Appendix 10-4: Investigation at unregulated waste disposal site – Castlemoate House, Dublin Airport

RPS

Investigation at Unregulated Waste Disposal Site - Castlemoate House, Dublin Airport



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Investigation at Unregulated Waste Disposal Site at Castlemoate House Dublin Airport

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1 SUMMARY

1.1 EXECUTIVE SUMMARY

Buried waste materials were encountered in March 2008 on Dublin Airport lands to the rear of Castlemoate House during excavation for a foul sewer connection to facilitate a WC for the new Dublin Airport reservoir. Initial investigations were conducted by DAA and the relevant authorities were notified (Fingal County Council, Environmental Protection Agency and Dept of Agriculture). RPS was appointed to assist in the assessment of the material having the competency and qualified resources to do so. Further systematic intrusive investigations were undertaken in consultations with the Local Authority (as the lead Agency), and the situation was assessed in accordance with the EPA Code of Practice for Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007.

The buried material comprised a mix of historical general waste and historical aircraft catering waste (designated as Category 1 animal by-products being catering waste from international transport). The waste was of considerable age and is estimated to have arisen at some time between the years 1975 and 1984, from dating components of the waste.

In terms of scale and severity, the phased intrusive investigations indicate that the total volume of the solid waste is estimated to be approximately 13,060m^3 (7,836 tonnes) and is located within the boundary of the field at the rear of Castlemoate House. The material was analysed and determined to be “non-inert non-hazardous” waste in character.

The initial screening process assessed the linkages between the Source, Pathways and Receptors according to the Code of Practice to determine prioritisation of risk. Four linkages were identified as having a Low Risk Rating. A single linkage was identified as potentially having a Moderate Risk Rating according to the EPA CoP rating system. No linkages were identified as having a High risk status.

- The pollutant linkage with the highest individual score was Linkage No.4, which relates to risks to the bedrock aquifer from contaminants in leachate via lateral and vertical migration in groundwater. The overall score for the site is therefore 42% which classifies it as a Class B moderate risk/moderate uncertainty site.

The findings of this report recommend that further monitoring of the contaminants in the leachate be undertaken for a further year (on a quarterly basis) to better understand the nature and movement of the fluid and clarify uncertainties identified. Such work would require the installation of automated data-loggers within selected deep groundwater and shallow leachate wells for a period of one year to monitor groundwater levels and parameters (including metals, ammonia and total petroleum hydrocarbons).

The Risk Assessment Report would then be updated to take account of the additional information.

The site shall be protected against further waste disposal activities and no unapproved intrusive excavations to take place which may introduce new linkages.

The approval of the Local Authority is required to proceed with this scope of work.

2 INTRODUCTION

2.1 BACKGROUND

RPS was commissioned by Dublin Airport Authority (DAA) to undertake an assessment of waste materials discovered on Dublin Airport lands to the rear of Castlemoate House in accordance with the RPS proposal document ref: MDE0792Rp0003A02, dated 27th January 2009. This land will be referred to as the 'site' in this report.

Buried waste materials were encountered in March 2008 during excavations for a foul sewer connection to facilitate a WC for the new Dublin Airport reservoir. An initial investigation comprising 5 no. trial pits was undertaken by DAA on 22nd April 2008 along the southern region of the site to determine the nature of the general waste and other materials (comprising historical aircraft catering waste). The management of this material would fall under Regulation (EC) No. 1774/2002 of the European Parliament and of the Council Decision of 3rd October 2002 concerning animal by-products not intended for human consumption transposed into Irish legislation by the Animal By-products Regulations 2003 (SI No. 248 of 2003), as amended, and is designated as Category 1 animal by-products (catering waste from international transport). The DAA Environment Dept sought anecdotal information from existing and retired staff members; however a small number of staff understood that any waste buried during Incinerator outages in the 1970/80's had been removed, as reflected in GIBB's 1997 Groundwater Study Phase 1. Fingal County Council, the Environmental Protection Agency and the Department of Agriculture Fisheries & Food were informed on 22nd May 2008, and Fingal County Council attended the site on 23rd May 2008 and on a number of subsequent occasions.

Phased investigations, surveys, sampling and analysis were undertaken in a structured format so as not to exacerbate any negative impacts. RPS were commissioned to initially undertake a desk study review of available information pertaining to the site and to design and undertake an intrusive site investigation and risk assessment as necessary.

A site investigation was undertaken by RPS in June 2008 and a report (MDE0792Rp0002F01) was subsequently prepared. This report identified additional historic buried waste across the site and provided recommendations for further investigations in the area.

An additional investigation was undertaken by RPS in June/July 2009 on behalf of the DAA with endorsement from Fingal County Council and DAA. It was agreed that the findings of all investigations to date be collated within a single report (herewith) which would replace any previously issued RPS reports – this report draws together various sources of information and the results of different analysis processes into a single document in accordance with the EPA Code of Practice for the Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007. **This report therefore supersedes RPS report MDE0792Rp002F01.**

2.2 OBJECTIVES

The principle objectives of this assessment were to:

- Determine the nature and extent of buried waste material within the field to the rear of Castlemoate House, and identify any other areas of potential waste disposal within the vicinity;
- Assess any potential risks to human or environmental receptors associated with the presence of the waste material; and

- Provide an outline strategy in relation to the management and remediation of the site.

2.3 OVERALL METHODOLOGY

In order to achieve the above objectives the following scope of work was undertaken:

- Desk Based Survey and Site Walkover including collation of information from relevant authorities (*i.e.* GSI borehole records, bedrock information from the surrounding area, percolation test reports on the site) and review of previous investigation reports.

- Development and subsequent refinement of a Conceptual Site Model based on available information.

- Design and Implementation of a Soil, Groundwater and Landfill Gas Site Investigation in accordance with BS 10175:2001.

- Qualitative and quantitative assessment of risks to human and environmental receptors in accordance with the Environmental Protection Agency (EPA) Code of Practice for the Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007.

- Liaison with DAA, Fingal County Council and the Department of Agriculture, Food and Rural Development to agree the scope of investigation works and risk assessment.

- Preparation of a report as per Chapter 8 “Reporting Requirements” in the EPA Code of Practice for Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007.

2.4 ASSESSMENT APPROACH

The initial investigation undertaken by the DAA identified buried material of both general waste and of aircraft catering galley waste in nature. Consequently, the assessment has been carried out in accordance with the EPA Code of Practice for the Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007 (EPA Code of Practice).

A consideration of the impact of the site on the environment is based on a risk assessment on the ‘Source – Pathway – Receptor’ model where the probability of damage occurring is considered in the context of the severity of consequence of that event actually happening. The S-P-R approach underpins the EPA Code of Practice.

The assessment looks at the relationship of possible contamination on the environment (*i.e.* the surroundings and habitats) and on range of receptors (such as humans, flora, fauna and ecological systems) to develop a conceptual understanding of what is occurring. The relevant components of the system are determined in conjunction with how they are potentially connected or linked. Aspects of the source material and impacts on the receptors are identified and measured as part of a characterisation process. This in turn facilitates the development of environmental engineering design controls to manage, mitigate, protect, and/or remediate the situation.

As the waste is buried beneath ground the primary environmental system which is exposed is the hydrological system (leachate, surface water flow, interflow and subsurface & groundwater flow) and landfill gas migration. A factor that makes this process difficult is that many of the processes in hydrology and hydrogeology are unseen, so there is a need for conceptualisation – shaping a

structure of the situation to aid understanding and development of a system model against which measurement can take place.

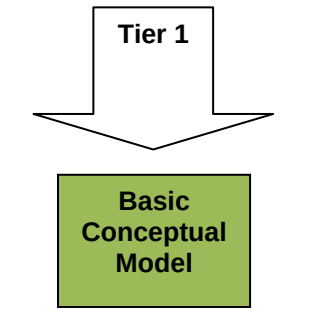
In this case, the relationship between the discrete **source** of the contamination (*i.e.* buried waste) and the receiving environment known as the **receptor** (*i.e.* the water systems, for example: groundwater bodies, soil matrix) is considered. The connecting route, known as the **pathway** (groundwater flow, drainage systems and soil systems) and the driving force in the form of a fluid (*i.e.* liquid in the form of rainfall and leachate, and gas such as landfill gas) can induce contamination to move through the system. Thus the system can be summarised by the following:

Source ⟶ Pathway ⟶ Receptor

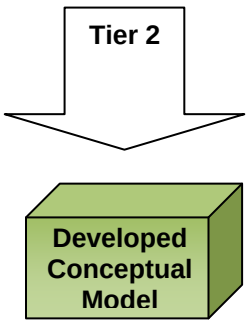
- **Source:** Substance or material that has the potential to cause harm to the environment or human health through by virtue of its physical or chemical characteristics.
- **Receptor:** A human or environmental entity which has the potential to be harmed through direct or indirect exposure to the source.
- **Pathway**: Mechanism by which the receptor can be exposed to the source.

In the EPA Code of Practice "Source-Pathway-Receptor" (SPR) approach to risk assessment, all three elements have to be present and linked in order for a risk to be present. If any of these components is absent there is, by definition, no risk.

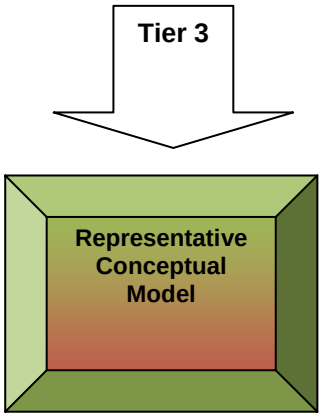
The Code of Practice utilises a structured phased approach to identify the S-R-P components and conduct a risk assessment of the linkages between the elements. The process involves preliminary site investigations and initial screening to indicate the range of high to low risk factors. Areas requiring further investigation are identified, and finally the model is fine-tuned. At each stage the information and risks are reviewed and assessed before progressing to the next phase. The Code of Practice tiered methodology is as follows:



CoP Chapter 2 — Preliminary Investigation (desk study and walkover), Development of Conceptual Site Model, Risk Screening and Prioritisation.



CoP Chapter 3 — Detailed Intrusive Investigation and Testing.



CoP Chapter 4 — Refinement of Conceptual Model, Quantitative Risk Assessment.

2.5 ASSUMPTIONS

Assumptions and uncertainties in the development of a conceptual model must be identified and clearly expressed to ensure that the degree of representation is understood before evaluation can meaningfully take place. The tiered technique of risk assessment within the Code of Practice seeks to minimise gaps in characterising each of the components within the S-P-R framework, so that at each stage the conceptual model is 'fine tuned' and uncertainties are reduced. Accordingly, the extent of information and data available at each stage of the model development is incorporated within each individual section of the assessment for Tiers 1, 2 and 3.

2.6 CONSULTATIONS & ATTENDANCES

On 22nd May 2008, DAA informed Fingal County Council, the Environmental Protection Agency and the Department of Agriculture of the presence of buried waste at the site following the preliminary exploratory investigation undertaken by DAA. Fingal County Council attended a meeting with the DAA on site on 23rd May 2008.

A site investigation proposal was sent to Fingal County Council and the Department of Agriculture. Representatives of Fingal County Council attended the site during the main investigation on Wednesday 30th July 2008.

The findings of the main investigation were used to undertake an initial risk assessment, the findings of which were presented to Fingal County Council in October 2008. These were discussed at a meeting between the DAA Fingal County Council and RPS on 4th December 2008.

A scope of work for an additional site investigation was subsequently submitted to Fingal County Council in February 2009 and a representative attended site on 30th June 2009 during the additional trial pitting and investigative works.

This Risk Assessment has been prepared for consideration by Fingal County Council as the designated body to carry out evaluation of historic unregulated waste disposal sites.

3 TIER 1 – PRELIMINARY INVESTIGATION & RISK SCREENING

3.1 INFORMATION SOURCES

3.1.1 Public Information

The following sources of publicly available information were consulted as part of the desk study:

- Ordnance Survey of Ireland, Discovery Series, Sheet 50;
- Ordnance survey of Ireland (OSI) Environmental Report, online historical maps and aerial photographs;
- Geology of Meath, Geological Survey of Ireland (GSI) (1:100,000), Sheet 13;
- GSI On-line Groundwater database. Aquifer Classification, Aquifer Vulnerability, Teagasc Soil Classification http://www.gsi.ie/Programmes/Groundwater/Groundwater+web+mapping.htm http://www.gsi.ie/Old+Mapping.htm#gsi;
- EPA Online Water Quality Mapping; http://www.epa.ie/rivermap/; and
- Consultation with the DAA.

3.1.2 Previous Investigations

Table 1 summarises the reports made available by DAA for this assessment.

Table 1 Summary of Previous Reports

Report Title	Author and Date	Summary
Groundwater Management Study, Phase I, Environmental Review	GIBB, September 1997	A review of site operations to identify potential sources of groundwater contamination.
Groundwater Management Study, Phase II, Conceptual Hydrogeological Model	GIBB, March 1999	Development of Conceptual Hydrogeological Model for entire airport with recommendations for minimising the impact of site operations on groundwater.
Environmental Assessment	Pollution and Waste Services Limited, 1999	Present findings of percolation tests undertaken in the field to the rear of Castlemoate House as part of the construction of a biocycle waste water treatment system.
Site Investigation Report for New Water Reservoir	RPS, October 2007	Factual report on intrusive geotechnical investigation for new reservoir to south-east of Castlemoate House. Investigation comprised 5 trial pits and 5 boreholes to

Table 1 Summary of Previous Reports		
Report Title	**Author and Date**	**Summary**
		maximum depth of 10 m.
Extract from Report on Historical Landfill at Rear of Castlemoate House, Dublin Airport	DAA, April 2008	Excavation of 5 no. trial pits to maximum depth of 3m.
SR Techniques Ltd Groundwater Monitoring Wells	DAA, Date Unknown	Borehole logs of historical monitoring wells between Hangar 1 and Hangar 6

3.2 SITE DESCRIPTION

3.2.1 Aerial Photographs

An aerial photo of the site taken in July 1999 was provided by DAA (see **Figure 1a and 1b** below). The site is covered in topsoil with no vegetation visible. The site appears to be flat and longitudinal dark areas running north-south are evident, indicating disturbed ground. The aerial photo is displayed below, with a close up version of the site and Castlemoate House.

Photos from a percolation test report dated 1999 also show the site with no vegetative cover and reworked clay at the surface (see **Figure 1c** and **1d**).

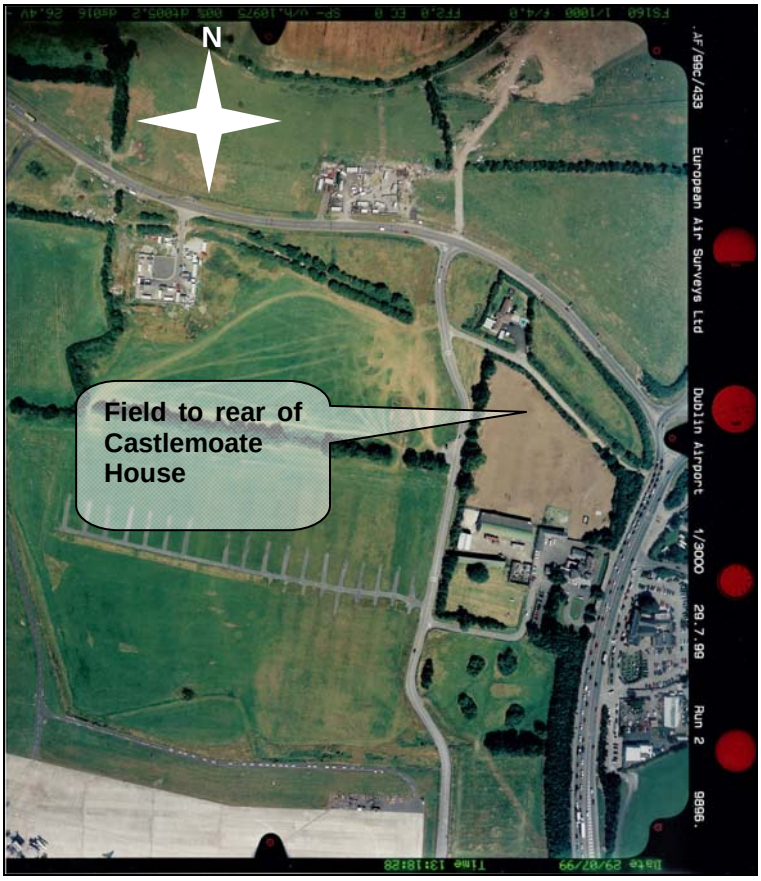


Figure 1a Aerial Photograph of site (July 1999)

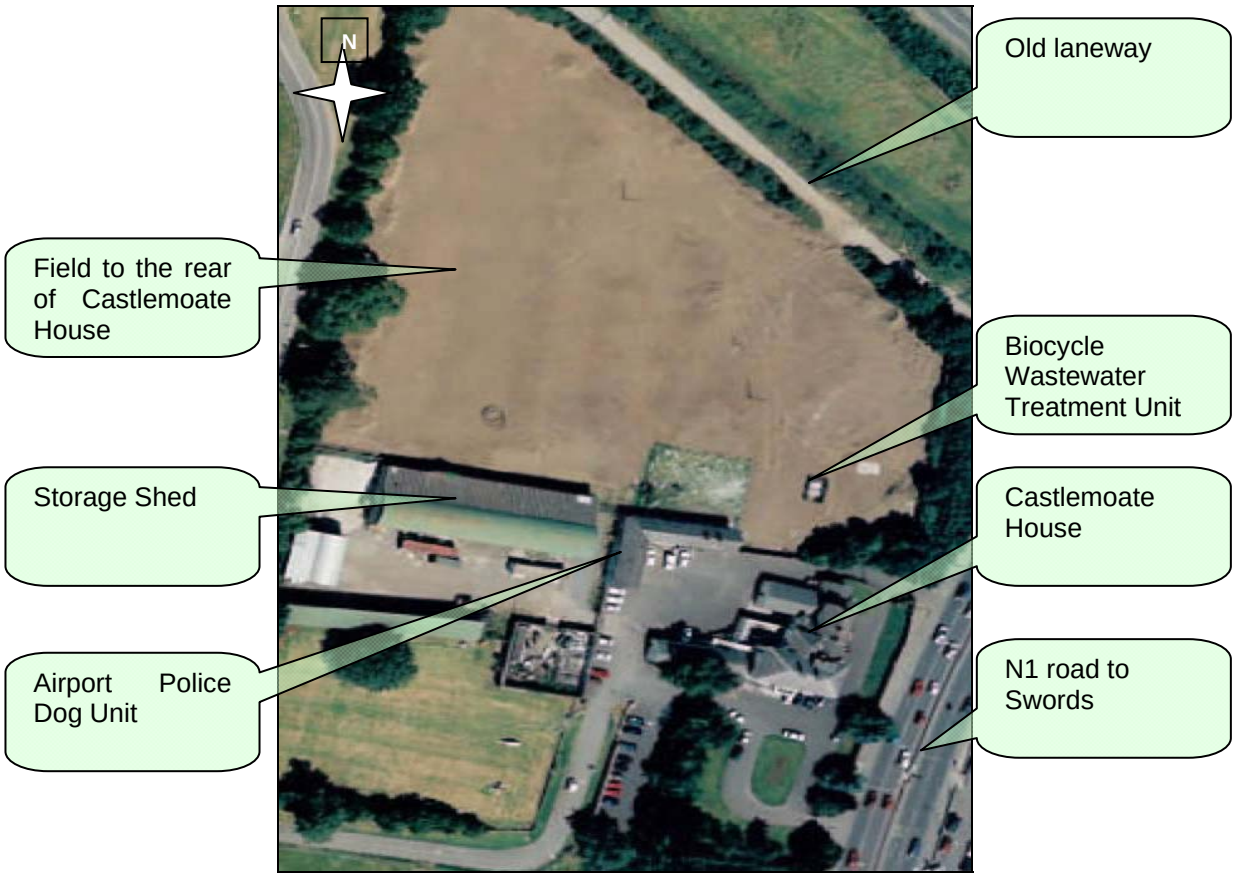


Figure 1b Aerial Photograph of site (July 1999) – zoomed in on Field behind Castlemoate House



Figure 1c Photograph of Trial Pit during percolation Test for Biocycle System in Castlemoate Field – 29th July 1999



Figure 1d Photograph of Soak Holes during percolation Test for Biocycle System in Castlemoate Field – 29th July 1999

3.2.2 Location & Setting

The site is located in the north east corner of the Dublin Airport campus which is located 10km to the north of the city of Dublin. The airport reference point (ARP) is published as 532517N, 061612W.

The site which is the subject of this investigation comprises a field to the north of Castlemoate House and Castlemoate Yard, where the DAA staff training centre and Airport Police Dog Unit is located. A biocycle plant is located in the south eastern corner of the field to process wastewater from Castlemoate House.

The site is trapezoidal in shape and is bound by the Swords Road (N1, R132) along the eastern perimeter of the site. Along the northern side is a laneway (an old county road), beyond which is another field and the Forrest Little Road (R108). Castlemoate Road is located along the west side of the site, beyond which is a contractor's compound and the newly constructed reservoir (south east corner). A building once used as a crèche is located to the north-east of the site adjacent to the northern field; however this facility closed down on 30th October 2009. The site location map is presented in **Figure 2** and the site layout is presented in **Figure 3**.

The area of the Castlemoate field is approximately 0.9 hectares. The site is bound by trees and hedgerows along the northern, eastern and western boundaries. The southern boundary is defined by the external walls of an old store building, the Dog Unit (outbuildings of Castlemoate House), and a 1.8m high timber fence. The ground surface is rough, uneven and grassed ground with brambles in the north west of the field. The site topography is predominantly flat but the ground level steps down slightly towards the east of the site.

Site services drawings show an underground electricity cable crossing the site, consisting of a 4" spun metal concrete lined cable, and an overhead telephone cable. There is a water main running in the field and along the laneway. A foul sewer line was installed in 2008 to connect a toilet in the new reservoir to the underground wastewater biocycle plant and percolation area in this field – it was during the installation of this service that the buried waste was discovered.

3.2.3 Historical Land Use

The historical land use of the site was principally used for agriculture, and was ancillary to the dwelling known as Castlemoate House – this building was taken over by the Dublin Airport Authority (as Aer Rianta) in 1975 and is currently used as a staff training centre. No other activities are currently known to have taken place in this field with the exception of storage/burial of discarded airline waste

3.2.4 Local Sensitive Sites

The site is fully within the boundary of Dublin Airport lands, and lies under the approach path of the proposed Parallel Runway which was first included in the County Development Plans in 1969; consequently, no development has taken place in the vicinity of the site since that time. Due to the aerodrome zoning assigned to this vicinity there is no planned use or further occupancy anticipated in this area.

The site is not proximate to existing or planned residential development or educational facilities. It is not in a high amenity area or area of special interest.

The site is not within or adjacent to wetlands, nor is it within a Natural Heritage Area (NHA), a candidate Special Area of Conservation (cSAC) or Special Protection Area (SPA).

3.2.5 Waste Disposal Activity

The Phase 1 Hydrogeological Assessment carried out by GIBB (1997) identified two areas of historic disposal of aircraft catering waste as follows:

- Rear of Castlemoate House (current site); and
- Fields adjacent to Primary Radar Station.

This report stated that all waste disposal activity ceased prior to 1980 and that previously buried waste had been excavated and disposed at a licensed landfill facility.

On 14th March 2008 evidence of waste material was identified in excavations to the rear of Castlemoate House for a foul sewer pipe from the new airport drinking water reservoir to the existing biocycle plant. The DAA Environment Department were informed and subsequently conducted a site walkover and initial exploratory investigation to determine nature and possible extent of waste and to assist in formulating next steps. Five trial pits were excavated on the site along the line of the proposed sewer connection line (along the southern region of the site) and the following waste types were encountered:

- General waste material mixed with soil; and
- Aircraft catering and galley waste

The aircraft waste would fall under Regulation (EC) No. 1774/2002 of the European Parliament and of the Council Decision of 3rd October 2002 concerning animal by-products not intended for human consumption transposed into Irish legislation by the Animal By-products Regulations 2003 (SI No. 248 of 2003), as amended, and is designated as “Category 1 animal by-products” being catering waste from international transport.

The condition and nature of the waste indicated it had been underground and buried for considerable number of years. The branding and logos of articles which were unearthed indicated that the waste originated from the era in and around 1980, however it was not certain whether the date was prior to the Waste Framework Directive (75/442/EEC) coming into force in 1977. Several staff (existing and retired) were interviewed to gather anecdotal information as there was no contemporaneous records available. It was generally understood that back in the 1970 to 1980's waste may have been buried when the incinerator on site was out of service, however, it was generally understood that the activity ceased by 1980. It was understood that any waste that was buried was recovered and disposed of at the time.

The waste was encountered at depths ranging between approximately 2m and 2.5m below ground level (bgl) and at least 2m in thickness. The base of the identified waste was not proven. Groundwater was encountered between 2.5m and 3m bgl and was noted to be in contact with the waste. Two samples were analysed for Diesel Range Organics (DRO), Polycyclic Aromatic Hydrocarbons (PAH), Mineral Oil, Benzene, Toluene, Ethylbenzene and Xylene (BTEX), and Polychlorinated Biphenyls (PCBs). PAHs were recorded at concentrations above the laboratory detection limit.

The DAA adopted a conservative approach and applied the precautionary principle of conducting further investigations to determine if the site posed a risk to the environment. RPS was engaged to conduct specialist investigations and undertake an assessment in accordance with the EPA Code of Practice for the Environmental Risk Assessment of Unregulated Waste Disposal Sites.

3.2.6 Geology

3.2.6.1 Regional Bedrock Geology

The Geology of Meath 1:100,000 map (GSI Sheet 13) of the area shows the site underlain principally by Waulsortian Limestones and Shale which comprise massive unbedded limestones and mudstones. The site appears to be on the boundary between the Waulsortian and the Malahide formations, with the Malahide formation, just present in the far north-west corner of the site. The Waulsortian limestones are commonly described as "reef" limestones and the Hydrogeological Conceptual Model undertaken by GIBB in 1999 suggests that this formation may be prone to karstification. This would be in contrast to the Malahide formation to the north which comprises argillaceous bioclastic limestone and is less prone to karstification due to higher clay content.

Limestone conglomerate (Tober Colleen Formation) is present to the south. All three formations form part of the Dinantian Limestone series and the GSI online bedrock map of Ireland classifies the bedrock underlying the site as Dinantian Pure Unbedded Limestones.

GSI Sheet 13 shows the boundary between the Waulsortian reef limestone and the Malahide formation to be formed by a southwest to northeast trending fault running beneath the site. This is illustrated on **Figure 4**. The bedrock throughout the area is extensively faulted and folded with measured dips ranging from 5° to 35°. Fold axes generally trend south-west to north-east with some faults following a similar trend. There are a series of north-west to south-east trending faults to the east of the site.

The GIBB conceptual model shows the depth to bedrock below ground level (bgl) to vary across the airport from less than 3m to greater than 10m. The area around Castlemoate House is indicated as being in an area where bedrock may be close to the surface.

3.2.6.2 Regional Quaternary Geology

According to the GSI/Teagasc online subsoil map of Ireland, the site and surrounding area is expected to be underlain by Made Ground. The greater surrounding area is shown to be underlain by tills derived chiefly from limestones.

The Phase 1 Environmental Review undertaken by GIBB (1997) indicates that Dublin Airport is underlain by Glacial deposits which are known as the Dublin Formation and the Irish Sea Formation. The area around Castlemoate House is underlain by the Irish Sea formation which comprises mixed deposits of clay, sand and gravel. The deposits tend to vary with depth with the top 2m to 3m comprising firm brown clay and deeper deposits comprising stiff black/dark grey clay. The firm brown clays are considered to represent a weathered horizon.

A review of existing SR Techniques borehole logs, as highlighted in Section 3.1.2, also indicated that geological conditions underlying the area of Dublin Airport, between Hangar 1 and Hangar 6, comprised dry brown and black boulder clays ranging in depth between 0.58 and 15.15 m bgl. Thickness of this clay material ranged between 1.5 and 12.95 metres.

3.2.6.3 Local Conditions

In 1999, Pollution and Waste Services Ltd. undertook percolation testing in the area of the wastewater biocycle plant in the south-east corner of the field at the rear of Castlemoate House. Seven percolation test holes and a trial pit were excavated, filled completely with water and allowed to seep overnight, see **Figures 1c** and **1d**.

The investigations showed topsoil to comprise light grey brown, firm clay with a high stone content and poor to moderate drainage capacity. The subsoils comprised firm grey gritty clay with high sand and pebble content with moderate to poor drainage characteristics.

Investigations carried out as part of the design and construction of the new reservoir to the west of the site encountered Made Ground to depths of between 0.7m bgl to 1.9m bgl. Drift deposits were present below the Made Ground to a depth of about 10m bgl. The drift deposits generally comprised clay and silt however a 1.2m thick layer of gravel was encountered at 5.5m bgl in BHC in the south east corner of the reservoir site. Particle size distribution (PSD) curves for the cohesive deposits recorded a fines (silt and clay) content of between 21% and 50% with clay contents ranging from 4% to 14%. Most of the samples were poorly sorted and described as gravelly sandy silt. These deposits are therefore considered to have low to moderate permeability.

3.2.6.4 Dust

The site is covered in established wild grasses and meadow vegetation, and the waste was undisturbed for an estimated 25 years to 35 years (newspaper dated 1984). Consequently, dust and fine particulates are not currently considered a primary source of pollution.

3.2.7 Hydrogeology & Hydrology

3.2.7.1 Aquifer Classification

The GSI online bedrock map of Ireland, classifies the limestone bedrock underlying the site as a locally important (LI) aquifer (i.e. bedrock which is moderately productive only in local zones). The Glacial Deposits are not classified as an aquifer by the GSI.

The groundwater within the bedrock has been classified as high – low vulnerability which indicates that only an interim study has taken place in this area. However, given the variability in depth to bedrock across the airport site the vulnerability rating is likely to vary from extreme to low.

3.2.7.2 Groundwater Flow

The conceptual model compiled by GIBB (1997) indicates that groundwater is encountered at three points within the glacial deposits:

- At the base of the weathered zone (firm brown clays);
- Within sand and gravel lenses; and,
- At the base of the stiff black clay close to the top of the bedrock.

The shallow water within the firm brown weathered clay is likely to represent rainfall which is prevented from migrating further due to the presence of the stiff black clay. Sand and gravel lenses within the Glacial Deposits are generally localised and therefore will represent only very minor bodies of water which would have little significance on flow within the overall Glacial Deposits. The low permeability Glacial Deposits are likely to act as a confining layer to groundwater within the underlying bedrock and groundwater encountered at depth within the stiff black clay are likely to be in hydraulic continuity with regional groundwater within the bedrock aquifer.

Groundwater was encountered in the trial pits excavated for the biocycle plant percolation testing, in the weathered zone, at a depth of 2.32m. Monitoring wells were installed in the Glacial Deposits as part of the investigation at the new reservoir site. Subsoils typically became moist at approximately 4m bgl and groundwater levels were found to rise to approximately 2m bgl. Groundwater flow direction in the Glacial Deposits appeared to be in an east to north-easterly direction.

The GIBB conceptual model was unable to identify a groundwater flow direction within the bedrock due to a lack of data. However, it was considered likely that groundwater flow directions will be largely controlled by topography, flowing in a generally easterly direction. The presence of a south-west to north-east trending fault in the vicinity of the Castlemoate site is likely to influence the local groundwater flow direction.

The rock matrix is likely to have a very low permeability, however where fracturing occurs, significant groundwater flow can occur.

3.2.7.3 Hydraulic Properties

The PSD curves for the Glacial Deposits, obtained from the reservoir investigation, indicate that the glacial deposits are low to moderate permeability silts and clays. This is supported by the percolation testing carried out at the biocycle plant site. Literature values for low to moderate, poorly sorted glacial deposits range from $8.64x10^{-3}$ m/day to 0.864 m/day (refer: Fetter CW Applied Hydrogeology, 1999. Prentice Hall)

Hydraulic conductivities derived from in-situ testing of the bedrock in the vicinity of the airport are reported within the GIBB Conceptual Model and range from 10 m/day to $1.5x10^{-3}$ m/day.

3.2.7.4 Water Quality

Groundwater within the limestone will be hard (>200 mg/l $CaCO_3$). The GSI memoir on the geology of Meath indicates that groundwater quality is generally good except where locally contaminated. Under the Water Framework Directive, groundwater status has been assessed as part of the River Basin District Management Projects. Groundwater within the limestone beneath Dublin Airport (and the site) is part of the Urban Dublin Groundwater Body and has been classified as having Good Status with regard to both quality and quantity (abstraction).

As part of the investigation carried out at the reservoir site samples were collected from standpipes within the glacial deposits. Groundwater samples were collected and tested for Polycyclic Aromatic Hydrocarbons (PAHs), Petrol Range Organics (PRO), Total Petroleum Hydrocarbons (TPH), phenols, metals, Semi Volatile Organics (sVOC) and VOCs. PRO and TPH were found to be slightly elevated. There was no visual or olfactory evidence of contamination from the groundwater.

3.2.7.5 Groundwater Users

Information from the DAA suggests that the closest borehole to the site is located in a contractor's compound to the south-west of the site. However, no borehole log is available.

The following boreholes were recorded by the GSI in the vicinity of the site:

- GSI well reference number 2923NEW034 is located approximately 700m to the south west of the site. The original name of the borehole was TW1, the depth of borehole is 13.7m bgl and the depth to rock is 11.6m bgl. The borehole is used for industrial use and the yield class is "good" and estimated at $300m^2$/d.

- GSI well reference number 2923NEW042 is located approximately 1km south of the site at Toberbunny. The well is described as a spring (possibly encountered artesian conditions during drilling).

- GSI well reference number 2923NEW021 is located approximately 1.3km north of the site in the townland of Nevinstown West. The borehole is 36.6m deep and is used for domestic and agricultural use. The yield class is "poor" with the yield at $38.2m^3$/d.

3.2.7.6 Surface water

The active areas of Dublin Airport are drained by six river catchments: the Santry River, the Mayne Stream, the Cuckoo Stream, Kealy's Stream, the Wad Stream, and the Forrest Little Stream.

The Castlemoate site is located within the catchment of the Forrest Little Stream. The stream runs in an east to west direction in the direct vicinity of the site (approximately 600m north of the site) before turning eastwards in the valley within Forrest Little Golf Course. The tributary of the Forrest Little Stream originates within the airport. The topography of the region is such that the Forrest Little Stream is at an elevation of approximately 20m below the ground level of Castlemoate Field. The Forrest Little Stream is located between the site and the Ward River, which is located approximately 2.5km to the north of the site. The majority of the Forrest Little catchment area is comprised of agricultural land although it also includes the northern corner of the airport including disused Runway 11/29 and the proposed northern runway.

The head of the Wad Stream starts approximately 320m from the site and runs south and then east at a very shallow gradient and elevation.

3.2.7.7 Recharge & Drainage

Due to the low permeability nature of the Glacial Deposits, recharge to the limestone aquifer will be limited in areas of thicker subsoils. In areas where subsoil is thin or absent, there may be hydraulic continuity between surface water streams and the bedrock aquifer. In areas of thicker low permeability subsoil their will be a minimal groundwater component.

3.3 TIER 1 – CONCEPTUAL MODEL

From the preliminary site investigations and collation of available information, a conceptual model was developed consisting of 2m to 2.5m of soil overlying approximately 2m thick layer of mixed general waste and aircraft catering waste interfacing with a subsurface groundwater system. The condition and make-up of the waste and the condition of the field indicated that it had lain undisturbed for approximately 25 years to 35 years. The line of old buildings and existing establishing hedgerows indicated that the extent of the waste would be confined to an area within the boundary of the field. Intrusive investigations on the eastern side of the field in 1999, as part of the installation of the biocycle wastewater treatment system for Castlemoate House, indicates that the waste did not pervade the entire field. The site is underlain by firm brown clay consistent with the region, with no liner.

3.4 TIER 1 – RISK SCREENING

The Code of Practice identifies eleven SPR linkages that should be considered within the conceptual model and assessed as part of the Tier 1 Assessment. Each of these linkages can be scored using the scheme provided in the EPA Code of Practice in order to provide an overall risk categorisation for the site.

An initial conceptual model was developed based on the information given above with consideration to the eleven Source-Pathway-Receptor (SPR) linkages identified in the EPA code of practice. At Tier 1 each aspect of each SPR linkage can be assessed according to particular criteria as defined within the EPA Code of Practice. The Code of Practice uses a separate scoring matrix for each aspect of each SPR linkage and these are defined within Tables 1a to 3f of the Code of Practice. Where an individual aspect is not present or not relevant within the context of the conceptual model it is given a score of 0.

The score for each linkage is normalised with respect to 100 by dividing the score for each linkage by the maximum available points for that linkage to give a percentage. The overall score for the site is taken as the maximum of the individual normalised scores. The site can then be placed in a prioritisation category depending upon the potential level of risk identified. Sites with a higher score represent those with either a higher level of risk, which may require remediation, or a high level of uncertainty, which requires further intrusive investigation. If a high score is due to a high level of uncertainty then the assessment should proceed to Tier 2.

The conceptual site model and risk scoring is presented in **Tables 2 and 3**. The full assessment is presented in Appendix A. The risk category bands relating to site scores as defined in the EPA Code of Practice are presented in **Table 2**.

Table 2 Risk Category and Prioritisation Class

Score	Priority Class	Risk Category	Definition
> 70%	A	High	High risk/high uncertainty sites. Further investigation required to confirm status. Presents potentially high risk to environment in current condition. Remediation / mitigation will be necessary. Highest priority with Regulating Authority.
40% to 70%	B	Moderate	Moderate risk/moderate uncertainty sites. Further investigation required to confirm status. Presents potentially moderate risk to environment in current condition. Remediation / mitigation may be required.
< 40%	C	Low	Low risk sites. Not considered to present risk to environment in current condition however further investigation may be required in case of change of land use.

Table 3 Tier 1 Conceptual Model & Risk Scoring

Source	Pathway	Receptor	% Score	Risk Classification
Leachate	Groundwater and Surface water Migration	Surface Water body	14%	Low
		Protected Area (Surface water dependent terrestrial ecosystem)	0%	No Linkage
	Groundwater Migration	Private well	18%	Low
		Protected Area (Groundwater dependent terrestrial ecosystem)	0%	No Linkage
		Aquifer	42%	Moderate
		Public Water Supply	0%	No Linkage
		Surface Water body	18%	Low
	Surface Water Migration	Surface Water body	0%	No Linkage
		Protected Area (Surface water dependent terrestrial ecosystem)	0%	No Linkage
Landfill Gas	Lateral Migration in Subsoil	(Human Presence (Buildings, enclosed spaces)	23%	Low
	Vertical Migration in Subsoil		0%	No Linkage

The pollutant linkage with the highest individual score was Linkage No.4, which relates to risks to the bedrock aquifer from contaminants in leachate via lateral and vertical migration in groundwater. The overall score for the site is therefore 42% which classifies it as a Class B moderate risk/moderate uncertainty site. There is therefore a need to progress to Tier 2 and gather further information through intrusive investigation and testing. The main areas of uncertainty to be addressed in the investigation are:

- The volume of waste;
- The quantity and nature of leachate and gas being produced within the waste;
- The thickness of low permeability clays beneath the waste; and,
- The presence of karst features within the limestone bedrock aquifer.

4 TIER 2 – SITE INVESTIGATION & TESTING

4.1 INTRODUCTION & OBJECTIVES

The Tier 1 assessment, which included information from a preliminary site investigation undertaken by DAA, identified the following potential risks in relation to the waste material:

- Low risks to humans and buildings in proximity to the site from migration of landfill gas;
- Low risks to surface water bodies (Forrest Little Stream) from migration of leachate within shallow groundwater;
- Low risks human health from abstraction of groundwater for private use; and
- Moderate risks to water quality in the limestone bedrock aquifer.

The overall objective of the site investigation was to reduce the uncertainty in the key areas identified in Section 2.3, by obtaining additional information on:

- The age and nature of the waste material;
- The lateral and vertical extent of the waste material;
- The volume and quality of leachate within the waste;
- The potential for gas generation;
- The ground conditions in the vicinity of the site in particular the presence and thickness of low permeability subsoil deposits between the waste and the limestone aquifer; and,
- Water quality within the limestone aquifer.

4.2 TIER 2 METHODOLOGY

4.2.1 Approach

The intrusive investigations were carried out in three phases as follows:

- **Exploratory Investigation:** This was carried out by DAA in April 2008 and formed part of the Tier 1 Preliminary Investigation reported in Section 2 above.
- **Main Investigation:** Undertaken by RPS in July 2008 and involved shell and auger drilling, trial pitting, groundwater sampling, soil sampling, and landfill gas monitoring. Monitoring wells were installed in saturated waste to collect leachate samples and to facilitate landfill gas monitoring.

- **Additional Investigation:** Undertaken by RPS in June 2009 following an initial risk assessment and consultation with Fingal County Council – included trial pitting, rotary borehole drilling, groundwater sampling, and indoor and outdoor landfill gas monitoring. Monitoring boreholes were installed within limestone bedrock to monitor groundwater quality in limestone aquifer.

The investigations were carried out in accordance with:

- BS 10175:2001, Investigation of potentially contaminated sites - Code of practice;
- BS 5930, Code of practice for site investigation;
- ISO standards for analysis and sampling;
- Relevant Health and Safety Regulations and Guidance (including the Health, Safety and Welfare at Work Act 2005, and Safety, Health and Welfare at Work (Construction) Regulations 2006, SI 504/06;
- EPA Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites, 2007, and,
- Environment Agency (EA) Guidance on Assessment of Risks from Landfill Sites.

4.2.2 Trial Pits

Five trial pits (unlabelled) were excavated to depths of approximately 4m bgl in the southern portion of Castlemoate field as part of the exploratory investigation by DAA in April 2008.

Ten trial pits (TP1 to TP10) were excavated across the Castlemoate field as part of the main investigation in July 2008. Pits were excavated to a depth of 3m bgl.

Three trial pits (TP13 to TP15) and **two trial trenches (TP11a&b and TP12a, b and c)** were excavated as part of the additional investigation in June 2009. The trial pits were excavated within the northern field and to the west of the Castlemoate field to depths of between 2.8m bgl and 2.95m bgl in order to determine whether additional waste material was present outside of the boundary of the Castlemoate field – this was to reduce the uncertainty that waste might have been placed outside of Castlemoate field. The trial trenches were excavated to depths of between 2m and 2.8m bgl within the northern area of the Castlemoate field in order to establish the northernmost extent of the waste material in this field – The objective of this exercise was to increase the certainty of how far the waste extended towards the boundary of the field.

The locations of the trial pits are presented on **Figure 5**. The trial pit photographs and logs from the main and additional investigations are presented in **Appendix B and C** respectively. There were no formal logs from the exploratory investigation. Photographs from the exploratory investigation are presented in the report referenced in Section 2.1.2.

All trial pits were excavated using a mechanical excavator and were back filled on completion by replacing material in the order in which it was excavated. Trial pits were made to be back filled on the same day to minimise the risk of bird hazard in the vicinity of the airport arising from open soil and exposed waste.

4.2.3 Borehole Drilling

Six boreholes (BH01, BH01A, BH02, BH03, BH04A and **BH04B**) were drilled across the Castlemoate field, using a shell and auger rig as part of the main investigation in July 2008. Two of the boreholes (BH01 and BH04A) did not encounter waste and were re-drilled closer to trial pit locations where waste was encountered (BH01A and BH04B). This indicated discontinuity in the layout of the buried waste and that the waste was confined in 'cells'.

BH01A, BH02, BH03 and BH04B were installed with monitoring standpipes screened in saturated waste material. The boreholes were drilled to depths of between 3m bgl and 4.1m bgl, terminating between 0.5m and 1m below the base of the waste material. Photograph 5 in Appendix B shows the drilling rig at location BH03.

Three boreholes (BH05, BH06 and **BH07)** were drilled using rotary coring methods as part of the additional site investigations in June 2009. BH05 was located within the Castlemoate field to the east of the known waste body and extended to a depth of 15m bgl in to limestone bedrock; BH06 was located within the northern field and was extended to a depth of 20.5m bgl; and BH07 was located in the north western corner of the site and was extended to a depth of 16m bgl. Groundwater monitoring wells were installed within all three boreholes. BH05 and BH07 were screened within the limestone bedrock. BH06 did not encounter any bedrock and was therefore screened within the encountered clay.

The locations of the boreholes are shown on **Figure 5** and the borehole logs are presented as **Appendix C**.

4.2.4 Sampling

Soil and groundwater samples were retrieved during the intrusive investigations as summarised in **Table 4**.

Table 4 Summary of Sample Collection

Investigation	Samples Collected
Exploratory Investigation	• **2 soil samples** from trial pits
Main Investigation	• **20 soil samples** from trial pits and boreholes • **8 groundwater samples** from shallow boreholes collected over two monitoring rounds in August 2008 and December 2008
Additional Investigation	• **8 groundwater samples** from shallow and deep boreholes (July 2009)

A pumping well (PW1) is located within a Contractor's compound to the south-west of Castlemoate field. There is no available log for this well but it is believed to have been drilled to a total depth of approximately 100m and is installed within the limestone bedrock. The borehole was accessed for sampling during the additional investigation in July 2009. Since that time, the hose connected to the well was damaged during the demobilisation of the plant by the Contractor.

4.2.5 Laboratory Analysis

Soil and groundwater samples were analysed for the general suite of parameters listed in **Table 5**.

Table 5 Summary of Laboratory Analysis	
Soil Analysis Suite	**Groundwater Analysis Suite**
• Heavy Metals • Cyanide • Sulphate • pH • Organic matter content • Petroleum Hydrocarbons • Benzene, Toluene, Ethylbenzene & Xylene (BTEX) • Polycyclic Aromatic Hydrocarbons (PAH) • Polychlorinated Biphenyls (PCBs) • Phenol • Waste Acceptance Criteria (WAC) eluate analysis	• Field Parameters (electrical conductivity, dissolved oxygen, pH, temperature) • Metals • Cyanide • Sulphate • Sulphide • Ammonia • pH • Organic matter content • Petroleum Hydrocarbons • BTEX • Polycyclic Aromatic Hydrocarbons (PAH) • Polychlorinated Biphenyls (PCBs) • Phenol • Volatile Organic Compounds (VOCs)

4.3 OBSERVED GROUND CONDITIONS

4.3.1 Made Ground

4.3.1.1 Topsoil

Topsoil was encountered in all locations to depths of between 0.1m to 0.6m. The topsoil typically comprised soft medium brown to orange-brown silty clay with frequent rootlets. There was no visual or olfactory evidence of contamination in the topsoil which consisted of reworked soil.

4.3.1.2 Reworked Clay

The topsoil was underlain by 0.5m to 2.3m of reworked clay in all trial pit and cable percussion boreholes in the Castlemoate field with the exception of TP4. The clay ranged from soft orange brown silty clay with frequent gravel to firm dark grey clay with frequent cobbles and occasionally contained ceramic pieces, cloth, metal, plastic and wood chips. The clay was damp in places. There was no visual or olfactory evidence of contamination.

4.3.1.3 Waste

During the main investigation waste was encountered below the reworked clay at all trial pit locations within the Castlemoate field with the exception of TP4 to the east of the site. The step down in ground level on the eastern side of the site was considered to mark the extent of the waste to the east. Two of the cable percussion boreholes (BH01 and BH04A) did not encounter waste but adjacent boreholes (BH01A and BH04B) did, indicating that the deposition of waste was not continuous across the site.

This information together with evidence from the aerial photograph, provided in the 1999 percolation report, indicates that the waste material was likely deposited in north-south trending trenches.

The depth of the waste within the trial pits varied from 1m to 3m bgl. The maximum observed depth of the solid waste within the boreholes was 3.5m within BH04B. In most trial pit locations, waste was not found to be continuous and the edge of a body of waste was noted (e.g. TP7, TP10, TP11A and TP11B). This again indicates that the waste may have been placed in cells or trenches, which are not interconnected. It appears that when the overburden was reworked, the waste was surrounded by walls of reworked silty clay. It is anticipated that the maximum depth of the waste material is approximately 3.5 to 4.0 metres based on visual evidence, borehole and trial pit logs in the waste area and the likely extent of reach of the excavator machinery used to bury the waste material

The additional investigation was used to further delineate the extent of the waste to the north and east. The absence of waste in the eastern area of Castlemoate field was confirmed by BH05. Trial trenches TP11 and TP12 were excavated in the north-west and north east corners of the raised portion of the Castlemoate field and were able to definitively identify the extent of the waste in these areas. Trial pits TP13-15 and boreholes BH06 and BH07 were excavated outside of the field being investigated and did not identify waste.

The waste typically comprised bags of airline catering waste and loose mixed waste consisting of plastic disposable cutlery and food containers, financial documentation including documents with Aer Lingus and Aer Rianta logos, airline food products and newspapers. The bagged waste was generally not significantly decomposed. The loose waste was often encountered in a gravelly clay matrix and evidence of burning was also evident. Possible agricultural waste (fertiliser bags, wood chippings and saw dust) was noted in TP2. Photographs 1 and 2 in **Appendix B** present the solid waste encountered and Photograph 4 displays waste mixed with clay. The waste was dated from newspapers and credit union slips. The most recent date recorded was 1984 indicating that some waste was disposed of in this area up until that date at the earliest.

The thickness and distribution of waste is presented as **Figure 6**. The volume of waste has been estimated as 13,060m^3 based on a maximum depth of 4m and on interpreted areas of distributed waste. Assuming a density of 0.6 kg/m^3, the mass of the waste is estimated as 7,836 tonnes.

4.3.2 Natural Ground

4.3.2.1 Glacial Till

Undisturbed ground was encountered in TP4 to the east of the Castlemoate field, in TP13 –15 outside of Castlemoate field, within the rotary boreholes BH05 to BH07 and beneath the waste within the cable percussion boreholes BH01A, BH02, BH03 and BH04B.

The undisturbed ground was generally consistent with the description of the Glacial Till provided within the previous investigations as discussed in Section 2. The material generally comprised 2m to 3m of dry soft to firm brown sandy gravelly clay underlain by dark brown and grey firm to stiff and very still gravelly clays. The total proven thickness of the clay ranged from 5.2m in BH05 in the east of Castlemoate field to greater than 20.4m in BH06 in the west of the northern field. BH07 in the north of the Castlemoate field recorded a thickness of 8m. Occasional discontinuous and localised bands of sand gravel or cobbles were also encountered.

A 0.3m thick layer of sand was encountered in BH05 in the east of the Castlemoate field at a depth of 3.5m bgl.

The significant difference in thickness of clay between BH07 and BH06, and BH05 and BH06 is attributed to both dipping bedrock and the presence of the fault identified from the geological map, which is believed to trend broadly south-west to north-east and is located in the western region of the Castlemoate field. The exact location of the fault is unknown but based on the observations made during the site investigation is likely to pass between BH06 and BH07. This means that the thickness of clay beneath the waste could vary from a minimum of approximately 3.5m to a maximum of approximately 16m depending upon the location of the fault and the orientation and magnitude of bedrock dip.

Permeability measurements of typical Dublin Boulder Clays, which are deemed similar in nature to the identified clays at this site, were recorded in the Dublin Upper Black Boulder Clays and Upper Brown Boulder Clays by Long and Menkiti (2007)[1] Typical values ranged between 10^{-9} and 10^{-11} m/s. A similar range of between 10^{-8} and 10^{-11} m/s was suggested by Lehane & Simpson (2000)[2]. Permeability measurements from mixed cohesive and granular zones, also similar to localised zones at the site, were measured ranging between 10^{-7} and 10^{-9}. As a reference, the EPA required specification for an engineered landfill clay liner is 10^{-9} m/s which is deemed suitable to prevent the vertical migration of contamination from a landfill.

4.3.2.2 Bedrock

Bedrock was encountered within rotary boreholes BH05 and BH07 at depths of 5.3m bgl and 8m bgl respectively. Bedrock was not encountered within BH06 which recorded Clay to a depth of 20.5m bgl. The bedrock comprised light grey limestone. The limestone was described as weathered in the top 0.5m and being competent thereafter. There was no evidence of karstification observed within the boreholes.

4.3.3 Groundwater Observations

Groundwater observations during the intrusive investigations can be divided into four categories as follows:

- Slight seepage of water at depths of approximately 2m to 3m bgl consistent with the boundary between the softer brown clay and the stiffer dark grey clay;
- Significant seepage of water within trial pits at around 2m to 3m bgl within the waste material;
- Noticeable water strikes within sand layers in the Glacial Till (BH05); and
- Significant water strikes within limestone bedrock at the boundary with clay. Water rose between 5.3m and 20m indicating pressurised groundwater within confined conditions.

The water within the waste is likely to be considered to be leachate and will be a result of rainwater infiltrating through the waste material and ponding on the low permeability clay beneath the waste material. A moderate waste odour was noted at most locations with a strong odour noted from TP9 and TP10, associated with more degraded waste.

[1] Long, M. & Menkiti, C.O. (2007). Geotechnique 57, No.7, 595-611

[2] Lehane, B. & Simpson, B. (2000). Modelling glacial till under triaxial conditions using a BRICK soil model. *Can*. *Geotech. J*. 37, No.5, 1078-1088.

Leachate samples were collected from the four boreholes on 13th August 2008. A strong organic waste odour was recorded from BH03, BH04B had a moderate odour, BH02 had a slight odour and BH01A had no odour.

Descriptions of the leachate samples are as follows:

- BH01A – Brown, silty water, no detectable odour;
- BH02 – Silty brown-grey water, slight organic waste odour, no sheen;
- BH03 – Dark-brown to grey silty water. Strong organic waste odour, no sheen; and
- BH04B – Silty brown-grey slightly organic waste odour.

Stabilised groundwater levels measured within the shallow boreholes in the waste and the deeper boreholes within the bedrock and Glacial Deposits are presented in **Table 6**.

Table 6 Stabilised Groundwater Levels

	Bore Hole	Groundwater Level (m bgl)			Groundwater Elevation (m AOD)		
		13-Aug-08	10-Jul-09	18-Aug-09	13-Aug-08	10-Jul-09	18-Aug-09
Leachate Levels within the waste	*BH01A*	*0.862*	*1.11*	*1.44*	*59.18*	*58.94*	*58.61*
	BH02	*1.232*	*1.37*	*1.44*	*58.26*	*58.12*	*58.05*
	BH03	*0.444*	*0.703*	*1.06*	*59.70*	*59.44*	*59.09*
	BH04b	*0.722*	*1.168*	*1.38*	*60.34*	*59.89*	*59.68*
Stabilised ground water levels	BH05	-	2.01	2.22	-	57.02	56.81
	BH06	-	1.11	1.15	-	59.13	59.09
	BH07	-	1.53	1.55	-	60.28	60.26

Based on the measured water levels, shallow leachate within the waste ranges from approximately 60m AOD to 58m AOD. The levels appear to decrease from west (BH04B) to east (BH02) indicating shallow groundwater flow from west to east. This follows the general topographic gradient of the area and would be consistent with observations of groundwater within the Glacial Deposits. However, if the waste was deposited in separate cells or trenches, as indicated from the desk study and site investigation, then shallow water within the waste may not necessarily be connected and could be forming localised bodies of water within the waste material.

Groundwater within the deeper clay and bedrock is confined by the presence of the low permeability Glacial Deposits giving sub-artesian conditions. The potentiometric surface has been recorded at similar elevations to the shallow water within the waste material indicating that the vertical gradient between leachate and the aquifer to be minimal which would limit downward migration of leachate. Groundwater flow within the deeper clay and bedrock would appear to be towards the east as speculated from the desk study including the Conceptual Model presented by GIBB.

The presence of the fault within the bedrock is likely to have an influence on groundwater flow within the bedrock. The exact location of the fault is unknown and groundwater observations within the limestone are limited. However, it is considered that there is continuity of flow between BH07 and BH05. An interpretation of groundwater flow is presented on **Figure 7** based on stabilised levels recorded on the 18th August 2009. The groundwater level within the well in the Contractor's compound (located to the south-west of the site) was recorded on the 2nd July 2009 and was significantly lower than the levels recorded in the other wells. This well has been pumped extensively in the past and is therefore not considered to be representative of background groundwater levels within the aquifer as had been initially anticipated. It has therefore been excluded from the interpretation presented in **Figure 6.**

4.3.4 Underground Services

Based on available services drawings, there are few underground services exist in the area of the waste with the exception of the 150mm diameter uPVC foul sewer in the southern region of the site. This sewer was constructed by excavating the encountered waste and replacing with inert low permeability material. There is a watermain across the field at approximately 1m depth which connects to the unoccupied Crèche Building. These services are not deemed likely to act as a potential pathway for any contaminated soil, water or leachate.

4.3.5 Summary of Ground Conditions

The general sequence of soil conditions encountered during the intrusive investigations in the vicinity of the illegal waste is presented in **Table 7.**

Table 7 Summary of Ground Conditions in Vicinity of Waste

Strata	Thickness	Descriptions
Topsoil	0.1 - 0.6m	Soft medium brown to orange-brown silty clay with frequent rootlets.
Reworked Clay	0.5 - 2.3m	Soft orange brown silty clay with frequent gravel to firm dark grey clay with cobbles ceramic pieces, cloth, metal, plastic and wood chips.
Solid Waste	1.2 - 2.8m	Plastic bags of airline waste within a clay soil matrix.
Glacial Till	4 - 16 m*	Soft to firm brown sandy gravelly clay underlain by wet dark grey gravelly clay.
Limestone	-	Limestone bedrock, 0.5 m weathered layer at top.

* indicates estimated thickness beneath waste based on penetrated clay thickness and thickness of waste.

A cross section based on the observations from the intrusive investigations is presented as **Figure 8**.

4.4 SOIL CHEMICAL RESULTS

Twenty soil samples were scheduled for laboratory testing, predominantly from the trial pits during the main investigation. Samples were taken from both the waste and the surrounding clay subsoil and were analysed for the broad suite of parameters listed in Table 5. The results are presented in **Appendix D**.

The following broad trends have been identified:

- The results generally do not differ significantly between samples for any of the determinants analysed;
- The soil is generally alkaline with pH values ranging from 8.2 to 8.9;
- Organic content by ignition ranged between 1% and 2%;
- Metals including arsenic, boron, cadmium, chromium (total), copper, lead, nickel, selenium and zinc were detected in all samples. Concentrations were generally consistent between samples. Mercury and hexavalent chromium were not detected;
- Cyanide was not detected above laboratory detection limits in any samples;
- Monohydric phenol was detected slightly above laboratory detection limits in one sample;
- PCBs were not detected above laboratory detection limits in any samples;
- Petroleum hydrocarbons were generally not detected above laboratory detections. A maximum total concentration of 130mg/kg was recorded in a sample from TP6 at 2.5m bgl. Where detected, hydrocarbons generally comprised the heavier chain fractions (C10 and above); and,
- Of the individual PAHs analysed, phenanthrene was the only compound to be recorded slightly above laboratory detection limits in most samples. All other compounds were generally not recorded above the laboratory detection limits with the exception of two samples (TP2 at 0.5m bgl and TP3 at 1.5m bgl).

In general, the soil results did not appear to indicate gross contamination. However, some potentially harmful substances were detected and therefore a generic quantitative risk assessment was undertaken. This was carried out as part of Tier 3 and is discussed in Section 4 below.

4.5 WASTE ACCEPTANCE CRITERIA

As part of the main investigation five samples from waste were tested for waste acceptance criteria (Murphy's suite), to give an initial indication of the likely waste classification of the material. Samples were taken from locations where the waste had a particularly strong odour. The results are presented in **Appendix D**.

The results were compared to EU guidance for the acceptance of waste at landfills. The PAH criteria is 100mg/kg for Murphy Environmental Landfill (the closest landfill to Dublin for inert material).

The following metals recorded concentrations which slightly exceeded their respective criteria for inert waste:

- Molybdenum and antimony within TP1;
- Lead within TP3; and

- Selenium within TP6.

Samples of waste from TP2 and TP9 did not exceed the criteria for inert waste. None of the samples tested exceeded criteria for hazardous waste. The results indicate that the waste is likely to be classified as "non-inert non-hazardous waste".

The following **Table 8** provides definitions relating to waste acceptance criteria:

Table 8	Definition of Waste Relating to Waste Acceptance Criteria
Inert Waste	Waste is inert if: (a) it does not undergo any significant physical, chemical or biological transformations; (b) it does not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health; and, (c) its total leachability and pollutant content and the eco-toxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water or groundwater.
Non-Hazardous Waste	Non-hazardous waste is waste which is stable and non-reactive, which means that the leaching behaviour of the waste will not change adversely in the long-term, under landfill design conditions or foreseeable accidents: (a) in the waste alone (for example, by biodegradation); (b) under the impact of long-term ambient conditions (for example, water, air, temperature, mechanical constraints), and, (c) by the impact of other wastes (including waste products such as leachate and gas).
Hazardous Waste	Hazardous waste is waste which possesses one or more of the following hazardous properties: explosive, oxidizing, flammable, irritant, harmful, toxic, carcinogenic, corrosive, infection, toxic for reproduction, mutagenic, releases toxic gases in contact with air, water or acid and ecotoxic.
Putrescible Waste	Putrescible waste is any waste which is subject to biological and chemical decomposition or decay.
International Swill	Catering waste containing products of animal origin generated from means of transport operating internationally.

4.6 GROUNDWATER CHEMICAL RESULTS

Groundwater samples were collected from shallow (leachate) wells on three separate occasions: August 2008, December 2008 and July 2009. Groundwater samples from the deeper wells were collected in July 2009 only. The samples were analysed for the broad suite of parameters listed in Table 5 and are presented in **Appendix E**.

Field parameters were measured 13th August 2008, 10th July 2009 and 18th August 2009. The results are presented in **Appendix E**.

The results indicate that the shallow groundwater within the waste material (leachate) exhibits a different chemical signature to the deeper groundwater within the Glacial Till and Limestone aquifer. Within the leachate BH04B generally recorded the highest concentrations. Within deeper groundwater BH06 and PW1 exhibited a slightly different profile to BH05 and BH07 indicating that water quality may be affected by the presence of the fault line. The predominant trends are summarised below:

- Both the leachate and the deeper groundwater is slightly acidic with pH values ranging from 6.34 to 7.3. Values are generally similar in all samples.

- Recorded values of electrical conductivity range from 1.249mS/cm to 3.78mS/cm within the leachate and from 0.843mS/cm to 1.588mS/cm within the deeper groundwater. The lowest value was recorded within BH06.

- Alkalinity is generally higher within the leachate than the groundwater although BH06 recorded the maximum value of 6,900mg/l which was considerably higher than any of the other samples.

- All samples show depleted oxygen with recorded concentrations ranging from 0.12mg/l to 3.3mg/l equating to a percentage saturation of between 1.4% and 34.9%. The values measured on 13th August 2008 were considerably lower than the two subsequent rounds.

- Heavy metals were detected in both leachate and deeper groundwater. The concentrations were of a similar order in both bodies of water although the highest concentrations were recorded in BH04B within the waste. BH06 and PW1 recorded considerably higher concentrations of metals than BH05 or BH07.

- The analysis results for August 2009 recorded higher concentrations of metals than the 2008 results. This is due to the 2009 results recording total metals rather than dissolved metals which were recorded in 2008. Total metals are likely to overestimate metal concentrations within the waters and therefore. dissolved metals, which are deemed more representative of site conditions, will be monitored going forward.

- Ammonia recorded concentrations between 31mg/l and 187mg/l within the leachate. Concentrations of ammonia within deeper groundwater was only recorded above laboratory detection limits in BH05, which recorded a concentration of 6.1mg/l.

- Sulphate was not detected within leachate but recorded concentrations between 62mg/l and 182mg/l in deeper groundwater, which indicates reducing conditions within the leachate.

- Phenols were detected within the leachate during both monitoring rounds in 2008 but were not detected within any samples during the July 2009 monitoring round.

- PCB congener PCB28 was detected slightly above the detection limit in BH04B in the July 2009 monitoring round. PCBs were not detected within this sample on previous monitoring rounds and were not detected in any other samples.

- Petroleum hydrocarbons have been recorded above laboratory detection limits within the leachate and generally comprise heavier chain fractions (>C10). Petroleum hydrocarbons have not been detected within the deeper groundwater.

- PAHs were generally not recorded above laboratory detection limits within deeper groundwater. PAHs were recorded within leachate. Naphthalene, which is the most soluble compound, recorded the highest concentrations.

- Volatile Organic Compounds (in particular Toluene and Ethylbenzene) recorded concentrations slightly above the laboratory detection limit within the leachate during the December 2008 monitoring round. Ethylbenzene was the only compound detected during the July 2009 monitoring. This result is not consistent with that for the petroleum hydrocarbons detected on site, which did not detect any low chain aromatic hydrocarbon fractions. VOCs

were not detected within the deeper groundwater. The hydrocarbon analysis is a more accurate test than the VOC analysis.

Overall the results indicate that the shallow water within the waste has been impacted by heavy metals, ammonia and hydrocarbons. Impact from ammonia is seen to a lesser extent within deeper groundwater. This could be attributable to the landfill but could also be a result of agricultural activity within the area and the presence of the nearby wastewater treatment system. However given the recent age of this system, it is deemed unlikely to be contributing the ammonia levels detected within the bedrock groundwater. A generic quantitative risk assessment has therefore been undertaken with respect to groundwater as part of Tier 3 and is discussed in Section 4 below.

4.7 GROUND GAS RESULTS

4.7.1 Borehole Gas Monitoring

Gas taps were installed on all monitoring wells installed within the boreholes located within the waste material and monitoring of oxygen, carbon dioxide and methane was carried out on 13th August 2008, 10th July 2009 and 18th August 2009. Gas levels were recorded using a Landfill Gas Analyser.

The monitoring was carried out during periods of low to moderate pressures and when the ground was both wet and dry. The boreholes were monitored for methane (CH_4), carbon dioxide (CO_2), oxygen (O_2), nitrogen, hydrogen sulphide (H_2S), flow and atmospheric pressure. It is recommended that a number of rounds of monitoring be carried out at low or falling atmospheric pressures i.e. <1000 mbar.

Tables 9a, 9b and **9c** below presents the range of ground gas readings over the 3 monitoring periods.

Table 9a Ground Gas Readings 13 August 2008

Location	Peak CH_4 (%)	CH_4 (%)	O_2 (%)	N_2 (%)	CO_2 (%)	H_2S (%)	Atm Pressure (mbar)
BH01	1.2	0.6	20.9	77.9	0.1	0	987
BH02	8.0	3.1	19.3	76.4	4.5	0	987
BH03	0.8	0.6	17.2	72.8	9.1	0	987
BH04	2.6	1.4	19.3	76.4	4.5	0	987

Table 9b Ground Gas Readings 10 July 2009

Location	Peak CH_4 (%)	CH_4 (%)	O_2 (%)	N_2 (%)	CO_2 (%)	H_2S (%)	Atm Pressure (mbar)
BH01	0.1	0.1	20.9	79.0	0.1	0	1002
BH02	0.2	0.2	20.9	78.3	0.6	0	1002
BH03	0	0	20.9	78.8	0.3	0	1002

Table 9c Ground Gas Readings 18 August 2009							
Location	**Peak CH_4 (%)**	**CH_4 (%)**	**O_2 (%)**	**N_2 (%)**	**CO_2 (%)**	**H_2S (%)**	**Atm Pressure (mbar)**
BH01	0	0	20.9	78.8	0.2	0	995
BH02	0	0	20.3	79.3	0.3	0	995
BH03	0	0	20.4	79.4	0.1	0	995
BH04	0.3	0	20.2	78.9	0.5	0	995

Existing criteria set out by the EPA, generally in a landfill setting, specify guideline trigger values for methane and carbon dioxide at 1.0% v/v and 1.5% v/v respectively. Other important values when interpreting landfill gas concentrations are the lower (LEL) and higher (HEL) explosive limits of methane. 5% v/v represents the LEL while 15% is the HEL. This means that at concentrations between 5% and 15% methane is readily explosive. It should also be noted that methane remains flammable at below 5% and cause asphyxiation at 30% or greater. Carbon Dioxide concentrations of greater than 3% can cause breathing difficulties, while levels of 5% in confined spaces can also cause asphyxiation.

Elevated peak levels of methane were recorded in July 2008 at BH02 (8.0%), BH01 (1.2%) and BH04 (2.6%). Stabilised levels of methane which were recorded shortly after the initial peak reading were markedly lower ranging between 0.6% and 3.1% during this period. Subsequent monitoring in July 2009 and August 2009 recorded low levels of methane being generated ranging between 0.0% and 0.2%.

Elevated levels of carbon dioxide were recorded in July 2008 at BH02 (4.5%), BH03 (9.1%) and BH04 (4.5%). Subsequent monitoring in July 2008 and August 2009 recorded levels of carbon dioxide significantly lower ranging between 0.1% and 0.6%.

Flow data recorded indicated low positive flows (ranging between 0.1 and 0.3 litres/hour) during all monitoring events indicating low level active gas generation.

Gas flows are a critical component in the analysis of monitoring data relating to the potential risk posed by ground gases. The highest risk regime for a gas well exists when there is both a high gas concentration and high gas flow rate.

Typical gas flows recorded by RPS at typical landfill sites have been up to 3 to 4 litres per hour. High gas flows generally indicate that there is a large volume of gas present probably at high concentrations. Low gas volumes, even at high concentrations, will seep out slowly as there is no pressure forcing the gas out of its trap. For example, a relatively small fragment of wood is capable of producing significant concentrations of methane in a monitoring borehole that happen to be installed close to it. However, large volumes of gas are required for the high concentrations to cause a problem.

4.7.2 Internal Building Gas Monitoring

In addition, 2 rounds of indoor gas monitoring were undertaken in the two adjacent buildings to the site (*i.e.* the Airport Police Dog Unit and a nearby store building) in August 2009. The monitoring was undertaken using a MicroFID gas analyser. No detections of carbon dioxide or methane were recorded.

Landfill gas can travel through loose compacted material and stone surrounding services serving a building in a preference in using transmissive routes. This means that occupiers or users of a building can be potential receptors to the potential landfill gas. In addition, monitoring adjacent to services may give an idea of mobile landfill gases.

Overall low levels of ground gases (i.e. methane and carbon dioxide) are being generated within the waste. Given the low flow rates and the non-detections within adjacent buildings, ground gases do not appear to be migrating laterally. This is consistent with the EPA Code of Practice expectation that landfill gas from pre-1977 biodegradable waste would be expected to be low. However, these observations are based on 3 rounds of monitoring and further monitoring is recommended to provide additional confidence of the low levels of ground gas generation at the site over a number of low and falling pressure periods.

4.8 CONCLUSIONS OF TIER 2 SITE INVESTIGATIONS

The findings of the Tier 2 intrusive investigations and testing has provided the following conclusions:

- The lateral extent of waste material is confined to the western and central portion of the field at the rear of Castlemoate House.

- The waste appears to have been deposited in discrete north-south trending trenches or cells and has a total volume of approximately 13,060m^3 and a mass of 7,836 tonnes.

- The fault identified on the GSI Geological map is likely to pass between BH07 within the Castlemoate field and BH06 in the northern field. The exact location of the fault is unknown.

- A minimum thickness of 4m of low permeability clay is present beneath the waste. The thickness of clay may be substantially greater depending upon the direction and angle of dip of bedrock and the exact location of the fault.

- The low permeability clay follows the regional pattern of 2m to 3m of soft to firm brown clay underlain by firm to stiff dark brown and dark grey clay with occasional discontinuous bands of sand gravel or cobbles. Permeability measurements of typical Dublin Boulder Clays, similar in nature to the identified clays at the site, have been recorded ranging between 10^{-8} and 10^{-11} m/s by Long and Menkiti (2007)[3] and Lehane & Simpson (2000)[4]. As a reference, the EPA required specification for an engineered landfill clay liner is 10^{-9} m/s which is deemed suitable to prevent the vertical migration of contamination from the landfill. In addition, a review of geological conditions from site investigations across the airport recorded dry brown and black firm to stiff boulder clays ranging in depth between 0.58 and 15.15 mbgl. Thickness of this clay material ranged between 1.5 and 12.95 metres.

- Leachate is present within the waste body and perched on the low permeability clay.

- Regional groundwater is present within the limestone bedrock and exhibits sub-artesian conditions with the low permeability clay acting as a confining layer.

[3] Long, M. & Menkiti, C.O. (2007). Geotechnique 57, No.7, 595-611

[4] Lehane, B. & Simpson, B. (2000). Modelling glacial till under triaxial conditions using a BRICK soil model. *Can*. *Geotech. J*. 37, No.5, 1078-1088.

- The leachate head within the waste and the potentiometric surface of the limestone aquifer have similar elevations and both indicate an eastward gradient following local topography but are not considered to be hydraulically connected.

- Low levels of ground gases (*i.e.* methane and carbon dioxide) are being generated within the waste. Given the low flow rates and the non-detections with adjacent buildings, ground gases do not appear to be migrating laterally. These observations are based on 3 rounds of monitoring and additional monitoring is recommended to adequately assess the generation of ground gases at the site over a number of low and falling pressure periods. In addition, gas protection measures may need to be considered if future construction/redevelopment works were to be undertaken at the site.

- Potentially harmful substances have been detected within soil and leachate in direct contact with the waste and a risk assessment is required to determine the significance of observed concentrations.

5 TIER 3 – REFINEMENT OF CONCEPTUAL MODEL & QUANTITATIVE RISK ASSESSMENT

5.1 REFINED CONCEPTUAL SITE MODEL

The conceptual model, initially developed at Tier 1 (refer to Section 2 above) has been refined based upon the findings of the site investigation. The Source-Pathway-Receptor Linkages identified at Tier 1 have been considered in more detail to take account of site specific conditions. The refined conceptual model is discussed in detail below and presented in **Figure 9**.

5.1.1 Source

The primary source of contamination at the site is the waste, which has been characterised as part of this investigation. The waste has given rise to a number of secondary source media as follows:

- Soil matrix within and surrounding the waste containing organic and inorganic substances;
- Shallow groundwater (leachate) in direct contact with the waste containing organic and inorganic compounds; and,
- Soil gas comprising carbon dioxide and methane.

Substances that may be harmful to human or environmental receptors have been recorded at detectable concentrations within the soil matrix and leachate. The contaminants of concern (CoC) with respect to human health and environmental receptors, in particular groundwater, that have been identified during the site investigation are summarised in **Table 10** below.

Table 10 Contaminants of Concern

CoC – Human Health		**CoC – Groundwater**
Non Volatile Inorganic Compounds	Metals	Heavy metals Ammonia Naphthalene Phenol Petroleum Hydrocarbons PCBs
Semi Volatile Organic Compounds:	Polycyclic Aromatic Hydrocarbons Phenol Petroleum Hydrocarbons (>C10) PCBs	
Volatile Organic Compound:	Not detected	

5.1.2 Receptors

The following potential receptors, which could potentially be affected by contamination at the site, are as follows:

- *Current site users.* The site is used occasionally by DAA workers for stockpiling of organic material (tree clippings etc). Members of the public are known to make use of the access track defining the northern boundary of the field.
- *Future site users (assuming change of use)*. Under current land use planning the field at the rear of Castlemoate House is within the approach (designated safety zone) of the proposed parallel runway.
- *Buildings and infrastructure*. Under the current land use there are no buildings or infrastructure in contact with the waste although this could change depending on future changes in land use.
- *Adjacent site users.* The DAA training centre and Airport Police Dog compound are located adjacent to the site. A crèche is adjacent to the northern field to the north east (since closed and not occupied) and a contractor's compound is located beyond Castlemoate Road.
- *Groundwater within the bedrock.* Groundwater is present within limestone bedrock which has been encountered within 6m below ground level immediately adjacent to the waste body.
- *Surface water courses*. The nearest surface water feature is the Forrest Little Stream approximately 600m north of the site.

5.1.3 Pathways

The pathways by which receptors are exposed to the identified sources will be dependent upon the source media and the nature of the receptor itself.

Due to the non volatile nature of the contaminants detected the only pathway by which human receptors could be impacted is via direct contact with the soil or leachate. Given that the waste is capped by at least 0.5m of low permeability reworked clay, direct exposure to the waste materials or soil matrix is considered unlikely under the current land use. In the future, construction workers may be exposed to the material as a result of a change of land use. There is considered to be no pathway of exposure for adjacent site users.

Leachate may potentially migrate laterally or vertically and impact groundwater or surface water although this will be limited by the low permeability nature of the subsoils. The Forrest Little Stream is unlikely to be impacted as the site investigation has shown that leachate is most likely to migrate eastwards in the direction of the topographical gradient rather than northwards towards the stream and there will therefore be considerable opportunity for attenuation. Vertical migration will be limited by the low permeability nature of the subsoils, however the thickness of subsoils directly beneath the waste is unknown but the site investigation has indicated that it could be at least 3.5m. Leachate and groundwater analysis has indicated that the horizontal migration is limited in extent with detections of ammonia being recorded in the down gradient monitoring well BH05.

Lateral migration of landfill gas will be limited by the low permeability nature of the subsoils. Methane and carbon dioxide are being generated within the waste body. However, the site investigation did not find any evidence of landfill gas within adjacent buildings. Therefore vertical migration is considered to be the only viable pathway. As there are no buildings located directly above the waste body this pathway is not relevant to current site users but may apply to future site users depending upon future land use.

5.1.4 Summary of Pollutant Linkages

The source-pathway receptor linkages that are considered to be relevant to the site are presented in **Table 11** below and illustrated in **Figure 9.**

Table 11 Summary of Pollutant Linkages		
Source	**Pathway**	**Receptor**
Contaminated shallow groundwater (leachate) in contact with waste	Downward percolation through subsoil	Groundwater in limestone aquifer
Contaminated soil in contact with waste	Direct contact with soil or leachate	Future site users/construction workers, buildings and infrastructure assuming a change in land use
Landfill Gas (methane and carbon dioxide)	Upward vertical migration	

These linkages have been considered further below in order to estimate and evaluate risks associated with each linkage. Where appropriate generic assessment criteria, relevant to each source media and receptor, have been compared with site data in order to quantify the risk. The selection of the generic assessment criteria is discussed in Section 4.2 below.

5.2 GENERIC ASSESSMENT CRITERIA

5.2.1 Introduction

Generic assessment criteria are soil concentrations that have been derived for a defined set of generic assumptions and are used as trigger values in determining whether further risk management action is required in cases where detailed quantitative risk assessment is not being undertaken.

5.2.2 Soil

The conceptual model has identified construction workers and future site users under a changed land use as the principal receptors with regard to contaminated soil.

There are no published Generic Assessment Criteria (GAC) for soils in the Republic of Ireland. Instead reliance is often placed on criteria from the UK and the Netherlands. Generic Assessment Criteria in the UK has been derived using the Contaminated Land Exposure Assessment (CLEA) model to be protective of human health for a number of different land uses. The Dutch Guideline values are derived based on a consideration of toxicity to human and ecological receptors and comprise a Target Value (DTV) which is generally based on background concentrations in Dutch soils and considered to be a value below which no unacceptable harm will occur and the Serious Risk Concentration (SRC) which indicates a need for further action.

The technical basis of the UK CLEA model was updated in August 2008 and as such any Soil Guideline values derived using the CLEA model prior to that date have been withdrawn and are

awaiting reissue within the UK. To date revised SGVs have been published for 14 contaminants. GAC for a further 35 contaminants (or groups of contaminants) have been derived by Land Quality Management Limited (LQM) in conjunction with the Chartered Institute of Environmental Health (CIEH) using the principles and algorithms presented in the technical guidance to the CLEA approach. The former SGVs are no longer considered appropriate for use in determining whether a site meets the statutory definition of contaminated land within the UK, however the science used is still largely valid. They remain a useful indicator of risk providing that there is an understanding of the assumptions upon which they were derived. The same is true of any GAC.

Neither the Dutch or the UK values have any legal standing within the Republic of Ireland, however, they do provide a means of placing the data within context when considering magnitude of risk and have been used in that capacity for this assessment**.** The main basis of the assessment remains the detailed conceptual model and consideration of the pollutant linkages.

Both the Dutch and the UK criteria consider chronic long term health effects. Risks to construction workers will be driven by short term acute health effects for which there are currently no generic assessment criteria. Therefore the criteria discussed above has been used to indicate whether soils would present a long term risk to future site users if the use of the site was changed. Risks to construction workers will be considered on a qualitative basis.

5.2.3 Groundwater

Leachate and groundwater concentrations have been compared in the first instance to the Interim Guideline Values (IGV) for Groundwater as presented in EPA interim report "Towards Setting Guideline Values for the Protection of Groundwater in Ireland" 2002. The IGVs have been selected on the basis of the lowest of either the drinking water standards, environmental quality standards for surface water or GSI trigger values and are therefore protective of all groundwater and surface water receptors.

Where IGVs are not available, reference has been made to the Dutch Serious Risk Concentrations (SRC) concentrations for groundwater, which indicate a need for remedial action.

There are currently no published generic assessment criteria for groundwater derived specifically to be protective of human health via direct contact. However it can be assumed that if water is considered safe for human consumption then there are no risks from direct contact. Construction workers in a future land use scenario are the only receptors likely to come into direct contact with leachate and risks to this group will be considered qualitatively.

5.2.4 Gas

Gas concentrations have been assessed using the:

- CIRIA 131 – The Measurement of Methane and other gases from the ground
- CIRIA 151 – Interpreting measurements of gas in the ground
- Measurement of gas emissions from contaminated land – BRE

Low levels of ground gases (*i.e.* methane and carbon dioxide) are being generated within the waste. Given the low flow rates and the non-detections with adjacent buildings, ground gases do not appear to be migrating laterally. These observations are based on 3 rounds of monitoring during periods of low and moderate atmospheric pressure conditions.

Based on the available information, ground gases are not deemed to pose a risk to the environment or to human health based on the current use of the site. Additional monitoring is recommended to adequately assess the generation of ground gases at the site over a number of low and falling pressure periods. In addition, gas protection measures may need to be considered if future construction/redevelopment works were to be undertaken at the site.

5.3 RISKS TO HUMAN HEALTH

5.3.1 Soil Source

A comparison of the soil data against UK and Dutch derived guideline values is presented in Appendix H. Results were compared to criteria for both a residential and commercial land use. None of the soil results exceeded either criteria indicating that soils, in direct contact with the solid waste will not present a risk to future users assuming a change to a more sensitive land use. The site is currently designated to form part of the approach to the new parallel runway which is a less sensitive land use than currently. Therefore, there is considered to be no risk to future site users.

There are no assessment criteria with which to assess acute risks to construction workers, however, exposure can be limited by the use of appropriate personal protective equipment (PPE) and good hygiene practices. By removing the pathway of exposure, the risk is effectively mitigated and removed. Therefore there is considered to be no risks to human health from contaminated soils at the site.

5.3.2 Leachate Source

Risks to human health from leachate will be driven by direct contact. This exposure will only occur during ground works carried out by construction workers as part of remediation activities or a change in land use. As discussed above for soils, this risk can be effectively mitigated by appropriate PPE and site protocols. Leachate is therefore not considered to present a risk to human health.

5.3.3 Gas Source

The conceptual model has identified that landfill gas does not currently pose a risk to current or adjacent site users. However, the reference to the above mentioned reports in Section 4.2.4 indicates that if the site use were to change to include buildings directly above the waste body then additional gas monitoring and gas protection measures would need to be considered.

5.4 RISKS TO GROUNDWATER

Leachate and deeper groundwater concentrations have been compared to the EPA Interim Guideline Values (IGV) for the Protection of Groundwater in Ireland. The comparison is presented in **Appendix E** and exceedence of the criteria is illustrated on **Figure 10**.

The main conclusions of the comparison are summarised below:

- **Heavy metals** including arsenic, chromium, copper, lead, nickel and zinc recorded concentrations in the leachate in excess of their respective guideline concentrations. Exceedences recorded in the August 2009 results, which measured total concentrations, were generally of the order of 2 to 5 times the IGV with the exception of lead which recorded an exceedence of 13 times the IGV. Concentrations in the 2008 results, which were based on dissolved concentrations, were considerably lower.

- Chromium, copper, lead and nickel recorded exceedence of their respective criteria in deeper groundwater within BH06 and PW1, which are located up-gradient of the waste. Lead and nickel were recorded slightly above their criteria in BH05, which is down gradient of the waste. These concentrations are based on total concentrations in water and are likely to have overestimated the mobile dissolved phase.

- Total **Phenols** were observed in three samples above the Interim Guideline Values in BH2, BH3 and BH4B in July 2008. Concentrations of 520µg/l, 590µg/l and 110µg/l respectively were detected. These exceed the Interim Guideline Value of 0.5µg/l for Total Phenols. Most of the phenol results in soils were below detection limits. Phenols were not detected within leachate or deeper groundwater during the August 2009 monitoring round.

- **Ammonia** has been consistently recorded within leachate at concentrations significantly greater than the IGV of 0.15mg/l. BH5 which is down gradient of the waste also recorded concentrations in excess of the IGV but at considerably lower concentrations than those observed within the leachate.

- **Petroleum hydrocarbons** including BTEX compounds and naphthalene have been recorded within leachate at concentrations above the IGV. These compounds have not been detected in deeper groundwater.

- All other parameters were below guideline concentrations.

The results of the assessment indicate that ammonia is the principal contaminant within the leachate recording the highest concentrations in relation to its guideline value. All other contaminants recorded minor exceedences only. Ammonia is also the only contaminant to have been recorded at a concentration significantly above its guideline value in deeper groundwater down gradient of the site.

Metal concentrations recorded within the aquifer are considered to represent background concentrations given the elevated results in up-gradient boreholes. The concentrations of dissolved metals within leachate are only slightly higher than guideline values. The relatively low concentrations of metals within the leachate are consistent with the largely putrescible nature of the waste and the alkaline soil conditions.

Based on the results of the assessment, ammonia within leachate would appear to be presenting a risk to groundwater. There are additional sources of ammonia within the area which could be contributing to the concentrations observed within BH05, such as the percolation area of waste water treatment unit in the south-east of the Castlemoate field and agricultural land to the north of the site. However, neither of these potential sources are located directly up-gradient of BH05 and the age of the treatment plant is such that leakage is unlikely. Therefore the landfill remains the most likely source of the ammonia contamination.

Given the general absence of other contaminants and the relatively low sensitivity of the aquifer, the contamination observed is considered to be minor. The risk to groundwater from the landfill is

therefore considered to be low to moderate in that contamination has been observed but is not having a significant detrimental impact on the receptor.

The observed risk could be mitigated by removing either the source of contamination i.e. removal of the waste or removal of the pathway, which may involve capping of the waste to limit leachate accumulation and downward migration. However, this assessment is based on a single monitoring round within the deeper groundwater. Therefore, before undertaking large scale remediation works, which may have the effect of mobilising further contamination, additional monitoring is required to confirm the presence of ammonia within deeper groundwater and to investigate the flow regime within the aquifer and the contribution from downward percolation of leachate.

6 CONCLUSIONS

An environmental risk assessment has been carried out with respect to buried waste material discovered within the field at the rear of Castlemoate House at Dublin Airport. The assessment was carried out in accordance with the EPA Code of Practice for Environmental Risk Assessment of Unregulated Waste Disposal Sites, 2007, and comprised Tier 1 Preliminary Assessment and Screening; Tier 2 Site investigation and Testing, and Tier 3 Conceptual Model Refinement and Quantitative Risk Assessment.

The assessment has concluded the following:

- The waste material comprises putrescible airline waste deposited approximately 25 to 35 years ago within discrete north-south trending trenches within the Castlemoate field. The results of waste acceptance criteria analysis indicate that the waste is likely to be classified as "non-inert non-hazardous waste" in character. The total volume of the solid waste is estimated to be approximately 13,060m^3 (7,836 tonnes).

- The low permeability clay follows the regional pattern of 2m to 3m of soft to firm brown clay underlain by firm to stiff dark brown and dark grey clay with occasional discontinuous bands of sand gravel or cobbles. Thickness of clays underlying the waste were recorded at 4.0 metres or greater. In addition, a review of existing SR Techniques borehole logs also indicated that geological conditions underlying the area of Dublin Airport, between Hangar 1 and Hangar 6, comprised dry brown and black boulder clays at depths up to 15.15 mbgl. Thickness of this clay material recorded ranged up to 12.95 metres. These records indicate that the thickness of underlying clays at the site is likely to be significant.

- Permeability measurements of typical Dublin Boulder Clays, similar in nature to the identified clays at the site, have been recorded following a literature review (see Section 4.3.2.1) ranging between 10^{-8} and 10^{-11} m/s. As a reference, the EPA required specification for an engineered landfill clay liner is 10^{-9} m/s which is deemed suitable to prevent the vertical migration of contamination from the landfill. Therefore the identified clays underlying the waste material at the site, which appear to comprise of low permeability clays of significant thickness, are preventing widespread vertical migration of leachate from the waste material.

- The soil and shallow groundwater (leachate) in contact with the waste contains low concentrations of metals and organic compounds. Elevated concentrations of ammonia are present within the leachate.

- Ground gases comprising methane and carbon dioxide is being produced within the waste material but is not detected within adjacent buildings.

- The risk screening process identifies "Moderate" risks to water quality in the limestone bedrock aquifer.

- Ammonia has been observed within deep groundwater down gradient of the site and the waste material is considered to present a low to moderate risk to groundwater quality within the limestone aquifer.

- There are no identified risks to current or adjacent site users from the waste material.

- Risks to future site users are driven by direct contact with soil or waste material and or leachate by construction workers. These risks can be mitigated by use of appropriate personal protective equipment and site protocols.

- Further monitoring is recommended to confirm the extent of ammonia contamination within borehole BH05 and the findings of the assessment before consideration is given to undertaking large scale remediation works. In addition, this monitoring will facilitate a determination if remediation of the waster via excavation will pose a greater risk to groundwater than leaving the material in-situ with an appropriate capping layer.

7 OPTIONS

The principle of the EPA Code of Practice for the Risk Assessment of Unregulated Waste Disposal Sites is to assess the intrinsic risk posed by the activity and to allow for the most appropriate approach to be taken to secure the protection of the environment and human health. This report sets out the nature of the source, identifies potential receptors and established the linkages between these two components. The investigative portion of the assessment seeks to characterise the components of the conceptual model and to quantify the environmental impact arising from the presence of the waste material. The detailed information obtained through the investigation programme informs the options to manage the risk which may involve breaking the pathway, removal of the source, or monitoring of the receptor. Options range from the minimum of 'doing nothing' to full site remediation:

- Do Nothing
- Monitoring & Reporting
- Removal of Waste

Option A – Do Nothing

Within the context of environmental protection and sustainability this option is not considered tenable.

Option B – Monitoring & Reporting

In the event that waste material does not present a significant risk to the environment (including interfering with sensitive receptors) the EPA Code of Practice allows for the waste to remain on site where it can be clearly demonstrated that this will lead to the greater protection of the environment and greater protection of human health.

Option C – Removal of Waste

Before an evaluation takes place in gathering site-specific information, the Code of Practice assumes that making safe the site includes: removal of the waste. This is on the basis that the waste likely poses a negative risk to the environment and/or health of the local population. In such cases it is presumed that waste recovery processes and waste disposal methods do not in themselves endanger the environment, or increase risk to the range of receptors (human or animal health, water, air, soil or plant life), cause a nuisance through noise or odours or adversely affect the countryside. Consequently, the manner of making good the site must take into account the totality of impacts in the life cycle of the remediation.

8 RECOMMENDATIONS

The assessment reported above has concluded that the buried waste of between 25 and 35 years in age within the Castlemoate field presents a “low to moderate risk” to groundwater quality within the limestone aquifer from ammonia in leachate. There is therefore a requirement for further risk management action along the single pathway linkage.

According to the Code of Practice, in order to mitigate a risk, the respective source-pathway-receptor linkage must be broken. In this instance, this could be achieved by removal of the source through excavation or treatment or capping of the waste material to prevent downward percolation of leachate. These actions are considered disproportionate with respect to the degree of contamination currently observed; and would likely give rise to fresh instances of nuisance or lead to the release of further contamination through disturbance of the material.

However, the evidence of impact within the limestone aquifer is based on a single monitoring round and therefore further risk management action should be focussed on additional data gathering. The **objectives** of this data gathering exercise are as follows:

1. To further understand the flow regime (including confirmation of groundwater flow direction and flow gradient) within the limestone aquifer and the interaction between leachate and deeper groundwater during a variety of seasonal climatic conditions (*e.g.* over a 12 month period incorporating both summer and winter conditions).

2. To further quantify the extent of identified ammonia compounds within the limestone aquifer and the leachate, in particular potential variations due to seasonal effects such as rainfall infiltration.

3. To determine the most appropriate remediation strategy that will pose the least risk to groundwater and the environment.

To this end, the following outline scope of work is recommended for the further monitoring of the receptor and ongoing reporting:

a) **Installation of automated data-loggers** within selected deep groundwater and shallow leachate wells for a period of one year to monitor groundwater levels over high and low rainfall periods. The data-loggers are proposed to be installed in the following shallow boreholes (BH2, and BH4B) and in the deeper boreholes (BH5 and BH7). Downloading of data to be undertaken on a quarterly basis to coincide with the groundwater monitoring outlined below;

b) **Sampling and monitoring of deep groundwater** (*e.g.* BH 5, BH6 and BH7) and **shallow leachate wells** (*e.g.* BH1A, BH2, BH3 and BH4) for a period of one year with an initial frequency of once per month for the first three months and on a quarterly basis thereafter. The monthly monitoring suite should include a reduced suite of analysis for particular compounds of concern including metals, hydrocarbon and ammonia. However the initial round of monthly sampling is should be analysed for a full suite of parameters to confirm the persistency of the results as recorded in the RPS investigation report. A recommended full and reduced suite of analysis is outlined in Table 12 below. An anticipated sampling program is provided in **Table 13.**

Table 12 Recommended Suite of Analysis	
Full Suite	**Reduced Suite**
Dissolved Metals (As, Br, Ca, Cd, Cr, Cu, Pd, Hg, Mn, K, Ni, S, Se, Zn)	Dissolved Metals (As, Br, Ca, Cd, Cr, Cu, Pd, Hg, Mn, K, Ni, S, Se, Zn)
Inorganics (pH, alkalinity, chloride, ammonical nitrogen, nitrate, nitrite, sulphate, phenols, sulphide, thiocyanate)	Total Petroleum Hydrocarbons (TPH)
SpeciatedTPH CWG	Ammonia
PCBs	Chloride
Speciated PAHs	
VOCs	

Table 13 Proposed Sampling Schedule	
Month	**Suite**
Month 1	Full Suite
Month 2	Reduced Suite
Month 3	Reduced Suite
Month 6	Full Suite
Month 9	Full Suite
Month 12	Full suite

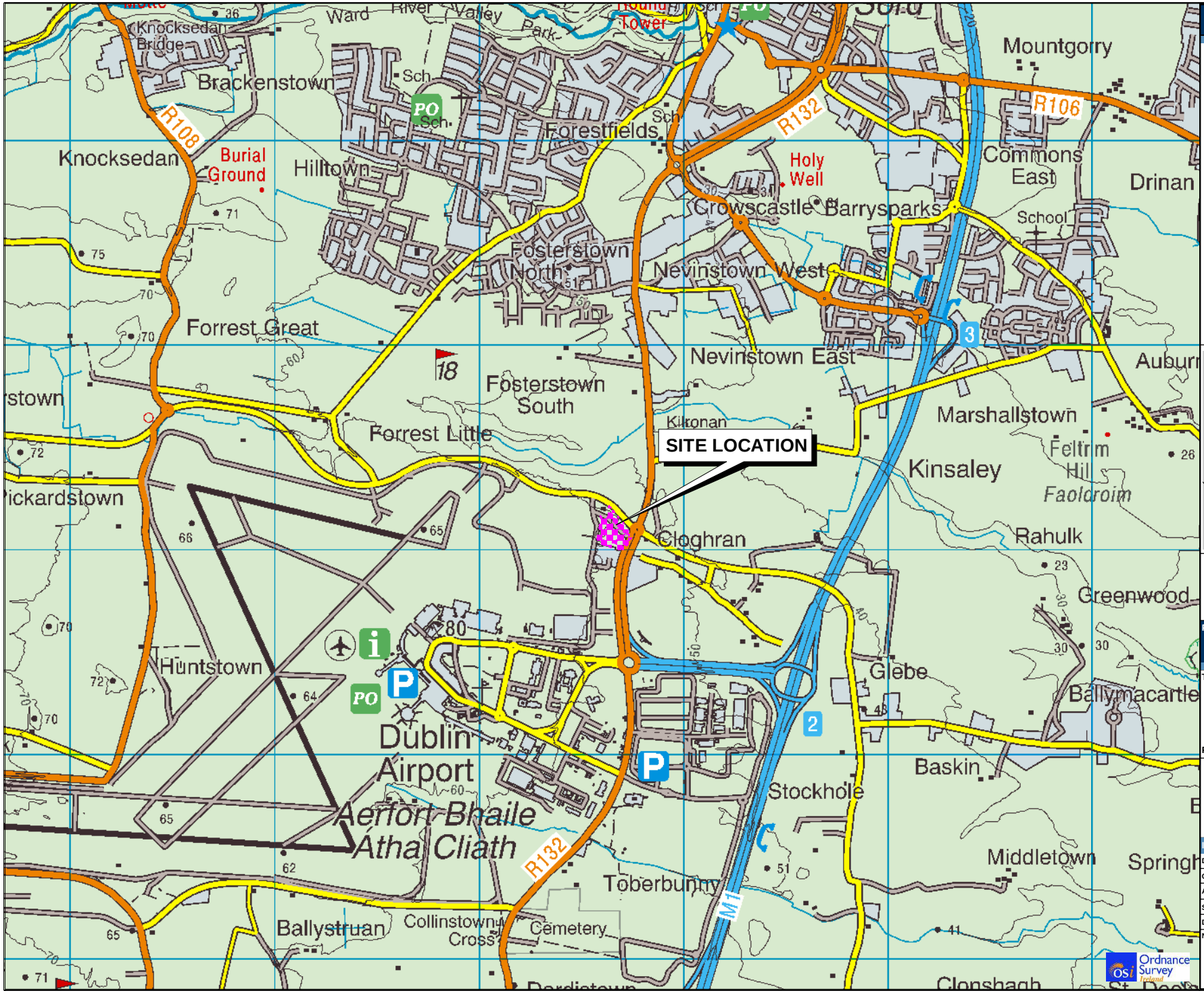
RPS proposes to commence the initial round of sampling in May 2010 and complete the sampling in 2011.

c) **Review of monitoring data and update of risk assessment** report after 12 months to reassess the need for remedial action or additional management options.

d) **Seek Local Authority endorsement** to undertake such investigations and all results to be submitted to the authority on receipt from laboratory.

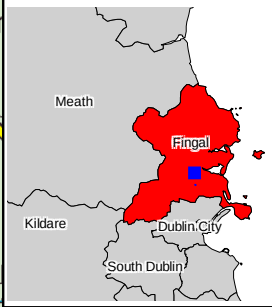
e) The **site** subject to this investigation to be **protected going forward against waste disposal activities** and shall be designated as “off limits” for intrusive excavation works which may exacerbate transmissivity between the source waste and the local environment (soil system and local water bodies), unless accompanied by approval of the Local Authority.

FIGURES



Legend

Site Location



DUBLIN AIRPORT AUTHORITY plc
ÚDARÁS AERFORT BHAILE ÁTHA CLIATH cpt

Project
Unregulated Landfill Site at Castlemoate House, Dublin Airport

Title
Site Location

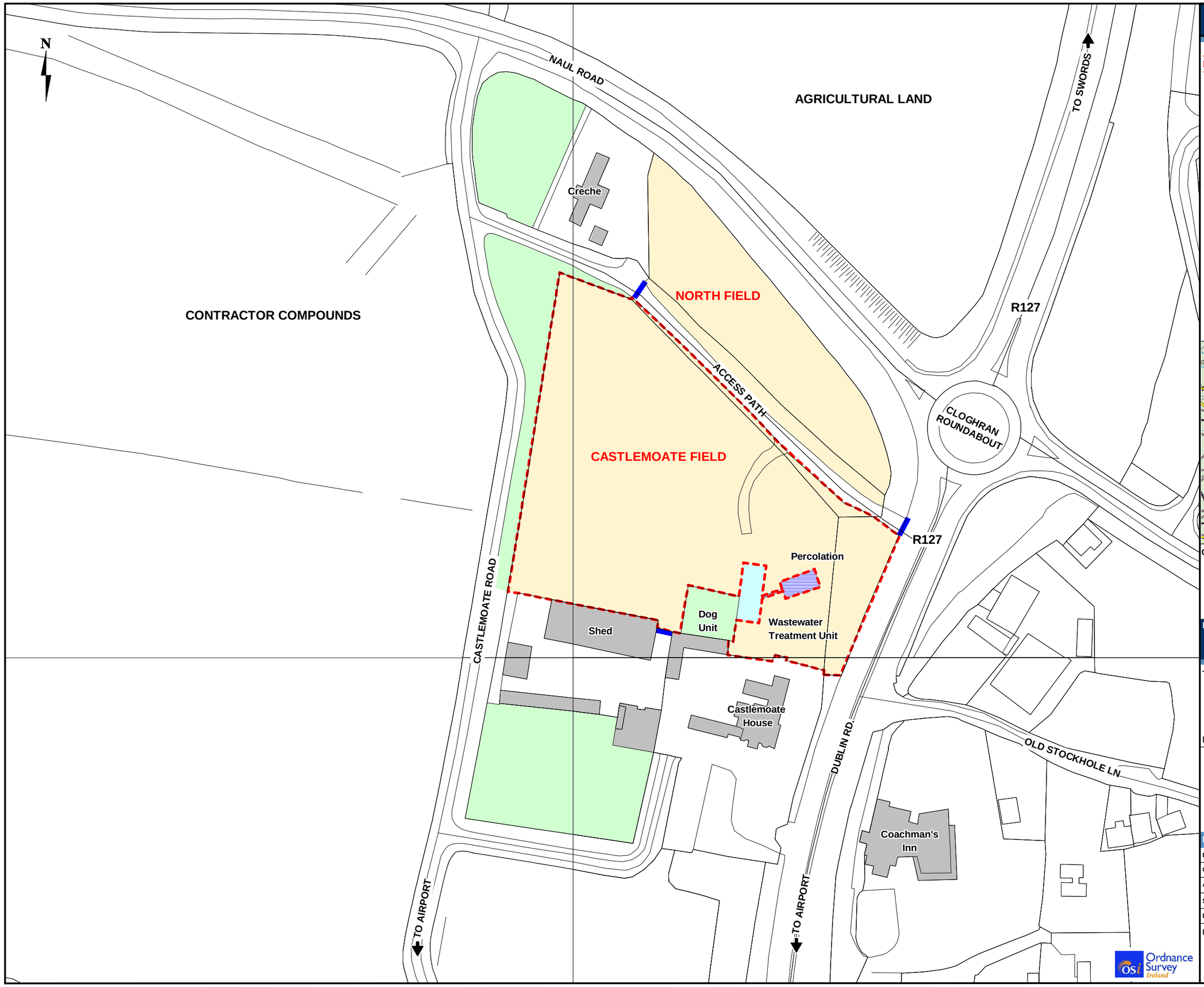
Figure 2

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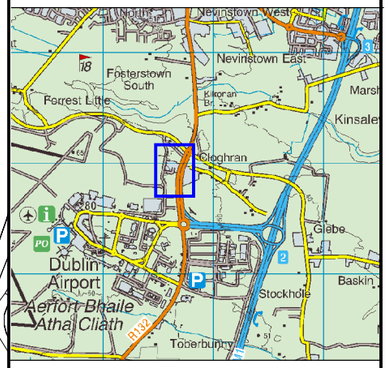
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Legend

- Castlemoat Field Boundary
- Areas of Investigation
- Buildings
- Open Grass
- Access Gate



Client

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ÚDARÁS AERFORT BHAILE ÁTHA CLIATH cpt

Project *Unregulated Landfill Site at Castlemoate House, Dublin Airport*

Title

Site Layout

Figure 3

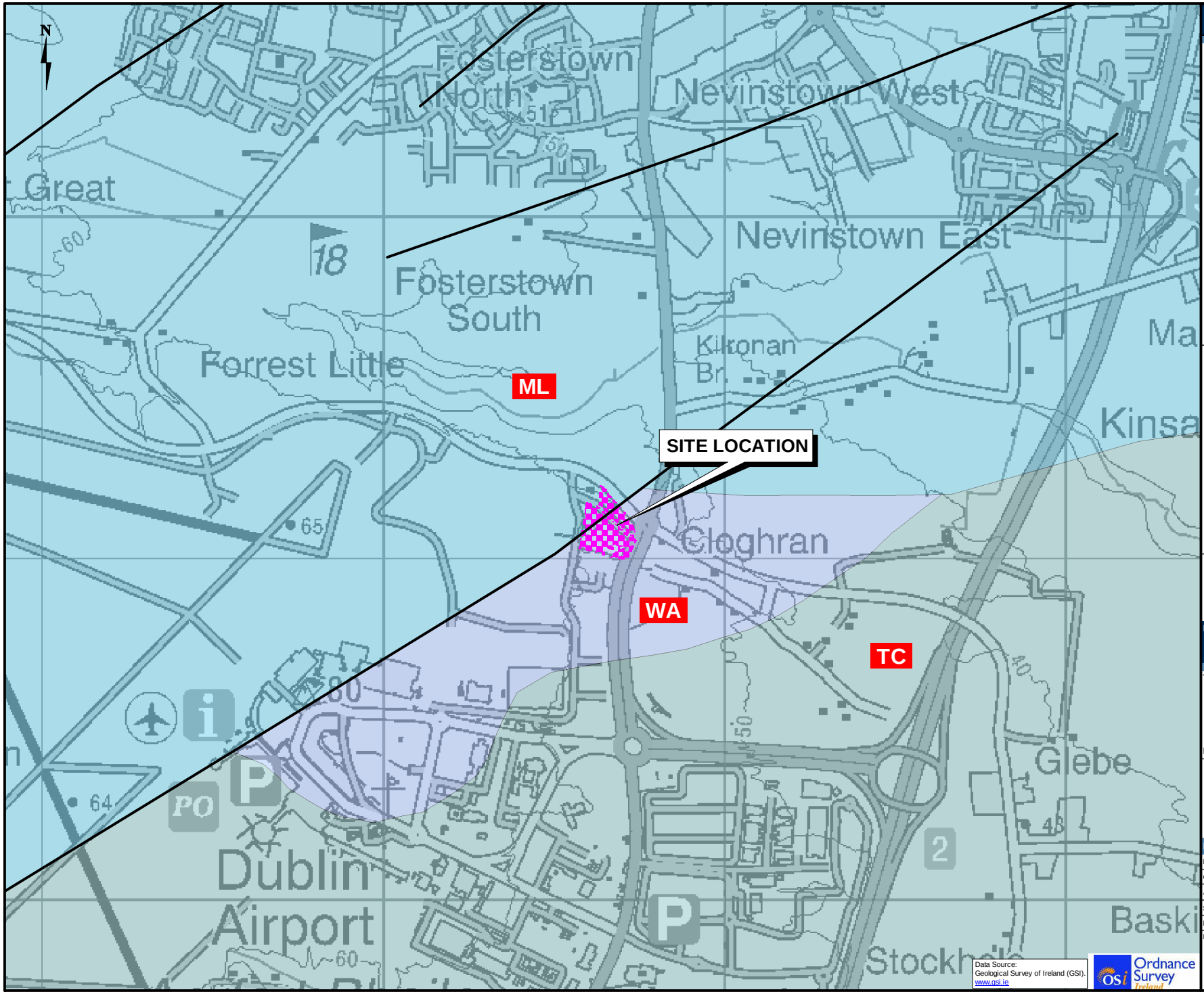
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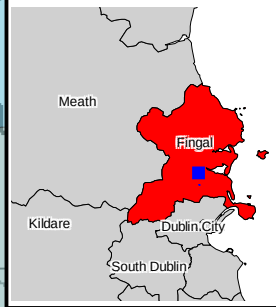


Legend

- Site Location

GSI Bedrock Geology 100k (2007)

- Malahide Formation
  Argillaceous bioclastic limestone, shale
- Waulsortian Limestones
  Massive unbedded lime-mudstone
- Tober Colleen Formation
  Calcareous shale, limestone conglomerate
- Fault Line



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Project
Unregulated Landfill Site at Castlemoate House, Dublin Airport

Title

Bedrock Geology

Figure 4

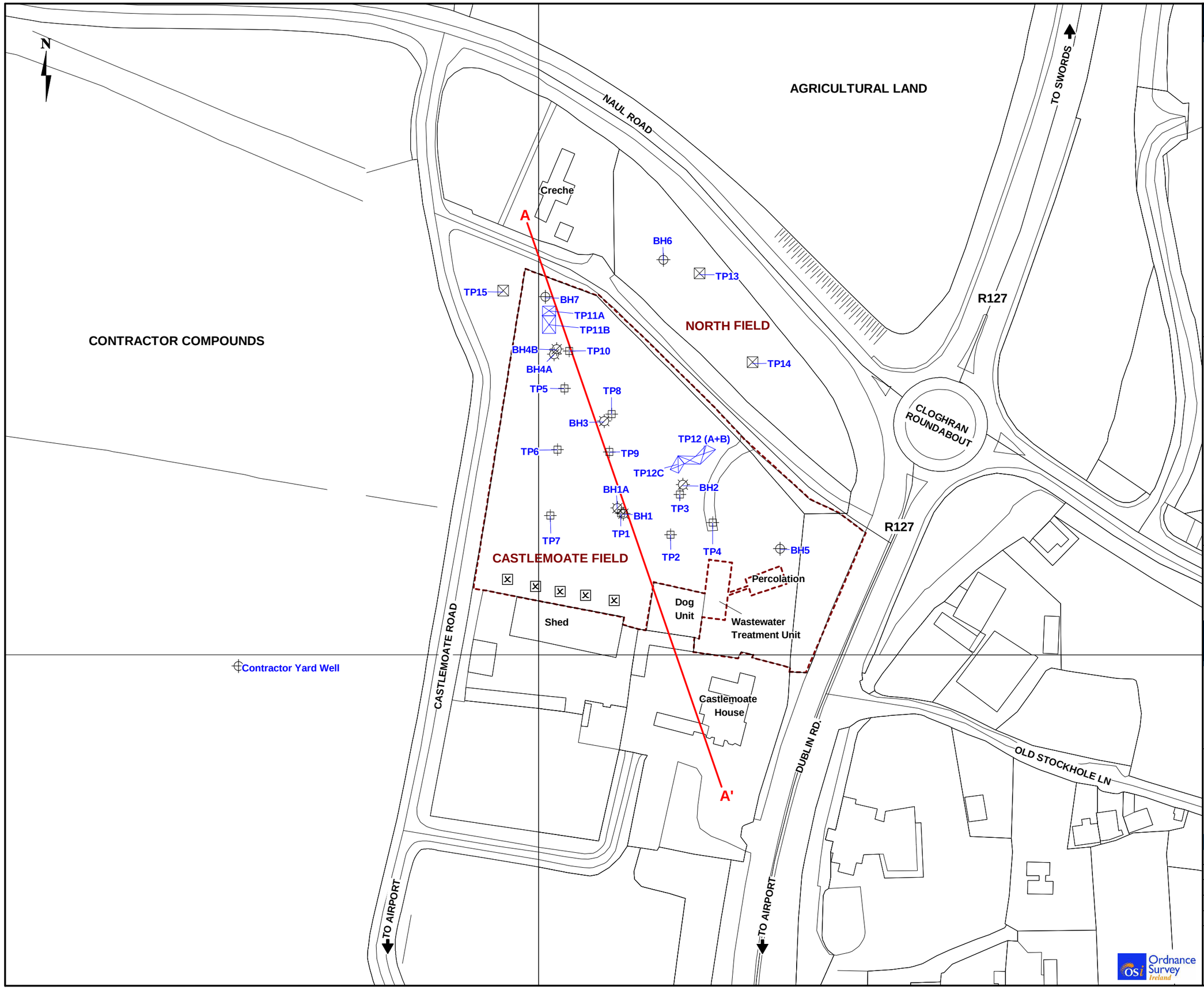
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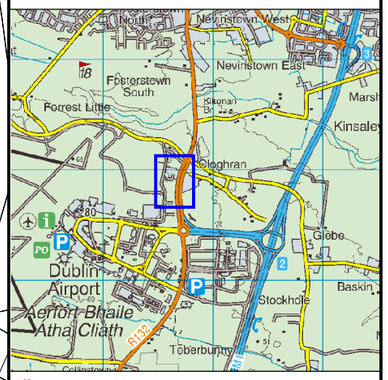
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Legend

- Bedrock Monitoring Well (RPS,2009)
- Shallow Leachate Monitoring Well (RPS,2008)
- Trial Pit (RPS,2009)
- Trial Pit (RPS,2008)
- Trial Pit (DAA,2008)
- Trial Trench
- Castlemoate Field Boundary
- A—A' Section



Client

DUBLIN AIRPORT AUTHORITY plc
ÚDARÁS AERFORT BHAILE ÁTHA CLIATH cpt

Project *Unregulated Landfill Site at Castlemoate House, Dublin Airport*

Title

Site Investigation Locations

Figure 5

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N

NAUL ROAD

Creche

AGRICULTURAL LAND

R127

CONTRACTOR COMPOUNDS

NORTH FIELD

CASTLEMOATE FIELD

CASTLEMOATE ROAD

CLOGHRAN ROUNDABOUT

DUBLIN RD.

OLD STOCKHOLE LN

Shed

Dog Unit

Percolation

Wastewater Treatment Unit

Castlemoate House

BH6

TP13 (0)

TP15 (0)

BH7

TP11A (0)

TP11B (1.8)

BH4B (2.1)

TP10 (2.0+)

BH4A (0)

TP14 (0)

TP5 (1.2+)

TP8 (1.5+)

BH3 (1.1)

TP12 (A+B) (0)

TP6 (1.5+)

TP9 (1.5+)

TP12C (1.7+)

BH2 (1.5)

BH1A (0.5)

TP3 (1.3+)

BH1 (0)

TP1 (2.0+)

TP7 (0.5)

TP2 (2.2)

TP4 (0)

BH5 (0)

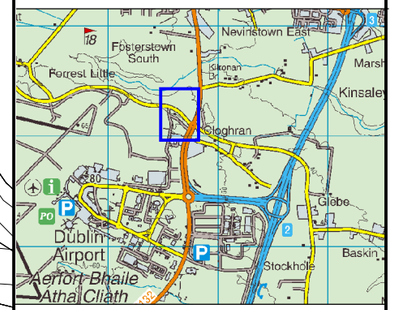
Contractor Yard Well

Legend

- Bedrock Monitoring Well (RPS,2009)
- Shallow Leachate Monitoring Well (RPS,2008)
- Trial Pit (RPS,2009)
- Trial Pit (RPS,2008)
- Trial Pit (DAA,2008)
- Trial Trench

Thickness of Waste (m)

- 0 - 1.0
- 1.0 - 1.5
- > 1.5
- No Waste
- (x) Thickness of Waste (m)
- Castlemoate Field Boundary
- Area of Identified Waste
- Area of Less Certainty



Client

DUBLIN AIRPORT AUTHORITY plc
ÚDARÁS AERFORT BHAILE ÁTHA CLIATH cpt

Project *Unregulated Landfill Site at Castlemoate House, Dublin Airport*

Title

Thickness of Waste

Figure 6

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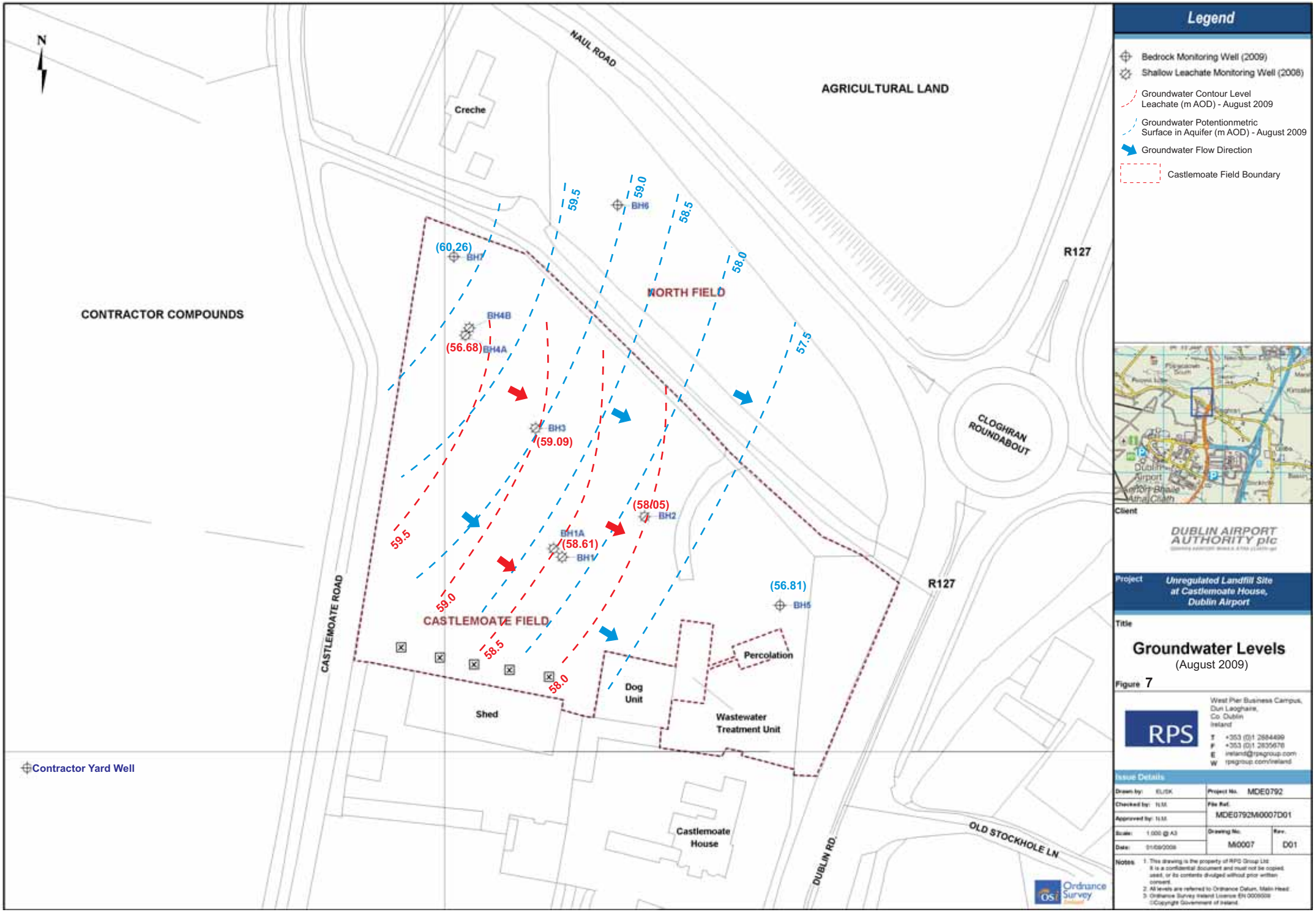
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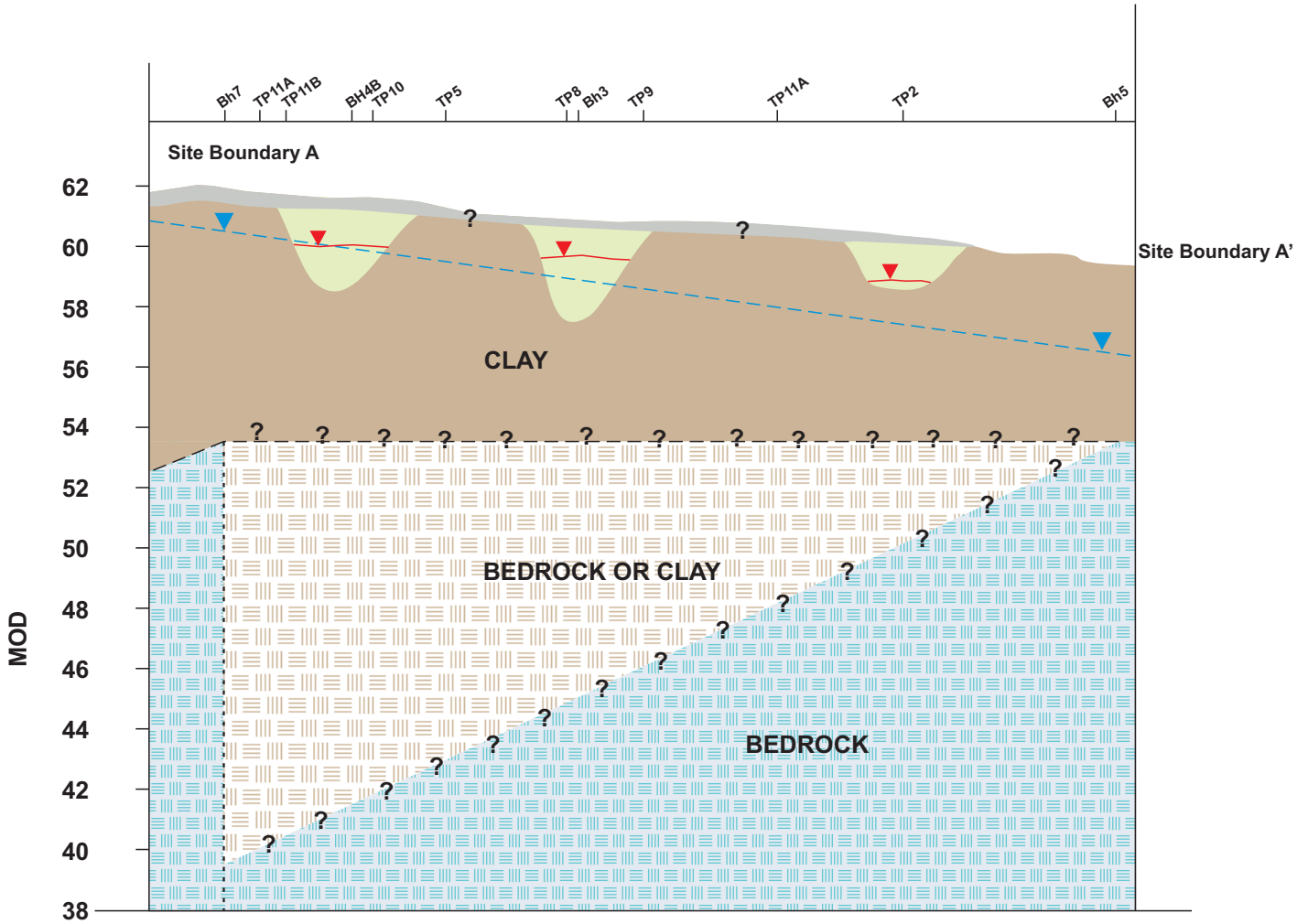
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N
NAUL ROAD
Creche
AGRICULTURAL LAND
R127
CONTRACTOR COMPOUNDS
NORTH FIELD
CASTLEMOATE FIELD
CASTLEMOATE ROAD
CLOGHRAN ROUNDABOUT
R127
OLD STOCKHOLE LN
DUBLIN RD.
Castlemoate House
Shed
Dog Unit
Wastewater Treatment Unit
Percolation
BH6
BH7
BH4B
BH4A
BH3
BH2
BH1A
BH1
BH5
(60.26)
(56.68)
(59.09)
(58/05)
(58.61)
(56.81)
59.5
59.0
58.5
58.0
57.5
Contractor Yard Well
Legend
Bedrock Monitoring Well (2009)
Shallow Leachate Monitoring Well (2008)
Groundwater Contour Level Leachate (m AOD) - August 2009
Groundwater Potentionmetric Surface in Aquifer (m AOD) - August 2009
Groundwater Flow Direction
Castlemoate Field Boundary
Client
DUBLIN AIRPORT AUTHORITY plc
Project
Unregulated Landfill Site at Castlemoate House, Dublin Airport
Title
Groundwater Levels
(August 2009)
Figure 7
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HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:200

NOTE:
Angle of Dip of Bedrock is unknown.

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NOTES

No:	Date:	Chk'd	Amendment / Issue:	App

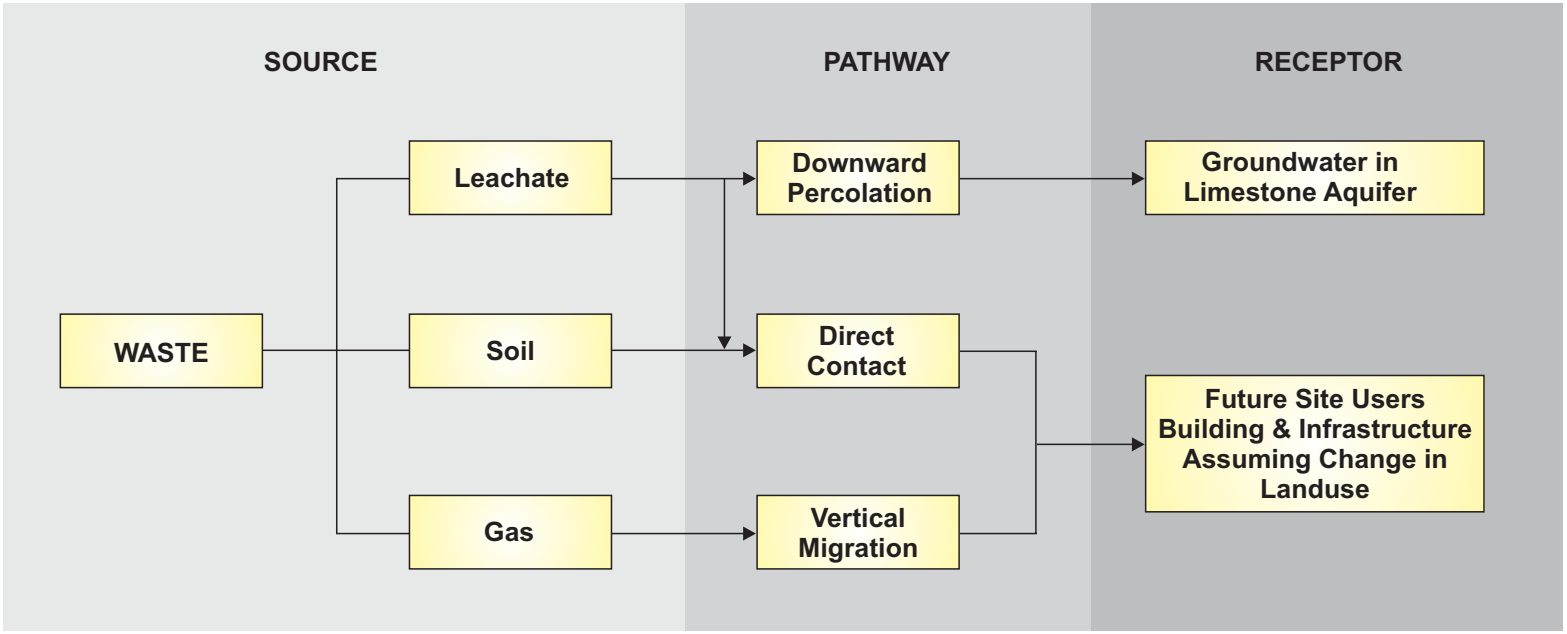
Client: Dublin Airport Authority

Project: Unregulated Landfill Site at Castlemoate House, Dublin Airport

Title: Figure 8: CROSS-SECTION A-A'

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Checked by:	NM	File No:	R/MDE0792/Gr
Approved by:	NM	Drg No:	MDE0792Gr0001
Scale:		Rev:	D01
Date:	01/09/2009		

Figure 9 Conceptual Site Model



N

NAUL ROAD

Creche

BH6

BH6 (µg(l))	
Copper	59.8
Leed	45.3
Nickel	86.1
Zinc	317.0

R127

BH7

NORTH FIELD

BH4A (µg(l))	
Arsenic	18
Chromium	42.2
Copper	142.0
Leed	130.0
Nickel	99.7
Zinc	343
Ammonia	40.5
TPH	364.0
Naphthalene	3.9

BH4B

BH4A

BH2 (µg(l))	
Nickel	23
Ammonia	58.2

CLOGHRAN ROUNDABOUT

CONTRACTOR COMPOUNDS

BH3

BH3 (µg(l))	
Copper	31
Leed	20
Ammonia	110.5
Naphthalene	3.57

BH2

BH1A

BH1

R127

BH5

CASTLEMOATE FIELD

BH1A (µg(l))	
Potassium	29
Sodium	151
Ammonia	187
TPH	25

Percolation

Dog Unit

Shed

Wastewater Treatment Unit

BH5 (µg(l))	
Leed	24
Nickel	21.4
Ammonia	6.1

CASTLEMOATE ROAD

Contractor Yard Well

Castlemoate House

DUBLIN RD.

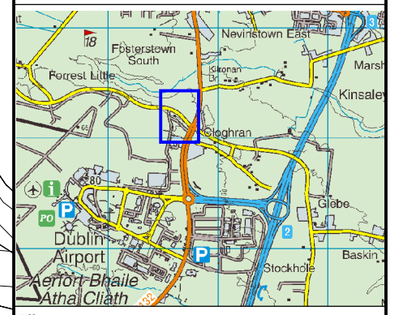
OLD STOCKHOLE LN

Well (µg(l))	
Chromium	41
Copper	44
Leed	43
Nickel	37.6

Ordnance Survey Ireland

Legend

- Bedrock Monitoring Well (RPS,2009)
- Shallow Leachate Monitoring Well (RPS,2008)
- Castlemoate Field Boundary



Client

DUBLIN AIRPORT AUTHORITY plc
ÚDARÁS AERFORT BHAILE ÁTHA CLIATH cpt

Project: *Unregulated Landfill Site at Castlemoate House, Dublin Airport*

Title

Elevated Groundwater Concentrations 2009

Figure **10**

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APPENDIX A

TIER 1 ASSESSMENT

TIER 1 ASSEMENT

Source Assessment	Score Matrix	Score	Max	Notes/Justification
Leachate	1a	7	10	Airline catering waste. Assumed to accupy the whole of Castlemoate field
Gas	1b	7	10	Airline catering waste. Assumed to accupy the whole of Castlemoate field
Leachate Migration Pathway Assessment	**Score Matrix**	**Score**	**Max**	
Vertical Pathway (Aquifer Vulnerability)	2a	3	3	Vulnerability assumed to be extreme based on variability noted in Gibb conceptual model
Horizontal Pathway (Groundwater Flow Regime)	2b	3	5	Aquifer classied as LI although Karst may be present in waulsortian limestones
Surface Water Pathway	2c	0	2	No drainage ditches in direct contact with waste
Gas Migration Pathway Assessment	**Score Matrix**	**Score**	**Max**	
Assuming lateral Migration (Buildings and enclosed spaces within 250 of site)	2d	1	3	Dog unit buildings located adjacent to site, low permeability soils.
Vertical migration (Buildings or enclosed spaces located above source)	2e	0	5	Buildings predate the waste so are not located directly above
Receptor Assessment	**Score Matrix**	**Score**	**Max**	
Residential dwellings with potential for private water supply	3a	1	3	Public house present approaximately 250 m from waste body. Creche located within 100m but all prperties believed to be on mains water. One well located within 1 km of site used for industrial purposes
Protected Areas	3b	0	3	
Aquifer	3c	4	5	Designated as locally important LI but karst may be present within Waulsortian limestones
Public Water Supply	3d	0	7	No public water supply within 1 km but karst may be present within Waulsortian limestones
Surface Water Bodies	3e	1	3	Forrest Little stream within 600m of site
Buildings and enclosed spaces used by humans or livestock	3f	5	5	Dog unit buildings located adjacent to field. Creche within 100m of northern boundary of field.

Tier 1 Environmental Risk Assessment

Site Name: Dublin Airport Castlemoate Field

Site Location: Dublin Airport

Carried out by: L Burden

Checked by: N Mitchell

Linkage No.	Source	Pathway	Receptor	Score Calculation *(Numbers refer to score matrix tables in EPA, 2007)*	Total Score	Maximum possible score	% Score	Risk Classification	Comment
1	***(1a) Leachate***	***(2a,b&c) Groundwater and surface water migration***	***(3e) Surface Water body***	***1a x (2a+2b+2c) x 3e***	42	300	14%	Low	Nearest receptor is 600m distant.
2			***(3b) Protected Area (Surface water dependent terrestrial ecosystem)***	***1a x (2a+2b+2c) x 3b***	0	300	0%	No Linkage	No sensitive receptors
3		***(2a&b) Groundwater Migration***	***(3a) Private well***	***1a x (2a+2b) x 3a***	42	240	18%	Low	Private wells possible but unlikely
4			***(3a) Protected Area (Groundwater dependent terrestrial ecosystem)***	***1a x (2a+2b) x 3b***	0	240	0%	No Linkage	No sensitive receptors
5			***(3c) Aquifer***	***1a x (2a+2b) x 3c***	168	400	42%	Moderate	Possible karst aquifer
6			***(3d) Public Water Supply***	***1a x (2a+2b) x 3d***	0	560	0%	No Linkage	No public water supplies
7			***(3e) Surface Water body***	***1a x (2a+2b) x 3e***	42	240	18%	Low	Low permeability soils
8		***(2c) Surface Water Migration***	***(3e) Surface Water body***	***1a x 2c x 3e***	0	60	0%	No Linkage	No direct connection between waste and water bodies
9			***(3b) Protected Area (Surface water dependent terrestrial ecosystem)***	***1a x 2c x 3b***	0	60	0%	No Linkage	No sensitive receptors
10	***(1b) Landfill Gas***	***(2d) Lateral migration in subsoil***	***(3f) Human Presence (Buildings, enclosed spaces)***	***1b x 2d x 3f***	35	150	23%	Low	Buidlings present adjacent to waste but low permeability subsoils
11		***(2e) Vertical Migration in subsoil***		***1b x 2e x 3f***	0	250	0%	No Linkage	Buidlings not located directly above waste

APPENDIX B

PHOTOGRAPHS



Main Investigation. Waste in Trial Pit 1



Main Investigation. Waste in Trial Pit 9



Main Investigation - Waste in Trial Pit 3



Main Investigation - Waste and fill material from Trial Pit 2



Main Investigation. Borehole BH03



Additional Investigation - Trial Pit 13 Adjacent to crèche



Additional Investigation - TP14 in Northern Field



Additional Investigation - TP15 to east of Castlemoate Field



Additional Investigation - TP11 A&B showing boundary between waste and clean material.



Additional Investigation. TP12 A&B looking south from north-east corner of Castlemoate Field



Additional Investigation - TP12C Boundary between waste and clean material.

APPENDIX C

TRIAL PIT & BOREHOLE LOGS

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP1**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	30-07-08		E 17,635.0 N 44,060.0	
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)		DESCRIPTION		
						(0.50)	0.50	Made Ground. Topsoil. Soft medium brown - orange sandy silt Clay with occassional angular gravel and rootlets.		
						(0.50)	1.00	Made Ground. Grading in a soft firm brown - grey silty Clay with occassional gravel and cobbles		
1.00						(2.00)	3.00	Silty Clay as above mixed with waste loose plastic, airline catering waste - damp. Moderate waste odour. Bags of waste encountered at 1.5m, less clay matrix. Content of waste : Bags of airline catering waste . Bags of credit union slips - dated 1983. Newspapers. Water ingress at base		
3.00										

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Trial pit terminated at 3m which appeared to be the base of the waste.

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP2**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	30-07-08			
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
0.60						(1.20) 1.20	Made Ground. Soft - firm brown grey silty Clay with occassional angular gravel and cobbles. Very occassional pieces of waste mixed through - disturbed ground		
1.60						(0.60) 1.80	Waste in soil matrix and solid waste bags , catering waste possibly agricultural waste, wood chippings / saw dust, fertiliser bags. Water Seepage at 1.2m		
2.25						(1.20) 3.00	Soft med brown - dark grey gravelly Clay. Damp with slight odour.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project	BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.	**TP4**

Job No	Date	Ground Level (m)	Co-Ordinates ()
MDE0792	30-07-08		

Contractor	Sheet
RPS	1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						0.20	Made Ground. Topsoil. Soft dark grey gravelly Clay with rootlets		
						(0.80) 1.00	Made Ground. Soft orange brown silty Clay with frequent gravel. Occassional ceramic pieces, cloth.		
1.00						(1.20) 2.20	Soft to firm orange brown gravelly Clay . Damp.		
2.20						(0.80) 3.00	Firm - dark grey Clay with frequent cobbles. Damp		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No water ingress

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP5**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08			
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA					
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
						(0.50) 0.50	Made Ground. Topsoil. Soft medium brown sandy silty Clay		
						(1.30) 1.80	Made Ground. Soft dark grey silty Clay with freqeunt angular gravel and some cobbles.		
2.00						(1.20) 3.00	Waste in bags - edge only visible		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No water ingress

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP6**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08			
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA					
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
						(1.00) 1.00	Made Ground. Topsoil. Soft medium brown sandy silty Clay.		
						(0.50) 1.50	Made Ground. Soft dark grey silty gravely Clay with occassional cobbles		
1.50						(1.50) 3.00	Waste. Catering waste dated 1984 from peanuts bag. Degraded waste in places. Mixed waste ranging in thickness from 0.5m to the base of the trial pit. Strong waste odour. High volume of water ingress. Walls falling in.		
2.50									

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				TP7
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08		E 17,656.0 N 44,051.0	
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						(0.60) 0.60	Made Ground. Topsoil - Soft medium brown - orange silty Clay with rootlets.		
0.70						(2.40) 3.00	Made Ground. Soft dark brown - grey gravelly clay with frequent angular cobbles. Water ingress ~ 1m. Some waste visible at East side of pit - very small amount. No further waste noted at base of pit. Clay becoming soft-firm dark greyand fiable with thin orange-brown sandy fiable. Possibly remarked with possible wood chips present. Soft - firm clay becoming dark grey with thin orange brown sand.		
2.00									

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP8**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08		E 17,660.0 N 44,068.0	
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						0.20	Made Ground. Topsoil. Soft medium brown - orange silty Clay with rootlets.		
						(2.30)	Made Ground. Soft medium grey gravelly Clay with occassional pieces of brick, ceramics and wood. Damp		
2.50						2.50			
						(0.50)	Some plastic waste visible, very localised. Water ingress, very slight odour.		
						3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Located behind piles of soil adjacent to reservoir pipes.

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP9**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08		E 17,674.0 N 44,056.0	
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						0.20	Made Ground. Topsoil. Soft medium brown silty Clay with occassional gravel.		
						0.50	Made Ground. Soft medium brown silty Clay with occassional gravel. Damp. Pieces of ceramics, plastic mixed through Clay.		
						(2.50)	Soft dark grey gravelly Clay. Waste from 1.5 to base of excavation. Catering waste, side of pit has no waste. Water at base of trench. Very strong odour Water ingress at 1m Water at base of trench.		
2.50						3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

BOREHOLE LOG

Project				BOREHOLE No
Investigation at Unregulated landfill site at Castlemoate House, Dublin Airport.				**TP10**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	31-07-08			
Contractor				Sheet
RPS				1 of 1

SAMPLES & TESTS			Water	STRATA					
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
						0.20	Made Ground. Topsoil. Soft medium orange brown silty Clay with gravel.		
						(0.80)	Made Ground. Soft medium orange brown silty Clay with gravel.		
						1.00			
						(2.00)	Waste at west of pit, bags of airline waste dated 1984, aer rianta bags, paperwork, plastic pipes , small tyre, trays, bottles etc. Waste appears to have been burnt. Strong odour Water ingress at 1m		
2.50						3.00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	

All dimensions in metres Scale 1:50	Client	Method/ Plant Used	Logged By Dominica Baird

AGS3 UK BH TEST.GPJ AGS 3_1.GDT 3/10/08

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Galway
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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				**TP 11(A)**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.15	Grass & TOPSOIL		
					0.50	MADE GROUND - Light brown dry slightly gravelly soft & soft to firm CLAY with occasional pieces of plastic sheeting, copper & plastic piping & timber fragments.		
					(1.70)	Dark brown dry slightly gravelly CLAY		
					2.20			
					(0.60)	Dark grey wet soft to firm gravelly CLAY. Gravel subangular to subrounded. Slight water seepages at 2.6mbgl.		
					2.80	End of Pit		

GENERAL REMARKS

Slight water seepages evident at 2.6mbgl.

Northern half of Trial Trench
Total length of Trench = 11m

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				**TP 11(B)**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.20	Grass & TOPSOIL		
					(1.20)	MADE GROUND - Grey wet soft gravelly CLAY. Slight organic odour. Occasional brick fragments, plastic, steel piping and timber.		
					1.40			
		1			(0.60)	MADE GROUND - Black wet waste material in a slightly clayey matrix. material comprised of wet black plastic, organic material, metal containers, foil cartons & timber & steel fragments. Water ingress at 1.7mbgl. Strong organic odour.		
		1			2.00	End of Pit		

GENERAL REMARKS

Black staining observed on water surface.
Strong organic odour.
water level at 1.7mbgl after 10 mins.

Southern half of Trial Trench
Total length of Trench = 11m

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				**TP 12(A)+(B)**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.15	Grass & TOPSOIL		
					0.50	MADE GROUND - Reworked brown dry slightly gravelly soft & soft to firm CLAY with occasional plastic & timber fragments & copper & plastic piping		
					(1.70)	Brown dry CLAY - occasional gravel fragments		
					2.20			
					(0.60)	Dark grey wet gravelly soft to firm CLAY. Gravel subangular to subrounded		
					2.80	End of Trial Pit		

GENERAL REMARKS

Slight water seepages at 2.6mbgl.
No evidence of contamination.

Northern & central region of Trial Trench
Total lenght of Trench = 20m

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				TP 12(C)
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.30	MADE GROUND - Reworked CLAY & rootlets		
					(1.10) 1.40	MADE GROUND - Grey reworked wet gravelly CLAY. Slight waste odour. Occasional brick fragments, plastic sheeting, steel piping & timber fragments		
					(0.60) 2.00	MADE GROUND - Black wet Airline Catering Waste. Moderate water ingress at 1.7mbgl. Strong waste odour.		
						End of Trial Pit - Unable to excavate further due to water ingress & collapsing pit walls.		

GENERAL REMARKS

Strong waste odour at 1.7mbgl
Moderate water ingress at 1.7mbgl

Southern area of Trench
Total length of Trench = 20m

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				TP 13
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.15	Grass & TOPSOIL		
					(2.35)	Brown dry soft & soft to frim gravelly sandy CLAY. Occasional subangular gravel and small (sandstone limestone) cobbles. Becoming slightly moist at 1.2mbgl. Large cobbles (~0.3m) at 2.0mbgl. Roots from 0.1 to 0.35m. Iron staining evident at 2.2mbgl. Becoming moist at 2.2mbgl. Slight seepages at 2.3mbgl.		
					2.50			
					(0.45)	Grey moist firm to stiff gravelly CLAY - becoming dry from 2.6mbgl.		
					2.95			
						End of Pit - Unable to penetrate further - Large Obstruction		

GENERAL REMARKS

No evidence of waste material or contamination.
Slight water seepages at 2.3mbgl.

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				TP 14
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.15	Grass & TOPSOIL & rootlets		
					(0.65) 0.80	Light brown dry friable very gravelly CLAY with occasional lenses of fine sand. Slightly moist at 0.8mbgl.		
					(1.50) 2.30	Dark brown/grey moist soft gravelly CLAY. Gravel subangular to subrounded. Limestone & occasional schist. Occasional dark grey lenses of wet coarse sand.		
					(0.50) 2.80	Black dry firm gravelly CLAY. Boulder encountered at 2.5mbgl.		
						End of Pit - Unable to penetrate further		

GENERAL REMARKS

No evidence of waste material or contamination.
Slight to moderate water seepages between 1.6 & 2.3mbgl.

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

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TRIAL PITS

Project				TRIAL Pit No
Dublin Airport Site Investigation				TP 15
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Kilwex				1 of 1

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.15	Grass & TOPSOIL		
					(1.35)	Brown dry soft to frim slightly gravelly CLAY. Frequent roots & rootlets.		
					1.50			
					(0.40)	Grey gravelly sandy CLAY. Very moist. Gravel subrounded and loose. Sand coarse. Moderate water seepages at 1.8mbgl.		
		1			1.90			
					(0.90)	Grey SANDS & GRAVEL. Gravel subrounded to rounded. Sand medium to coarse graines. Wet.		
					2.80			
						End of Pit		

GENERAL REMARKS

Moderate water seepages at 1.8mbgl.
Water Level rose to 2.05mbgl after 5mins.
Water Level rose to 1.95mbgl after 15mins.
No evidence of waste material or contamination.

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used JCB	Logged By NM

RPS TRIAL PIT TEST DUBLIN AIRPORT.GPJ AGS 3_1.GDT 7/8/09

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH01

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 3.00m		Dublin Airport Authority	08-0528
	Location	**Dates** 31/07/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(2.50)	MADE GROUND: Firm to stiff grey brown gravelly CLAY with cobbles and occasional shells		
						2.50			
						(0.50)	Firm to stiff brown sandy gravelly CLAY with occasional cobbles		
				31/07/2008:DRY		3.00			
							Complete at 3.00m		

Remarks

Scale (approx)	Logged By
1:25	TC/HH

Figure No. 08-0528.BH01

Glover Site Investigations Ltd

Site Monitor Wells in Dublin Airport, North Dublin			**Borehole Number** BH01A
Boring Method Cable Percussion	**Casing Diameter** 200mm cased to 3.80m	**Ground Level (mOD)**	**Client** Dublin Airport Authority	**Job Number** 08-0528
	Location	**Dates** 31/07/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(2.30)	MADE GROUND: Firm to stiff grey brown gravelly sandy CLAY with occasional cobbles		
				Seepages(1) at 1.70m.					▽1
						2.30			
						(0.50)	MADE GROUND: Firm to stiff grey brown gravelly sandy CLAY with occasional cobbles and with plastic bags etc		
						2.80			
						(1.00)	Stiff dark brown gravelly sandy CLAY with occasional cobbles		
				31/07/2008:		3.80			
							Complete at 3.80m		

Remarks
Water level after pulling casing: 2.10m.
Standpipe installed.

Scale (approx)	Logged By
1:25	TC/HH

Figure No. 08-0528.BH01A

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH02

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 4.10m		Dublin Airport Authority	08-0528
	Location	**Dates** 01/08/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(0.60)	MADE GROUND: Stiff brownish grey gravelly cobbly CLAY		
						0.60			
						(1.00)	MADE GROUND: Stiff brownish grey gravelly cobbly CLAY with plastic bags etc		
						1.60			▽1
				Seepage(1) at 1.60m.		(1.50)	MADE GROUND: Plastic bags, pieces of paper, wood etc in a matrix of stiff brownish grey gravelly cobbly clay		
						3.10			
						(1.00)	Stiff dark brown gravelly sandy CLAY with numerous cobbles		
				01/08/2008:		4.10			
							Complete at 4.10m		

Remarks
Water level after pulling casing: 3.90m.
Standpipe installed.

Scale (approx)	Logged By
1:25	TC/HH

Figure No. 08-0528.BH02

Glover Site Investigations Ltd

Site Monitor Wells in Dublin Airport, North Dublin			**Borehole Number** BH03
Boring Method Cable Percussion	**Casing Diameter** 200mm cased to 3.40m	**Ground Level (mOD)**	**Client** Dublin Airport Authority	**Job Number** 08-0528
	Location	**Dates** 01/08/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(1.80)	MADE GROUND: Firm to stiff grey brown gravelly CLAY with occasional cobbles		
				Seepage(1) at 1.80m.		1.80			▽1
						(1.10)	MADE GROUND: Plastic bags, paper, wood etc in a matrix of grey brown gravelly sandy clay		
						2.90			
						(0.50)	Very stiff dark brown gravelly sandy CLAY with numerous cobbles		
				01/08/2008:3.20m		3.40			
							Complete at 3.40m		

Remarks
Standpipe installed.

Scale (approx)	Logged By
1:25	TC/HH

Figure No. 08-0528.BH03

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH04A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 3.00m		Dublin Airport Authority	08-0528
	Location	**Dates** 01/08/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(3.00)	Firm to stiff dark brown gravelly sandy CLAY with occasional cobbles		
				01/08/2008:DRY		3.00	Complete at 3.00m		

Remarks

Scale (approx)	Logged By
1:25	TC/HH/DC

Figure No. 08-0528.BH04A

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH04B

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 4.00m		Dublin Airport Authority	08-0528
	Location	**Dates** 04/08/2008	**Engineer** RPS Group	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(1.40)	MADE GROUND: Firm brown gravelly sandy CLAY with numerous shells		
				Seepage(1) at 1.40m.		1.40			▽1
						(2.10)	MADE GROUND: Plastic bags, paper, wood etc in a matrix of soft to firm grey brown clay		
						3.50			
						(0.50)	Firm to stiff dark brown gravelly sandy CLAY with cobbles		
				04/08/2008:3.80m		4.00			
							Complete at 4.00m		

Remarks
Standpipe installed.

Scale (approx)	Logged By
1:25	TC/HH/DC

Figure No.
08-0528.BH04B

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH01A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Dublin Airport Authority	08-0528

Location	Ground Level (mOD)	Engineer	Sheet
		RPS Group	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
	∇_1			0.20	Concrete
				2.00	Bentonite Seal
				3.00	Well Screen
				3.80	General Backfill

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		1.70		Seepages					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
31/07/08							3.80			

Instrument Groundwater Observations

Inst. [A] Type :

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

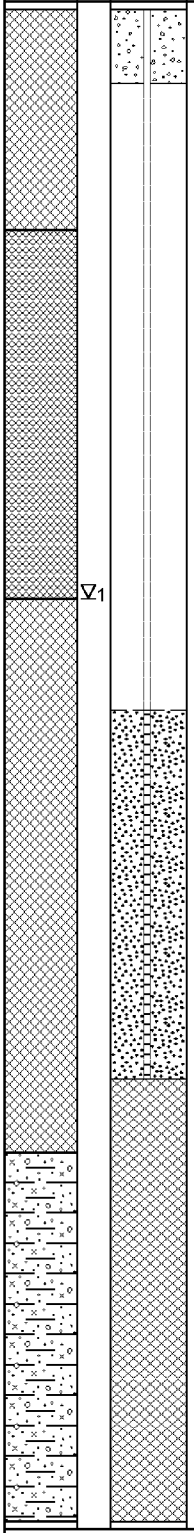
Remarks
Upright cover fitted.

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH02

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Dublin Airport Authority	08-0528

Location	Ground Level (mOD)	Engineer	Sheet
		RPS Group	1/1



Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		1.60		Seepage					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
01/08/08							4.10			

Instrument Groundwater Observations

Inst. [A] Type :

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

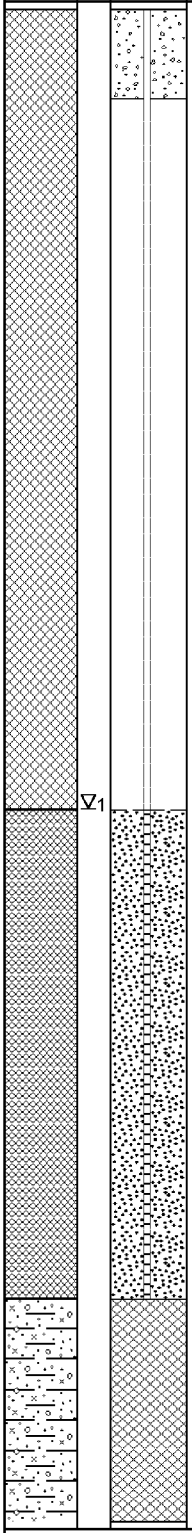
Remarks
Upright cover fitted.

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH03

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Dublin Airport Authority	08-0528

Location	Ground Level (mOD)	Engineer	Sheet
		RPS Group	1/1



Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		1.80		Seepage					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
01/08/08							3.40		3.20	

Instrument Groundwater Observations

Inst. [A] Type :

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

Remarks
Upright cover fitted.

Glover Site Investigations Ltd

Site	Borehole Number
Monitor Wells in Dublin Airport, North Dublin	BH04B

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Dublin Airport Authority	08-0528

Location	Ground Level (mOD)	Engineer	Sheet
		RPS Group	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				0.20	Concrete
					Bentonite Seal
	▽1			1.50	
				3.50	Well Screen
				4.00	General Backfill

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		1.40		Seepage					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
04/08/08							4.00		3.80	

Instrument Groundwater Observations

Inst. [A] Type :

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

Remarks
Upright cover fitted.

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH05
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				1 of 2

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.10	Grass & TOPSOIL		
					(2.90)	Brown dry soft to firm gravelly CLAY. Gravel subangular to subrounded. Moist at 2.0mbgl.		
					3.00			
					(0.50)	Dark brown dry slightly sandy soft to firm CLAY		
					3.50			
					3.80	Dark brown clayey gravelly SAND. Wet. Water strike at 3.5mbgl.		
		1			(1.50)	Brown/grey dry firm slightly gravelly CLAY - becoming firm to stiff with depth. Limestone gravel - increased gravel with depth.		
					5.30			
						Weathered LIMESTONE bedrock. Water strike at 5.3mbgl. Competent limestone at 5.8mbgl.		

GENERAL REMARKS

Water strike at 5.3mbgl.
Rose to 4.5mbgl after 15mins.

Instatllation Details:
Screen: 15.0 - 7.5mbgl
Bentonite: 7.0 - 0.5mbgl
Gravel: 15.0 - 7.0mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH05
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				2 of 2

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					(9.70)	Weathered LIMESTONE bedrock. Water strike at 5.3mbgl. Competent limestone at 5.8mbgl. *(continued)*		
					15.00	End of Borehole		

GENERAL REMARKS

Water strike at 5.3mbgl.
Rose to 4.5mbgl after 15mins.

Instatllation Details:
Screen: 15.0 - 7.5mbgl
Bentonite: 7.0 - 0.5mbgl
Gravel: 15.0 - 7.0mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH06
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				1 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					0.10	Grass & TOPSOIL Dark brown dry soft to firm sandy CLAY		
					(1.40) 1.50			
					(0.70) 2.20	Light brown slightly moist to moist gravelly CLAY - increased gravel with depth. Moist to wet at 2.0mbgl.		
					(2.80) 5.00	Dark brown wet firm to stiff gravelly CLAY. Water strike between 2.1 & 2.3mbgl. Water strike between 3.5 & 3.9mbgl. Dry between 2.3 & 3.5mbgl & between 3.9mbgl & 5.0mbgl.		
					(0.80) 5.80	Grey wet soft slightly gravelly CLAY - increased gravel content with depth.		
						Grey dry soft and soft to firm gravelly clay. Gravel subangular to subrounded.		

GENERAL REMARKS

Water strike between 2.1 & 2.3mbgl.
Waterstrike between 3.5 & 3.9mbgl.

Installation Details:
Screen: 6.0 - 2.0mbgl
Gravel: 6.0 - 1.8mbgl
Bentonite: 10.0 -6.0mbgl
1.8 - 0.5mbgl
Infill: 20.5 - 10.0mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				**BH06**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				2 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					(8.20)	Grey dry soft and soft to firm gravelly clay. Gravel subangular to subrounded. *(continued)*		
					14.00	Grey/brown dry gravelly firm CLAY		

GENERAL REMARKS

Water strike between 2.1 & 2.3mbgl.
Waterstrike between 3.5 & 3.9mbgl.

Installation Details:
Screen: 6.0 - 2.0mbgl
Gravel: 6.0 - 1.8mbgl
Bentonite: 10.0 -6.0mbgl
1.8 - 0.5mbgl
Infill: 20.5 - 10.0mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH06
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				3 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					(6.50)	Grey/brown dry gravelly firm CLAY *(continued)*		
					20.50	End of Borehole		

GENERAL REMARKS

Water strike between 2.1 & 2.3mbgl.
Waterstrike between 3.5 & 3.9mbgl.

Installation Details:
Screen: 6.0 - 2.0mbgl
Gravel: 6.0 - 1.8mbgl
Bentonite: 10.0 -6.0mbgl
1.8 - 0.5mbgl
Infill: 20.5 - 10.0mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				**BH07**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				1 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					(1.00) 1.00	Grass & light brown dry soft gravelly CLAY		
					(1.30) 2.30	Dark brown dry soft to firm gravelly CLAY. Gravel subrounded.		
		2			(5.70)	Dark brown dry firm to stiff gravelly CLAY. Gravel limestone fragments.		
		1			8.00			

GENERAL REMARKS

Water Level at 7.4mbgl after 30mins following completion. Water Level at 5.16mbgl after 45mins following completion.

Instatllation Details:
Screen: 15.0 - 9.0mbgl
Bentonite: 8.5 - 0.5mbgl
16.0 - 15.0mbgl
Gravel: 15.0 - 8.5mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH07
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				2 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
					(0.50) 8.50	Weathered light grey LIMESTONE bedrock. Wet. Waterstike at 8.0mbgl.		
					(7.50) 16.00	Competent LIMESTONE bedrock. Wet.		

GENERAL REMARKS

Water Level at 7.4mbgl after 30mins following completion. Water Level at 5.16mbgl after 45mins following completion.

Instatllation Details:
Screen: 15.0 - 9.0mbgl
Bentonite: 8.5 - 0.5mbgl
16.0 - 15.0mbgl
Gravel: 15.0 - 8.5mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

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BORE HOLE

Project				Bore Hole No
Dublin Airport Site Investigation				BH07
Job No	Date	Ground Level (m)	Co-Ordinates ()	
MDE0792	01-07-09 01-07-09			
Contractor				Sheet
Glover Site Investigation Ltd. (IGSL)				3 of 3

SAMPLES & TESTS			STRATA					
Depth	Type No	Sample Name	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
						End of Borehole		

GENERAL REMARKS

Water Level at 7.4mbgl after 30mins following completion. Water Level at 5.16mbgl after 45mins following completion.

Instatllation Details:
Screen: 15.0 - 9.0mbgl
Bentonite: 8.5 - 0.5mbgl
16.0 - 15.0mbgl
Gravel: 15.0 - 8.5mbgl

All dimensions in metres Scale 1:50	Client DAA	Method/ Plant Used Comacchio Symmetrix Rotary Rig - Geo 205	Logged By NM

RPS BH EF DUBLIN AIRPORT.GPJ AGS 3_1.GDT 27/7/09

APPENDIX D

SOIL RESULTS & WAC RESULTS

2008 Soil Results

STL Sample #						10702661	10702662	10702663	10702664	10702665	10702666	10702667	10702668	10702669	10702670	10702671	10702672	10702673	10702674	10705104
Sample Date						30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	01/08/2008
Matrix						Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample ID		**Guideline**	**Guideline**	**Guideline**		**TP1 1.00m**	**TP1 3.00m**	**TP2 0.50m**	**TP2 1.60m**	**TP2 2.00m - 2.50m**	**TP3 1.50m**	**TP3 2.60m**	**TP5 2.00m**	**TP6 1.00m - 1.50m**	**TP6 2.50m**	**TP7 0.70m**	**TP8 2.50m - 3.00m**	**TP9 2.00m - 2.50m**	**TP10 2.50m - 3.00m**	**BH3 @ 3.00m**
Analyte	**Units**	**UK Commercial**	**UK Residential**	**Dutch SRC**	**LOD**															
Metals																				
Arsenic as As, dry weight	mg/kg	640	32	85	1.0	13	9.7	16	N/S	11	12	16	9.5	11	11	14	11	12	12	6.9
Boron as B, hot water sol dw	mg/kg	192000	291		0.25	0.65	0.41	1.3	N/S	0.3	1.5	0.65	0.47	0.86	0.4	2.1	0.42	0.99	0.68	0.49
Cadmium as Cd, dry weight	mg/kg	230	10	13	0.50	2.2	2.2	2	N/S	1.8	2	1.9	1.7	2.2	1.5	2.3	1.5	1.8	2	1.2
Hexavalent Chromium, as dry we	mg/kg			78	0.10	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium as Cr, dry weight	mg/kg	30400	3000	380	5.0	16	13	21	N/S	12	20	17	12	17	13	16	13	15	16	83
Copper as Cu, dry weight	mg/kg	71700	2330	96	5.0	31	25	33	N/S	30	42	23	28	28	26	34	28	28	30	27
Lead as Pb, dry weight	mg/kg	450	750	580	10.0	34	21	67	N/S	27	84	29	22	36	22	160	24	31	37	100
Mercury as Hg, dry weight	mg/kg	26	1	36	0.25	<0.25	<0.25	<0.25	N/S	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.42
Nickel as Ni, dry weight	mg/kg	1800	130	100	5.0	44	37	38	N/S	39	40	43	39	41	37	38	39	36	44	73
Selenium as Se, dry weight	mg/kg	1300	350		0.30	1.6	3.3	1.2	N/S	3.3	1	0.74	3.8	0.99	3.1	0.91	4.4	3.7	1.2	0.63
Zinc as Zn, dry weight	mg/kg	665000	3750	350	10	65	54	120	N/S	55	92	61	62	70	47	70	51	65	68	94
Inorganics and physical parameters																				
Moisture Content Ratio at 105C	% ratio				0.10	43.57	N/S	N/S	0.48	N/S	N/S	0.47	N/S	N/S	10.98	N/S	N/S	0.88	N/S	
Cyanide, Free	mg/kg				5.0	<5.0	<5.0	<5.0	N/S	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cyanide, Total	mg/kg				2.5	<2.5	<2.5	<2.5	N/S	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	2.5	<2.5
Moisture at 105c	%				0.10	30	N/S	N/S	0.47	N/S	N/S	0.47	N/S	N/S	9.9	N/S	N/S	0.87	N/S	
Monohydric Phenols, Total Dist	mg/kg	3200	420	14	0.75	0.82	<0.75	<0.75	N/S	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75	<0.75
Sulphate, Total as SO4 dry wei	mg/kg				240	<240	<240	250	N/S	<240	360	<240	320	<240	<240	280	<240	<240	<240	250
Sulphide	mg/kg				7.5	<7.5	<7.5	<7.5	N/S	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5
Sulphur as SO4, Total	%				0.01	0.13	1.4	0.21	N/S	0.14	0.098	0.11	1.7	0.14	1.6	0.14	0.8	0.19	0.18	1.5
Thiocyanate as CN, dry weight	mg/kg			620	0.20	<0.20	<0.20	<0.20	N/S	<0.20	0.36	0.32	<0.20	0.22	<0.20	<0.20	<0.20	0.27	0.4	<0.20
Toluene Extractable Matter	mg/kg				400	740	490	460	N/S	<400	590	760	<400	<400	<400	460	<400	650	710	<400
Organic Carbon, Total by Ignit	%				0.1	1.3	N/S	N/S	1.9	N/S	N/S	1.1	N/S	N/S	2.1	N/S	N/S	2	N/S	
pH	pH units				2.0	8.6	8.8	8.4	N/S	8.9	8.4	8.7	8.7	8.4	8.7	8.3	8.7	8.6	8.2	8.9
PCBs																				
PCB 28	ug/kg			0.69	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 52	ug/kg			0.28	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 101	ug/kg			0.61	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 118	ug/kg			1.9	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 138	ug/kg			0.32	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 153	ug/kg			0.46	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB 180	ug/kg			0.17	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB, Total of 7 Congeners	mg/kg				0.10	<0.010	N/S	N/S	<0.010	N/S	N/S	<0.010	N/S	N/S	<0.010	N/S	N/S	<0.010	N/S	

2008 Soil Results

STL Sample #						10702661	10702662	10702663	10702664	10702665	10702666	10702667	10702668	10702669	10702670	10702671	10702672	10702673	10702674	10705104
Sample Date						30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	30/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	01/08/2008
Matrix						Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample ID		**Guideline**	**Guideline**	**Guideline**		**TP1 1.00m**	**TP1 3.00m**	**TP2 0.50m**	**TP2 1.60m**	**TP2 2.00m - 2.50m**	**TP3 1.50m**	**TP3 2.60m**	**TP5 2.00m**	**TP6 1.00m - 1.50m**	**TP6 2.50m**	**TP7 0.70m**	**TP8 2.50m - 3.00m**	**TP9 2.00m - 2.50m**	**TP10 2.50m - 3.00m**	**BH3 @ 3.00m**
Analyte	**Units**	**UK Commercial**	**UK Residential**	**Dutch SRC**	**LOD**															
Petroleum Hydrocarbons																				
VPH >C5 - C6, aliphatic	mg/kg	6200	55	40	0.1	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
VPH >C6 - C8, aliphatic	mg/kg	18000	160	128	0.1	<0.10	1.3	<0.10	N/S	<0.10	<0.10	<0.10	1.4	<0.10	<0.10	<0.10	1.2	<0.10	<0.10	<0.10
VPH >C8 - C10, aliphatic	mg/kg	5100	46	33	0.1	<0.10	0.18	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	<0.10
EPH >C10 - C12, aliphatic	mg/kg	24000	230	180	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	2.7	<1.0	<1.0	<1.0	<1.0	3.5	<1.0	2
EPH >C12 - C16, aliphatic	mg/kg	83000	1700	56800	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	4.2	<1.0	8.2	<1.0	<1.0	6.1	<1.0	2.9
EPH >C16 - C35, aliphatic	mg/kg	1800000	64000		1.0	<1.0	<1.0	14	N/S	<1.0	<1.0	<1.0	4	<1.0	37	6.2	<1.0	17	<1.0	3.2
EPH >C35 - C44, aliphatic	mg/kg	1800000	64000		1.0	<1.0	<1.0	7.3	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	6.8	<1.0	<1.0	<1.0	<1.0	<1.0
EPH >C5 - C44, Total aliphatic	mg/kg				5.0	<5.0	<5.0	21	N/S	<5.0	<5.0	<5.0	12	<5.0	52	6.2	<5.0	26	<5.0	8.1
VPH >C5 - C6, aromatic	mg/kg	49000	130	33	0.01	<0.010	<0.010	<0.010	N/S	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
VPH >C7 - C8, aromatic	mg/kg	110000	270	73	0.01	0.35	0.02	<0.010	N/S	<0.010	<0.010	<0.010	<0.010	<0.010	0.018	<0.010	<0.010	0.013	0.016	0.02
VPH >C8 - C10, aromatic	mg/kg	8600	65	141	0.1	0.11	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	<0.10
EPH >C10 - C12, aromatic	mg/kg	29000	160	366	1	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
EPH >C12 - C16, aromatic	mg/kg	37000	310	8000	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	11	<1.0	<1.0	<1.0	<1.0	<1.0
EPH >C16 - C21, aromatic	mg/kg	28000	480	17700	1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	17	<1.0	<1.0	<1.0	<1.0	<1.0
EPH >C21 - C35, aromatic	mg/kg	28000	1100	19200	1.0	<1.0	<1.0	29	N/S	<1.0	<1.0	<1.0	<1.0	15	32	23	<1.0	<1.0	<1.0	<1.0
EPH >C35 - C44, aromatic	mg/kg	28000	1100		1.0	<1.0	<1.0	24	N/S	<1.0	<1.0	<1.0	<1.0	<1.0	13	<1.0	<1.0	<1.0	<1.0	<1.0
EPH >C5 - C44, Total aromatic	mg/kg				5.0	<5.0	<5.0	52	N/S	<5.0	<5.0	<5.0	<5.0	15	73	23	<5.0	<5.0	<5.0	<5.0
EPH >C5 - C44, Total	mg/kg				5.0	<5.0	<5.0	73	N/S	<5.0	<5.0	<5.0	12	15	130	29	<5.0	26	<5.0	8.1
BTEX, Total	mg/kg	95			0.10	0.11	N/S	N/S	<0.10	N/S	N/S	<0.10	N/S	N/S	<0.10	N/S	N/S	<0.10	N/S	
Mineral Oils, >C10 - C40	mg/kg				50	<50	N/S	N/S	86	N/S	N/S	<50	N/S	N/S	<50	N/S	N/S	<50	N/S	
PAH																				
naphthalene	mg/kg	480	3.7	17	0.1	<0.10	<0.10	0.11	N/S	0.11	0.19	<0.10	<0.10	<0.10	<0.10	<0.10	0.1	0.1	<0.10	<0.10
acenaphthylene	mg/kg	98000	400		0.1	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
acenaphthene	mg/kg	97000	480		0.1	<0.10	<0.10	<0.10	N/S	<0.10	0.13	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
fluorene	mg/kg	69000	380		0.1	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
phenanthrene	mg/kg	22000	200	31	0.1	<0.10	0.14	0.24	N/S	0.19	0.62	<0.10	0.14	<0.10	0.14	0.1	0.13	0.11	<0.10	0.14
anthracene	mg/kg	540000	49000	1.6	0.1	<0.10	<0.10	<0.10	N/S	<0.10	0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
fluoranthene	mg/kg	23000	460	260	0.1	0.13	<0.10	0.38	N/S	0.18	0.5	<0.10	<0.10	<0.10	<0.10	0.12	<0.10	<0.10	<0.10	<0.10
pyrene	mg/kg	54000	1000		0.1	<0.10	<0.10	0.31	N/S	0.14	0.5	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
benzo(a)anthracene	mg/kg	95	4.7	2.5	0.1	<0.10	<0.10	0.16	N/S	<0.10	0.22	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
chrysene	mg/kg	140	8	35	0.1	<0.10	<0.10	0.15	N/S	<0.10	0.2	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
benzo(b)fluoranthene	mg/kg	100	6.5		0.1	<0.10	<0.10	0.15	N/S	<0.10	0.15	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
benzo(k)fluoranthene	mg/kg	140	9.6		0.1	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
benzo(a)pyrene	mg/kg	14	0.94	7	0.1	<0.10	<0.10	0.19	N/S	<0.10	0.18	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dibenz(a,h)anthracene	mg/kg	13	0.86		0.1	<0.10	<0.10	<0.10	N/S	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Benzo(g,h,i)perylene	mg/kg	660	46	33	0.1	<0.10	<0.10	0.15	N/S	<0.10	0.16	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Indeno(1,2,3-c,d)pyrene	mg/kg	61	3.9	1.9	0.1	<0.10	<0.10	0.13	N/S	<0.10	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PAH, Total of 16 EPA	mg/kg				1.0	<1.0	<1.0	2	N/S	<1.0	3.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PAH, Total of 17 WAC	mg/kg				1.0	<1.0	N/S	N/S	<1.0	N/S	N/S	<1.0	N/S	N/S	<1.0	N/S	N/S	<1.0	N/S	

Red = Soil guideline Value published by Defra and EA
Blue = Former SGV published by Defra and EA
Black = GAC derived by LQM/CIEH using CLEA methodology

WAC Eluate Results

Sample Number	**Criteria**	10702661	10702664	10702667	10702670	10702673
Job Number	**Inert Waste**	535889	535889	535889	535889	535889
Sample ID		TP1 1.00m	TP2 1.60m	TP3 2.60m	TP6 2.50m	TP9 2.00m -
Date Sampled		30/07/2008	30/07/2008	30/07/2008	31/07/2008	31/07/2008
PARAMETERS		**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/Kg**	**mg/Kg**
Arsenic as As	0.5	<0.050	<0.050	<0.050	<0.050	<0.050
Barium as Ba	20	0.75	0.55	0.45	1.4	0.47
Cadmium as Cd	0.04	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chromium as Cr	0.5	<0.025	<0.025	<0.025	<0.025	<0.025
Copper as Cu	2	<0.10	<0.10	<0.10	<0.10	0.20
Mercury as Hg	0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum as Mo	0.5	0.81	0.18	0.33	0.43	0.36
Nickel as Ni	0.4	<0.20	<0.20	<0.20	<0.20	<0.20
Lead as Pb	0.5	<0.10	<0.10	1.5	<0.10	<0.10
Antimony as Sb	0.06	0.17	<0.060	<0.060	<0.060	<0.060
Selenium as Se	0.1	<0.10	<0.10	<0.10	0.50	<0.10
Zinc as Zn	4	<0.25	<0.25	<0.25	<0.25	<0.25
Chloride as Cl	800	110	210	60	57	<20
Fluoride as F	10	5.0	2.5	3.9	3.6	3.0
Sulphate as SO_4	1000					
Total Dissolved Solids (TDS)	4000	<2000	<2000	<2000	<2000	<2000
Phenol Index	1	<0.50	<0.50	<0.50	<0.50	<0.50
Dissolved Organic Carbon (DOC)	500	83	63	49	15	60

APPENDIX E

GROUNDWATER RESULTS

2008 Groundwater Results

					Waste Boreholes (Sept 2008)				Waste Boreholes (Dec 2008)			
STL Laboratory Number					10726658	10726659	10726660	10726661	10966250	10966251	10966252	10966253
Customer Sample Ref.					**BH1**	**BH2**	**BH3**	**BH4**	**BH1**	**BH2**	**BH3**	**BH4**
Sample Matrix					Water	Water	Water	Water	Water	Water	Water	Water
Sample Date		**Guideline**	**Dutch**	**Dutch**	13/08/2008	13/08/2008	13/08/2008	13/08/2008	17/12/2008	17/12/2008	17/12/2008	17/12/2008
Analyte	**Units**	**IGV**	**SRC**	**Intervention Value**								
METALS												
Arsenic, Soluble	ug/l	10	33	60	<50	<50	<50	<50	**67**	3.5	3.8	4.6
Boron, Soluble	ug/l	1000			91	110	110	120	130	59	75	52
Cadmium, Soluble	ug/l	5	10	6	<2	<2	<2	<2	0.45	0.28	0.2	0.35
Chromium, Soluble	ug/l	30	166	30	<1	<1	<1	<1	**41**	**37**	**45**	**39**
Copper, Soluble	ug/l	30	19	75	-	-	-	-	**32**	<7	<7	<7
Lead, Soluble	ug/l	10	17	75	<50	<50	<50	<50	4.3	<0.5	<0.5	<0.5
Mercury, Soluble	ug/l	1	0.37	0.3	<4	<4	<4	<4	<0.3	0.67	<0.3	<0.3
Nickel, Soluble	ug/l	20	500	75	22	26	26	26	15	**29**	17	**32**
Sulphurous Compounds, Total	mg/l				6.4	2.7	2.1	7.4				
Selenium, Soluble	ug/l				<6	<6	<6	<6	N/S	6.5	5.3	6.9
Zinc, Soluble	ug/l	100	91	800	<1	14	14	14	10	18	9.4	25
INORGANICS												
Sulphate as SO4, Filtered	mg/l	200							I/S	44.2	52.4	24.3
Hexavalent Chromium	mg/l				<0.002	<0.002	<0.002	<0.002	<0.010	<0.010	<0.010	<0.010
Cyanide, Total	mg/l	0.01			<0.05	<0.05	<0.05	<0.05	<0.050	<0.050	<0.050	<0.050
Mono. Phenols,Total Dist.	mg/l	0.0005			-	-	-	-	0.12	0.2	0.18	<0.050
Thiocyanate as CN	mg/l		0.375	1.5	-	-	-	-	<0.050	<0.050	<0.050	<0.050
Toluene Extractable Matter	mg/l				-	-	-	-	I/S	<1.0	<1.0	<1.0
Ammonia as N	mg/l	0.15			-	-	-	-	130	51	99	31
Sulphate as S)3	g/l				<0.02	<0.02	<0.02	<0.02	-	-	-	-
Sulphide as S	mg/l				<0.01	7.1	7.1	7.1	I/S	0.034	<0.010	I/S
pH	pH units	6.5-9.5			7.1	7.1	7.2	6.8	6.8	6.8	6.7	6.9
PETROLEUM HYDROCARBONS*												
TPH >C6 - C10	ug/l	10			<100	<100	<100	<100	I/S	<10	<10	**170**
TPH >C10 - C20	ug/l	10			<100	170	580	720	I/S	<10	**740**	**780**
TPH >C20 - C40	ug/l	10			<100	420	840	770	I/S	<10	**1100**	**780**
TPH >C6 - C40, Total	ug/l	10			<100	590	1400	1500	I/S	<10	**1800**	**1700**
POLYCHLORINATED BIPHENYLS												
PCB 28	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 52	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 101	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 118	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 153	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 138	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB 180	ug/l				-	-	-	-	I/S	<0.10	<0.10	<0.10
PCB, Total as Aroclors	ug/l				<1	<1	<1	<1	-	-	-	-
Phenols, Total	ug/l				<0.5	520	590	110	-	-	-	-
POLYCYCLIC AROMATIC HYDROCARBONS												
naphthalene	ug/l	1	290		<2	<2	<2	2.8	0.038	0.094	**6.9**	**3.8**
acenaphthene	ug/l		2570		<2	<2	<2	<2	0.033	0.7	2.1	0.012
acenaphthylene	ug/l				<2	<2	<2	<2	<0.010	<0.010	**0.057**	**0.73**
fluorene	ug/l				<2	<2	<2	<2	**0.017**	**0.17**	**1.1**	**0.53**
phenanthrene	ug/l		30		<2	<2	<2	<2	<0.010	0.29	0.67	0.26
anthracene	ug/l	10,000	1.4		<2	<2	<2	<2	0.022	0.031	0.18	0.13
fluoranthene	ug/l	1	30		<2	<2	<2	<2	<0.010	0.29	0.11	0.15
pyrene	ug/l		11		<2	<2	<2	<2	<0.010	0.21	0.076	0.32
benzo(a)anthracene	ug/l		1		<2	<2	<2	<2	<0.010	0.083	0.34	0.32
chrysene	ug/l		1.2		<2	<2	<2	<2	<0.010	0.16	0.57	0.4
benzo(b)fluoranthene	ug/l	0.5	17		<2	<2	<2	<2	<0.010	0.094	0.013	0.021
benzo(k)fluoranthene	ug/l	0.05	0.36		<2	<2	<2	<2	<0.010	**0.059**	0.01	0.015
benzo(a)pyrene	ug/l	0.01	0.72		<2	<2	<2	<2	<0.010	**0.092**	**0.026**	**0.03**
Dibenz(a,h)anthracene	ug/l		0.71		<2	<2	<2	<2	<0.010	0.021	<0.010	**0.014**
Benzo(g,h,i)perylene	ug/l		0.05		<2	<2	<2	<2	<0.010	**0.075**	**0.025**	**0.031**
Indeno(1,2,3-c,d)pyrene	ug/l	0.05	0.04		<2	<2	<2	<2	<0.010	**0.17**	0.023	0.021
PAH, Total	ug/l				<20	<20	<20	<20	0.13	**2.539**	**12.2051**	**6.784**
VOLATILE ORGANIC COMPOUNDS												
vinyl chloride	ug/l				-	-	-	-	<10	<10	<10	<10
1,1-dichloroethene	ug/l				-	-	-	-	<10	<10	<10	<10
dichloromethane	ug/l	10			-	-	-	-	<10	<10	<10	<10
trans-1,2-dichloroethene	ug/l				-	-	-	-	<10	<10	<10	<10
1,1-dichloroethane	ug/l				-	-	-	-	<10	<10	<10	<10
2,2-dichloropropane	ug/l				-	-	-	-	<10	<10	<10	<10
cis-1,2-dichloroethene	ug/l				-	-	-	-	<10	<10	<10	<10
bromochloromethane	ug/l				-	-	-	-	<10	<10	<10	<10
chloroform	ug/l	12			-	-	-	-	<10	<10	<10	<10
1,1,1-trichloroethane	ug/l	500			-	-	-	-	<10	<10	<10	<10
carbon tetrachloride	ug/l				-	-	-	-	<10	<10	<10	<10
1,1-dichloropropene	ug/l				-	-	-	-	<10	<10	<10	<10
benzene	ug/l	1	110		-	-	-	-	<10	<10	<10	<10
1,2-dichloroethane	ug/l	3			-	-	-	-	<10	<10	<10	<10
Trichloroethene	ug/l	70			-	-	-	-	<10	<10	<10	<10
1,2-dichloropropane	ug/l				-	-	-	-	<10	<10	<10	<10
dibromomethane	ug/l				-	-	-	-	<10	<10	<10	<10
bromodichloromethane	ug/l				-	-	-	-	<10	<10	<10	<10
trans-1,3-dichloropropene	ug/l				-	-	-	-	<10	<10	<10	<10
toluene	ug/l	10	5070		-	-	-	-	<10	**21**	<10	**17**
cis-1,3-dichloropropene	ug/l				-	-	-	-	<10	<10	<10	<10
1,1,2-trichloroethane	ug/l				-	-	-	-	<10	<10	<10	<10
Tetrachloroethene	ug/l				-	-	-	-	<10	<10	<10	<10
1,3-dichloropropane	ug/l				-	-	-	-	<10	**11**	<10	<10
dibromochloromethane	ug/l				-	-	-	-	<10	<10	<10	<10
1,2-dibromoethane	ug/l				-	-	-	-	<10	<10	<10	<10
chlorobenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,1,1,2-tetrachloroethane	ug/l				-	-	-	-	<10	<10	<10	<10
ethylbenzene	ug/l	10	3329		-	-	-	-	**10**	<10	**21**	**13**
m&p-Xylene	ug/l				-	-	-	-	<20	<20	<20	<20
o-xylene	ug/l		1000		-	-	-	-	<10	<10	<10	<10
styrene	ug/l				-	-	-	-	<10	<10	<10	<10
bromoform	ug/l				-	-	-	-	<10	<10	<10	<10
iso-Propylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
bromobenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,2,3-trichloropropane	ug/l				-	-	-	-	<10	<10	<10	<10
1,1,2,2-tetrachloroethane	ug/l				-	-	-	-	<10	<10	<10	<10
n-propylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
2-chlorotoluene	ug/l				-	-	-	-	<10	<10	<10	<10
4-chlorotoluene	ug/l				-	-	-	-	<10	<10	<10	<10
1,3,5-trimethylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
tert-butylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,2,4-trimethylbenzene	ug/l				-	-	-	-	<10	<10	<10	**23**
sec-butylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,3-dichlorobenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,4-dichlorobenzene	ug/l				-	-	-	-	<10	<10	<10	<10
p-isopropyltoluene	ug/l				-	-	-	-	<10	<10	<10	<10
1,2-dichlorobenzene	ug/l	10			-	-	-	-	<10	<10	<10	<10
n-butylbenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,2-Dibromo-3-chloropropane	ug/l				-	-	-	-	<10	<10	<10	<10
1,3,5-trichlorobenzene	ug/l				-	-	-	-	<10	<10	<10	<10
1,2,4-trichlorobenzene	ug/l	40			-	-	-	-	<10	<10	<10	<10
hexachlorobutadiene	ug/l	0.1			-	-	-	-	<10	<10	<10	<10
1,2,3-trichlorobenzene	ug/l				-	-	-	-	<10	<10	<10	<10

* Petroleum hydrocarbons have been compared to the UK drinking water standards for emulsified hydrocarbons

**Values below detection limit have been assumed to be 1/2 the detection limit when calculating sum of PCBs

Concentrations exceed Guideline Value

Concentrations exceed detection limit where no guidelines are available

2009 Groundwater Results

					Waste Boreholes				Bedrock Boreholes			
STL Laboratory Number					**11299026**	**11299027**	**11299028**	**11299029**	**11299030**	**11299031**	**11299032**	**11299033**
Customer Sample Ref.					**BH1A**	**BH2**	**BH3**	**BH4A**	**BH5**	**BH6**	**BH7**	**PW1**
Sample Matrix					**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**	**Water**
Sample Date	**20/07/2009**	**Guideline**	**Dutch**	**Dutch**								
Analyte	**Units**	**IGV**	**SRC**	**Intervention Value**								
METALS												
Arsenic, Total as As	ug/l	10	33	60	<1	<1	7	**18**	5	9	3	<1
Boron , Total as B	ug/l	1000			<300	<300	<300	99.3	<300	6.2	<300	580
Cadmium , Total as Cd	ug/l	5	10	6	<0.3	<0.3	0.7	64.8	<0.3	5.1	<0.3	4.2
Chromium - Hexavalent	mg/l				<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Chromium , Total as Cr	ug/l	30	166	30	<1	<1	7	**42.2**	4	25.6	3	**41**
Copper , Total as Cu	ug/l	30	19	75	4	7	**31**	**142**	15	**59.8**	4	**44**
Lead , Total as Pb	ug/l	10	17	75	4	5	**20**	**130**	**24**	**45.3**	5	**43**
Mercury, Total as Hg	ug/l	1	0.37	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Nickel , Total as Ni	ug/l	20	500	75	18.5	**23**	16.6	**99.7**	**21.4**	**86.1**	4	**37.6**
Potassium , Total as K	mg/l	12			**29**	8.52	12	9.77	3.96	4.67	4.19	2.36
Selenium, Total as Se	ug/l				<1	<1	1	9	<1	3	13	<1
Sodium , Total as Na	mg/l	150			**151**	48	40	13.2	28	15.6	50	53
Zinc , Total as Zn	ug/l	100	91	800	2	9	56	**343**	62	**317**	19	41
INORGANICS												
pH	pH units	6.5-9.5			7.1	7	7	6.9	7.3	7.5	7.7	8.1
Alkalinity as CaCO3	mg/l	NAC			1480	859	1050	831	702	6900	429	219
Ammoniacal Nitrogen as N	mg/l				154	47.9	91	33.4	5	<0.3	<0.3	<0.3
Ammonia as NH3	mg/l	0.15			**187.0**	**58.2**	**110.5**	**40.5**	**6.1**	<0.4	<0.4	<0.4
Nitrate as N	mg/l	25			<0.3	<0.3	<0.3	<0.3	0.4	<0.3	<0.3	<0.3
Nitrite as N	mg/l	0.1			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate as SO4	mg/l	200			<5	<5	<5	<5	63	62	105	182
Cyanide, Free as CN	mg/l	0.01			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cyanide, Total as CN	mg/l	0.01			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenols Mono (Phenol Index)	mg/l	0.0005	1331		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphide as S	mg/l				0.3	0.28	0.12	0.27	0.18	0.27	<0.02	0.29
Thiocyanate as SCN	mg/l		375	1500	0.2	0.2	0.2	0.2	0.2	<0.1	0.2	0.2
Cyclohexane Extractable Matter	mg/l				<1.0	<1.0	<1.0	1.5	<1.0	<1.0	<1.0	<1.0
PETROLEUM HYDROCARBONS*												
VPH>C5-C6 Aliphatic	ug/l	10	711		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C6-C8 Aliphatic	ug/l	10	519		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C8-10 Aliphatic	ug/l	10	18		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C5-C10 Aliphatic	ug/l	10			<10	<10	<10	<10	<10	<10	<10	<10
VPH>C5-C7 Aromatic	ug/l	10	570		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C7-C8 Aromatic	ug/l	10	989		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C8-C10 Aromatic	ug/l	10	1331		<10	<10	<10	<10	<10	<10	<10	<10
VPH>C5-C10 Aromatic	ug/l	10			<10	<10	<10	<10	<10	<10	<10	<10
VPH>C5-10, Total	ug/l	10			<10	<10	<10	<10	<10	<10	<10	<10
EPH>C10-C12 Aliphatic	ug/l	10	12		<10	<10	<10	<10	<10	<10	<10	<10
EPH>C12-C16 Aliphatic	ug/l	10	0.59		<10	<10	<10	<10	<10	<10	<10	<10
EPH>C16-C35 Aliphatic	ug/l	10	0.001		<10	<10	<10	**17**	<10	<10	<10	<10
EPH>C35-C44-Aliphatic	ug/l	10			<10	<10	<10	<10	<10	<10	<10	<10
EPH>C10-C44 Aliphatic	ug/l	10			<10	<10	<10	**17**	<10	<10	<10	<10
EPH>C10-C12 Aromatic	ug/l	10	1331		**10**	<10	<10	**237**	<10	<10	<10	<10
EPH>C12-C16 Aromatic	ug/l	10	1331		**15**	<10	<10	**110**	<10	<10	<10	<10
EPH>C16-C21 Aromatic	ug/l	10	543		<10	<10	<10	<10	<10	<10	<10	<10
EPH>C21-C35 Aromatic	ug/l	10	7		<10	<10	<10	<10	<10	<10	<10	<10
EPH>C35-C44 Aromatic	ug/l	10			<10	<10	<10	<10	<10	<10	<10	<10
EPH>C10-C44 Aromatic	ug/l	10			**25**	<10	<10	**347**	<10	<10	<10	<10
EPH>C10-C44	ug/l	10			**25**	<10	<10	**364**	<10	<10	<10	<10
TPH>C5-C44 Aliphatic	ug/l	10			<10	<10	<10	**17**	<10	<10	<10	<10
TPH>C5-C44 Aromatic	ug/l	10			**25**	<10	<10	**347**	<10	<10	<10	<10
TPH>C5-C44 Total Ali and Aro	ug/l	10		600	**25**	<10	<10	**364**	<10	<10	<10	<10
POLYCHLORINATED BIPHENYLS												
PCB 28	ug/l				<0.002	<0.002	<0.002	**0.003**	<0.002	<0.002	<0.002	NS
PCB 52	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCB 101	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCB 118	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCB 153	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCB 138	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCB 180	ug/l				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NS
PCBs (Sum of 7 congeners)				0.01	-	-	-	*0.009***				
POLYCYCLIC AROMATIC HYDROCARBONS												
Acenaphthene	ug/l		2570		<0.01	<0.01	0.64	0.05	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	ug/l				<0.01	<0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01
Anthracene	ug/l	10,000	1.4		<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (a) anthracene	ug/l		1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	ug/l	0.05	0.18		0.01	0.02	0.01	<0.01	<0.01	0.03	0.03	<0.01
Benzo (a) pyrene	ug/l	0.01	0.72		<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	ug/l	0.5	17		<0.01	0.02	<0.01	<0.01	<0.01	0.01	0.01	<0.01
Benzo (k) fluoranthene	ug/l	0.05	0.36		<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Chrysene	ug/l		1.2		<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Dibenz (a,h) anthracene	ug/l		0.71		0.02	0.02	0.02	<0.01	<0.01	0.04	0.04	<0.01
Fluoranthene	ug/l	1	30		<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	ug/l				<0.01	0.01	0.18	0.06	<0.01	<0.01	<0.01	<0.01
Indeno (1,2,3) cd pyrene	ug/l	0.05	0.04		0.03	0.04	0.02	<0.01	<0.01	0.04	0.05	0.01
Naphthalene	ug/l	1	290		0.01	0.03	**3.57**	**3.9**	0.01	0.02	<0.01	<0.01
Phenanthrene	ug/l		30		<0.01	0.02	0.08	0.03	<0.01	0.02	<0.01	<0.01
Pyrene	ug/l		11		<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PAH, Total	ug/l				0.07	**0.23**	**4.46**	**4.07**	0.01	**0.17**	**0.14**	0.01
VOLATILE ORGANIC COMPOUNDS												
Dichlorodifluoromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromomethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dichloromethane	ug/l	10			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,2-Dichloropropane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	ug/l	12			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromochloromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	ug/l	500			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloropropene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichloroethane	ug/l	3			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzene	ug/l	1	110		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichloropropane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichloroethene	ug/l	70			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromodichloromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibromomethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,3-Dichloropropene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Toluene	ug/l	10	5070		<1.0	<1.0	1.1	<1.0	<1.0	<1.0	<1.0	<1.0
trans-1,3-Dichloropropene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2-Trichloroethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon Tetrachloride	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl Chloride	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3-Dichloropropane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tetrachloroethene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibromochloromethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorobenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1,2-Tetrachloroethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ethyl Benzene	ug/l	10	3329		<1.0	<1.0	14.3	<1.0	<1.0	<1.0	<1.0	<1.0
m,p-Xylene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
o-Xylene	ug/l		1000		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Styrene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromoform	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Isopropylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-1,2-Dichloroethene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2,2-Tetrachloroethane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3-Trichloropropane	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
n-Propylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromobenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorotoluene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chlorotoluene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
tert-Butylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
sec-Butylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
p-Isopropyltoluene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3-Dichlorobenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,4-Dichlorobenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
n-Butylbenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	ug/l	10			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromo-3-chloropropane	ug/l				<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2,4-Trichlorobenzene	ug/l	40			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobutadiene	ug/l	0.1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	ug/l	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3-Trichlorobenzene	ug/l				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
MTBE	ug/l	30			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0