**, confirming the risk assessment assigned to the site in the 2011 OCM Tier 3 report as presented in Section 2.2.

The EPA describes these sites as having "a high risk or high level of uncertainty, which requires further examination through Risk Assessment Methodology Tier 2".

3.4 Updated Remediation Recommendations

The remediation recommendations presented in the OCM Tier 3 reported were reviewed by FT following the updated risk assessment.

3.4.1 Surface Water

The updated risk assessment following the analysis of monitoring data between 2011 and 2015 confirms the requirement for remedial measures as recommended in the OCM Tier 3. The recommended remedial measures to reduce the impact to surface water were:

- Install a low permeability cap over the waste to reduce rainwater infiltration and hence decrease the leachate head generated within the waste;
- Investigate source of contamination in drain entering site from the west (upstream monitoring point)

The updated risk assessment confirms this requirement.

3.4.2 Groundwater

The installation of an engineered landfill capping over the waste area as previously recommended to reduce rainwater infiltration into the waste body, reducing leachate generation and hence reducing impacts on the groundwater quality.

Further to this, a program of groundwater monitoring on a biannual following capping of the landfill was recommended.

The updated risk assessment confirms this requirement.

3.4.3 Landfill Gas

Updates monitoring results for landfill gas were not available to include in this report. FT however agree with the recommendations made in the OCM Tier 3 to reduce the risk of landfill gas are still appropriate given the nature of the interred waste and the proximity of receptors. The recommended remedial measures to reduce the impact to surface water were:

- Maintain existing gas wells and install additional landfill gas ventilation wells installed across the site to minimise the risk of build-up of landfill gas and minimise the risk of landfill gas migration;
- Install a landfill gas cut-off trench along the southern boundary of the capped fill area;
- Monitor all gas monitoring wells at least annually.

The updated risk assessment confirms this requirement.

4 CONCLUSION

This document was prepared as an addendum to the Tier 3 prepared by OCM in 2011, to include for monitoring data results gathered since the Tier 3 was completed and was consequently used to update the ERA and classification of the site. The revised ERA accounts for environmental monitoring undertaken by TCC and the EPA between 2011 and 2015 of groundwater monitoring wells, leachate wells and surface water sampling points.

The Tier 3, undertaken by OCM included leachate, surface water, groundwater and landfill gas monitoring, analysis of these results and a revision of the ERA presented in the Tier 2 report. The Tier 3 classified the site as High Risk (Class A) due to risks to surface water and landfill gas migration. It was concluded from the surface water monitoring results that the risk posed to the surface water quality was low, however there are surface water drains present within 50m of the site. The risk of landfill gas migration was assigned due to the building located on the site, although it is unused and will be demolished.

To account for the environmental monitoring undertaken by TCC and the EPA between 2011 and 2015 an update of the ERA and site classification the following tasks were undertaken:

- Review of the following data collected between 2011 and 2015
  - Surface water monitoring results
  - Groundwater monitoring results
  - Leachate monitoring results
- Confirmation of the flow regime of land drains surrounding the site
- ERA review and update
- Review of remediation options presented in the Tier 3

The analysis of the surface water monitoring results was considered inconclusive in determining the impact of the landfill on surrounding water bodies. The results suggest that while there is some evidence of contamination at locations downstream of the landfill, there is also evidence to suggest that run-off from the surrounding agricultural land is impacting on water quality at monitoring locations upstream and downstream of the landfill.

The flow regime observed in the AA and the Tier 3 is in contradiction with the EPA watercourse mapping. Large volumes of spoil have been deposited on the site, raising the land level, which may have altered the course of these streams. The headwaters of the Fidaghta are not located at the north-eastern corner of the wetland as indicated by the EPA, due to either a mapping error, or the deposition of spoil historically which may have altered to course of stream in this area and have not been recorded.

The groundwater monitoring results available from TCC and the EPA exceeded the groundwater IGVs for all parameters measured in exceeded in the Tier 3 Report, with the addition of arsenic, mercury and potassium. The Tier 3 concluded that there were some leachate impacts detected in shallow groundwater, however due to the thickness of the subsoil above the bedrock aquifer, the risk posed to the bedrock aquifer was considered Low.

It was determined from the leachate monitoring results that the leachate quality is typical of weak leachate sampled from large landfills, as outlined in the Landfill Operational Practices Guidance Manual, EPA 1997 and EPA Manual on Landfill Site Design (2000).

The risk assessment classification determined in the OCM Tier 3 was reviewed and updated by FT based on the available 2011-2015 monitoring data. The results of the updated ERA indicate the site retains its a high-risk classification (Class A). In consideration of the site retaining its high-risk status FT also reviewed the original 2011 remediation measures.

The remediation options recommended in 2011 are endorsed by FT following this review include:

- Installation of an engineered cap over the waste body to reduce rain infiltration to minimise the generation of leachate and the impact to groundwater and surface water;
- Biannual groundwater monitoring after landfill cap is installed;
- Installation of gas ventilation wells installed across the site to minimise the risk of build-up of landfill gas and minimise the risk of landfill gas migration;
- Install a landfill gas cut-off trench along the southern boundary of the capped fill area;
- Annual gas monitoring.

Appendix 1

OCM Tier 3 Environmental Risk Assessment

O' Callaghan Moran & Associates

Tier 3 Environmental Risk Assessment

Former Landfill at Tipperary Town

Prepared For:

South Tipperary County Council

Prepared By: -

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October 2011

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1. INTRODUCTION

1.1 Site Description

The site is located in the Townland of Carrownreddy and is within the northern outskirts of Tipperary Town. The waste deposition area was originally a lake that was drained in circa 1940 to allow wastes to be disposed. The site served as the landfill for Tipperary Town from ca1940, until it closed in 1990. It is accessed off the Lake Road and is currently used by Tipperary Town Council as a Depot for road maintenance materials and machinery.

The site occupies 1.8 hectares and contains within it a fenced off area of 0.2 hectares, which was apparently used exclusively for the disposal of wastewater treatment sludge. In addition to the sludges, the other wastes accepted were predominantly from households and businesses.

The southern, and part of the eastern and western boundary is fenced, but there is no visible boundary, other than the raised fill area, on the northern side. There is a steel framed building on site which was used for the storage for piping and other Council materials. Due to vandalism this building is no longer in use and has been boarded up. It is intended to demolish it in the future. Portions of the landfill have been capped with topsoil imported to site in recent years through these materials have not been significantly compacted or graded.

There is a marsh along the north-western, northern and north-eastern boundaries, which was associated with the original lake. The lands in the immediate vicinity to the east, south and west are used for low intensity agriculture, (animal grazing). The lands to the south are also currently used for grazing. The lands to the east of the drain have all been reclaimed along its entire length as far as Lake Road with construction demolition fill.

A halting site, located approximately 150m to the south of the site, contains the nearest occupied residences. There are at least 20 private dwellings within 250m of the northwest and western site boundaries and a newly developed housing estate approximately 250m to the southeast. A residential development (~250 houses) is under construction approximately 200m to the northeast of the site.

It is intended to develop the lands south of the landfill for social housing and light industrial use and the area between the site and the residential estate to the north east for light industrial warehousing. There are no proposals to develop the lands to the west.

1.2 Tier 1 and 2 Assessment

In 2009, South Tipperary County Council (the Council) completed a Tier 1 Assessment of the closed Tipperary Town Landfill in accordance with the 'Code of Practice Environmental risk Assessment for Unregulated Waste Disposal Sites' (CoP) published by the Environmental Protection Agency (Agency).

The Assessment concluded that the site was a Class A – High Risk, due to the risk of leachate migration to surface water and the risk to humans from landfill gas based on the nature of the underlying bedrock.

The Council appointed O'Callaghan Moran & Associates (OCM) to carry out a Tier 2 Assessment, which included Exploratory and Detailed Site Investigations completed in November 2009. The Tier 2 Assessment confirmed that the site was a Class A.- High Risk based on the risk of leachate migration to surface waters. The risk presented by landfill gas was considered to be Moderate, due to the low levels of gas detected outside the fill and the proposal to remove the on-site building.

The main findings of the Tier 1 & 2 Assessments were as follows;

- The Tier 1 assessment identified the underlying bedrock as a Regionally Important Karstified (Rkd) aquifer based on the Geological Survey of Ireland mapping. The logs of the boreholes installed in the Detailed Investigations and the geophysical survey indicate that the bedrock beneath the site is a shaley limestone, which was a locally important aquifer (Ll)
- It is possible that leachate migration is occurring toward the marsh and into a surface water drain to the east that ultimately discharges to the River Ara;
- The impact on surface water quality in the drain is low, with only ammonia exceeding the relevant water quality limit. This is attributed to a combination of natural attenuation within the marsh and the very high rainfall preceding and during the investigations;
- Shallow groundwater movement is towards a low point near the marsh and the marsh is the local groundwater discharge point;
- There is significant dilution of leachate occurring between the body of the waste and the groundwater monitoring wells located within 5-10m of the edge of the waste;
- Water quality in a public groundwater abstraction well, located 1.4km down hydraulic gradient of the site, is good with no evidence of any impact associated with leachate;

- The waste is actively producing landfill gas, with high levels of methane (31-55%v/v) recorded at monitoring wells inside the waste body. However, the levels detected at monitoring points outside the fill were low (1.1 to 1.3% v/v methane at one location) and further monitoring was required to establish the risk posed to off-site receptors, and

- Remedial measures (capping of the waste) may be required to minimise the risk posed by leachate and landfill gas to off-site receptors, but further monitoring (landfill gas, surface water and groundwater) was required to establish the extent of the remediation actions.

The Council submitted the Tier 2 Report to the Agency for comment. The Agency agreed with the conclusion that further monitoring was required to assist in the completion of a quantative risk assessment and determine the required remedial measures. The Agency did not accept the change to the aquifer classification from Regionally Important Karstified (Rkd) to Locally important (Ll) based on the findings of the intrusive investigations and geophysical survey and considered that the GSI mapping took precedence.

The Agency recommended that groundwater levels should be measured to confirm the results of first round of groundwater monitoring and that the potential for a 'swallow hole' near one of the monitoring wells be assessed. The Agency also recommended that an ecology assessment of the marsh and drain should be considered.

In relation to the landfill gas risk, the Agency considered that the risk remained high due to the presence of the building within the site and the proposed capping measures. The Agency recommended that a gas probe survey should be considered in the area north of the landfill, where ground conditions had prevented gas monitoring, ahead of boreholes as a more cost effective method of assessing risk, but boreholes could be installed if the findings of the probe survey warranted them.

1.3 Tier 3Work Scope

OCM developed the following scope for the Tier 3 based on the Tier 2 findings and the Agency's comments;

- Surface water monitoring at additional points up stream and downstream of the landfill.

- Monitoring of leachate levels and quality in two leachate wells (MW-2 and MW-3) within the waste body

- Monitoring water levels and quality in five groundwater wells (MW- 4, 5, 6, 7 and 8) outside the fill area.

- Landfill gas monitoring in the existing leachate and groundwater wells and a spike probe survey of the lands to the north of the landfill.

- An ecological assessment of the marsh and drain.

- Review of the Conceptual Site Model

- Completion of a Generic Quantitative Risk Assessment

- Preparation of Remedial Action Plan

2. MONITORING

2.1 Surface Water

2.1.1 Monitoring Locations

The Tier II Assessment involved monitoring at one location (SW-1) in the drain downstream of the marsh and south of the landfill. Following completion of the Tier II Risk Assessment further monitoring was undertaken by STCC, who undertook new upstream (SW-3) and additional downstream (SW-2) monitoring points to those used by OCM in the Tier II Assessment. SW-3 is the upstream location, SW-2 is in the drain just downstream of the marsh and SW-1 is the downstream sampling location in the drain. A drain located to the south between the landfill and the halting site is identified on the updated monitoring locations Figure. While this drain was identified during site walkover in Tier II it was observed to be completely dry and was constructed to allow drainage into rather than away from the site. It is not considered to be significant in terms of environmental risk presented by the landfill site. The revised monitoring locations are indicated on Figure 2.1.

2.1.2 Methodology

The monitoring was conducted by Council staff on July 13th 2010 and August 17th 2010. In August, the drain was dry and it was not possible to collect samples at SW-2 and SW-3.

2.1.3 Laboratory Analysis

The samples taken on 13th July 2010 were submitted to the Agency laboratory in Kilkenny for analysis for analysis for pH, electrical conductivity, dissolved oxygen, ammonia, nitrite, nitrate, orthophosphate, potassium, sodium, chloride, sulphate, metals, alkalinity, suspended solids, total oxidised nitrogen (TON), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

The samples taken on August 17th 2010 were analysed at the Council's laboratory in Clonmel, for a reduced range of parameters. This is consistent with the monitoring frequencies for operational landfills, where a full suite is conducted annually, with monitoring for leachate indicator parameters carried out more frequently. The reduced suite included pH, electrical conductivity, chloride, total ammonia, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

2.1.4 Laboratory Results

The laboratory test reports are contained in Appendix 1 and the results are summarised in Table 2.1. The Table includes, for comparative purposes, the Environmental Quality Standards (EQS) published by the Agency. The EQS are proposed water quality standards and are derived from the EU Directive on Drinking Water Quality 80/778/EEC and the Directive on the Protection of Groundwater against pollution caused by certain dangerous substances 80/66/EEC.

Table 2.1 Surface Water Results, Tipperay Town Landfill

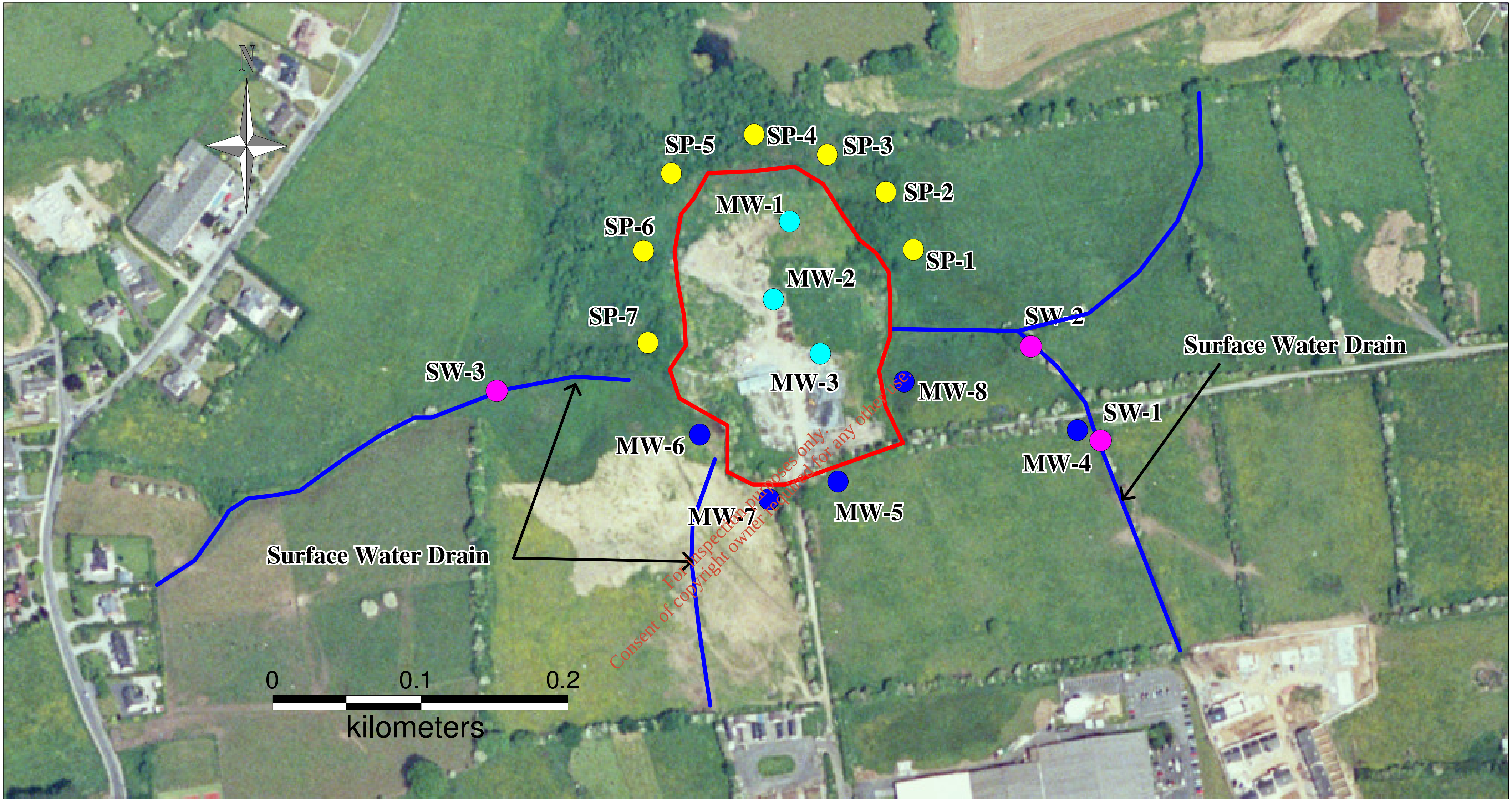
Sample I.D.	Units	SW-1	SW-2	SW-3	SW-1	EQS
		14/07/2010	14/07/2010	14/07/2010	17/08/2010	
pH	pH Units	7.300	7.100	7.600	7.950	4.5-9
Electrical Conductivity	uS/cm	913	969	765	941	-
Arsenic	mg/l	0.002	0.001	0.005	-	0.025
Antimony	mg/l	<0.0005	<0.0005	<0.0005	-	-
Aluminium	mg/l	<0.025	<0.025	0.046	-	-
Barium	mg/l	0.140	0.200	0.210	-	-
Beryllium	mg/l	<0.0005	<0.0005	<0.0005	-	-
Boron	mg/l	0.066	0.083	0.056	-	-
Cadmium	mg/l	<0.0005	<0.0005	<0.0005	-	0.0015
Cobalt	mg/l	0.0005	0.0005	0.0009	-	-
Copper	mg/l	0.0006	0.0008	0.0046	-	0.03
Lead	mg/l	<0.0005	<0.0005	<0.0005	-	0.0072
Manganese	mg/l	0.80	0.84	1.60	-	-
Magnesium	mg/l	0.010	0.011	0.006	-	-
Mercury	mg/l	<0.0005	<0.0005	<0.0005	-	0.00007
Molybdenum	mg/l	<0.0005	<0.0005	<0.0005	-	-
Nickel	mg/l	0.0009	0.0008	0.0023	-	0.02
Iron	mg/l	1.8	2.8	3.4	-	1*
Total Chromium	mg/l	0.014	0.015	0.011	-	0.0047
Selenium	mg/l	0.0008	0.0007	0.0006	-	-
Thallium	mg/l	<0.0005	<0.0005	<0.0005	-	-
Tin	mg/l	<0.001	<0.001	<0.001	-	-
Uranium	mg/l	<0.0005	<0.0005	<0.0005	-	-
Vanadium	mg/l	<0.0005	<0.0005	<0.0005	-	-
Zinc	mg/l	0.018	0.022	0.034	-	0.1
Chloride	mg/l	67.00	83.00	17.00	57.54	250*
Calcium	mg/l	84.00	88.00	110.00	-	-
Orthophosphate	mg/l	0.02	0.29	0.08	-	-
Total Oxidised Nitrogen	mg/l	<0.5	<0.5	<0.5	-	No Ab change
Total Suspended Solids	mg/l	<18.2	34.00	89.00	-	-
Total Alkalinity as CaCO3	mg/l	359.00	391.00	291.00	-	-
BOD	mg/l	3.20	7.10	5.70	7.90	5
COD	mg/l	48.00	73.00	91.00	51.00	-
Potassium	mg/l	6.30	7.20	0.80	-	-
Sodium	mg/l	36.00	43.00	9.30	-	-
Ammonia*	mg/l	6.10	7.50	0.03	4.70	0.02
Nitrite	mg/l	0.01	<0.002	<0.002	-	-

* EQS taken from 1997 report as no EQS exists in 2007 report
ND Denotes Not Detected

There was slightly elevated ammonia at the upstream location on the drain entering the marsh from the west, with higher levels in the drain leaving the marsh.

Manganese and iron exceeded the EQS in all the samples, with the highest levels in the drain upstream of the landfill. Chromium levels exceeded the EQS at all locations.

While the results indicate that leachate may be impacting on the surface water quality downstream of the site, they also indicate an impact on the water quality in the drain entering the marsh from the west and up gradient of the landfill. It is possible that the ammonia levels in the drain are associated with the naturally occurring anoxic conditions in the marsh, which were observed and reported by Ecofact as part of the Ecological Assessment of the marsh that is discussed further in Section 3.



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environmental management for business

CLIENT

South Tipperary County Council

TITLE

Groundwater Landfill Gas Well Locations

Legend

- Groundwater Well
- Gas Well
- Surface Water Location
- Spike Probe Location

FIGURE No.

2.1

SCALE

2.2 Leachate

2.2.1 Monitoring Locations

Leachate samples were collected from leachate monitoring wells MW-1 and MW-2, as shown on Figure 2.1.

2.2.2 Methodology

The monitoring was conducted by Council staff on 13th July and the 17th August 2011.

2.2.3 Laboratory Analysis

The samples taken on 13th July 2010 were submitted to the Agency laboratory in Kilkenny for analysis for analysis for pH, electrical conductivity, dissolved oxygen, ammonia, nitrite, nitrate, orthophosphate, potassium, sodium, chloride, sulphate, metals, alkalinity, suspended solids, TON, BOD and COD.

The samples taken on August 17th 2010 were analysed at the Council's laboratory in Clonmel, for a reduced range of parameters that included pH, electrical conductivity, chloride, total ammonia, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

2.2.4 Laboratory Results

The laboratory test reports are contained in Appendix 1 and the results are summarised in Table 2.1. The Table includes, for comparative purposes, the relevant EQS

Table 2.2 Leachate Results July 13th 2010

Sample I.D. / Sample Date	Units	MW-2	MW-3	IGV
Arsenic	µg/l	31	14	10
Aluminium	µg/l	2200	1300	200
Antimony	µg/l	2.7	1.3	-
Barium	µg/l	320	1700	100
Beryllium	µg/l	<0.5	<0.5	-
Boron	µg/l	1600	640	1,000
Cadmium	µg/l	1.3	<0.5	5
Chromium	µg/l	37	49	30
Cobalt	µg/l	7.9	3.8	-
Copper	µg/l	43	30	30
Mercury	µg/l	<0.5	<0.5	1
Molybdenum	µg/l	14	1.1	-
Nickel	µg/l	21	8.7	20
Lead	µg/l	110	95	10
Selenium	µg/l	18	3	-
Thallium	µg/l	<0.5	<0.5	-
Tin	µg/l	1	<1	-
Uranium	µg/l	<0.5	<0.5	9
Vanadium	µg/l	17	9.5	-
Zinc	µg/l	280	190	100
Iron	µg/l	3800	9300	200
Manganese	µg/l	480	510	50
Calcium	mg/l	30	160	200
Magnesium	mg/l	33	44	50
Chloride	mg/l	875	1320	30
Fluoride	mg/l	0.37	0.15	1
Total Alkalinity as CaCO3	mg/l			NAC
Orthophosphate	µg/l	440	160	30
Potassium	mg/l	150.0	62.0	5
Sodium	mg/l	430	650	150
pH	pH units	8.70	7.20	6.5-9.5
Electrical Conductivity	µS/cm	4300	5330	1,000
Total Oxidised Nitrogen	mg/l	<0.5	<0.5	NAC
Ammonia	mg/l	120.00	37.00	0.15
Nitrite	mg/l	<0.002	<0.002	0.1
BOD	mg/l	<30	<30	-
COD	mg/l	562	480	-
Sulphate	mg/l	100	16	200

Table 2.3 Leachate Results August 17th 2010

Sample I.D. / Sample Date	Units	MW-2	MW-3
Chloride	mg/l	966	1269.6
pH	pH units	8.78	7.3
Electrical Conductivity	µS/cm	4370	5190
Ammonia	mg/l	133	30.8
BOD	mg/l	25	12
COD	mg/l	241	115

The results confirm the presence of an aged Stage IV leachate.

2.3 Groundwater Monitoring

2.3.1 Monitoring Locations

Groundwater monitoring was conducted at five groundwater wells (MW-4, 5, 6, 7 and 8), whose locations are shown on Figure 2.1.

2.3.2 Methodology

Groundwater samples were collected by Council staff on the 13th July and 17th August 2010. In the July event, MW-7 was not samples as it was inadvertently thought to have been backfilled at that time. In August MW-1 and MW-5, were dry but a sample was obtained from MW-7 following confirmation by OCM that the well was intact. Groundwater level data was conducted by OCM in September 2010.

2.3.3 Laboratory Analysis

The samples collected on 13th July 2010 were submitted to the Agency's laboratory in Kilkenny for analysis for pH, electrical conductivity, dissolved oxygen, ammonia, nitrite, nitrate, orthophosphate, potassium, sodium, chloride, sulphate, alkalinity, metals, TON, BOD and COD.

The samples taken on August 17th 2010 were analysed at the Council's laboratory in Clonmel for a reduced range of parameters, which included pH, electrical conductivity, chloride, total ammonia, BOD and COD.

2.3.4 Laboratory Analysis

The full laboratory test reports are in Appendix 1 and the results are summarised in Tables 2.4 and 2.5. The Tables include Interim Guideline Values (IGV) published by the Agency. The IGVs are not statutory, but were developed to assist in the assessment of impacts on groundwater quality in the context of the implementation of the EU Water Framework Directive. The guidelines are based on, but are more conservative than the Drinking Water quality standards.

Table 2.4 Groundwater Monitoring Results July 13th 2010

Sample I.D. / Sample Date	Units	MW-4	MW-5	MW-6	MW-8	IGV
Arsenic	µg/l	1.7	3.4	1.6	6.6	10
Aluminium	µg/l	910	1900	800	290	200
Antimony	µg/l	<0.5	<0.5	<0.5	<0.5	-
Barium	µg/l	240	220	140	1000	100
Beryllium	µg/l	<0.5	<0.5	<0.5	<0.5	-
Boron	µg/l	20	40	120	29	1,000
Cadmium	µg/l	<0.5	<0.5	<0.5	<0.5	5
Chromium	µg/l	21	21	29	24	30
Cobalt	µg/l	1.8	4.5	2.9	2.1	-
Copper	µg/l	4.8	15	8.4	12	30
Mercury	µg/l	<0.5	<0.5	<0.5	<0.5	1
Molybdenum	µg/l	<0.5	<0.5	<0.5	<0.5	-
Nickel	µg/l	4.9	9.3	7.2	8.6	20
Lead	µg/l	6.7	13	6.2	5.4	10
Selenium	µg/l	0.8	<0.5	1	0.9	-
Thallium	µg/l	<0.5	<0.5	<0.5	<0.5	-
Tin	µg/l	<1	<1	<1	<1	-
Uranium	µg/l	0.7	0.5	1.7	1.7	9
Vanadium	µg/l	2	4.8	1.4	1.6	-
Zinc	µg/l	29	48	28	27	100
Iron	µg/l	1300	2500	940	1500	200
Manganese	µg/l	160	360	1400	1500	50
Calcium	mg/l	120	71	150	140	200
Magnesium	mg/l	9	7	13	15	50
Chloride	mg/l	61	279	28	341	30
Fluoride	mg/l	0.07	0.09	0.08	0.09	1
Total Alkalinity as CaCO3	mg/l	408	545	576	407	NAC
Orthophosphate	µg/l	<10	<10	80	60	30
Potassium	mg/l	0.7	1.2	4.8	0.7	5
Sodium	mg/l	45	240	22	160	150
pH	pH units	7.10	7.80	7.00	7.00	6.5-9.5
Electrical Conductivity	µS/cm	936	1748	1110	1916	1,000
Total Oxidised Nitrogen	mg/l	2.01	0.75	4.13	0.53	NAC
Ammonia	mg/l	0.03	0.03	0.37	0.03	0.15
Nitrite	mg/l	<0.002	<0.002	0.004	0.003	0.1
BOD	mg/l	-	-	-	-	-
COD	mg/l	-	-	-	-	-
Sulphate	mg/l	-	-	-	-	200

Elevated aluminium, barium, iron and manganese were detected in all of the wells. Lead was slightly elevated in MW-5. Elevate orthophosphate was detected in MW- 6, and MW-8; sodium in MW-5 and MW-8 and chloride in MW-4, 5 and 8, while electrical conductivity is elevated in all the wells.

Table 2.5 Groundwater Monitoring Results August 17th

Sample I.D. / Sample Date	Units	MW-4	MW-6	MW-7	MW-8	IGV
Chloride	mg/l	57.5	37.2	77.1	414	30
pH	pH units	7.25	7.22	7.37	7.16	6.5-9.5
Electrical Conductivity	µS/cm	1147	1147	1146	2110	1,000
Ammonia	mg/l	0.42	0.52	0.11	0.1	0.15
BOD	mg/l	1.3	1.3	0.9	2.7	-
COD	mg/l	23	27	15	28	-

Chloride and electrical conductivity was elevated in all the wells, while ammonia was elevated in MW-4 and MW-6. The data indicates the presence of leachate impact on the groundwater in the subsoil. The contaminant concentrations decrease moving from MW-8, which is close to the waste body, to MW-4 approximately 150m east of the landfill.

2.4 Landfill Gas

2.4.1 Locations

Landfill gas monitoring was conducted included all eight wells (MW-1 to MW-8). A spike probe survey was carried out in the area north of the fill area. The monitoring locations are shown on Figure 2.1

2.4.2 Methodology

The gas monitoring was conducted by Council staff in March, April and May 2010 and by OCM in September 2010. The Council staff used a Geotechnical Instruments GA 2000 gas analyser. OCM used a Gas Data LSMx gas analyser. The meters were calibrated before use. The detection limit is 0.1% for methane, carbon dioxide and oxygen.

The spike probe survey undertaken by OCM in September 2010 involved the use of a steel probe slotted in the lower 0.25m which was driven between 0.5 and 0.75m into the ground at each probe location. The gas analyser was attached to the top of the probe to monitor for landfill gas. During the survey there was no evidence of vegetation die back at the ground surface at any of the probe locations.

2.4.3 Results

The results are presented in Tables 2.6 – 2.8, which, includes guideline limits taken from the Department of the Environment (DOE) publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

MW-1, MW-2 and MW-3 are within the waste body. Carbon dioxide and methane were detected in all three wells, ranging from 26% to 80.6% for methane, and 1.5% to 16% for carbon dioxide. Oxygen levels ranged from0.8% to 1.4%.

MW-4, MW-5, MW-6, MW-7 and MW-8 are outside the waste body. Methane was not detected in any of the wells. Carbon dioxide was detected in all of the wells, with the concentrations ranging from 0.1% to 5%. The DOE limit of 1.5% was regularly exceeded in MW-4, 6 and 8. The oxygen levels ranged from 2.9% to 22.6%, with the lowest level detected in MW-8.

Table 2.6 Landfill Gas Monitoring Data: November 2009 – September 2010

Well ID	Methane							Carbon Dioxide						
	23/11/09	02/12/2009	08/12/2009	23/03/2010	23/04/2010	31/05/2010	09/09/2010	23/11/2009	02/12/2009	08/12/2009	23/03/2010	23/04/2010	31/05/2010	09/09/2010
MW-1	31.5	53	52	63.4	75.1	73.6	80.6	12	15	16	16.7	18.7	18	17.2
MW-2	55	55	56	21	38.7	9.3	26.4	3.6	3.9	4.1	3.7	4.1	6.5	5.9
MW-3	35	37.5	38	32.6	34.4	26	27	1.5	3.6	3.7	2.4	3.7	5.6	5.9
MW-4	0	0	0	Water to top	Water to top	0	0	1.9	2.1	2.5	Water to top	Water to top	0.2	0
MW-5	0	0	0	0	0	0	0	1.6	0.9	1	0.1	0.3	0	1.3
MW-6	0	0	0	0	0	0	0	1.8	4	3.6	4.5	4.8	5	3.8
MW-7	0	0	0	Water to top	Water to top	0	0	0	0.9	1	Water to top	Water to top	0	0
MW-8	0.8	1.1	1.3	0.8	0	0.2	0	5	4.5	4.6	2.1	2.3	4.2	1.9
DOE Limit (%)	**1%**							**1.5%**						

Table 2.7 Landfill Gas Monitoring Data: November 2009 – September 2010

Well ID	Oxygen							Barometric Pressure						
	23/11/2009	02/12/2009	08/12/2009	23/03/2010	23/04/2010	31/05/2010	09/09/2010	23/11/2009	02/12/2009	08/12/2009	23/03/2010	23/04/2010	31/05/2010	09/09/2010
MW-1	1.4	1.1	1	3.5	0.3	0.4	0.4	1002	1001	1002	N/m	1002	1006	999
MW-2	1.3	1.1	1.1	4.8	0.4	0.5	0.1	1002	1001	1002	N/m	1002	1006	975
MW-3	1.1	0.8	0.9	3.5	0.4	1.1	0.9	1002	1001	1002	N/m	1002	1006	995
MW-4	22.3	19.9	18.4	Water to top	Water to top	21.4	20.3	1002	1001	1002	Water to top	Water to top	1005	1000
MW-5	18.1	21.8	21.6	20.7	20.9	21.4	18.3	1002	1001	1002	N/m	1002	1006	999
MW-6	21	20.1	20.1	12.2	12	13.9	14	1002	1001	1002	N/m	1002	1006	1000
MW-7	22.6	3.7	19.1	Water to top	Water to top	21.5	20.6	1002	1001	1002	Water to top	Water to top	1006	999
MW-8	2.9	3.6	3.6	10.3	7.8	4.9	1.4	1002	1001	1002	N/m	1002	1006	999
DOE Limit (%)	-							-						

The monitoring confirmed that high methane and carbon dioxide levels are present within the waste, with the highest levels occurring in the northern part of the site of the site around MW-1. There is no evidence of significant methane migration from the fill, with methane only detected at one monitoring point (MW-8) once in the four monitoring events. Slightly elevated carbon dioxide levels were detected in three locations (MW-4, 6 and 8).

Table 2.8 Spike Probe Results September 2010

Spike Probe Points	Methane	Carbon Dioxide	Oxygen	Barometric Pressure
	09/09/2010	09/09/2010	09/09/2010	09/09/2010
SP-1	0	0.2	20.3	987
SP-2	0	0.1	20.8	978
SP-3	0	0.2	20.5	979
SP-4	0	0	20.6	989
SP-5	0	0.2	20.1	999
SP-6	0	0.1	20.4	998
SP-7	0	0	20.6	986
DOE Limit (%)	**1%**	**1.5%**	**-**	**-**

Methane was not detected and carbon dioxide levels were low, typical of background conditions. The results indicate that despite the high methane levels detected in the waste, particularly in the northern portion, there is no evidence of landfill gas migration in the shallow subsurface.

3. ECOLOGICAL SITE SURVEY

An ecological survey was undertaken by Ecofact Ecological Consultants (Ecofact) in September 2010. The Ecofact report is included in Appendix 2 and the main findings are presented below.

The assessment identified the presence of reed swamp (FS1) habitat, with some wet alder / willow woodland (WN6). A small stand of non-native Japanese Knotweed was noted. This habitat is considered to be of high local importance and is connected with the Carrownreddy Lough and associated wetlands, to the north.

There is no data available on the diversity or ecological importance of this habitat or the biodiversity value of Carrownreddy Lough prior to the use of the site as a landfill to provide a benchmark for the current status. However, the botanical community within this habitat is likely to maintain its diversity despite further leachate inputs from the landfill.

Water levels were found to be very low during the assessment, both in the reed swamp habitat and in the land drain, although there was evidence in the botanical community that this habitat is water-logged throughout the year.

It is considered that the surrounding lands currently provide little dilution of leachate to the land drain. This drain was receiving minimal flows from the swamp and was barely flowing on the day of the survey, with pooled water observed in sections downstream. The substrate of the swamp and land drain was found to be anoxic, although this is considered to be a combined function related primarily to the stagnant conditions within the low-lying swamp.

The reed swamp is considered to be providing an important function as a natural attenuation of the leachate from the former landfill. This habitat will require the maintenance of a high water table or permanent standing water for its ongoing viability.

The reed swamp and wet woodland is considered to comprise an important habitat for breeding birds, with at least one pair of moorhens recorded on the day of the survey.

Although water quality in the reed swamp is likely to be affected by the leachate, the botanical community recorded is indicative of a semi-natural habitat. More significant impacts may relate to the macro invertebrate communities present. Based on the observations during the site assessment, which was during low flow conditions, the drain leaving the site appears to be affected by water quality impacts.

4. CONCEPTUAL SITE MODEL & QRA

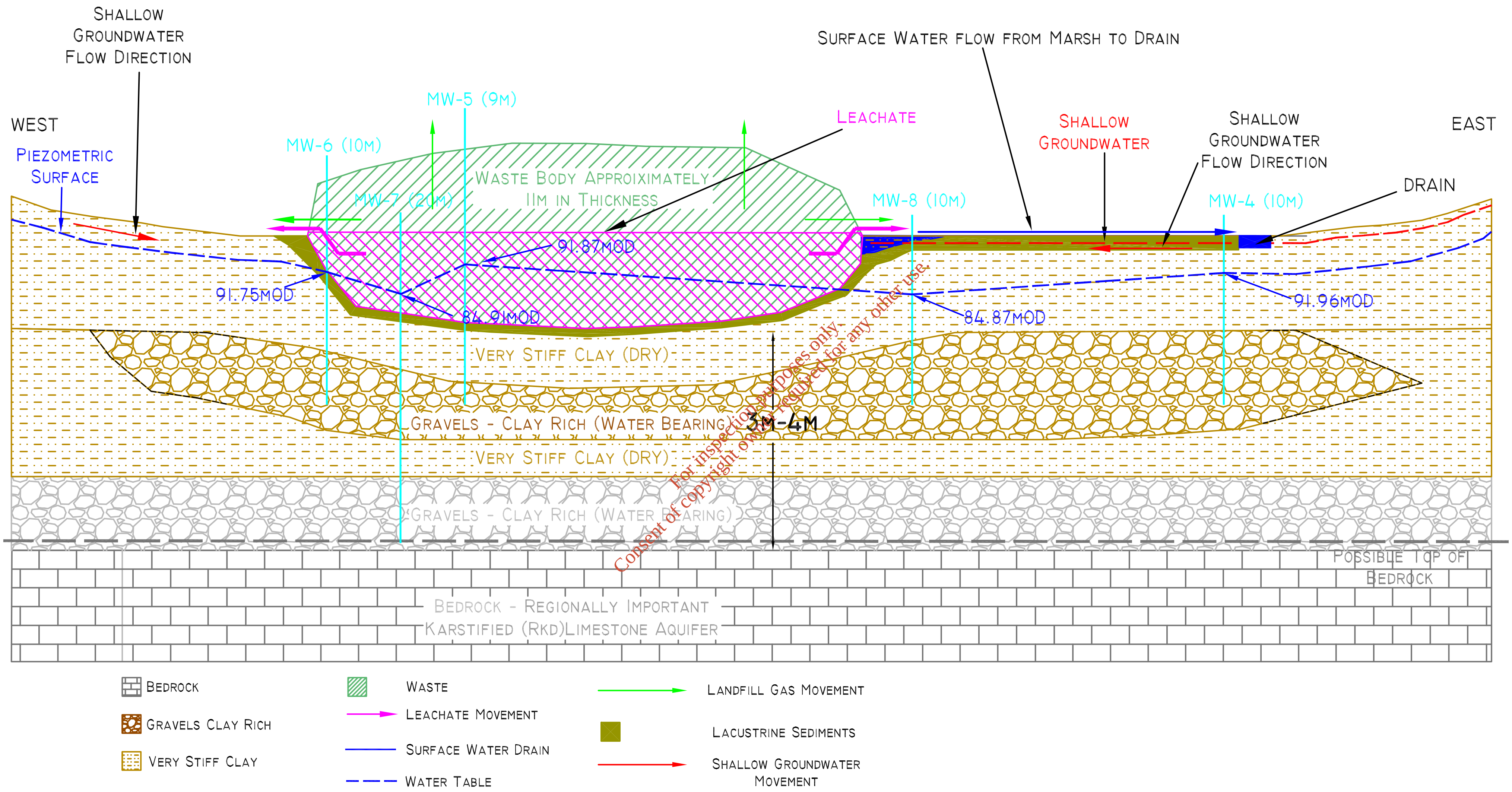
4.1 Tier 3 Revised Conceptual Site Model

The Tier 3 Revised Conceptual Site Model is presented on Figure 4.1. The subsoils at the site consist of a thin layer of lacustrine sediments underlain by a low – to moderate permeability boulder clay and gravel, which in turn are underlain by layer of low permeability hard clays. Beneath the clay is a lower layer of gravels. Based on the field observations and geophysics investigations the gravels appear to be underlain by shaley limestone Ll aquifer. However, for the purposes of this risk assessment and as requested by the Agency it has been assumed that the underlying bedrock is a Regionally Important Karst bedrock (Rkd).

The landfill is at a low point in a local catchment, where both groundwater and surface water discharge into the marsh. During the drilling of the wells outside the landfill (MW-4 -8) the first groundwater strikes were encountered at approximately 8.5m below ground level. The well screens are open to the subsoil and underlying upper gravel formation. The subsoils above the bedrock were observed to be poorly permeable, while the gravels are very permeable and water bearing. It is considered therefore that groundwater level monitoring indicates a variable static water level across the site and that the variations in water levels are indicative of a piezometric head consistent with a partially confined water table in the upper gravel layer beneath the clay. The upper and lower gravel layers are separated by very stiff, dry clay layer.

The leachate level within the waste is higher than the piezometric head in the surrounding natural ground and, as such, there is the potential for leachate to enter the shallow groundwater in the lacustrine sediments and possibly the underlying clays where the lacustrine sediments may have been disturbed when waste was being deposited. However, the low permeability clay subsoil layer beneath the sediments inhibits downward movement and there is no direct pathway to either the underlying deeper gravel formation or the bedrock aquifer. It is likely that because of the low permeability of the subsoils that the preferential flow path is along the surface into the Marsh.

A surface water drain leaves the marsh and flows to the south. This drain is seasonal and occasionally dries up. The direct discharge of contaminated shallow groundwater to the drain is not likely, but there is an indirect discharge as water levels rise in the marsh in the winter period**.**



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CLIENT	details	FIGURE No.
South Tipperary County Council		4.1
TITLE		SCALE / REV.
Conceptual Site Model		

Very high landfill gas levels are present within the landfill, but have not been detected in the surrounding subsoils, which indicate that the current landfill gas risk is low. However, because capping of the fill area is likely, remedial action will be required to mitigate leachate impacts and the risk of landfill gas migration which may increase due to the build up gases beneath the cap.

4.2 Surface Water

There are two potential surface water inflow areas to the marsh. The first is a recently dug drain, which appears to originate near the halting site to the south and runs north before turning east into the marsh. There was no flow in this drain in September 2010 but it is possible that there may be some flow in the winter months.

The second inflow originates at the boundary of a private dwelling approximately 400m to the west of the marsh. This may possibly be either a spring or a culverted section of a drain, but as it was not possible to get access to the dwelling, it was not possible to confirm the position.

Water leaves the marsh in a drain on its eastern boundary and flows for c.150m and then turns south and passes beneath the landfill access road (Lake Road) and flows towards a recently constructed residential development, where it is culverted and eventually discharges to the River Ara.

Within the landfill, the leachate levels measured in September 2010 by OCM range from 91.27mOD in MW-1 to 92.25mOD in MW-2 and MW-3. These levels are just below that of the surrounding natural ground (c.92.2mOD). While the levels are lower than those recorded in November 2009, the potential for migration into the marsh during wetter periods remains.

No leachate seepages were observed around the margins of the landfill and the ecological assessment concluded that the marsh area does not appear to have been be significantly impacted by leachate.

The impact of the leachate on water quality in the drain downstream of the site is limited, being confined to elevated ammonia, although there may also be a contribution from the naturally occurring anoxic conditions within the marsh. Iron manganese and chromium exceed the surface water EQS limits but are most likely representative of local background conditions, as the concentrations are similar and in the case of manganese and iron, higher in the drain that enters the marsh upstream of the landfill from the west than those leaving it to southeast.

4.3 Groundwater

The Agency commented on the potential for a swallow hole effect just east of the fill area (MW-8) and required an assessment of this as part of the Tier 3. The direction of groundwater flow is shown on Figure 4.2, which is based on groundwater levels measured by OCM in September 2010.

There is no field evidence of either a swallow hole or other karst features at or in the vicinity of the site and the GSI karst database does not contain any record of any karst features in this area. While the GSI maps indicate that the site in underlain by karstified bedrock, the site investigation data (field observations and geophysical data) indicates it is most likely to be underlain by shaley limestone.

The landfill is located in a former lake that was drained in ca 1940. The groundwater table reflects the local topography, with flow towards the fill area from all directions. This is consistent with groundwater flow towards a lake, which typically occupies a low point in a catchment and acts a discharge area for groundwater.

The groundwater level in MW-7 and 8 (84.91mOD and 84.97mOD respectively) are significantly lower than those in MW-4, 5 and 6 (91.96mOD, 91.87mOD and 91.75mOD respectively). This variation indicates variable piezometric head levels in the subsoil reflecting localized differences in permeabilities.

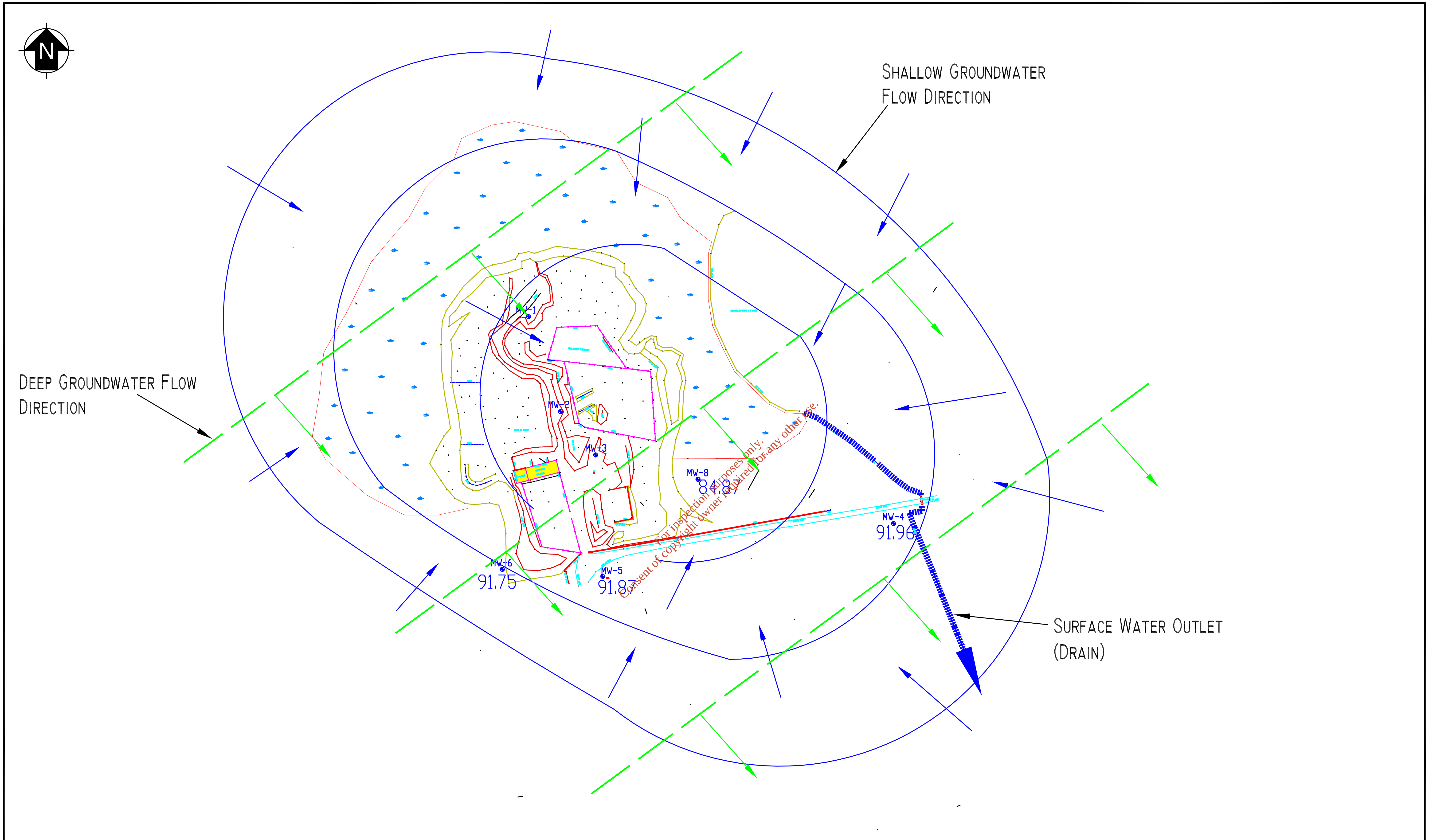
The leachate level in the waste is higher than the groundwater level in the surrounding subsoil. The difference in levels indicates the potential for the migration of leachate from the waste. The very hard, dry boulder clay underlying the landfill probably results in most of the leachate preferentially discharging to marsh where it appears to be significantly attenuated.

The monitoring data has established that leachate is impacting on the shallow groundwater, with elevated manganese, iron, aluminium, barium, ammonia and chloride. However the impacts are significantly attenuated with distance from the fill area. There is no evidence of any impact on the closest water supply well (Tipperary Co-Op) located 1.5 km to the south of the site.

It is likely that because of the topography that the monitoring wells surrounding the site are up hydraulic gradient of the landfill but that they are close enough to be affected by leachate migrating from the margins of the landfill due to the head of leachate in the waste mass perched above the natural gorund. The levels of ammonia, chloride, iron and manganese detected in the wells, compared to those in the leachate, indicates that substantial dilution and attenuation is occurring within 5-10m of the landfill

However the hydraulic gradient indicates movement of groundwater toward rather than away from the landfill. Because the wells are screened to monitoring shallow groundwater flow in the subsoils/gravels, they intercept the shallow leachate plume around the landfill area. Given the thickness of the underlying clays, it is likely that the groundwater in the deeper gravel zone is uncontaminated. It is likely that the direction of groundwater flow in the bedrock is to the southeast following the topographic gradient.

The presence of a relatively low permeability, thick subsoil immediately beneath the waste inhibits the vertical migration to the underlying water bearing gravels. The low permeability clay that underlies the gravels also inhibits the downward movement of any contaminated groundwater to the bedrock.



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environmental management for business

CLIENT	SOUTH TIPPERARY COUNTY COUNCIL
TITLE	INTERPRETED GROUNDWATER FLOW SEPTEMBER 2010
DRAWING No.	4.2
SCALE	
REV.	
NOTES	

4.4 Assessment of Landfill Gas Pathway

The monitoring in the waste body (MW-1, 2 and 3) indicates that methane and carbon dioxide are still being generated at significant levels. The monitoring in the perimeter wells identified carbon dioxide levels ranging from 0.1 - 5%, however methane was only detected at one monitoring point (MW-8) on one occasion. The spike probe survey indicates that gas migration to the north of the landfill is not occurring in the shallow subsurface.

The on-site building is no longer used and it is planned to demolish it in the near future, which will eliminate the risk associated with landfill gas.

A halting site, located approximately 150m to the south of the site, contains the nearest occupied residences. There are at least 20 private dwellings within 250m of the northwest and western site boundaries and a newly developed housing estate approximately 250m to the southeast. A residential development (~250 houses) is under construction approximately 200m to the northeast of the site.

It is intended to develop the lands south of the landfill for social housing and light industrial use and the area between the site and the residential estate to the north east for light industrial warehousing.

Given that remedial measures will include capping of the landfill, the risk posed by landfill gas will increase and must be mitigated.

The in-situ boulder clay surrounding the waste body has a moderate to low permeability, which inhibits gas movement. The water saturated conditions in the marsh along the landfill's north-western, northern and north-eastern margins will also inhibit gas migration and, when water levels drop in drier periods, possibly allow passive ventilation. The nearest existing residences are more than 250 m. The only area where landfill gas migration has the potential to occur to any great extent is to the south, where the nearest occupied buildings (Halting Site) are located.

4.5 Revised Risk Assessment

OCM modified the Tier 2 Assessment based on the Tier 3 findings and the EPA comments. The changes are highlighted in red.

4.6 Revised Risk Assessment

Table 6

Ref	**Source**	*Score*	*Rational*
1a	Leachate	7	▪ <5 hectares ▪ Waste likely to be both municipal & industrial
1b	Gas	7	▪ <5 hectares ▪ Highest rating given as proportion of municipal: industrial wastes is not known.

Table 7

Ref	**Pathways**	*Score*	*Rational*
2a	Groundwater vulnerability	2	▪ GSI data states that the site is rated as having high vulnerability. While the Agency recommended the Extreme vulnerability rating be used, OCM considers the Vulnerability to be High. The risk is to the bedrock aquifer and not the boulder clay subsoil, which is not classified as an aquifer.
2b	Groundwater flow regime	5	▪ Agency states that the aquifer should not be reclassified based on geophysics. OCM has reverted to the aquifer classification as Rkd despite strong field evidence to the contrary
2c	Surface water drainage	2	▪ Landfill is reportedly connected to town surface water drainage system
2d	Landfill gas lateral migration	3	▪ Residences not currently within 250m of site, but could be within 5 years. ▪ Karst bedrock
2e	Landfill gas vertical migration	5	▪ As long as building remains on-site; risk should remain high.

Table 8

Ref	**Receptors**	*Score*	*Rational*
3a	Human presence (leachate)	2	▪ Currently no houses within 250m, there will be within 5 years ▪ Note: All houses can be served by public water
3b	Protected areas	1	▪ No protected areas within 1 km of site ▪ The marsh has been considered as an undesignated GWDTE based on the precautionary approach. ▪ No consultation with the NPWS has taken place.
3c	Aquifer category	5	▪ Agency requires the aquifer to be classified as Rkd
3d	Public water supply	3	▪ Public water supply is greater than 1km away (Tipperary Co-op) ▪ Karst bedrock – but different geological formation ▪ Precautionary approach assumed
3e	Surface water bodies	3	▪ Surface water drain within 50m of site boundary
3f	Human presence (gas)	5	▪ Houses proposed within 50m of site boundary

The site remains High risk for leachate impacts on the surface water system, because of the presence of a pathway from the landfill to the marsh and the outlet drain.

The landfill gas risk has been increased to High, based on the Agency's recommendations that the on-site buildings risk be retained and also due to the proposal to cap the waste. Landfill gas levels may accumulate beneath the cap and increase the risk of migration.

While some impacts have been detected in the groundwater, it is considered likely that the risk posed to the bedrock aquifer is Low.

Note: The table below represents the Tier II Risk rating for this site. SPR1 to 9 represent the leachate risk scores. SPR10 & 11 represent Landfill Gas Risk. The migration pathways are colour coded as follows:

Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical

Calculator		SPR Values	Maximum Score	Normalised Score
SPR1	1a x (2a + 2b + 2c) x 3e	189	300	63.00%
SPR2	1a x (2a + 2b + 2c) x 3b	63	300	21.00%
SPR3	1a x (2a + 2b) x 3a	98	240	40.83%
SPR4	1a x (2a + 2b) x 3b	49	240	20.42%
SPR5	1a x (2a + 2b) x 3c	245	400	61.25%
SPR6	1a x (2a + 2b) x 3d	147	560	26.25%
SPR7	1a x (2a + 2b) x 3e	147	240	61.25%
SPR8	1a x 2c x 3e	42	60	70.00%
SPR9	1a x 2c x 3b	14	60	23.33%
SPR10	1b x 2d x 3f	105	150	70.00%
SPR11	1b x 2e x 3f	175	250	70.00%
Overall Risk Score		245		**70.00%**
				A

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	**Greater than or equal to 70% for any individual SPR linkage**
Moderate Risk (Class B)	**Between 40-70% for any individual SPR linkage**
Lowest Risk (Class C)	**Less than or equal to 40% for any individual SPR linkage**

Risk Classification	**HIGHEST**

5. CONCLUSIONS

5.1 Surface Water

There is the potential for leachate to migrate from the waste via the lacustrine sediments into the adjoining marsh. Water from the marsh enters a drain that ultimately discharges to the River Ara several kilometres downstream of the site.

The impact of the leachate on water quality in the drain leaving the marsh is limited, being confined to elevated ammonia, although there may also be a contribution from the naturally occurring anoxic conditions within the marsh.

The elevated iron manganese and slightly elevated chromium detected in the samples collected from the drain leaving the landfill site are most likely representative of local background conditions, as similar levels are present in the drain that enters the marsh from the west. There is no water quality data for the drain entering the marsh from the south.

Remedial measures are required to minimise the risk to surface water. Such measures may include the provision of a low permeability cap over the waste. This will reduce rainfall infiltration that generates a leachate head within the waste, which can then enter the lacustrine sediments and flow into the marsh

5.2 Groundwater

Based on the groundwater flow direction data shallow groundwater in the catchment is moving toward a low point in the former lake area and discharging into the marsh. The shallow groundwater and surface water run-off enter the marsh and discharge to the drain along the eastern landfill boundary.

Some leachate impacts have been detected in the shallow groundwater. These are considered to originate as discharges into the subsoil along the margins of the landfill. The leachate migration away from the margins of the landfill is not considered to be significant laterally because of the direction of groundwater flow and vertically because of the presence of hard low permeability boulder clay underlying the lacustrine sediments beneath the landfill.

Given the thickness of the subsoil above the bedrock aquifer, the risk posed to the bedrock aquifer is considered to be Low.

5.3 Landfill Gas

Methane and carbon dioxide are still being generated at significant levels within the waste body, however currently there is no evidence of any significant migration of gas away from fill area.

The on-site building is no longer used and it is planned to demolish it in the near future, which will eliminate the risk associated with landfill gas. There is a Halting Site 150m to the south of the site, but there are no other residential dwellings within 250m. It is possible that at some time in the future the lands immediately surrounding the site could be developed for residential and/or commercial purposes.

The in-situ boulder clay surrounding the waste body has a moderate to low permeability, which inhibits gas movement while the water saturated conditions in the marsh along the landfill's north-western, northern and north-eastern margins also inhibit gas migration in these directions. The only area where landfill gas migration has the potential to occur to any great extent is to the south, where the nearest occupied buildings (Halting Site) are located.

5.4 Ecosystem

The marsh comprised reed swamp (FS1) habitat, with some wet alder / willow woodland (WN6). A small stand of non-native Japanese Knotweed is present. This habitat is considered to be of high local importance and is connected with the Carrownreddy Lough and associated wetlands, to the north. It is also an important habitat for breeding birds.

The reed swamp provides an important function as a natural attenuation of the leachate from the former landfill. This habitat will require the maintenance of a high water table or permanent standing water for its ongoing viability.

There is the potential for the remedial works (placement of low permeability cap over the waste) to encroach into the reed swamp habitat at the existing toe of the landfill. An Appropriate Assessment Screening, completed as part of the ecological assessment and included in the Ecofact Report, conclude that the remedial works will not result in significant impacts affecting the Natura 2000 site network, in particular the River Suir SAC.

The Japanese knotweed on the site will require a management and control. The small stands present on the site would be much easier to treat and control in the short term, rather than allow the spread and colonisation of large areas of the site by this species.

5.5 Risk Category

The site is a Class A High Risk Site, based on the risk to surface water and the risk of landfill gas migration and remedial measures are required to mitigate the risk to surface water.

6. RECOMMENDATIONS

6.1 Surface Water

The source(s) of surface water contamination in the drain entering the marsh from the west should be investigated.

Should surface water flow be observed in the drain entering the marsh from the south the water quality should be monitored to establish its status. It appears that this drain has recently been dug and if the monitoring identifies an impact, the drain should be blocked to prevent discharge to the marsh.

The landfill should be capped to minimise the infiltration of rainfall to the waste. required in some portions of the site but some compacting, grading, surface drainage. The Council has already capped a portion of the fill area but additional compacting and grading of those area may be required.

The alternative to capping the landfill is

a) Do nothing and allow the existing leachate generation within the waste through rainfall infiltration to continue to impact on the surface water drain downstream of the facility.

b) Remove the waste. The environmental impact caused by this option would most likely have a greater impact on the ecology of the wetland and on surface water quality downstream of the site. In addition the financial cost would be much larger than undertaking a remedial solution in-situ.

6.2 Landfill Gas

The existing landfill gas wells should be retained and additional landfill gas ventilation wells installed across the site to minimise the risk of build up of landfill gas pressures and minimise the risk of landfill gas migration.

A landfill gas cut-off trench should be installed along the southern boundary of the capped fill area to minimise the risk of landfill gas migration toward existing and/or future dwellings proposed for this area once the landfill is capped.

Landfill gas monitoring should be undertaken in wells MW5, 6 and 7 at monthly intervals to assess the risk of off-site migration toward the Halting Site and the residential area further south. Should the levels remain low after 12 months the monitoring frequency could be reduced to quarterly in Year 2 and Bi-annually thereafter.

All the gas monitoring wells should be monitored at least annually. If development occurs within 250m of the site boundary, more frequent monitoring may be required.

6.3 Ecology

Plant used in the remedial works should not be allowed to enter the marsh. Ground disturbance within 5-10m of the landfill margins adjacent to the marsh should be minimised using silt curtains and appropriate site fencing.

The Japanese knotweed should be treated and controlled to prevent it from becoming a dominant invasive species in the marsh wetland area.

6.4 Groundwater

Following capping, groundwater monitoring should be undertaken to establish the effectiveness of the works. The monitoring should be at least bi-annual.

6.5 Remedial Works

The scope of the proposed remedial works are set out in the Preliminary Remedial Action Plan in Appendix 3.

APPENDIX 1

Laboratory Analytical Data

Environmental Protection Agency
Regional Inspectorate
Seville Lodge, Callan Road,
Kilkenny

Report of: Surface Waters - Tipperary Town Landfill
Report to: South Tipperary Co. Co.
Report date: 07/09/10

Location sampled: Miscellaneous Surface Water
Date sampled: 13/07/2010 Date received: 14/07/2010

	Laboratory Ref:	1003149	1003150	1003151
	Type of sample:	Misc	Misc	Misc
	Sampling point:	SW1 (10-0858)	SW2 (10-0859)	SW3 (10-0860)
	Sampled by:	Denis McGuire	Denis McGuire	Denis McGuire
	Time Sampled:	14:30	12:15	12:00
	Start/End - Dates of Analysis:			
	Status of results:	Final Report	Final Report	Final Report
Parameter	**Units**			
Alkalinity-total (as CaCO3)	mg/l CaCO3	359	391	291
Biochemical Oxygen Demand	mg/l O2	3.2	7.1	5.7
Chemical Oxygen Demand	mg/l O2	48	73	91
Conductivity @25°C	µS/cm	913	969	766
Fluoride	mg/l F	nm	nm	nm
Sulphate	mg/l SO4	nm	nm	nm
Aluminium	ug/l	<25	<25	46
Antimony	ug/l	<0.5	<0.5	<0.5
Arsenic	ug/l	1.9	1.3	4.5
Barium	ug/l	140	200	210
Beryllium	ug/l	<0.5	<0.5	<0.5
Boron	ug/l	66	83	56
Cadmium	ug/l	<0.5	<0.5	<0.5
Calcium	mg/l	84	88	110
Chromium	ug/l	14	15	11
Cobalt	ug/l	0.5	0.5	0.9
Copper	ug/l	0.6	0.8	4.6
Iron	ug/l	1800	2800	3400
Lead	ug/l	<0.5	<0.5	0.7
Magnesium	mg/l	10	11	6.2

	Laboratory Ref:	1003149	1003150	1003151
	Type of sample:	Misc	Misc	Misc
	Sampling point:	SW1 (10-0858)	SW2 (10-0859)	SW3 (10-0860)
	Sampled by:	Denis McGuire	Denis McGuire	Denis McGuire
	Time Sampled:	14:30	12:15	12:00
	Start/End - Dates of Analysis:			
	Status of results:	**Final Report**	**Final Report**	**Final Report**
Parameter	**Units**			
Manganese	ug/l	800	840	1600
Mercury	ug/l	<0.5	<0.5	<0.5
Molybdenum	ug/l	<0.5	<0.5	<0.5
Nickel	ug/l	0.9	0.8	2.3
Potassium	mg/l	6.3	7.2	0.8
Selenium	ug/l	0.8	0.7	0.6
Sodium	mg/l	36	43	9.3
Thallium	ug/l	<0.5	<0.5	<0.5
Tin	ug/l	<1	<1	<1
Uranium	ug/l	<0.5	<0.5	1.1
Vanadium	ug/l	<0.5	<0.5	0.6
Zinc	ug/l	18	22	34
Ammonia	mg/l N	6.1	7.5	0.03
Chloride	mg/l Cl	67	83	17
Nitrite (as N)	mg/l N	0.007	<0.002	<0.002
ortho-Phosphate (as P)	mg/l P	0.18	0.29	0.08
Total Oxidised Nitrogen (as N)	mg/l N	<0.50	<0.50	<0.50
pH	pH	7.3	7.1	7.6
Suspended Solids	mg/l	<18.2	34	89

Comments: Surface water samples taken from Tipp town landfill. For South Tipp Co. Co.

1) Results highlighted and in bold are outside specified limits.
2) All Metals Analysed in the EPA Dublin Laboratory, Cyanide Analysed in the EPA Cork Laboratory. Phenols Analysed in the EPA Castlebar Laboratory.
3) nm "Not measured"
4) nd "None detected"
5) nt "No time" - Time not recorded
6) tntc "Too numerous to count"
7) F "Field measured parameters"

Signed: [signature] Date: 7/9/10

Caroline Bowden, A/Regional Chemist

Environmental Protection Agency
Regional Inspectorate
Seville Lodge, Callan Road,
Kilkenny

Report of: Groundwater - Tipperary Town Landfill
Report to: South Tipperary Co. Co.
Report date: 07/09/10

Location sampled: Miscellaneous Landfill Groundwater
Date sampled: 13/07/2010 Date received: 14/07/2010

		Laboratory Ref:	1003152	1003153	1003154	1003155	
		Type of sample:	Misc	Misc	Misc	Misc	
		Sampling point:	MW8 - 10-0861	MW6 - 10-0862	MW5 - 10-0863	MW4 - 10-0864	
		Sampled by:	Denis McGuire	Denis McGuire	Denis McGuire	Denis McGuire	
		Time Sampled:					
		Start/End - Dates of Analysis:					
		Status of results:	**Final Report**	**Final Report**	**Final Report**	**Final Report**	
Parameter	**Units**	**Limits**					
Alkalinity-total (as CaCO3)	mg/l CaCO3		407	576	545	408	
Conductivity @25°C	µS/cm		1316	1110	1748	936	
Fluoride	mg/l F		0.09	0.08	0.09	0.07	
Sulphate	mg/l SO4		56	41	53	20	
Aluminium	ug/l		290	800	1900	910	
Antimony	ug/l		<0.5	<0.5	<0.5	<0.5	
Arsenic	ug/l		6.6	1.6	3.4	1.7	
Barium	ug/l		1000	140	220	240	
Beryllium	ug/l		<0.5	<0.5	<0.5	<0.5	
Boron	ug/l		29	120	40	20	
Cadmium	ug/l		<0.5	<0.5	<0.5	<0.5	
Calcium	mg/l		140	150	71	120	
Chromium	ug/l		24	29	21	21	
Cobalt	ug/l		2.1	2.9	4.5	1.8	
Copper	ug/l		12	8.4	15	4.8	
Iron	ug/l		1500	940	2500	1300	
Lead	ug/l		5.4	6.2	13	6.7	
Magnesium	mg/l		15	13	6.6	8.5	
Manganese	ug/l		1500	1400	360	160	
Mercury	ug/l		<0.5	<0.5	<0.5	<0.5	

		Laboratory Ref:	1003152	1003153	1003154	1003155	
		Type of sample:	Misc	Misc	Misc	Misc	
		Sampling point:	MW8 - 10-0861	MW6 - 10-0862	MW5 - 10-0863	MW4 - 10-0864	
		Sampled by:	Denis McGuire	Denis McGuire	Denis McGuire	Denis McGuire	
		Time Sampled:					
		Start/End - Dates of Analysis:					
		Status of results:	**Final Report**	**Final Report**	**Final Report**	**Final Report**	
Parameter	**Units**	**Limits**					
Molybdenum	ug/l		<0.5	<0.5	<0.5	<0.5	
Nickel	ug/l		8.6	7.2	9.3	4.9	
Potassium	mg/l		0.7	4.8	1.2	0.7	
Selenium	ug/l		0.9	1	<0.5	0.8	
Sodium	mg/l		160	22	240	45	
Thallium	ug/l		<0.5	<0.5	<0.5	<0.5	
Tin	ug/l		<1	<1	<1	<1	
Uranium	ug/l		1.7	1.7	0.5	0.7	
Vanadium	ug/l		1.6	1.4	4.8	2	
Zinc	ug/l		27	28	48	29	
Ammonia	mg/l N		0.03	0.37	0.03	0.03	
Chloride	mg/l Cl		341	28	279	61	
Nitrite (as N)	mg/l N		0.003	0.004	<0.002	<0.002	
ortho-Phosphate (as P)	mg/l P		0.06	0.08	<0.01	0.03	
Total Oxidised Nitrogen (as N)	mg/l N		0.53	4.13	0.75	2.01	
pH	pH		7.0	7.0	7.8	7.1	

Comments:

1) Results highlighted and in bold are outside specified limits.

2) All Metals Analysed in the EPA Dublin Laboratory,
Cyanide Analysed in the EPA Cork Laboratory.
Phenols Analysed in the EPA Castlebar Laboratory.

3) **nm** "Not measured"
4) **nd** "None detected"
5) **nt** "No time" - Time not recorded
6) **tntc** "Too numerous to count"
7) F "Field measured parameters"

Signed: Date: 7/9/10

Caroline Bowden, A/Regional Chemist

Environmental Protection Agency
Regional Inspectorate
Seville Lodge, Callan Road,
Kilkenny

Report of: Leachate - Tipperary Town Landfill
Report to: South Tipperary Co. Co.
Report date: 07/09/10

Location sampled: Miscellaneous Leachate
Date sampled: 13/07/2010 Date received: 14/07/2010

	Laboratory Ref:	1003156	1003157	
	Type of sample:	Misc	Misc	
	Sampling point:	MW3 - 10-0865	MW2 10-0866	
	Sampled by:	Denis McGuire	Denis McGuire	
	Time Sampled:			
	Start/End - Dates of Analysis:			
	Status of results:	**Final Report**	**Final Report**	
Parameter	**Units**			
Biochemical Oxygen Demand	mg/l O2	<30	<30	
Chemical Oxygen Demand	mg/l O2	480	562	
Conductivity @25°C	µS/cm	5330	4300	
Fluoride	mg/l F	0.15	0.37	
Sulphate	mg/l SO4	16	100	
Aluminium	ug/l	1300	2200	
Antimony	ug/l	1.3	2.7	
Arsenic	ug/l	14	31	
Barium	ug/l	1700	320	
Beryllium	ug/l	<0.5	<0.5	
Boron	ug/l	640	1600	
Cadmium	ug/l	<0.5	1.3	
Calcium	mg/l	160	30	
Chromium	ug/l	49	37	
Cobalt	ug/l	3.8	7.9	
Copper	ug/l	30	43	
Iron	ug/l	9300	3800	
Lead	ug/l	95	110	
Magnesium	mg/l	44	33	
Manganese	ug/l	510	480	

		1003156	1003157	
Laboratory Ref:		1003156	1003157	
Type of sample:		Misc	Misc	
Sampling point:		MW3 - 10-0865	MW2 10-0866	
Sampled by:		Denis McGuire	Denis McGuire	
Time Sampled:				
Start/End - Dates of Analysis:				
Status of results:		**Final Report**	**Final Report**	
Parameter	**Units**			
Mercury	ug/l	<0.5	<0.5	
Molybdenum	ug/l	1.1	14	
Nickel	ug/l	8.7	21	
Potassium	mg/l	62	150	
Selenium	ug/l	3	18	
Sodium	mg/l	650	430	
Thallium	ug/l	<0.5	<0.5	
Tin	ug/l	<1	1	
Uranium	ug/l	<0.5	0.5	
Vanadium	ug/l	9.5	17	
Zinc	ug/l	190	280	
Ammonia	mg/l N	37	120	
Chloride	mg/l Cl	1320	875	
Nitrite (as N)	mg/l N	<0.002	<0.002	
ortho-Phosphate (as P)	mg/l P	0.16	0.44	
Total Oxidised Nitrogen (as N)	mg/l N	<0.50	<0.50	
pH	pH	7.2	8.7	

Comments:

1) Results highlighted and in bold are outside specified limits.
2) All Metals Analysed in the EPA Dublin Laboratory,
Cyanide Analysed in the EPA Cork Laboratory.
Phenols Analysed in the EPA Castlebar Laboratory.
3) **nm** "Not measured"
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5) **nt** "No time" - Time not recorded
6) **tntc** "Too numerous to count"
7) **F** "Field measured parameters"

Signed: [signature] Date: 7/9/10

Caroline Bowden, A/Regional Chemist

APPENDIX 2

Ecofact Report

Former Landfill at Tipperary Town

Ecological Assessment
And
Appropriate Assessment Stage 1: Screening

Version: 13th October 2011

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TABLE OF CONTENTS

1 INTRODUCTION

The current report provides the results of an ecological assessment undertaken at the former landfill site, on the northern outskirts of Tipperary town at Carrownreddy. The assessment has been undertaken as part of the Tier 3 Risk Assessment for the closed landfill, on behalf of O'Callaghan Moran and Associates. The site has been categorised as being a Class A – High Risk site due to the risk to humans from landfill gas and also due to the potential for leachate migration.

Ecofact Environmental Consultants Ltd. have been commissioned to carry out an ecological assessment of the marsh / reed swamp area adjacent to the closed landfill to evaluate the impacts, if any, of the closed landfill on this area.

Additionally, an Appropriate Assessment Stage 1 Screening has been carried out for the proposed remediation measures to assess whether this proposal is likely to have a significant effect on the Natura 2000 site network. Effects upon the conservation objectives and qualifying interests (including habitats and species) within the affected designated areas are considered. An Appropriate Assessment is required under Article 6 of the Habitats Directive (92/43/EEC), in instances where a plan or project may give rise to significant effects upon a Natura 2000 site. Natura 2000 sites are those identified as sites of European Community importance designated under the Habitats Directive (SACs) or the Birds Directive (SPA).

The current document meets this requirement by providing a Screening Assessment of the proposed remediation works in Appendix 1 of the current report and follows the guidance for screening published by the National Parks and Wildlife Service (NPWS 2009) '*Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities'*. The area of marsh / reed swamp habitat adjacent to the landfill, within the study area is not designated within any Natura 2000 site and is not considered within the context of an Appropriate Assessment.

2 METHODOLOGY

A desktop review was carried out to identify features of ecological importance within the study area. Sources included the National Parks and Wildlife Service online database of protected species. A full bibliography of reports and publications used in the desk study are provided in the references section of this report. A review of the published literature was undertaken in order to collate data on the receiving environment, including species and habitats of conservation concern in the study area. The collation of this information, as well as examination of Ordinance Survey mapping, aerial photography and conservation designations from the NPWS online mapping allowed areas of potential ecological importance to be highlighted prior to the field survey.

A site walkover of the closed landfill site was undertaken by a qualified ecologist (MIEEM) with a particular focus on the marsh area and the connection between the landfill site and the existing land drain to the east. This drain was sampled using a sweep net to identify the macroinvertebrate community present, to allow for an evaluation of the biological water quality within the drain. Water levels within the drain were found to be low and the substrate was dominated by silt and decaying vegetation; therefore unsuitable for the application of the EPA Q-value assessment or the EPA Small Streams Risk Score (SSRS) assessment.

Habitats were classified according to habitat descriptions and codes published in the Heritage Council's '*A Guide to Habitats in Ireland*' (Fossitt, 2000). Plant species nomenclature follows Stace '*New Flora of the British Isles*' (1997) and scientific names are given at first mention. An assessment of fauna within the study area was made during the site visit, with particular emphasis on the presence of protected species.

3 RESULTS

3.1 Habitat survey

Habitats recorded from the site are classified according to Fossitt (2000) and are described in detail below. The wetland habitat within the site was surveyed and the results are discussed under the relevant habitat type – Reed / large sedge swamp (FS1).

3.1.1 Improved Agricultural grassland (GA1)

The field directly east of the closed landfill site, containing the southern portion of the reed swamp wetland was characterised as improved agricultural grassland. The field was grazed by horses and floral diversity was low. The sward was dominated by a rye-grass mix *Lolium* sp. with broadleaved herbs typical of this habitat recorded including: Nettle *Urtica dioica*, Creeping buttercup *Ranunculus repens,* Meadow buttercup *Ranunculus acris,* Broad dock *Rumex obtusifolius,* Ragwort *Senecio jacobaea* and Dandelions *Taraxacum officinale agg.*

3.1.2 Reed / Large sedge swamp (FS1)

The marsh habitat referred to in the Tier 3 Risk Assessment was found to be dominated by Bulrush Typha latifolia, with abundant Yellow Iris *Iris pseudacorus*; this results in the classification as a reed / large sedge swamp where the overall diversity within this habitat was found to be species poor. Broad leaved herbs occurred, comprising a small percentage of the overall habitat. Additional species recorded from the swamp and its margins included Floating sweet-grass *Glyceria fluitans,* Yorkshire fog *Holcus lanatus,* Cocksfoot grass *Dactylis glomerata,* Tussock-grass *Deschampsia cespitosa,* Hard rush *Juncus inflexus,* Soft rush *Juncus effusus*, Common marsh-bedstraw *Galium palustre,* Willowherb *Epilobium sp.,* Meadowsweet *Filipendula ulmaria,* Silverweed *Potentilla anserina,* Woody nightshade *Solanum dulcamara*, Water-cress *Rorippa nastutium-aquatica,* Water horsetail *Equisetum fluviatile* (and other Equisetum species), Hemlock water-dropwort *Oenanthe crocata* and Duckweed *Lemna* spp. recorded from the small pools of open water. Alder and willow woodland was recorded from the northern portion of the swamp as described below.

The botanical community recorded from within this swamp habitat is indicative of permanent water-logging, with some standing water evident in pools, although *Lemna* sp. was found to be abundant. Water quality may present a constraint to the naturalness or diversity of flora within this habitat, however, the current community represents a wetland habitat of local ecological importance, both botanically and in relation to the wildlife value it provides (i.e. breeding birds and invertebrates).

3.1.3 Wet willow-alder-ash woodland (WN6)

The northern portion of the reed swamp wetland was found to include alder *Alnus glutinosa* with some willow *Salix* spp. This woodland was not associated with fen peat. This alder woodland would fall within the *Alnus glutinosa* – *Fillipendula ulmaria* association identified in the NSNW (Perrin *et al*., 2008). This wet woodland is considered to be of high local ecological importance, with cognisance of its connection with Carrownreddy Lough and the associated wetland ecological connectivity.

3.1.4 Drainage ditch (FW4)

Due east of the closed landfill site, the reed swamp was found to discharge to a land drain which flows from the swamp in a south easterly direction. However, on the day of the survey no flow was detectible in the drain due to low water levels. The substrate was found to comprise black, anoxic muds with decaying vegetation (high volume of *Lemna* sp.). A light film of hydrocarbons was evident in standing water where the swamp habitat and the drainage ditch converged. Aquatic macrophyte growth was low, with flora limited to the margins of the drain. Species recorded included Duckweed *Lemna* spp., Water-cress *Rorippa nastutium-aquatica,* Floating sweet-grass *Glyceria fluitans* and Yorkshire fog *Holcus lanatus.*

The land drain is evaluated as being of low ecological importance.

3.1.5 Treeline (WL2)

The line of the drainage ditch to the east of the reed swamp, within the agricultural grassland included a treeline dominated by Ash *Fraxinus excelsior* with some Alder *Alnus glutinosa* and Hawthorn *Crataegus monogyna*. Flora recorded from the understory included Brambles *Rubus fruticosus agg.,* Hart's-tongue Fern *Phyllitis scolopendrium,* Ivy *Hedera helix* and Dog-rose *Rosa canina agg.* This treeline was not continuous along field boundary, although treelines and hawthorns were common along field boundaries within the local context.

The treeline along the land drain is evaluated as being of local ecological importance, although it is fragmented and is not properly connected with the treeline network within the local landscape. The infilling of the surrounding fields with construction and demolition (C&D) waste has disrupted the hedgerow and treeline corridors within the local context.

3.1.6 Spoil and bare ground (ED2)

Directly north of the closed landfill compound an area of open bare ground and spoil was recorded where top-soil material, vegetation cuttings and some C&D waste had recently been dumped. This material was banked along the northern periphery of the elevated landfill, with a turning circle cleared in the centre. Some of this material was found to be slipping down the embankment to the wetland habitat surrounding the northern and eastern perimeter of the closed landfill.

This habitat was evaluated as being of low ecological importance.

3.1.7 Recolonising bare ground (ED3)

A significant portion of the lands to the north and east of the reed swamp wetland comprised recolonising bare ground, where C&D waste was becoming re-vegetated with ruderal broadleaved species. Grass cover was very low. The elevated fill material was well-compacted and it is expected that recolonisation will take a period of years.

Species recorded from within this habitat included Docks, Nettle, Willowherb, Ragwort, Thistle species, Plantain species *Plantago* spp., Lesser Burdock *Arctium minus,* Groundsel *Senecio vulgaris,* Japanese knotweed *Fallopia* japonica (limited to the southeastern corner of the closed landfill site, due south of the reed swamp habitat). Elder *Sambucus nigra,* Buddleja *Buddleja davidii,* Travellers Joy *Clematis vitalba,* Butterbur *Petasites hybridus,* Winter heliotrope *Petasites fragrans* and Brambles *Rubus fruticosus agg.*

This habitat was evaluated as being of low ecological importance.

3.2 Additional ecological observations

The swamp habitat identified along the northern and eastern boundary of the site contains a botanical community identified as compatible with the requirements of whorl snails (*Vertigo* spp.). A screening search for these species was undertaken on the site and none were recorded. It is considered that the background water quality issues at the site are having an impact on the macroinvertebrate communities (both aquatic and semi-aquatic). Given the constraints at the site, it is considered that whorl snail species are unlikely to occur, with no records of these species previously recorded from the study area.

A sweep-net sample was taken from the land drain directly below the discharge from the swamp. An EPA biotic index (Q-value) would not be applicable to this site given the size of the drain and low flow conditions present. However, it is noted that the macroinvertebrate diversity recorded were limited to taxa tolerant of pollution, as shown in Table 1. No pollution sensitive taxa were recorded.

No connection was noted between the land drain on the site and the upper reaches of the Fidaghta River, which flows to the north of the study area. The land drain from the closed landfill site was followed downstream to Rosanna Road where it was culverted below a new residential development. Upstream of the road the drain created a wide area of wet grassland and marsh habitat as shown. No open water or flow was visible in the culvert under the road. According to the EPA Envision online mapping the surface water flows from the marsh area are within the Fidaghta River catchment. However, from onsite walkover studies undertaken by O'Callaghan Moran & Associates, it has been determined that these flows are to the Ara River catchment, which flows to the south of Tipperary town.

Table 1 Macroinvertebrates recorded during the sweep-net sampling at the land-drain due east of the Tipperary closed landfill.

Group / organism	Pollution sensitivity group	Functional group	Abundance
TRUE FLIES (Diptera)			
Family Chironomidae			
Green chironomid	C	Filtering collector	Common
Chironomous sp.	E	Filtering collector	Common
SNAILS (Mollusca, Gastropoda)			
Ramshorn Snail (Family Planorbidae)			
Planorbis sp.	C	Scraper	Present
Family Lymnaeidae			
Lymnaea peregra	D	Filtering collector	Fair numbers
MUSSELS (Mollucsa, Lamellibranchiata)			
Orb/Pea Mussels (Sphaeridae)	D	Filtering collector	Present
CRUSTACEANS (Crustacea)			
Isopoda (Family Asellidae)			
Asellus aquaticus	D	Shredder	Common
LEECHES (Hirudinae)			
Family Glossiphonidae			
Helobdella stagnalis	D	Predator	Present
TUBIFICID WORMS	D	Collector	Common

No observations or evidence of protected mammals were recorded during the site survey and it is considered unlikely that the site is important for protected species. The standing water within the swamp habitat provides suitable habitat for frogs and newts, although neither species were recorded on the day of the survey.

The invasive, non-native species Japanese knotweed *Fallopia japonica* was recorded from the south eastern corner of the closed landfill site, adjacent to the laneway. The disturbed nature of the site provides ideal habitat for the spread of this species which will require further management and control.

4 DISCUSSION

The ecological assessment of the wetland habitat at the former landfill at Tipperary town has identified the presence of reed swamp (FS1) habitat, with some wet alder / willow woodland (WN6). This habitat is evaluated as being of high local importance and is connected with the Carrownreddy Lough and associated wetlands, to the north. There is no data available on the diversity or ecological importance of this habitat or the biodiversity value of Carrownreddy Lough prior to the landfill, to provide a benchmark for the current situation at this reed swamp. However, the botanical community within this habitat is likely to maintain its diversity despite any further leachate inputs from the landfill (based on the current situation).

Water levels were found to be very low on the site during the current assessment, both in the reed swamp habitat and in the land drain, although there was evidence in the botanical community that this habitat is water-logged throughout the year.

It is considered that the surrounding lands are currently providing little dilution of leachate to the land drain which was receiving minimal flows from the swamp and was barely flowing on the day of the survey, with pooled water observed in sections downstream. The substrate of the swamp and land drain were found to be anoxic, although this is considered to be a combined function related primarily to the stagnant conditions within the low-lying swamp.

The reed swamp is considered to be providing an important function as a natural attenuation of the leachate from the former landfill, in agreement with the findings of the '*Tier 2 Detailed Site Investigation*' (OCM, 2009). This habitat will require the maintenance of a high water table or permanent standing water for its ongoing viability.

Although water quality in the reed swamp is likely to be affected by the leachate from the reed swamp, the botanical community recorded is indicative of a semi-natural habitat. More significant impacts may relate to the macroinvertebrate communities present. This reed swamp and wet woodland is considered to comprise an important habitat for breeding birds, with at least one pair of moorhens recorded on the day of the survey.

Based on the current one-off site visit during low flow conditions, the land drain on the site appeared to be affected by water quality impacts requiring further remediation measures during the Tier 3 Risk Assessment.

The proposed remediation at the landfill site will require the placement of a 0.5-1m cap across the whole of the landfill. There is the potential for these works to encroach into the reed swamp habitat at the existing toe of the landfill. Impacts affecting the reed swamp will be reduced by restricting machinery access to the top of the existing landfill and avoiding any machinery within the wetland area. There remains the potential for some disturbance at the perimeter of the existing landfill i.e. within 5-10m of the landfill margins in the west, north and east of the landfill with the potential for silt and clay run-off during the capping process. This will be mitigated against effectively using silt curtains and appropriate site fencing. Following the completion of capping the revegetation of the landfill will stabilize sediments on the banks of the landfill.

There is an overall beneficial impact to the reedbed habitat at this location arising from the proposed remediation works, where leachate and surface water runoff will be minimized by the proposed works resulting in an improvement in water quality within this water dependant habitat. There will be further downstream impacts benefiting the Ara River, in the local context. There are no impacts affecting the reedbed / wetland habitat at this site which would have any effects on the Natura 2000 site network. This semi-aquatic habitat is not designated within any Natura 2000 site and is indirectly connected to the River Suir SAC via the land drain and the Ara River, which is a tributary of the Aherlow River.

With regard to the Appropriate Assessment Screening Report (see Appendix 1) it is concluded that the proposed Tier 3 Remediation works for the former Tipperary Landfill will not result in significant impacts affecting the Natura 2000 site network, in particular the River Suir SAC. Therefore it is not considered necessary for the 'Appropriate Assessment' process to proceed to Stage 2. Impacts arising from the proposed works are evaluated as being limited to the local context and would not extend in significance to the SAC which is located approximately 16 river kilometres downstream of the landfill site. Any beneficial impacts arising from the proposed remediation works would affect the Ara River within the local context; however, it is considered that this would not have any significant positive impact on the River Suir SAC, downstream of the Ara and Aherlow Rivers.

The Japanese knotweed on the site will require a management and control strategy for inclusion in the Remediation Measures during Tier 3. The small stands present on the site would be much easier to treat and control in the short term, rather than allow the spread and colonisation of large areas of the site by this species.

REFERENCES

European Commission (2001) *Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC*. European Commission Environment DG

Fossitt, J. (2000). A Guide to Habitats in Ireland. The Heritage Council, Kilkenny

NPWS (2009) *Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities*. Department of the Environment, Heritage and Local Government, Ireland.

OCM (2009) Tier 2 Detailed Site Investigation Former Landfill at Tipperary Town.

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PLATES

Plate 1 View of the agricultural grassland to the east of the closed landfill. The swamp habitat is visible in the centre left of the image, where it meets the land drain, along the treeline (centre).

Plate 2 View of the eastern portion of the reed swamp, where it discharges to the land drain. Emergent flora within the swamp and drain were searched for whorl snails.

Plate 3 Water levels in the land drain were found to be very low, with no noticable flow.

Plate 4 View west from the elevated C&D waste spoil. The swamp habitat is visible in the centre of the image, with the elevated closed landfill in the background.

Plate 5 View north across the recolonising bare ground of the C&D waste spoil.

Plate 6 View of the drier margins of the swamp where the C&D spoil has altered the water table.

Plate 7 View of the *Typha* dominated swamp directly east of the closed landfill.

Plate 8 *Typha* dominated swamp with Alder woodland along the northern line of the closed landfill. *Juncus* was common along the interface between the drier C&D spoil and the reed swamp wetland.

Plate 9 The northern portion of the swamp, view west. Alder and willow wet woodland was recorded from within the permanent wetland habitat.

Plate 10 Limited open areas of water were noted. Duckweed was found to be abundant wherever they occurred. Moorhens were recorded from within the swamp.

Plate 11 Japanese knotweed was recorded along the road margin at the south eastern corner of the closed landfill site. It is considered that the site presents suitable habitat for the spread of this species, which will continue if unmanaged.

Plate 12 View of the old buildings and material storage on the closed landfill site.

Plate 13 A view north showing the fenced compound on the closed landfill site. The swamp habitat is located to the east (right of the image).

Plate 14 To the north of the fenced compound on the landfill there is an area of freshly dumped topsoil, construction waste and vegetation. This is piled along the embankment at the edge of the swamp habitat.

Plate 15 The dumped material was found to be unstable and slipping downslope into the swamp habitat. It is expected that suspended solids and run-off from this waste is washing down into the swamp.

Plate 16 The land drain due south of the landfill was found to be impounded. No flow was recorded from the drain downstream. Pooled water was recorded directly adjacent to the road.

Plate 17 View north from Rosanna Road. No flow was recorded from the land drain due south of the closed landfill, at Rosanna Road. The construction of new residential developments as depicted and across the road to the south are likely to have altered the flow of this drain. The wet grassland / marsh habitat visible in this image is attributed to frequent high water levels within the land drain.

Appendix 1 Appropriate Assessment Screening Report

Table A1.1 Appropriate Assessment Screening Matrix for the proposed Tier 3 remediation works at the former Tipperary Landfill, Tipperary Town

Screening matrix	
Brief description of the project or plan	The current Tier 3 remediation works proposal for the former landfill at Carrownreddy, Tipperary Town has identified the need for the placement of a 0.5-1m cap across the whole of the landfill. Currently the site has been categorised as being a Class A – High Risk site due to the risk to humans from landfill gas and also due to the potential for leachate migration. The remediation works proposed will not require dewatering or alteration of the local drainage network. The net effect of capping would be an improvement in water quality reaching the local drainage network and a reduction in leachate, as rainwater is diverted from the waste mass.
Brief description of the Natura 2000 site network	The former landfill at Tipperary Town is located within 15km of the following Natura 2000 sites: -The Lower River Shannon SAC (002165), approximately 10km due north -The Galtee Mountains SAC (000646), approximately 9km due south -Moanour Mountain (002257), approximately 6km due southwest None of these designated Natura 2000 sites are connected to the former landfill site, either geographically or via hydrological or hydrogeological connections. The former landfill site is within the River Suir catchment and a drainage channel adjacent has been found to be connected to the Ara River (and not the Fidaghta River as shown on EPA Envision mapping). The Ara River is a tributary of the Aherlow River which confluences with the River Suir. The Ara River flows to the south of Tipperary Town; within one kilometre of the former landfill site at its closest point. The Ara River meets the Aherlow River, which is designated within the River Suir SAC, approximately 15 river kilometres downstream of Tipperary Town. Therefore the River Suir SAC is the only designated Natura 2000 site with any connection to the former landfill site; with regard to the indirect connection between the site and the SAC via the Ara River.
Assessment criteria	
Describe the individual elements of the project (either alone or in combination with other plans or projects) likely to give rise to impacts on the Natura 2000 site.	The proposed Tier 3 remediation works at the former landfill site will require capping of the landfill site to minimise run-off and leachate entering the drainage network. There is potential for the proposed works to cause disturbance to the drainage regime within the former landfill site, with the associated potential for the mobilisation of settled leachate material into the drainage network during the construction phase. The mobilisation of leachate material within the land drain adjacent to the site may result in the transportation of suspended solids and leachate pollutants to the Ara River, with the further potential for the transportation of this material downstream to the Aherlow River within the SAC.

Describe any likely direct, indirect or secondary impacts of the project (either alone or in combination with other plans or projects) on the Natura 2000 site by virtue of: • size and scale; • land-take; • distance from the Natura 2000 site or key features of the site; • resource requirements (water abstraction etc.); • emissions (disposal to land, water or air); • excavation requirements; • Transportation requirements; • duration of construction, operation, decommissioning, etc.; • other.	There are no likely direct impacts of the proposed remediation works affecting the River Suir SAC, as there are no direct connections to the SAC, neither are there any land-take requirements within a designated Natura 2000 site. There are no resource requirements, emissions, excavation requirements or transportation requirements likely to give rise to direct impacts on any Natura 2000 site. There are no likely indirect or secondary impacts arising from the proposed works which may affect the Natura 2000 site network, or the River Suir SAC in particular, with regard to the size and scale of the proposed works; land take; resource requirements, excavation requirements, transportation requirements or the duration of the proposed works. Indirect impacts in relation to emissions from the proposed site to water and the distance to the River Suir Natura 2000 site are identified as being relevant. However, the distance between the site and the SAC is approximately 15 river kilometres downstream; where the connection between the site and the Ara River is via a small, low capacity land drain.
Describe any likely changes to the site arising as a result of: • reduction of habitat area: • disturbance to key species; • habitat or species fragmentation; • reduction in species density; • changes in key indicators of conservation value (water quality etc.); • climate change.	From the current assessment there are no likely changes to the River Suir SAC arising as a result of any reduction in habitat area or disturbance to key species. The proposed works do not give rise to the likelihood for habitat or species fragmentation or a reduction in species density within the SAC. There are no likely changes to the key indicators of conservation value i.e. water quality within the SAC, located 15 river kilometres downstream of the site. In fact it is considered that the proposed works will have a beneficial impact on water quality within the Ara catchment with the minimisation of leachate and run-off from the existing un-capped landfill (as identified in the Tier 2 Hydrogeological Report).
Describe any likely impacts on the Natura 2000 site as a whole in terms of: • interference with the key relationships that define the structure of the site; • interference with key relationships that define the function of the site.	The current assessment has identified that the proposed remediation works at the former Tipperary Landfill site will not have any direct, indirect or secondary / cumulative impact on the Natura 2000 site network, or the River Suir SAC in particular, with regard to interference with the key relationships defining the structure and function of the site. Furthermore there are significant beneficial impacts arising from the proposed works with regard to water quality within the undesignated Ara catchment. The area of marsh habitat adjacent to the landfill, within the study area is not designated within any Natura 2000 site and is not considered within the context of an Appropriate Assessment.
Provide indicators of significance as a result of the identification of effects set out above in terms of: • loss; • fragmentation; • disruption/disturbance; • change to key elements of the site (e.g. water quality).	The proposed remediation works at the former Tipperary Landfill site will not have any significant impacts, direct, indirect or cumulative on the River Suir SAC in terms of loss or fragmentation. There will be no significant impacts with regard to disturbance or disruption of the conservation interests and key relationships of the site. There will be no significant impacts arising which would result a change to the key elements of the site (i.e. water quality). In fact it is considered that the proposed remediation works would result in a positive impact on water quality in the Ara River downstream of the works. However, this is considered unlikely to result in any perceptible change in water quality in the River Aherlow, given the distance and dilution between the Aherlow and the landfill site.
Describe from the above those elements of the project or plan, or combination of elements, where the above impacts are likely to be	There are no impacts arising from the proposed remediation works likely to significantly affect the Natura 2000 site network. There is no potential for direct impacts on any Natura 2000 site arising from the proposed works and indirect impacts are limited to the hydrological connection between the site and the River Suir SAC. However, the connecting

<table>
<tr><td>significant or where the scale or magnitude of impacts is not known.</td><td colspan="3">watercourses (land drain and Ara River) and the distance (approx. 15Rkm) between the site and the SAC, results in the conclusion that there will be no significant impacts arising.</td></tr>
<tr><th colspan="4">Finding of no significant effects report matrix</th></tr>
<tr><td>Is the project or plan directly connected with or necessary to the management of the site (provide details)?</td><td colspan="3">The proposed Tier 3 remediation works are not directly connected with or necessary to the management of the River Suir SAC.</td></tr>
<tr><td>Are there other projects or plans that together with the project or plan being assessed could affect the site (provide details)?</td><td colspan="3">There are no other projects or plans in the Ara River catchment, or the River Aherlow / River Suir catchment which could give rise to cumulative impacts affecting the SAC, as there are no significant impacts identified arising from the proposed works in isolation and the scale of the proposed works with respect to the Ara River are considered to be imperceptible positive, due to the minimisation of leachate and surface water run-off.</td></tr>
<tr><th colspan="4">The assessment of significance of effects</th></tr>
<tr><td>Describe how the project or plan (alone or in combination) is likely to affect the Natura 2000 site.</td><td colspan="3">The proposed Tier 3 remediation works are considered to have no significant impact on the River Suir SAC. There are imperceptible positive impacts identified for the Ara River, which is a tributary of the River Aherlow, with regard to the minimisation of leachate and surface water run-off – however this is not considered to be of a scale that would be quantified within the River Suir SAC, downstream of the confluence between these watercourses.</td></tr>
<tr><td>Explain why these effects are not considered significant.</td><td colspan="3">The small size and scale of the proposed works, combined with the limited hydrological connection to the Ara River within the River Suir catchment (Aherlow sub-catchment) is considered to be the primary limiting factor in relation to the significance of effects. The distance of the proposed works to the SAC (approximately 15 river kilometres) also results in significant river recovery and dilution within the Ara River, in the event of any downstream dispersion of leachate or polluting material. It is not considered likely that this would give rise to any significant effects within the River Suir SAC.</td></tr>
<tr><th colspan="4">Data collected to carry out the assessment</th></tr>
<tr><td>Who carried out the assessment</td><td colspan="3">ECOFCACT Environmental Consultants Ltd., on behalf of O'Callaghan Moran and Associates</td></tr>
<tr><td rowspan="2"></td><td>Sources of data</td><td>Level of assessment completed</td><td>Where can the full results of the assessment be accessed and viewed?</td></tr>
<tr><td>National Parks and Wildlife Service (NPWS): http://www.npws.ie</td><td>Article 6 Screening Assessment</td><td>The full Assessment is contained within the current document.</td></tr>
<tr><th colspan="4">Overall conclusions</th></tr>
<tr><td colspan="4">The proposed Tier 3 Remediation works for the former Tipperary Landfill will not result in significant impacts affecting the Natura 2000 site network, in particular the River Suir SAC. Therefore it is not considered necessary for the 'Appropriate Assessment' process to proceed to Stage 2. Impacts arising from the proposed works are evaluated as being limited to the local context and would not extend in significance to the SAC which is located approximately 15 river kilometres downstream of the landfill site. Any beneficial impacts arising from the proposed remediation works would affect the undesignated Ara River within the local context; however, it is considered that this would not have any significant positive impact on the River Suir SAC, downstream of the confluence of the Ara River with the Aherlow River.</td></tr>
</table>

References

NPWS (2009) *Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities*. Department of the Environment, Heritage and Local Government, Ireland.

European Commission (2001) *Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC*. European Commission Environment DG

APPENDIX 3

Remedial Action Plan

O' Callaghan Moran & Associates

environmental management for business

PRELIMINARY

REMEDIAL ACTION PLAN

TIPPERARY TOWN LANDFILL

Prepared For: -

South Tipperary County Council.,

Prepared By: -

O'Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork.

October 2011

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DRAWINGS

1. INTRODUCTION

The Tier 3 Risk Assessment of the former Tipperary Town Landfill categorised the site as High Risk due to the potential for leachate impact on surface water quality and landfill gas migration. The assessment identified that remedial measures, including the capping of the fill area and the installation of a landfill gas control measures were required.

The report presents the preliminary design of the remedial measures and forms part of the Tier 3 Risk Assessment Report that will be submitted to the Environmental Protection Agency (Agency) as part of the Unregulated Landfill Certification process.

The preliminary design is based on the Agency's Landfill Manuals on Landfill Site Design (2000) and Landfill Restoration and Aftercare (1999) which presents guidance on landfill closure and restoration measures.

2. LANDFILL CAP

2.1 Restoration Profile

The site topography is illustrated on Drawing No. 1.The placement of both the waste and existing cover material has resulted in a landform which generally falls from a central plateau ranging from 97-99mOD in all directions to the surrounding natural ground.

The natural ground forms a low depression which was the original lake but the ground level is higher to the south and west. It is approximately 96mOD along the southern boundary with the landfill. Along the northwest landfill boundary with the marsh the natural ground level is approximately 91.8mOD. The natural ground in the east and also rises up away from the landfill. The lands to the east have been reclaimed with construction/demolition waste which has raised the profile by approximately 1-1.5m to the east of the site.

Within the landfill there are a number of stockpiles of construction demolition waste in the western part of the site that have not been graded. The northwestern portion of the landfill contains a fenced-off sludge disposal area, which is overgrown with vegetation. The southern section of the landfill is occupied by a gravel covered hard stand area which was used as a parking compound for plant when the site was operational. There is an un-occupied building located to the northwest of the parking compound.

Approximately 50% of the site has been covered with soil and vegetated. However, the cover is not uniform in thickness and has not been properly graded to enhance surface water run-off. The existing layout is shown on Drawings 1 and 4.

The proposed finished profile, which is shown on Drawing No. 2, comprises a uniform shallow (1:25) gradient from the south to the north. This gradient will assist surface water drainage. It is the Council's preference that the site be restored as grassland. Given the relatively small area that will be restored, ca 1.8 ha, and the overall size of the site (ca 1.5 ha) it is not necessary to provide hedgerows to subdivide the land into smaller fields and it will not be necessary to plant trees.

Grass is the most suitable vegetation as it provides all year round soil cover and promotes the development of a soil structure and animal grazing is the intended use identified by the landowner. This land use also minimises the potential for soil damage as it does not require field work during late autumn, winter or early spring.

2.2 Design Objectives

The design objectives were to minimise the infiltration of incident rainfall into the waste mass, which is considered to be the primary source of leachate generation at the site, ensure that the site was suitable for the end-use and minimise the long term aftercare maintenance.

2.3 Options

An assessment of suitable capping system options for the site was carried out taking into consideration the Agency's Landfill Manuals on Landfill Site Design and Landfill Restoration and Aftercare and the findings of the Tier 2 and 3 investigations.

The recommended capping design for non-hazardous landfill includes a minimum total topsoil and subsoil thickness of 1 m overlying a drainage layer of minimum thickness of 0.5 m, a low permeability barrier and a landfill gas collection layer. The thickness of the layers is intended to allow for post closure settlement and the installation of pollution control systems.

However, given the age of the landfill and the total depth 11.5m the likelihood of significant future settlement is low. While landfill gas is being generated, this is primarily associated with limited area used for sludge disposal with localised source areas for landfill gas elsewhere. However, in those areas the gas levels are likely to be reducing over time. Some portions of the site have already been covered by subsoils. It is unlikely therefore that a 1 m thickness of subsoils and topsoil and a gas collection layer across the entire site is required.

The Landfill Manual on Site Design recommends that the barrier layer consist of either a low hydraulic conductivity mineral layer or a synthetic layer such as a flexible membrane liner (FML) or geosynthetic clay liner (GCL). The minimum thickness of the mineral layer should be 0.6 m with a hydraulic conductivity of $1x10^{-9}$m/s. Where a geosynthetic material is used, it should provide the equivalent protection.

The use of FMLs and GCLs requires the installation of perimeter anchor trenches that would cause significant disturbance of the marsh adjoining the fill area. Therefore, a mineral layer comprising a 0.6 m engineered clay cap (ECC) is the preferred barrier layer.

2.4 Surface Water Management

Rainfall infiltrating through the subsoils in the capping system will be collected in the drainage layer that overlies the low permeability layer and flow along the contours to a perimeter swale. Surface run-off from the capped area will also be intercepted by the swale. The water will infiltrate to ground in the swale and feed into the marsh. This will assist in maintaining the high water table needed to sustain the marsh habitat.

2.5 Proposed Capping System

The proposed capping system is shown on Drawing No.2 comprises the following: -

- 0.15 m topsoil,
- 0.5 m subsoil,
- 0.3 m drainage layer (hydraulic conductivity $1x10^{-4}$m/s),
- 0.6 m engineered clay layer (hydraulic conductivity $1x10^{-9}$m/s).
- 0.3m gas collection layer

2.6 Works Programme

Given the size of the site the low permeability barrier, drainage layer, subsoils and top soils will be installed in one phase and as part of one contract. The seeding of the topsoil will be included in the contract. As there are no on-site sources of subsoil or topsoil, imported soils will have to be used. The materials for use in the drainage and barrier layers must also be imported.

A detailed design and specification will be prepared for the works, which will include a construction quality assurance plan and a construction method statement. The plan will include specifications for the materials to be used in the capping system and the quality control and assurance methods and testing that must be applied to ensure that the system is installed properly. The detailed design will be submitted to the Agency for its approval prior to the works commencing.

The installation of the capping system will be supervised by a competent person who will prepare a construction quality assurance validation report upon the completion of the works. At this time, it is estimated that the works can be completed in 4 - 6 weeks.

2.7 Aftercare Stage

Based on the age and limited extent of the fill, no appreciable degree of post closure settlement is expected. Given the local rainfall amounts and the proposed restoration profile erosion of the capping materials will not be a significant issue.

The Council will carry out regular inspections of the site in the aftercare period to monitor for settlement or erosion, which could impact on the integrity of the capping system. In the unlikely event of significant settlement or erosion, the Council will immediately undertake remedial work, subject to the agreement of the landowner/occupier.

The aftercare monitoring programme will include groundwater and landfill gas monitoring in wells adjoining the site and landfill gas and leachate level monitoring in the wells inside the waste. Initially it is proposed to conduct the monitoring bi-annually, after which the data be reviewed to establish trends.

3. LANDFILL GAS CONTROLS

Significant landfill gas concentrations have been recorded in the three monitoring wells located in the body of the waste body, however there is no evidence of any lateral migration from the fill area. This is most likely due to the fact that landfill gas can vent freely to atmosphere, thereby minimizing the accumulation of gas and build up of pressure within the waste, which is the main driver for gas migration.

3.1 Design Objectives

The design objectives were to minimise the risk of landfill gas migration towards the nearest occupied dwellings following the installation of the capping system, to protect future development, and have low maintenance requirements.

3.2 Options

An assessment of suitable control options for the site was carried out taking into consideration the Agency's Landfill Manuals and the findings of the Tier 2 and 3 investigations.

While the concentrations of methane measured within the waste body are high, given the age and size and depth of the fill area, the volumes of gas being generated are not sufficient to sustain active abstraction and flaring and utilisation.

The in-situ boulder clay surrounding the waste body has a moderate to low permeability, which inhibits gas movement while the water saturated conditions in the marsh along the landfill's north-western, northern and north-eastern margins also inhibit gas migration in these directions.

The only area where landfill gas migration has the potential to occur to any great extent is to the south, where the nearest occupied buildings (Halting Site) are located. Future development of residential and commercial use is also planned for these lands.

The most effective control measure for the site is a combination of a gas collection layer incorporated into the capping system, passive vents installed within the waste body and a cut off trench install outside the landfill footprint around the south western, southern and south eastern edges of the fill. The gas collection layer is required to encourage gas flow towards the vents and vent to atmosphere. The cut-off trench is intended to intercept gas migration to the south and allow it to vent to atmosphere.

3.3 Proposed Controls

The proposed gas control measures incorporated into the capping system are shown on Drawing No 3. The location of the cut-off trench is shown on Drawing No 4. Drawing No. 5 shows the detail of the Gas Cut-Off trench.

The cut off trench will be excavated to a maximum depth of 2m below ground level. The trench should be excavated in a manner that allows short sections to be excavated, lined and backfilled without the need for leaving the trench open for extended periods of time. The trench will be set back away from the waste mass where possible by at least 2m and will extend into the marsh area along the western portion of the site.

All sharp objects and protrusions, such as large stones, roots and the like, shall be removed from the floor and the side of the excavation to be lined, i.e. opposite side to the waste. Where necessary these surfaces shall be 'dressed' to provide a smooth and even surface free of protrusions. The floor of the excavation should be trimmed to remove all loose debris and objects potentially deleterious to the liner. Any waste and soil arising from the excavations shall be used in other earthworks on the site or disposed at a suitably licensed facility as appropriate

The trench will be lined with geosynthetic clay liner (GCL) and covered by a protective geotextile before being backfilled with granular material. The GCL will be cut to the correct length as required and lowered into the excavation so that it lines the surface away from the waste. The GCL will be overlapped by a minimum 300mm. Following installation of the GCL, a protective geotextile shall be placed on top

Following completion of the lining works, the trench will be backfilled with venting stone to the top of trench.

3.4 Works Programme

A detailed design and specification will be prepared for the works, which will include a construction quality assurance plan and a construction method statement. The plan will include specifications for the materials to be used in the installation of gas control measures and the quality control and assurance methods and testing that must be applied to ensure that the system is installed properly. The detailed design will be submitted to the Agency for its approval prior to the works commencing.

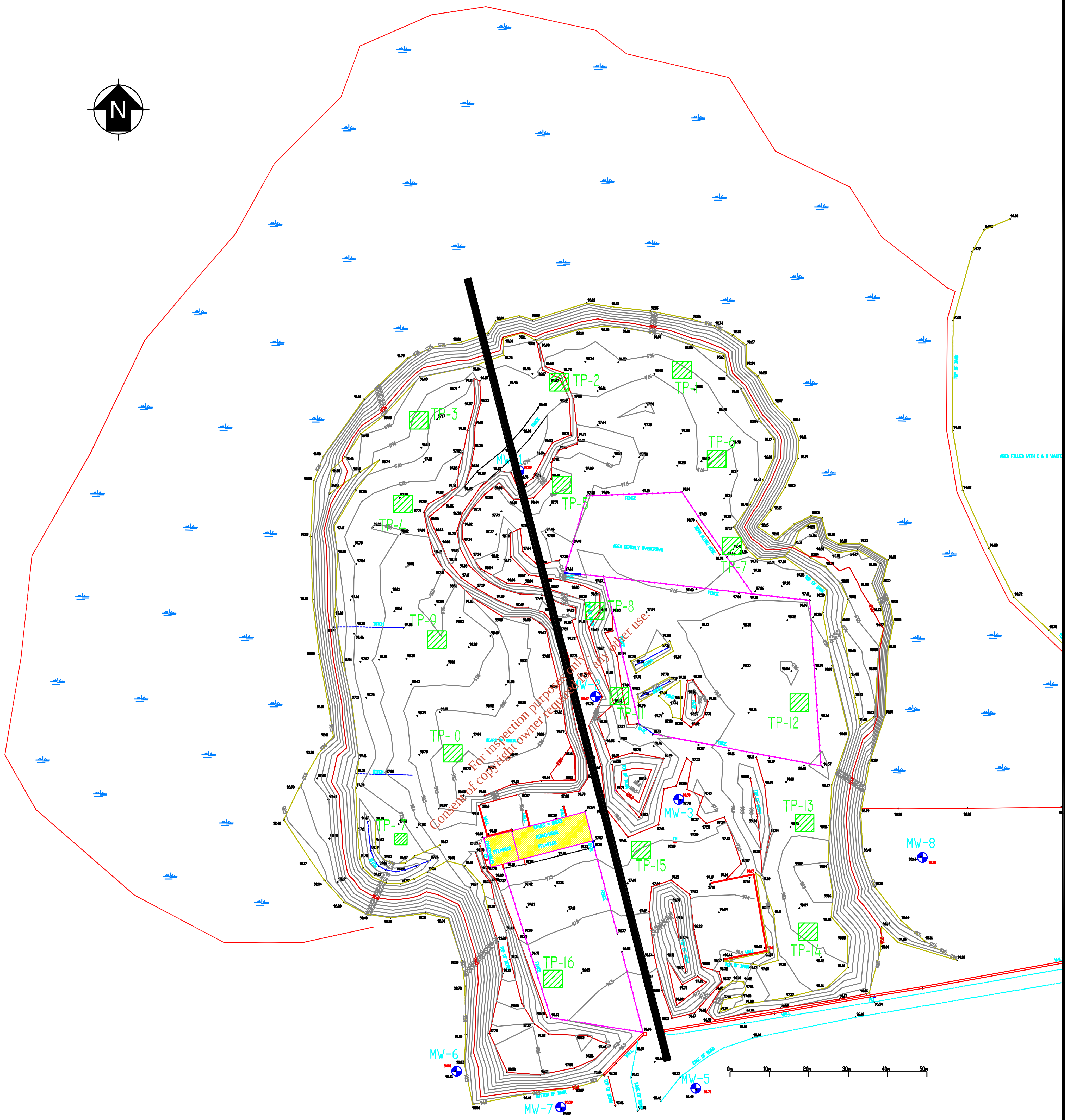
The installation of the cut off-trench will be supervised by a competent person who will prepare a construction quality assurance validation report upon the completion of the works. At this time it is estimated that the works can be completed in 2-4 weeks

3.5 Aftercare Stage

The Council will carry out regular inspections of the site in the aftercare period to monitor for settlement or erosion, which could impact on the integrity of the gas control system. In the unlikely event of significant settlement or erosion, the Council will immediately undertake remedial work, subject to the agreement of the landowner/occupier.

DRAWINGS

July 2011 (SM/JOC)



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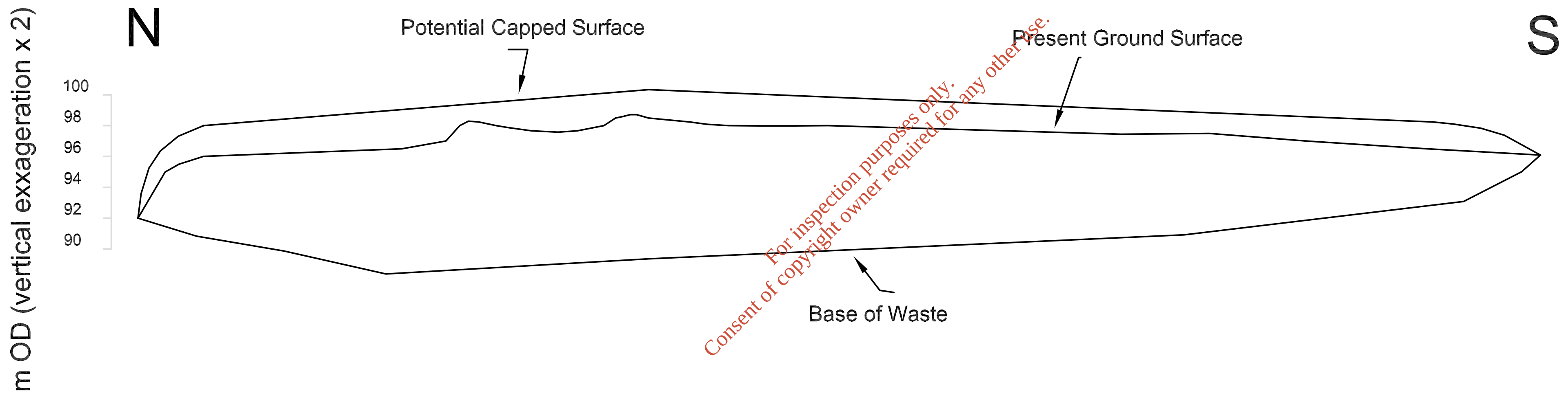
CLIENT	DETAILS	Figure No.
SOUTH TIPPERARY COUNTY COUNCIL		1
TITLE		SCALE
SITE TOPOGRAPHY		1:1,000



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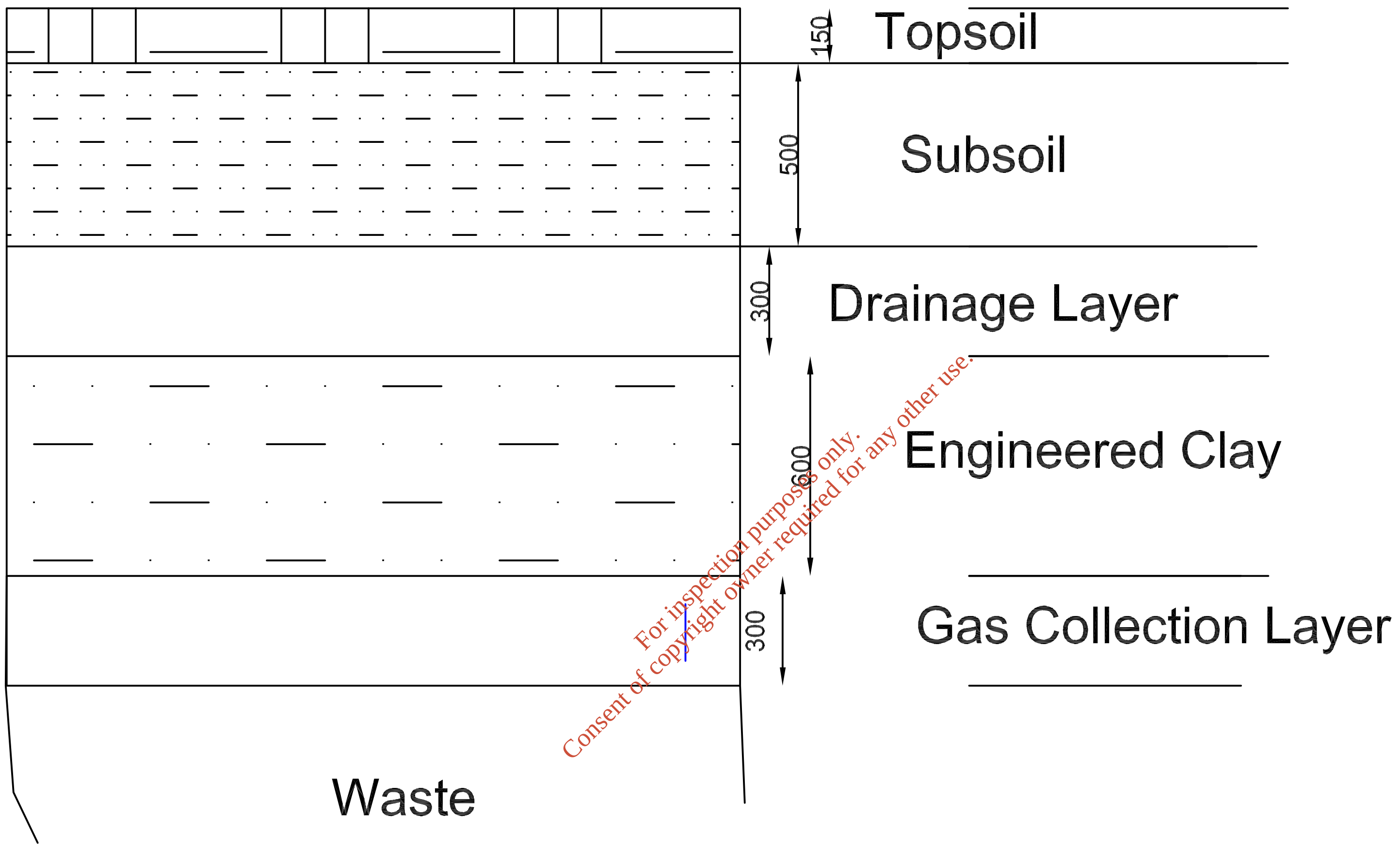
CLIENT: South Tipperary County Council	details	FIGURE No. 2	
TITLE: Proposed Finished Profile		SCALE 1:800	REV.



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CLIENT	South Tipperary County Council
TITLE	Proposed Capping System
details	
FIGURE No.	3
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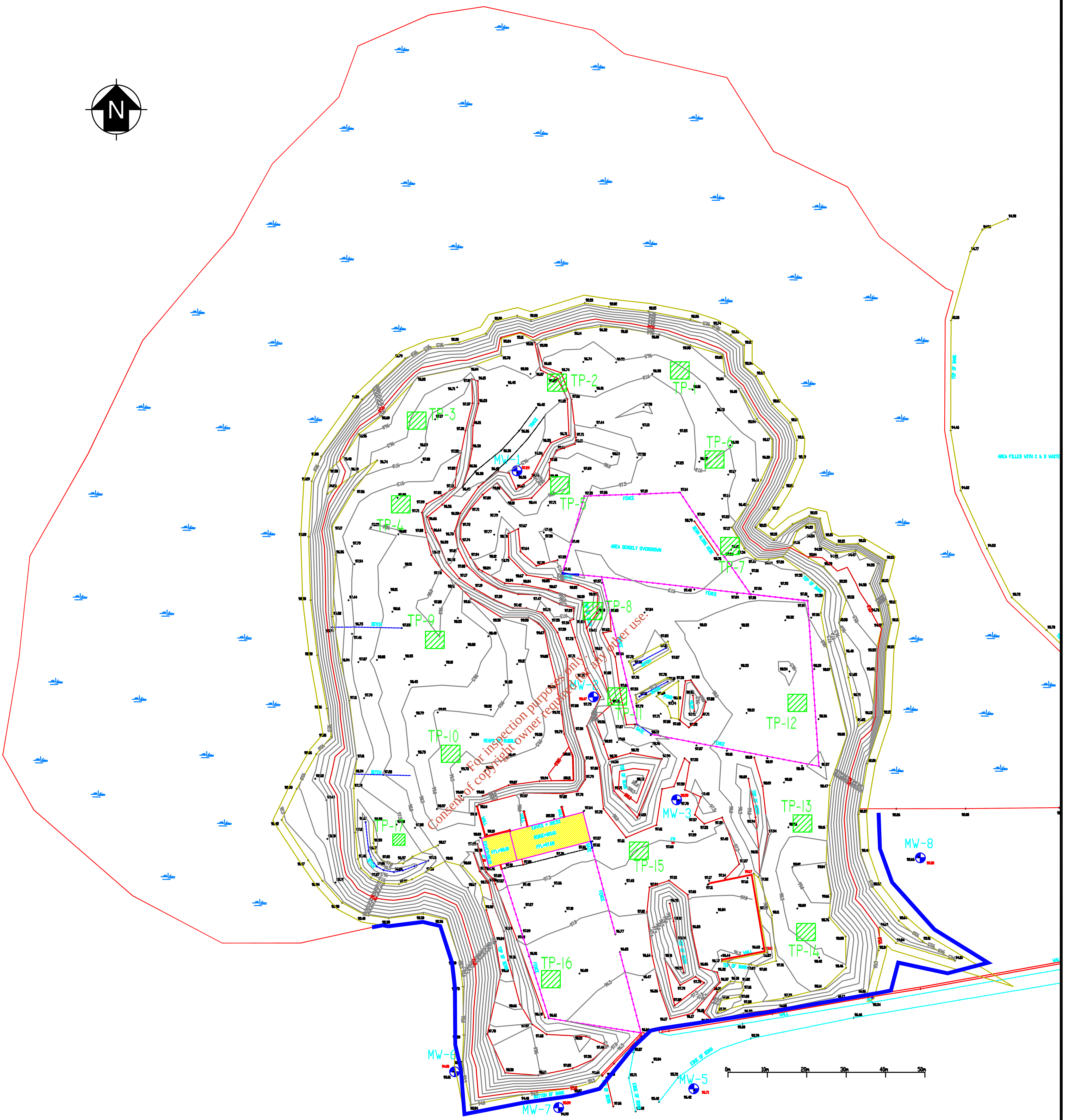
REV.	



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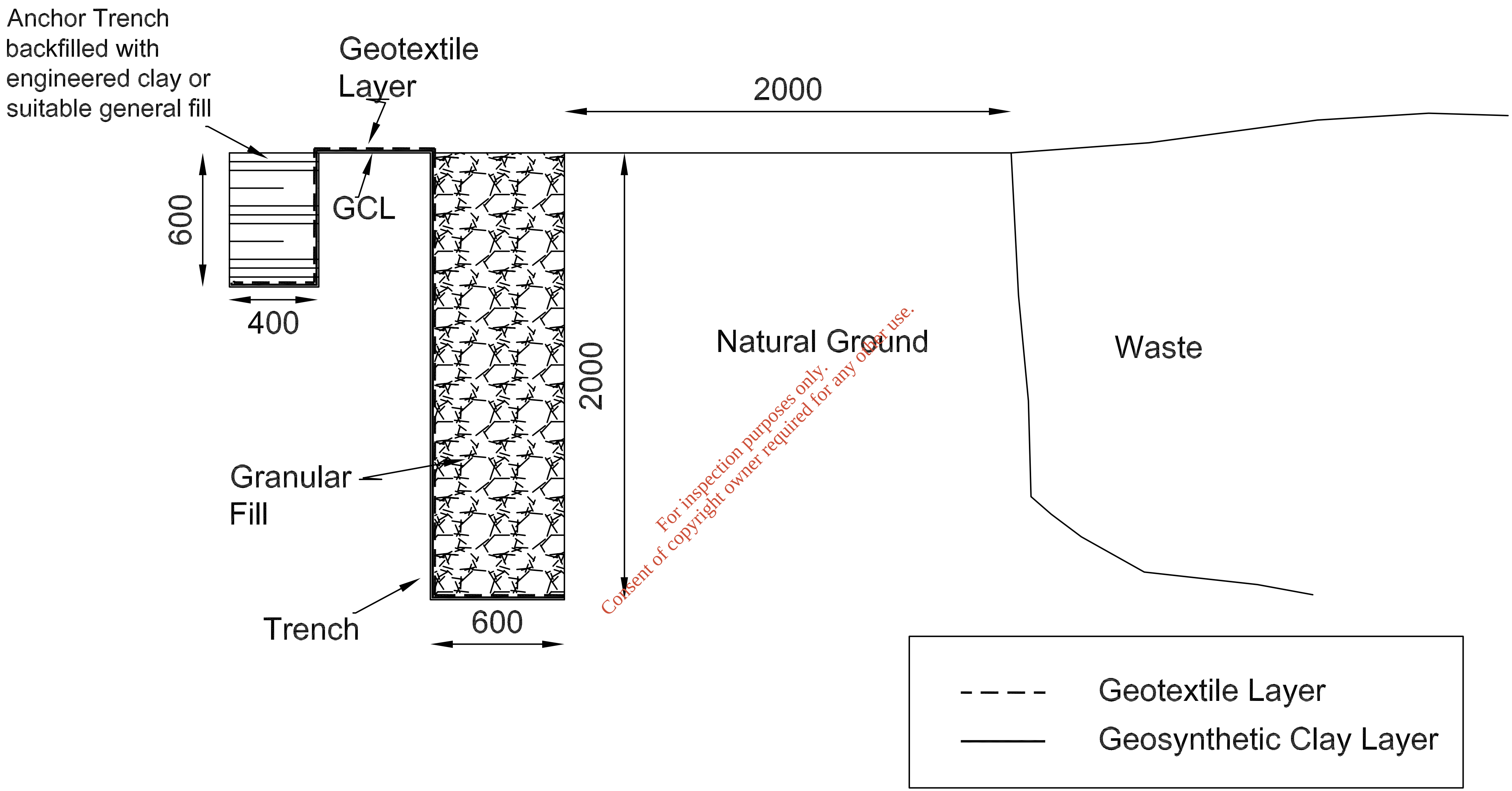
CLIENT	DETAILS	Figure No.
South Tipperary County Council	Gas Trench	4
TITLE		SCALE
Site Layout and TRENCH LOACTION		1:1,000



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CLIENT
South Tipperary County Council

TITLE
Gas Cut-Off Trench Detail

details

FIGURE No. 5

SCALE 1:25

REV.

Appendix 2

Monitoring Results

Surface Water Monitoring Reports 2010 - 2014

Sample Date	14/05/14		22/01/14		12/12/13		
Sample Location	**SW1**	**SW2**	**SW1**	**SW2**	**SW1**	**SW2**	**SW3**
Cond. (μs/cm)			482	636	782	782	781
BOD (mg/L)		1.13	0.21	0.79	1.04	0.84	5.03
COD (mg/L)	28	25	25	18			
Ammonical Nitrogen (mg/L)			0.18	0.86	3.7	3.65	0
Chloride (mg/L)			94	65	45	48	21
Iron (μg/L)			720	320	3700	2950	1165
Manganese (μg/L)			214	112	770	655	385
Ortho-Phosphate PO4 (mg/L)					0.655	0.655	0.371
pH	7.752	7.772	7.85	7.85			
Suspended Solids (mg/L)					22	18	100
Total Suspended Solids (mg/L)		2	20	2			

Sample Date	26/09/13			08/05/13			24/01/13		
Sample Location	SW1	SW2	SW3	SW1	SW2	SW3	SW1	SW2	SW3
Cond. (μs/cm)		747	510	324	461	312	648	639	657
BOD (mg/L)		7.49	1.29	1.5	0.1	1.9	0.82	0.74	0.78
COD (mg/L)		66	34	18	24	21	21.9	21.2	18.8
Ammonical Nitrogen (mg/L)		0.37	0.2	0.32	0.5	0	1.4394	1.6485	0.0635
Chloride (mg/L)		74.9	17.65	31	50	14.3	18.13	19.56	28.63
Iron (μg/L)		640	1030	400	410	900	220	130	340
Manganese (μg/L)		785	348	225	294	155	149	134	261
Ortho-Phosphate PO4 (mg/L)									
pH	7.3	7.52	7.82	7.384	7.498	7.657	7.388	7.273	7.995
Suspended Solids (mg/L)									
Total Suspended Solids (mg/L)		16	13	7	6	29	0	0	6
Dissolved Oxygen % Saturation		1.8	4.7						

Sample Date	11/12/12			19/09/12			04/04/12		
Sample Location	SW1	SW2	SW3	SW1	SW2	SW3	SW1	SW2	SW3
Cond. (µs/cm)	688	676	684	642	745	749	803	888	954
BOD (mg/L)	0.26	0.06	0.42	0	0	0	3	1.04	6.07
COD (mg/L)	24.7	17.1	22.3	42	36	39			
Ammonical Nitrogen (mg/L)	0.089	1.83	1.36	1.4056	2.73	2.94	3.23	4.52	
Chloride (mg/L)	43.9	33.88	30.5	11.93	40.56	25.29			
Iron (µg/L)	1020	80	720	4750	410	1250	570	40	16300
Manganese (µg/L)	312	144	176	289	313	398	12	22	1510
Ortho-Phosphate PO4 (mg/L)							0.15	0.15	0.21
pH	7.902	7.206	7.175	7.68	7.253	7.331			
Suspended Solids (mg/L)							12	6	216
Total Suspended Solids (mg/L)	29	2	17						
Dissolved Oxygen % Saturation									

Sample Date	18/01/12			09/12/11			17/08/10		
Sample Location	SW1	SW2	SW3	SW1	SW2	SW3	MW2	MW3	SW1
Cond. (µs/cm)	728	721	472	606	581	498			
BOD (mg/L)	4.87	6.42	31.2	2.85	1.23	44.1			
COD (mg/L)	6.5	14.5	191	27.6	27.3	310.2			
Ammonical Nitrogen (mg/L)	1.2127	1.25	0.76	1.16	1.53	0.82			
Chloride (mg/L)	24	28	5				966	1269.6	57.5
Iron (µg/L)	260	240	9150	270	250	780			
Manganese (µg/L)	154	149	257	147	144	499			
Ortho-Phosphate PO4 (mg/L)				0.04	0.02	0.03			
pH	7.51	7.48	6.83						
Suspended Solids (mg/L)				5	8	260			
Total Suspended Solids (mg/L)	2	1	50						
Dissolved Oxygen % Saturation									

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Sample Date		23/07/2014						
Sample Location	**Unit**	**MW1**	**MW2**	**SW1**	**SW2**	**MW4**	**MW8**	**GW IGV**
Temperature	°C	15.4	18.8	17.8	17.7	14.3	14.8	
Dissolved Oxygen (as %Sat)	-	nm	nm	95	25	-	-	NAC
pH	pH	7.3	8.6	7.4	7.4	7	7	6.5-9.5
Conductivity @25°C	µS/cm	4780	3140	797	965	758	1243	1000
1,1,1,2-Tetrachloroethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,1-Trichloroethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,2,2-Tetrachloroethane	µg/l	<1	<1	<1	<1	<1	<1	
1,1,2-Trichloroethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloropropene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2,3-Trichlorobenzene	µg/l	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,3-Trichloropropane	µg/l	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	
1,2,4-Trichlorobenzene	µg/l	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,4-Trimethylbenzene	µg/l	2.8	2	<0.5	<0.5	<0.5	<0.5	
1,2-Dibromo-3-Chloropropane	µg/l	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	
1,2-Dibromoethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichlorobenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloroethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloropropane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3,5-Trimethylbenzene	µg/l	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-Dichlorobenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-Dichloropropane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,4-Dichlorobenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
2,2-Dichloropropane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
2-Chlorotoluene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
4-Chlorotoluene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
4-Isopropyltoluene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Benzene	µg/l	0.8	2	<0.5	<0.5	<0.5	<0.5	
Bromobenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromochloromethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromodichloromethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromoform	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromomethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
c-1,2-Dichloroethene	µg/l	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	
c-1,3-Dichloropropene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Carbon Tetrachloride	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chlorobenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chloroform	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dibromochloromethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	

Sample Date		23/07/2014						
Sample Location	**Unit**	**MW1**	**MW2**	**SW1**	**SW2**	**MW4**	**MW8**	**GW IGV**
Dibromomethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichlorodifluoromethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichloromethane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Ethylbenzene	µg/l	1.2	1.5	<0.5	0.7	0.9	0.8	
Hexachlorobutadiene	µg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Isopropylbenzene	µg/l	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	
m,p-Xylene	µg/l	1.1	0.8	<0.5	<0.5	<0.5	0.5	
Naphthalene	µg/l	4.5	<0.5	<0.5	<0.5	<0.5	<0.5	
n-Butylbenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
n-Propylbenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
o-Xylene	µg/l	1.4	1	<0.5	<0.5	<0.5	<0.5	
sec-Butylbenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Styrene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,2-Dichloroethene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,3-Dichloropropene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
tert-Butylbenzene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Tetrachloroethene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Toluene	µg/l	1.7	7	<0.5	<0.5	0.9	<0.5	
Trichloroethene	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Trichlorofluoromethane	µg/l	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	
Vinyl Chloride	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Ammonia	mg/l N	260	82	4.2	6.7	<0.020	0.062	0.15
Chloride	mg/l Cl	370	564	43	64	40	120	30
ortho-Phosphate	mg/l P	<0.010	0.37	0.21	0.1	<0.010	0.069	0.03
Total Oxidised Nitrogen	mg/l N	<0.20	<0.20	0.26	<0.20	1.1	<0.20	NAC
Chemical Oxygen Demand	mg/l O2	776	220	40	144	308	3910	
BOD	mg/l O2	28	23	<6	8.2	<50	<600	
Suspended Solids	-	-	-	23	244	-	-	
Alkalinity-total	mg/l CaCO3	-	-	350	400	323	455	NAC
Fluoride	mg/l F	<2.0	<2.0	<0.20	<0.20	<0.20	<0.4	1
Sulphate	mg/l SO4	<20.0	50	14	5	14	35	200
Aluminium	ug/l	580	1300	11	14	4900	180	200
Arsenic	ug/l	4.7	8.1	1.7	1.5	3	21	10
Barium	ug/l	180	210	130	160	240	620	100
Beryllium	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Boron	ug/l	1400	1400	68	120	29	48	1000
Cadmium	ug/l	0.7	0.49	<0.020	<0.020	0.16	0.29	5
Calcium	mg/l	160	30	120	130	130	140	200
Cobalt	ug/l	12	3.7	<1.0	<1.0	2.1	1.3	
Iron	ug/l	4300	2700	1800	3900	3700	2300	1000
Lead	ug/l	20	46	<1.0	<1.0	7.5	2.3	10
Magnesium	mg/l	89	34	11	14	9	14	50

Sample Date		23/07/2014						
Sample Location	Unit	MW1	MW2	SW1	SW2	MW4	MW8	GW IGV
Manganese	ug/l	620	290	1100	1300	130	1700	50
Nickel	ug/l	16	13	<1.0	<1.0	6.9	5.1	20
Potassium	mg/l	200	130	6.5	10	2.9	0.91	5
Selenium	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Sodium	mg/l	280	400	27	40	33	110	150
Strontium	ug/l	600	260	210	220	170	240	
Thallium	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Uranium	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	2.6	9
Vanadium	ug/l	4.2	5.8	<1.0	<1.0	8.9	<1.0	
Mercury	ug/l	<0.50	<0.50	<0.50	<0.50	<0.50	2.8	1
Antimony	ug/l	1.1	1.9	<1.0	<1.0	<1.0	<1.0	
Chromium	ug/l	13	7.6	2	1.5	9.2	3	30
Copper	ug/l	6.3	18	<1.0	<1.0	7.7	26	30
Molybdenum	ug/l	1.3	8.3	<1.0	<1.0	<1.0	<1.0	
Zinc	ug/l	59	140	18	26	39	34	100
Total Organic Carbon (mg/l C)	mg/l C	-	-	-	-	2	8.7	NAC
E Coli (per 100ml)	per 100ml	-	-	-	-	<10	310	
Total coliforms (no/100ml)	No/100 ml	-	-	-	-	41	>24000	

Sample Date	01/10/2014					
Sample Location	**MW2**	**MW3**	**SW1**	**MW4**	**MW6**	**GW IGV**
Cond. (μs/cm)	3240	4680	801	811	1024	1000
BOD (mg/L)	8.4	22	6.5	<6	<8	
COD (mg/L)	128	181	51	21	33	
Ammoniacal Nitrogen (mg/L)	81	250	0.69	0.021	0.06	0.15
Chloride (mg/L)	626	349	56	43	30	30
Ortho-Phosphate PO4 (mg/L)	0.5	0.014	0.26	<0.010	<0.010	0.03
pH	8.9	7.1	7.7	7.3	6.8	6.5-9.5
Suspended Solids (mg/L)			49	-	-	NAC
Cyanide (mg/L)	<0.05		<0.05			
Temperature (°C)	12.3	12.6	12.9	13.1	13.2	
DO (% saturation)	nm	nm	58	32	45	
Nitrite (mg/ L N)	<0.004	<0.004	0.005	<0.004	0.044	0.1
Total Oxidised Nitrogen (mg/L N)	<0.20	<0.20	<0.20	2.2	3.1	
Alkalinity-Total (mg/L CaCO3)			325	349	481	NAC
1,1,1,2-Tetrachloroethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,1-Trichloroethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,2,2-Tetrachloroethane (μg/L)	<1	<1	<1	<1	<1	
1,1,2-Trichloroethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloropropene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2,3-Trichlorobenzene (μg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,3-Trichloropropane (μg/L)	<0.6	<0.6	<0.6	<0.6	<0.6	
1,2,4-Trichlorobenzene (μg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,4-Trimethylbenzene (μg/L)	4	3.5	<0.5	<0.5	<0.5	
1,2-Dibromo-3-Chloropropane (μg/L)	<1.3	<1.3	<1.3	<1.3	<1.3	
1,2-Dibromoethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichlorobenzene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloroethane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloropropane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3,5-Trimethylbenzene (μg/L)	1	<0.5	<0.5	<0.5	<0.5	
1,3-Dichlorobenzene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-Dichloropropane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
1,4-Dichlorobenzene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
2,2-Dichloropropane (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
2-Chlorotoluene (μg/L)	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	
4-Chlorotoluene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
4-Isopropyltoluene (μg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	

Sample Date	01/10/2014					
Sample Location	MW2	MW3	SW1	MW4	MW6	GW IGV
Benzene (µg/L)	1.5	<0.5	<0.5	<0.5	<0.5	
Bromobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromochloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromodichloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromoform (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromomethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
c-1,2-Dichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
c-1,3-Dichloropropene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Carbon Tetrachloride (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Chlorobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Chloroform (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Dibromochloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Dibromomethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichlorodifluoromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Ethylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Hexachlorobutadiene (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	
Isopropylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
m,p-Xylene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Naphthalene (µg/L)	0.5	<0.5	<0.5	<0.5	<0.5	
n-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
n-Propylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
o-Xylene (µg/L)	<0.5	0.8	<0.5	<0.5	<0.5	
sec-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Styrene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,2-Dichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,3-Dichloropropene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
tert-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Tetrachloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Toluene (µg/L)	1.8	<0.5	<0.5	<0.5	<0.5	
Trichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
Trichlorofluoromethane (µg/L)	<0.6	<0.6	<0.6	<0.6	<0.6	
Vinyl Chloride (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	
E Coli (per 100ml)	-	-	-	<10	<10	
Total coliforms (No/100 ml)	-	-	-	470	>24000	
Total Organic Carbon (mg/l C)	-	-	-	2.5	5.9	

Sample Date	21/09/2015							
Sample Location	MW1	MW2	SW1	SW2	MW4	MW5	MW6	GW IGV
Cond. (µs/cm)	3000	2930	759	806	742	3950	1107	1000
BOD (mg/L)	<6	36	5.6	3.1	<6	<6	<10	
COD (mg/L)	116	145	41	44	104	78	174	
Ammonical Nitrogen (mg/L)	160	77	1.4	1.7	<0.020	<0.020	0.12	0.15
Chloride (mg/L)	157	534	69	84	28	1070	37	30
Ortho-Phosphate PO4 (mg/L)	<0.010	0.41	0.14	0.15	<0.010	<0.010	<0.010	0.03
pH	6.9	9	6.5	7	6.7	6.9	6.7	6.5-9.5
Suspended Solids (mg/L)	-	-	<20	<8	-	-	-	
Cyanide (mg/L)	<0.05	<0.05	<0.05	<0.05	-	-	-	
Temperature (°C)	12.8	12	11.7	12.5	12.2	12.4	12.7	
DO (% saturation)	nm	nm	33	23	42.0	56.0	84.0	
Total Oxidised Nitrogen (mg/L N)	<0.20	<0.20	0.2	<0.20	0.61	0.42	5	NAC
Alkalinity-Total (mg/L CaCO3)	1360	553	273	286	337	293	479	NAC
1,1,1,2-Tetrachloroethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,1-Trichloroethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1,2,2-Tetrachloroethane (µg/L)	<1	<1	<1	<1	<1	<1	<1	
1,1,2-Trichloroethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,1-Dichloropropene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2,3-Trichlorobenzene (µg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,3-Trichloropropane (µg/L)	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	
1,2,4-Trichlorobenzene (µg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
1,2,4-Trimethylbenzene (µg/L)	4.3	2.2	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dibromo-3-Chloropropane (µg/L)	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	
1,2-Dibromoethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichlorobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloroethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,2-Dichloropropane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3,5-Trimethylbenzene (µg/L)	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-Dichlorobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,3-Dichloropropane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
1,4-Dichlorobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
2,2-Dichloropropane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
2-Chlorotoluene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
4-Chlorotoluene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
4-Isopropyltoluene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Benzene (µg/L)	1.3	2.8	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromochloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromodichloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Bromoform (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	

Sample Date	21/09/2015							
Sample Location	**MW1**	**MW2**	**SW1**	**SW2**	**MW4**	**MW5**	**MW6**	**GW IGV**
Bromomethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
c-1,2-Dichloroethene (µg/L)	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
c-1,3-Dichloropropene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Carbon Tetrachloride (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chlorobenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chloroform (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Copper (µg/L)	1	5.1	<1.0	<1.0	1.2	3.7	4.3	30
Dibromochloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dibromomethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichlorodifluoromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Dichloromethane (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Ethylbenzene (µg/L)	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Hexachlorobutadiene (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Isopropylbenzene (µg/L)	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
m,p-Xylene (µg/L)	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Naphthalene (µg/L)	0.6	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
n-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
n-Propylbenzene (µg/L)	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
o-Xylene (µg/L)	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
sec-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Styrene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,2-Dichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
t-1,3-Dichloropropene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
tert-Butylbenzene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Tetrachloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Toluene (µg/L)	1.3	2.4	<0.5	0.8	<0.5	1.3	<0.5	
Trichloroethene (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Trichlorofluoromethane (µg/L)	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	
Vinyl Chloride (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Fluoride (mg/L)	<1	<1	<0.20	0.2	0.23	<1	0.22	1
Sulphate (mg/L)	17	87	12	4	10	51	47	200
Aluminium (µg/L)	42	140	16	<10	110	160	220	200
Arsenic (µg/L)	<1.0	3.8	<1.0	<1	<1.0	<1.0	<1.0	10
Barium (µg/L)	110	110	91	95	140	560	140	100
Beryllium (µg/L)	<1.0	<1.0	<1.0	<1	<1.0	<1.0	<1.0	
Boron (µg/L)	420	1700	92	97	32	56	140	1000
Cadmium (µg/L)	<0.020	0.1	<0.020	<0.02	0.03	0.02	0.32	5
Calcium (mg/L)	200	31	110	110	140	310	220	200
Cobalt (µg/L)	4.1	1.6	<1.0	<1.0	<1.0	<1.0	1.5	
Iron (µg/L)	4300	440	660	700	140	140	300	1000
Lead (µg/L)	<0.1	3.2	<1.0	<1.0	<1.0	<1.0	3.8	10
Magnesium (mg/L)	50	22	9.2	10	8.1	29	18	50
Manganese (µg/L)	780	170	330	330	9.3	11	1100	50

Sample Date	21/09/2015							
Sample Location	**MW1**	**MW2**	**SW1**	**SW2**	**MW4**	**MW5**	**MW6**	**GW IGV**
Nickel (µg/L)	<1.0	5.6	<1.0	<1.0	<1.0	<1.0	3.5	20
Potassium (mg/L)	98	130	8.2	9.9	0.75	2.8	5.2	5
Selenium (µg/L)	1.5	1.5	1.2	<1.0	1.2	8.1	2.1	
Sodium (mg/L)	61	380	40	52	23	630	22	150
Strontium (µg/L)	870	510	190	200	170	460	380	
Thallium (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Uranium (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.6	9
Vanadium (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Mercury (µg/L)	<0.50	0.6	<0.50	<0.5	<0.50	<0.50	0.52	1
Antimony (µg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Chromium (µg/L)	1.1	1.1	<1.0	<1.0	<1.0	<1.0	1.1	30
Molybdenum (µg/L)	<1.0	23	<0.1	<1.0	<1.0	<1.0	<1.0	
Zinc (µg/L)	10	17	9	8.8	11	11	14	100
E Coli (per 100ml)	-	-	-	-	10	31	<10	
Total coliforms (No/100 ml)	-	-	-	-	1100	>24000	17000	
Total Organic Carbon (mg/l C)	-	-	-	-	2	2	7	NAC