Executive Summary

Preliminary Risk Assessment
Midland Road Former Landfill Site
Scunthorpe
North Lincolnshire

Final May 2012

1. Executive Summary

The "site": A former ironstone quarry in central Scunthorpe, which covers an area of 40 hectares and which was backfilled with waste from approximately 1945 until 1979. The site is now used for public open space and an industrial estate.

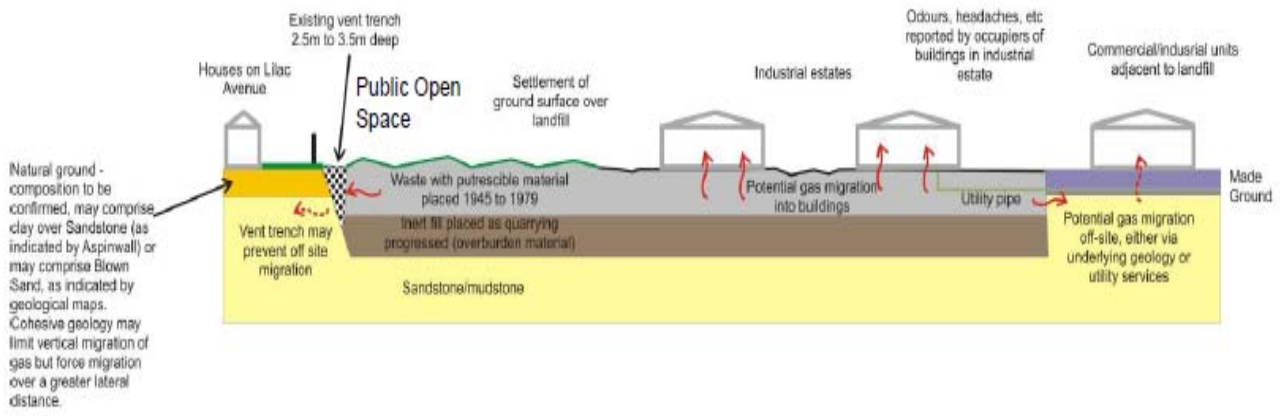
Context of the assessment:
Enable NLC as the enforcing authority to exercise its powers of detailed inspection and identification of contaminated land under the Environmental Protection Act 1990 Part 2A, and make a bid for Contaminated Land Capital Grant Funding to carry out detailed inspection of the site. This assessment is required as a matter of urgency due to unconfirmed anecdotal reports of potential gas migration into buildings.

Landfill design: Site is unlined and not capped, with a shallow depth of top soil on the public open space area (0.1-0.3m). Expected depth of waste 5.0m .Gas management on the site is a vent trench located on the western boundary of the site which was installed to protect the residential houses from gas migration. There are four gas monitoring wells located on the eastern boundary of the vent trench, which are currently monitored by the Council. There is no leachate control system in place at the site.

Development history: Searches of the planning archives have confirmed that approximately 133 of the 136 business premises located on the site were developed prior to 1994. This equates to 98% of the business premises on site being established prior to 1994. Post 1994 1% of new premises have not had contaminated land conditions applied to decision notices (this equates to two permissions granted in 1995 by Scunthorpe Borough Council and in 1998 granted by North Lincolnshire Council). These two premises will not influence the cost design and scope of the proposed site investigation, which is designed to cover the whole area, not specific buildings.

Conceptual site model
The main risk drivers for the site are considered to be those associated with landfill gas.
The conceptual model for the site in relation to landfill gas is shown on Figure 1 below.

Figure 1



The key points in the site conceptual model are:

a) Landfilling was completed in 1979. If conditions have been suitable the bulk of gas
generation should be complete by now. The majority of the waste should be in the maturation stage of decomposition with gas generation well below peak levels. There is reference in some instances to dry waste so there may be areas where decomposition has not been significant and large scale gas generation could commence in future if the waste became wet. There will also be a reservoir of old gas in the ground.

b) Historical records indicate the ironstone band that was worked was at least 3m thick with between 1m to 2.5m of overburden material above it.

c) The depth of waste material that contains some degradable material is typically less
than 4m deep, although in some locations the thickness of waste has not been proven.

d) An existing vent trench is in place between the landfill and the houses adjacent to the western boundary of the site which will limit the potential for off site migration. The vent trench is between 2.5m and 3m depth, though the depth is not proven.

e) There is an absence of an engineered cap and off site migration will be limited over the public open space as gases will be allowed to vent to atmosphere.

f) There have been complaints of odours, headaches, etc from occupiers of commercial/industrial buildings located over the top of the landfill.

g) There is evidence of settlement across the whole area of the landfill. Given the depth of the landfill much of this settlement will have been due to decomposition of the waste.

h) There are elevated concentrations of methane and carbon dioxide within the landfill. The available data indicates the higher gas concentrations recorded on site to be typically associated with exploratory hole locations which recorded higher volumes of putrescible material, notably BH2 on the western site boundary.

i) There is evidence that gas migration into buildings has occurred in the past and this has never been resolved in a satisfactory manner.

Identified Sources

The following gas generation potential, level of risk to on-site development and level of risk from lateral migration are summarised in Table A below.

Table A

Source	Generation potential	Level of risk for an on site development	Level of risk Risk of lateral migration
Landfill 1945 to mid 1960s	Low / moderate wastes deposited unknown (likely to include commercial/industrial waste	Low / moderate	Low
Landfill mid 1960's to early 1990's	Moderate to very high. Waste includes domestic untreated and mechanically pulverised domestic waste and construction and demolition waste	Moderate to very high (depends on current nature of fill and whether waste is dry or wet and also on type of floor slab)	Moderate to very high (reflecting fractured rock in surrounding solid geology which could provide pathway for migration). Depends on effectiveness of vent trench.

Based on Local Authority Guide to Ground Gas (CIEH 2008)

Migration Pathways

The principal mechanisms for gas migration include diffusion and pressure differential flow and the main ingress routes are considered to be:

a) Cracks in the ground bearing floor slab (as identified in the structural review of buildings which noted numerous settlement cracks); and
b) Through gaps around service penetrations which penetrate the floor slab construction.

Off site migration out of the landfill could occur via the following routes;

c) Preferential migration along utility service trenches; and
d) Migration through drift geology (notably Blown Sand, if it is present); and
e) Preferential migration along fractures or bedding in the surrounding. This is the most likely route. The existing vent trench will prevent this if it is in a reasonable condition and reaches a suitable depth.

Potential receptors

Receptors on this site may be broadly divided in two;

a) On-site (occupants of the commercial / industrial units and maintenance workers in the ground); and
b) Off-site (notably of the residential dwellings to the west and immediately adjacent commercial properties).

The main uncertainty associated with the receptors is the condition of the floor slabs and the precise dimensions and internal layout of the buildings. There is also uncertainty regarding internal detection of "landfill gas" within some buildings and the condition and construction of the existing vent trench.

Complete Pollutant Linkages

The following high risk pollutant linkages have been identified which impact upon occupants of on site commercial/industrial units:

A. Gas migration and accumulation into buildings through cracks and penetrations in floor slabs and
B. Gas migration and accumulation into service pits

The following medium risk pollutant linkages have been identified which impact upon off site adjacent residential dwellings and adjacent industrial/commercial premises:

C. Lateral migration via diffusion flow in drift deposits
D. Lateral migration via pressure driven flow in bedrock
E. Lateral migration via preferential pathways (utility services)

Overall Risk

Overall the site has been assessed as low to medium risk, but there is unacceptable uncertainty in the current data collected. Further information is required in order to provide a robust risk assessment of the gas pollutant linkages. The investigation should target the following issues:

A. The current state of decomposition of the waste
B. The future potential to generate gas
C. Detailed geology of the area including groundwater levels and permeability of strata
D. Depth/extent of vent trench
E. Conditions of floor slabs and precise dimensions and internal layout of the buildings

The uncertainty that has been identified is not acceptable for the acute risks associated with landfill gas (explosions and asphyxiation).

Secondary Risks Relevant To The Site

Secondary risks relevant to the site have also been identified; however it is considered that these secondary risks alone would not cause the site to be brought forward for Part 2A inspection as overall these risks are considered to be low but warrant further investigation in order to clarify the risks identified. These risks are chronic in nature and do not pose an immediately realisable risk in the same way that landfill gas does.

Due to the construction of the landfill (no cap) secondary risks to human receptors on the site are those associated with contaminants in the surface soils and shallow waste deposits. Receptors and pathways associated with these secondary risks can be broadly divided into two:

a) On site (occupants of commercial/industrial units and maintenance workers in the ground); and
b) On site users of the public open space (adults, children and pets); and

Due to the construction of the landfill (no cap/liner/leachate recirculation system) secondary risks to controlled waters can be broadly divided into two:

c) underlying secondary aquifer and
d) adjacent surface water

Preliminary Risk Assessment

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2 INTRODUCTION

The Midland Road Landfill “the site” which is the subject of this assessment is a former landfill site which was owned and operated between 1961 and 1979 by the former Humberside County Council, which through local government reorganisation became the unitary authority of North Lincolnshire Council in 1996. Between 1952 and 1961 the nature of the wastes deposited and the ownership of the site is unknown.

2.1 The legal context of the assessment

1 Enables North Lincolnshire Council as the enforcing authority to exercise its powers under the framework of the Environmental Protection Act 1990 Part 2A, namely that of detailed inspection and identification of contaminated land.
2 Is defined by the “suitable for use approach” as set out in the definition of contaminated land under the Environmental Protection Act 1990 Part 2A
3 Is to consider unacceptable risks to human health and the environment in relation to the current use and circumstances of the land.
4 Is to consider the use of the land that is likely to be made and which is consistent with any existing planning permission or is lawful under town and country planning legislation.

2.2 The financial context of the assessment

1 Is to enable North Lincolnshire Council to identify whether or not it is necessary to make a bid to Defra to obtain Capital Grant funding to carry out detailed inspection of the site.
2 If Capital Grant funding is obtained from Defra following a bid, it will enable the council to identify whether or not the site meets the statutory definition of contaminated land as defined under the Environmental Protection Act 1990 Part 2A.
3 North Lincolnshire Council currently has no identified budget to manage and assess “the site” and if Capital Grant funding is not available the council will consider alternative funding sources.

2.3 The commercial context of the assessment

1 Approximately 20% of “the site” is currently public open space owned by North Lincolnshire Council, with the remaining 80% of the land laid out to a mixed use of commercial/industrial premises. Of this 80% North Lincolnshire Council owns approximately 60 % of the land allocated to commercial/industrial use, some of which it currently rents out to local businesses.
2 North Lincolnshire Council has no plans to develop, sell or change current the landholdings on “the site”.

2.4 Report Objectives

The objectives of the report are to:

1. Collate and review available data for the Midland Road landfill site including:

- historical and environmental data;
- site reconnaissance data
- exploratory site investigation data and gas monitoring results
- risk management measures in place at the site

2. Undertake a preliminary risk assessment in order to:

    - identify reasonably possible pollutant linkages associated with the former Midland Road landfill
    - develop an initial conceptual site model for the site
    - assess the risks posed by identified pollutant linkages in order to establish whether or not potential unacceptable risks are likely to exist.

3. Identify and evaluate uncertainties and gaps in information gathered and evaluated

4. Identify, describe and justify what further action is appropriate for the site to determine whether or not the site is contaminated land as defined under the Environmental Protection Act 1990 Part 2A.

5. Ensure that in carrying out steps 1-4 above the technical framework for risk management of land affected by contamination contained in the procedural guidance CLR 11 *Model Procedures for the Management of Contaminated Land (*Environment Agency 2004) is followed.

2.5 North Lincolnshire Council Non Statutory Assessment of Cottage Beck Road Council Depot

North Lincolnshire Council owns a commercial depot which is located on top of the former Midland Road landfill site. The depot is occupied by council employees and is thought to be at risk from ground gas ingress. The risk of the potential ground gas ingress was highlighted in a recent incident where elevated levels of flammable gases were identified inside the council building (see section 9.0 for further details). As a result of this incident the council has installed a fixed gas monitor inside the building in order to ensure that the council complies with its duties under the Health and Safety at Work Act 1974.

North Lincolnshire Council wishes to carry out a specific site investigation of the Cottage Beck Road depot in order to:

1. identify whether or not the current risk management measures in place at the site are sufficient to address the risks posed by ground gases
2. identify what additional risk management measures might be required to managed the risks from ground gases at the site
3. assess whether or not the risks presented by the ground gases are low enough to allow the fixed gas monitoring system to be removed.

If North Lincolnshire Council is successful in obtaining Capital Grant funding for the detailed site investigation of Midland Road, then it is hoped that the council can itself directly fund and investigate the Cottage Beck Road depot concurrently whilst at the same time being able to benefit from anticipated economies of scale by using the same contractor as for the Capital Grant funded aspect of the detailed inspection of Midland Road landfill.

In order to facilitate this quotes have been obtained for the proposed separate non statutory site investigation of the council's Cottage Beck Road depot. Informal discussions were held with the Contaminated Land Capital Grant Funding Team of the Environment Agency on the acceptability of this proposal before proceeding with obtaining quotations. At the time it was suggested that it might be acceptable provided clear distinctions were made in any future contract.

3. SOURCES OF INFORMATION

The following information has been utilised in preparation of this report:

A. Enquiries made to North Lincolnshire Council Development Control Department in 2011
B. Enquiries made to North Lincolnshire Council Asset and Estate Management Department in 2011
C. Enquiries made to North Lincolnshire Council Building Control Section 2012
D. Information from North Lincolnshire Council Petroleum Licensing Officer
E. North Lincolnshire Council Environment Team Archaeology and Ecological Information
F. Contains Environment Agency information © Environment Agency and database right (included in Appendix 4.3.3)
G. Landmark maps and historical information
H. Humberside County Council File Digest presented at Appendix 4.6.U
I. Plan of Scunthorpe Midland Road, referenced S/17956, drawn by Wimpey Laboratories. Prepared from drawing no. EN/C622^{A}/487 Supplied by Borough of Scunthorpe presented with key at Appendix 4.6.W
J. Ionising Radiation Regulations 1999
K. Health Protection Agency Radon Advice
L. Health & Safety Executive Radon Advice
M. BE 211-2007 Guidance on protective measures in new buildings
N. BE 293-2011 Radon in the workplace
O. Anglian Water and Severn Trent utility enquiries
P. Environment Agency Midlands Region Non Nuclear Radioactive Substances Regulation Team
Q. Environment Agency Groundwater Team (Midlands Region)

Historical ground investigations and desk study reports have been undertaken on the site and have been utilised in the compilation of this document. The reports include:

R. Ground Investigation Report, Cottage Beck, Scunthorpe dated December 1990, prepared by Humberside County Council, Technical Services Department- Materials Testing Laboratory. Referenced 84/12/3/MFW/SAR
S. AEA Environment and Energy. A report on a landfill gas survey at Midland Road Industrial Estate, Scunthorpe. Report reference AEA-EE-0071
T. AEA Environment and Energy. A report on a landfill gas survey at Midland Road Industrial Estate, Scunthorpe. Report reference AEA-EE-0094
U. Site Investigation Report – LAS Metals, Midland Road, Scunthorpe dated 1 August 2006, and prepared by T.L.P. Ground Investigations in support of a planning application 2008/1404

4. SITE DESCRIPTION

4.1 Site Location

The site is known as Midland Road Former Landfill and is located in Scunthorpe, North Lincolnshire at approximate National Grid Reference SE9067810329. The site covers an area of approximately 39.8 hectares and is shown on the site location map presented in Appendix 4.1. The site boundary is outlined in red with a 250 metre buffer zone shown in green.

4.1.2 Site Boundary

The site is thought to have been quarried from 1908 to approximately the late 1940's as shown on the historical maps dating between 1887 and 1995 presented in Appendix 4.6(a) to 4.6(i). The site is then thought to have been used as a landfill site, from approximately 1952 to 1979. The maps presented in Appendices 4.6W and 4.9D to 4.9E show the dates and areas of known tipping. This landfill information is summarised on a Table and presented in Appendices 4.1.2a to g. This information has been used to draw the final site boundary along with known natural road boundaries presented in Appendix 4.1.2h.

The site is now predominantly developed with 80% commercial/industrial premises with the remaining 20% of the site being public open space. The layout of the development can be seen on the aerial map presented in Appendix 4.1.2i.

The site is bounded by Cottage Beck Road to the north, Brigg Road to the east, East Common Lane to the south and Warwick Road and Lilac Avenue to the west.

4.1.3 Topography

The site is an irregular shape and is 30m above sea level. It is relatively flat but undulating in places due to landfill settlement.

4.1.4 Buffer Zone 250 metre from site boundary

The landfill site is bordered by a mixture of residential and commercial/industrial uses. Table 4.1.4 below sets out the adjacent land uses.

Table 4.1.4

Cardinal Point	**Land Use**
Eastern boundary	Scunthorpe Integrated Steel Works
North and North West boundary	Commercial/Industrial premises and some residential development beyond
Western boundary	Residential development and recreational use
Southern boundary	Industrial/commercial uses

4.1.5 Cottage Beck Road Council Depot

The council's Cottage Beck Road depot (see section 2.5 for details of proposed additional investigation and section 9.0 for details of the incidents associated with this building) is located in the northern area of the former Midland Road landfill. It covers an area of 0.9 hectares and is currently used by the council's Fleet Management Services and consists of council office buildings and a large external area used for storage and cleaning of domestic refuse and recycling vehicles. Plans showing the location of the site are presented in Appendix 4.1.5 (a) and (b).

4.2 Site Walkover Inspection

Site walkovers were carried out on all premises located on top of the former landfill site boundary. The area amounts to approximately 40 hectares' and therefore, the site was divided into 3 sections for the purposes of conducting site walkovers. The sections are:

- Cottage Beck Road council depot
- Council owned recreational Field
- Commercial/industrial premises

4.2.1 Site Walkover – Cottage Beck Road Depot

North Lincolnshire Council owns the Cottage Beck Road Depot and it is occupied and used by the council's Street Scene and Landscapes Department. The offices have been the subject of complaints of odour by staff and suspected ground gas ingress was identified in 2010. Full details of the ground gas ingress incident can be found in section 9.0 of this report. The building has no gas protection measures incorporated into the building structure but a fixed gas monitoring system was installed by the Council in 2010.

Notes prepared following the site walkover are presented in Appendix 4.2.C Table 4.2.1 below sets out the main findings of the site walkover.

Table 4.2.1

	History	Use	Building structure and condition	Activities
1	Built early 1960's	Used by the council as a waste transfer station and is licensed with the Environment Agency under Licence number 43128 (55/26/829). A map of the site is attached at Appendix 4.2.A	Ground bearing floor slab. Extension has DPM.	Road cleaning vehicles are emptied via an interceptor system to the main sewer. A discharge consent held.
2	Originally 2 buildings, one demolished	Offices, vehicle garage, welfare facilities, vehicle	A main sewer runs under the site at a depth of between 1.6-2.3m. See Appendix 4.2.B.	A fuel additive is stored on site in an IBC in a bunded area.

	2009.	parking. MOT servicing. Waste storage		
3			The older part of the depot shows signs of historical cracking.	Clinical waste is stored on site prior to disposal to incineration

4.2.2 Site Walkover – Recreational Field

The recreational field is under the ownership of North Lincolnshire Council. There is a vent trench located on its western boundary adjacent to residential houses on Lilac Avenue. There are currently four ground gas monitoring wells on the site which are adjacent to the vent trench on the landfill site side. The site is generally overgrown and is predominantly used for dog walking; a playground is located on the south western boundary. Table 4.2.2 below sets out the main findings of the site walkover.

Table 4.2.2

	Land condition	Vegetation	Vent Trench	Boreholes	Appendices
1	Predominantly level, with some evidence of subsidence in the north eastern boundary and towards the centre	Predominantly grassed, some young trees	Overgrown, some areas of gravel seen	Boreholes 1 and 2 found easily	A map of the recreational field is attached at Appendix 4.2.D
2	Some flytipping – garden waste, plastic bags, a mattress etc.	Subsidence area to north east and central area showed grass to be a paler green.	Large trees were adjacent	Borehole 3 not found	A total of seven photographs of the site and boreholes found are attached at Appendix 4.2.E
3	North west boundary fenced off, start of industrial estate properties	Some dead trees to north eastern area	Some depressions seen, possibly subsidence.	Borehole 4 found but not easily accessed. Appeared to have been set fire to.	Notes prepared following the site walkover can be seen at Appendix 4.2.F
4	Some small burned areas – traveller fires	Generally a wide range of tree & flower species, beech, ash, buddleia & sloe			

4.2.3 Site Walkover – Commercial Premises

Site walkovers were carried out at 146 commercial premises located on top of the landfill site. A copy of the site walkover form can be found in Appendix 4.2.G. The main findings of the site walkover are tabulated at Appendix 4.2I.

I. **Building design**: Detailed design drawings of the buildings were not available from the council's Building Control Department, however the site walkover indicated that foundations were predominantly of solid ground bearing floor slab.

II. **Gas protection measures**: Information gathered from the site walkover suggests that gas protection measures exist in only 18 recently developed office/warehouses. No property had a fixed gas detection system other than NLC Cottage Beck Road Depot referred to in section 4.2.1. The results of the survey were compared against the scoring system in Table 3 of BS 8485:2007. Of the 146 properties, 83 premises scored 0.5 and 14 premises scored 1. The remainder scored zero.

Sites with a score of zero did not know the design of their building structure. Sites with a score of 0.5 had a ground bearing floor slab. Sites with a score of 1 had a gas membrane installed, however verification details were unavailable and the exact foundation design was unknown.

III. **Drainage**: Foul waste is disposed of to mains sewer. Surface water appears to discharge to a mixture of soakaways and a combined system which accepts both foul and surface water. Occupiers of some premises complained about the subsidence in the roads and considered this to be contributing to some drainage problems such as flooding in very heavy rain.

IV. **Structural Repair:** Many premises were in a poor state of repair with evidence of cracking and subsidence being found. Subsidence is also evident along the public highway. Appendix 4.2.H shows photographs of those properties with structural defects presented at Appendix 4.2I.

V. **General Housekeeping and Health and Safety:** The general housekeeping standards of many premises were poor and many of the sites appeared to have a low regard to health & safety.

VI. **Inspection Pits:** Site visits revealed 18 inspection pits although most were either infilled or not in use. Activities were varied amongst the premises visited and there were 62 recorded premises with indoor sources of ignition such as welding.

VII. **Evidence of gas emissions:** Four premises recorded experiencing indoor odour problems, usually after the building had been closed for a period of time, one alleged gassy/sewerage type drinking water problem. Two premises had noted bubbling in puddles after rainfall.

VIII. **Evidence of waste:** Three premises had found waste during excavation works and one had dropped through into a void area. Another site had identified waste (cloth and newspaper) that had not biodegraded. They described the waste as being dry.

4.2.4 Residential properties on the western boundary of the landfill

A site walkover of the residential properties on Lilac Avenue and Warwick Road was not undertaken due to the fact that it is unclear at this stage whether or not a detailed site investigation will proceed on the site. It was however possible to view some of the rear gardens of the properties from the recreation ground during the site walkover. No stressed vegetation was noted at the time.

4.2.6 Building Control Enquiries

Enquiries were made of the council's Building Control Department in order to ascertain the foundation design of commercial buildings located on top of the former Midland Road landfill and the foundation design of the residential properties bordering the western edge of the landfill on Lilac Avenue and Warwick Road. The enquiries did not

produce any detailed foundation design drawings, although Building Control advised that due to the age of the residential properties on Lilac Avenue and Warwick Road (1950's) the properties would not have any gas protection measures in place and foundation design is likely to be a ground bearing floor slab.

4.3 Hydrology

4.3.1 Surface Waters

Brumby Beck is located on the eastern boundary of the site adjacent to Brigg Road and Cottage Beck is located to the northern boundary of the site adjacent to Cottage Beck Road. Both of these surface waters are culverted underground. Brumby Beck is sampled at an outlet on the Scunthorpe Steel Works site by the Environment Agency using the General Quality Assessment (GQA) scheme to assess river water quality by looking at chemistry, biology and nutrients. It has been given the following River Quality Classification for 2009

Chemistry: Poor
Biology: Bad
Nitrates: Moderately low
Phosphates: Very high

River Quality Classifications for 1990 to 2009 are presented in Appendix 4.3.1

4.3.2 Flood Risk

On line Environment Agency Flood Risk Maps indicate that the site is not within an identified flood risk area.

4.3.3 Pollution Incidents

The following information was supplied by the Environment Agency dated 23rd February 2011 and is presented in Appendix 4.3.3.

The following pollution incidents took place within 250 m of the site as detailed below:

A. NIRS 00380002:24/02/2006 approx 500l of gas oil leaked to ground from a storage tank. A site warning was issued and extensive remedial work undertaken.

B. NIRS: 271238 11/10/2004 – Unauthorised waste management activity. Site visited and enforcement action taken.

C. NIRS: 26404 23/08/2001 Incident on Midland Road. Fire reported by Humberside Fire Service involving large wood fire not attended by EA

D. NIRS: 444866 16/10/2006 Incident involving dust on motor vehicles on Brigg Road. Dust found to contain slag and small amount of iron bearing materials. Corus investigated complaint.

E. NIRS: 380002 24/02/2006 Incident at PD Logistics Midland Road oil leaking from storage tank and entering old railway embankment. Site attended and measures put in place to remediate and clear oil.

4.4 Hydrogeology

Bedrock geology aquifer designations based upon BGS 1:50K DigimapGB-50 data identifies the underlying **Frodingham Ironstone Formation as a Secondary A aquifer.** A map of the aquifer designation is presented in Appendix 4.4 a. As the Frodingham Ironstone is expected to have been quarried within the landfill area the underlying **Scunthorpe Mudstone Formation has also been identified as a Secondary A aquifer** as the limestone banding within the mudstone provides a permeable layer capable of supporting local water supplies.

A secondary A aquifer is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers which were formerly classified as minor aquifers.

The aquifer designation of superficial deposits based upon BGS 1:50K DigimapGB-50 data identifies the **clays/silt/sand/gravel on the north west of the site as a secondary undifferentiated aquifer.**

This aquifer has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

The blown sand deposits which border the east, south and west boundaries of the site are identified as Secondary A aquifers. These aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. A plan of the aquifer designation for drift deposits is presented in Appendix 4.4 b.

4.5 Source Protection Zones

Source Protection Zones protect large and public potable groundwater drinking abstractions. They provide an additional protection to safeguard drinking water through constraining the proximity of an activity that may impact upon the drinking water abstraction.

Environment Agency polygon data identifies that the site and surrounding 250m buffer zone does not lie within a designated Source Protection Zone.

4.6 Historical Site Development

The history of the site and of the area within 250m of the site has been identified by assessment of the following information sources:

- Historical maps dated 1887-1995 presented at Appendices 4.6a to 4.6i
- Landmark polygon maps with key presented at Appendices 4.6j to 4.6r
- Historic landfill maps presented at Appendices 4.9D and 4.9E
- Information provided by North Lincolnshire Council's Petroleum Licensing Officer, see map and Table showing Former Fuel Storage presented at Appendices 4.6s and 4.6t.
- Humberside County Council: Site File Digest presented at Appendix 4.6u.
- Wimpey Laboratory Map S/17956 with key presented at Appendices 4.6v and w.

4.6.1 Site History

Notable on site features obtained from historical maps and their associated potential sources of contamination have been summarised on Table 4.6.1(a) below.

Table 4.6.1(a) On-Site Features

Date	Notable on site features	Potential Contamination Sources
1887	One building on the north boundary possibly associated with a pump. A section of railway present on far north east of site. Buildings named 'Sandhouse' on the west boundary. A small site labelled 'Magazine' on the lower south west boundary, landmark information reports weapons and ammunition manufacture and storage c. 1889. However it is possible that the site was manufacturing explosives for blasting of ironstone. Road on south east boundary of site. Remaining site open ground with areas planted with trees on north boundary and centrally.	Building - possibly pump. Railway Weapons and ammunition manufacture and storage
1908	Building centre north boundary remains with addition of a quarry. A building of unknown use has been located near the north east boundary of the site adjacent to the railway. Extension of railway through centre of site to south boundary and from north west of site diagonally across site down to south boundary. Quarry edge shown from north west corner of site diagonally across site down to south boundary, adjacent to railway. Buildings 'Sandhouse' on the west boundary unchanged. Remainder of site open ground, trees gone.	Building - pump Railway Quarry Building - use unknown
1944-78	Historic Landfill	Landfilling
1948-99	12 former petrol storage sites	Former petrol storage sites
1956-58	Building on north boundary gone, the quarry remains, allotments to south of site of original building. Section of railway through the centre of the site has gone. Section of railway on north east boundary remains. Building near north east boundary remains. A well is shown on far west boundary. The south of the site appears to be rough grassland	Allotments Unidentified building
1960-71	The railway remains on the north east boundary. A depot is located in the centre of the north boundary associated with a refuse tip.	Railway Depot

	Allotments are located on the west boundary of the site. Commercial development has taken place in the far south of the site with a section of Midland Road being developed and various works buildings and depots. Tanks are shown associated with many of the depots and works.	Refuse tip Allotments Commercial development - works and depots and associated tanks
1962-77	The railway remains on the north east boundary. A depot is located in the centre of the north boundary associated with a refuse tip. To the south of the refuse tip is a sand pit. Allotments are located on the west boundary of the site. Commercial development has taken place in the far south of the site with a section of Midland Road and various works buildings and depots. From north to south, through the centre of the site a slope or the edge of a quarry or pit is shown. The edge of a quarry or pit is also shown immediately behind the depot to the north of the site and on the east boundary.	Railway Depot Refuse tip Allotments Works buildings Depots Quarry
1962-93	The railway embankment remains, however it is unclear if the railway is still present. Banbury Road has been located across the north of the site behind the depot. The refuse tip is now considerably smaller. The sandpit remains. The pit/quarry edge has gone from behind the depot in the north but remains on the east boundary and through the centre of the site from north to south. The allotments remain on the west boundary. Commercial development remains in the far south of the site with a section of Midland Road and various works buildings and depots with associated tanks.	Railway embankment Depot Refuse Tip Quarry Allotments Works and Depots with associated tanks
1966-91	The railway on the north east boundary has been dismantled. Midland Road has been extended up through the centre of the site to meet with Banbury Road. Commercial development has taken place along the length of the Midland Road and in the Banbury Road area. The allotments remain on the west boundary. A refuse tip and a scrap yard have been located in the north west of the site. A further scrap yard has been located centrally on the site. North of Nostell Road on the east boundary of the site a quarry or an embankment is located.	Railway embankment Commercial development - including a builders yard, garages, engineering works, depots and associated tanks Refuse tip Scrap yards Allotments
1970-80	The railway embankment remains on the north east boundary. The depot on the north boundary has been extended, with Banbury Road behind. The associated refuse tip has gone. The allotments on the west boundary have gone and have been replaced by a refuse tip. Further commercial development has taken place to the north west. The quarry or embankment remains north of Nostell Road. The area is marked on the map as Midland Road Industrial Estate.	Railway embankment Depot and other works Refuse tip quarry
1970-95	The railway embankment remains on the north east boundary. The refuse tip has gone; part of this area has been developed with commercial buildings. The remainder of the land on the west boundary remains open. The quarry/embankment north of Nostell Road has gone.	Railway embankment Commercial development - works and depots.

Notable features within the 250m buffer zone of the site which have been identified on historical maps and their associated potential sources of contamination have been summarised on Table 4.6.1(b) below.

Table 4.6.1(b) Adjacent to Site - within 250m Buffer Zone

Date	Notable features	Potential Contamination Sources
1887	Railway to the north Road networks to the north east and south. The remainder is undeveloped.	Railway
1908	The railway remains in the north. Allotments are now located in the north. In the far north east an iron and steel works is located with associated railway, a chemical works is also located in this area. An Ironstone quarry is located in the east and the south.	Railway Allotments Steel works Chemical works Quarry
1948-99	Six former petrol storage sites Information provided by the North Lincolnshire Council (NLC) Petroleum Licensing Officer.	Former petrol storage sites
1956-58	The railway remains to the north. Allotments in the north are gone. Steel works, associated railways and chemical works remain in the north east. Extensive quarrying to the east, in conjunction with extensions to the railway. Quarrying in the south. Residential development immediately adjacent to the site on the west boundary. Commercial development immediately adjacent to the site on the north west boundary with domestic development beyond.	Railway Allotments Steel works Chemical works Quarry Commercial development Residential development
1960-71	Commercial development adjacent to the north boundary has taken place. Steel works, associated railways and chemical works remain in the north east. Quarrying to the north east continues, associated with the railway. To the east, a refuse/slag heap has been located, beyond this the steel works buildings, blast furnaces and the rod mill have been located. A factory is located on the west boundary in the north, with a TA Centre beyond. Commercial development, marked as a depot remains on the north west boundary, backed by residential development. Residential development remains to the west. Works and depots have been developed to the south west and the south of the site.	TA Centre Quarrying Refuse/Slag heap Steel works - blast furnaces & rod mill Factory Commercial development
1962-77	Commercial development remains adjacent to the north boundary including a builder's yard. Quarrying to the east continues, associated with the railway, beyond a slag heap is located and a slag preparation works backed by the blast furnaces. Various works and depots are located in the south and south east. Residential development remains on the west boundary. A depot remains on the north west boundary with the TA centre and other commercial premises beyond. The factory remains on the north west boundary. Works and depots remain in the south west and to the south of the site.	Builders Yard Works/Depots Quarrying Slag heap Slag preparation works Blast furnaces. Residential and commercial development TA Centre Factory
1962-93	The builders' yard remains to the north. The map is incomplete to the east - no information available. Various works and depots remain in the south and south east. Residential properties remain on the west. A depot, TA centre and factory remain as above.	Builders Yard Works/Depots Residential and commercial development TA Centre Factory

1966-91	The builders' yard remains to the north. Map incomplete to the east. Further commercial development in the south of premixed concrete works, engineering works, depots, and associated tanks. Residential properties remain to the west. The factory in the north west has been expanded; a dairy has been located to the west of the factory. Further commercial development in the north west has taken place with an additional factory, warehouse and depot.	Builders yard Premixed cement works, engineering works and associated tanks Factory Dairy Residential Warehouse
1970-80	All quarrying and slag heaps in the east have gone. No further changes appear to have taken place.	
1970-95	No further changes appear to have taken place	

4.6.2 Summary of Potentially Contaminative Land Uses

Based on a review of the available information, the following potential contaminative land uses have been identified, on site (in relation to current users) and adjacent to the boundary which could have impacted upon site conditions. The information has been summarised for on site sources in Table 4.6.2(a) below and for off site sources in Table 4.6.2(b) below.

Table 4.6.2(a) On-site Contaminative Former Uses:

Date	**Potential Contamination Sources**	**Potential Contaminants**
1887	Building - Pump? Railway Made ground associated with railway Weapons and ammunition manufacture and storage	Metals, fuel oils Organic chemicals - PAH's, chlorinated aliphatic hydrocarbons, PCBs. Inorganic chemicals, asbestos Solvents, creosote, herbicides Metals and metal compounds. Inorganic and organic compounds, explosives, acids, fuels, pcb's, fuel oils, asbestos, chlorinated organic solvents, hydraulic oils
1908	Quarry Building - use unknown	Oil/fuel hydrocarbons Metals and metal compounds. Inorganic and organic compounds, acids, fuels, pcb's, asbestos, chlorinated organic solvents, hydraulic oils
1944-1978	Landfill	Metals, semi-metals and non-metals Inorganic chemicals, asbestos, pH Organic chemicals - oil/fuel hydrocarbons, PAH's, Chlorinated aromatic hydrocarbons, PCB's, dioxins and furans.
1948-1999	Petrol storage	Metals, Asbestos, ph Organic chemicals - oil/fuel hydrocarbons, aromatic hydrocarbons, PAHs, Chlorinated aliphatic hydrocarbons, organolead compounds.
1956-58	Allotments	Metals, PAHs
1960-71	Commercial Development - Engineering works, Depots Tanks - fuel	Metals, semi-metals and non-metals Inorganic chemicals, asbestos, pH Organic chemicals, acetone, aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, PCBs, phenol, PAHs, oil/fuel hydrocarbons Solvents, combustible materials
1962-77	As above	

1962-93	As above	
1966-91	Scrap yard Builders yard Garages	Metals, semi-metals and non-metals, inorganic chemicals, asbestos, acids, organic chemical - oils, fuels, hydrocarbons, PCB's
1970-80	As above	
1970-95	As above	

Table 4.6.2(b) Adjacent to Site - within 250m Buffer Zone

Date	**Potential contamination sources**	**Potential contaminants**
1887	Railway Made ground associated with railway	Metals Organic chemicals - PAH's, chlorinated aliphatic hydrocarbons, PCBs. Inorganic chemicals, asbestos Solvents, creosote, herbicides
1908	Quarrying Allotments Chemical works Steel works	Oil/fuel hydrocarbons Metals, semi-metals and non-metals, asbestos, pH Inorganic chemicals - PAHs. Organic chemicals - Phenols, acetone, aromatic hydrocarbons, chlorinated aromatic hydrocarbons.
1948-1999	Petrol storage	Metals, Asbestos, ph Organic chemicals - oil/fuel hydrocarbons, aromatic hydrocarbons, PAHs, Chlorinated aliphatic hydrocarbons, organolead compounds.
1956-58	Factory	As above
1960-71	Refuse tip/slag heap Blast furnaces Rod Mills TA Centre Works and depots	Metals, semi-metals and non-metals, Inorganic chemicals, asbestos, pH. Organic chemicals - Phenol, acetone, aromatic hydrocarbons, oil/fuel hydrocarbons, PAHs, chlorinated aliphatic hydrocarbons, PCBs Solvents, combustible materials
1962-77	Builders yard Quarrying	As above
1962-93	As above	
1966-91	Premixed concrete works Engineering works Depots & fuel tanks Dairy Warehouse	Metals, semi-metals and non-metals, Inorganic chemicals, asbestos, pH. Organic chemicals - acetone, oil/fuel hydrocarbons, PAH's, PCB's, aromatic hydrocarbons, chlorinated aliphatic hydrocarbons, Phenol, organolead compounds.
1970-80	As above	
1970-95	As above	

4.7 Geology

4.7.1 Superficial Geology

Maps of the superficial geology are presented in Appendix 4.7.1. Digital British Geological Survey maps 1:50,000 indicate that drift deposits are absent over the majority of the site, with some blown sand deposits potentially being present on the south west periphery of the site. The Blown Sand deposits are of the Quaternary Age and are well sorted uncemented deposits which are pale brown and fine grained in texture.

The north eastern boundary of the site may have worked deposits of sand with clay and gravel which now appear to form an old railway cutting on this perimeter boundary. These are generally poorly sorted and poorly stratified deposits formed mostly by solifluction and/or hillwash and soil creep. The deposits comprise of sand and gravel, locally with lenses of silt, clay or peat and organic material.

4.7.2 Bedrock (Solid) Geology

Digital British Geological Survey maps 1:50,000 and British Geological Survey: 1982 – 1:50,000 Scale Geological Map Sheet 89, Brigg – Drift Edition indicate the site is underlain by:

- **Lower Jurassic Frodingham Ironstone**, which forms the upper part of the Scunthorpe Mudstone Formation as presented in Appendix 4.7.2. The depth of the ironstone is thought to reach a maximum depth in the order of 9.0m.

- The **Scunthorpe Mudstone formation** is grey, variably calcareous and silty, blockey or fissile mud stone with thin beds of argillaceous limestone and calcareous siltstone particularly near the base and in the upper part which is ferruginous in the type area. Expected maximum thickness is 128m.

- **Penarth Group** which are grey to black mudstones with subordinate limestone's and sandstones; predominantly marine in origin. It is thought to have a maximum depth of 12m.

- **Triassic Mercia Mudstone** which form deposits of green grey mudstones and siltstones, expected thickness is in excess of 1350m.

4.7.3 Made Ground

Digital British Geological Survey maps 1:50,000 indicate the site and surrounding area is underlain by made ground. This is due to the extraction of the underlying Frodingham Ironstone which was used to supply the iron and steel making business in Scunthorpe. A map of the made ground can be found in Appendix 4.7.3. The site investigation undertaken in by the council 1990 proved the made ground to comprise of:-

4.8 Mining and Mineral Extraction

4.8.1 Mining

There is no recorded evidence that underground mining was ever carried out on the site or within 250m of the site.

The geology indicates that coal mining in the Scunthorpe area has never been undertaken due to lack of carboniferous deposits. The site was, however, subjected to mineral ore extraction.

4.8.2 Mineral Extraction

The extraction of Lower Jurassic Frodingham ironstone commenced soon after its discovery in 1859 and led to the subsequent development of the iron and steel industry in Scunthorpe. Historic maps show a quarry being present on the site in approximately 1908 and it remained on maps until around 1956-58.

Maps recording areas of ironstone extraction were obtained from Tata Steel and are presented in Appendices 4.8.2 A, B, C, & D. The maps indicate that an area just south west of the mineral railway line was first worked in the 1890's and progressed to towards the south west until around 1926. This area was then "given up" and further extraction has taken place in a south westerly direction towards Sandhouse into the 1930's. The workings appeared to operate from pre 1905 until 1945.

Historic council records suggest that extraction from the Midland Road area had ceased by the late 1940's when infilling began on a small scale.

Opencast mining had given way to underground techniques in the 1930's where the iron-bearing strata dipped further below the surface. However the Midland Road former landfill site had its iron ore extracted using the open cast method alone. Iron ore mining had ceased in North Lincolnshire in 1989.

4.9 Landfilling

4.9.1 Expected Dates of Tipping:

The creation of a void for the future Midland Road landfill site was the result of the extraction of ironstone and sand which commenced soon after its discovery in 1859 and led to the subsequent development of the iron and steel industry in Scunthorpe. Historical mapping data suggests that quarrying on the site commenced around 1908 when a mineral railway line can be seen on the 1908 map presented in Appendix 4.6b.

It is thought that landfilling may have started at the Midland Road site some time after the ironstone extraction ceased in 1945. A plan of the tipping history presented in Appendix 4.6.W titled Scunthorpe Midland Road, referenced S/17956 and drawn by Wimpey Laboratories:\supplied by Scunthorpe Borough Council) indicates that an area of the recreational field was tipped prior to 1948.

4.9.2 Impact of legislative control and tipping practices upon Midland Road landfill:

A. **The 1936 Public Health Act** was the first legislation to set out rules for landfill operation though they were not strictly enforced. The Second World War brought about an increased effort in recycling and composting and as a result items going to landfill reduced. Post Second World War the nature of waste began to change with increased amounts of packaging going to landfill, and with the increase in manufacturing there was less emphasis on recycling. During this period much of the waste was burnt on a daily basis at the landfill so the waste was predominantly ashes and cinders. Midland Road landfill was thought to have been operating some time around 1948.

B. **In 1947 the Town and Country Planning Act** required all new landfills to have planning permission; this did not apply to existing sites. The first planning permission granted for part of the site was in 1953, this indicates that the site was operating prior to 1947.

   At this time Midland Road landfill operated as an unlined landfill with no leachate or gas control systems place. There was little or no effort to control the types of wastes accepted by these types of sites.

C. **The Clean Air Act 1956** reduced the amount of burning that was possible and therefore the volume of waste increased as the opportunity for burning rubbish reduced. The content and nature of domestic bins changed from mostly ash to degradable material like paper and food. Ash content by the 1960's had been reduced to 10%.

   There are no pre-1961 records of waste types deposited at the Midland Road site. But due to the complex industrial history of Scunthorpe it is possible that industrial wastes including chemicals/drums were deposited in the landfill site at this time.

In the document ‘Report on a Landfill Gas Survey at Midland Road Industrial Estate, Scunthorpe – dated November 1990, referenced AEA-EE-0071 and prepared by The Environmental Safety Centre, Harwell Laboratory’ there is reference made to a 1950’s map (not included in the report) suggesting that ’two layers of wastes’ were placed over the south east of the area. It is thought to have been slag/high ash waste and was confirmed by trial pits in the area during the 1990 intrusive works. A record of those results is presented in Appendix 4.9.A.

Records indicate that this former landfill site was operated by Humberside County Council between 1961 and 1978/9, following extraction of the iron ore. Wastes accepted included pulverised refuse, scrap metal, construction, excavation, building waste and untreated domestic refuse. Environment Agency data presented in Table 1 below suggests that planning permission was granted for the deposit of pulverised waste in 1962.

D. **The Deposit of Poisonous Waste Act 1972** was passed which required a system of notification to control and record the volumes, movement and disposal of poisonous, noxious, or polluting waste to prevent pollution to land or water. Around this time an increasing amount of industrial and chemical wastes were being deposited in some landfills, however there are no waste records for Midland Road Landfill. This is due to the fact that records were probably lost when the then Humberside County Council became North Lincolnshire Council Unitary Authority in 1996.

E. **The Control of Pollution Act (COPA) 1974 and Co-disposal.** COPA 1974 emphasised the environmental effects of waste disposal upon leachate generation and led to a waste classification system. However the system gave little or no regard to landfill gas generation. Co-disposal of domestic refuse with a wide range of hazardous materials was also accepted at this time. Evidence gathered to date does not indicate that this practice took place during the 60’s and 70’s at this site. Pictures of the site presented in Appendices 4.1.1 to 4.1.15 indicate pulverised domestic refuse and non hazardous trade/industrial waste. This is also supported by the trial pits presented on the Wimpey plan of the site presented in Appendix 4.6.W. This identifies the waste as being, bricks, squeezy bottles, stone, rubble, large lumps of timber, polythene sheeting and piping. It is known that another deeper landfill in North Lincolnshire operated by Humberside County Council was used to deposit hazardous industrial and commercial wastes. This site is currently managed and monitored by North Lincolnshire Council in terms of leachate production and gas emissions .At this stage however it cannot be ruled out completely that some co-disposal might have taken place at the site. This is due to the fact that anecdotal evidence suggests domestic and industrial wastes were often illegally tipped onto the site as there were little or no boundary controls in place and as such it was easily accessible for dumping of uncontrolled wastes.

The site was closed and restored in 1978 shortly after the introduction of the Control of Pollution Act 1974. No monitoring data or evidence is available in terms of gas/leachate analysis or the type of cover provided for the site. There was at this time no necessity to establish that leachate and gas were not posing a risk to the environment or human

health. There are no records of the depth or nature of any capping system being placed at the site.

Table 4.9 below summarises the known tipping history of the site.

Table 4.9

Date	Origin of information	Waste input where known	Appendix
Pre 1948	Plan of Scunthorpe Midland Road, referenced S/17956 and drawn by Wimpey Laboratories. Origin of information Scunthorpe Borough Council	No details of waste input recorded,	Appendix4.6.W
1952	North Lincolnshire Council Planning Department SB/1952/0567 – Planning permission to use land for controlled tipping of refuse – disused railway cutting west of Brigg Road – granted unconditionally on 5.1.53 to Scunthorpe Borough Council.	No details of waste input recorded	4.9.B
1954	North Lincolnshire Council Planning Department SB/1954/0059 – Planning permission to use land for the controlled tipping of selected material (not domestic refuse) up to the level of the surrounding ground – East Common Lane – granted unconditionally on 9.3.54 Scunthorpe Borough Council.	No details of waste input recorded	4.9.B
1955	North Lincolnshire Council Planning Department SB/1955/0745 – Planning permission to use land for controlled tipping of refuse – between East Common Lane and Cottage Beck Road – granted unconditionally on 14.10.55 Scunthorpe Borough Council.	No details of waste input recorded	4.9.B
Prior to 1961	Plan of Scunthorpe Midland Road, referenced S/17956 and drawn by Wimpey Laboratories. Origin of information Scunthorpe Borough Council.	No details of waste input recorded,	4.6.W
1961 to 1978	Humberside County Council File Digest dated 20/12/1990 unconditional planning permission dated 14/8/1962 to Scunthorpe Borough Council.	Pulverised refuse, Scrap metal, construction, excavation, building waste and untreated domestic refuse.	3 4.6.U
1978-79	Humberside County Council File Digest dated 20/12/1990	Site restored.	4.6.U

4.9.3 Humberside County Council and Environment Agency Data:

The information presented in Table 4.9.3 below is a transcript of the document Humberside County Council File Digest dated 20/12/1990 which is at Appendix 4.6.U. This information was obtained from the Environment Agency in 2002.

Table 4.9.3

Site number	180
Site name	Cottage Beck Road (Midland Road)
Reference Number	55/17/0018
Site Type	17
Number	18
Status	Closed (Humberside County Council)
OS Map number	112
Grid Reference	SE906103
District Council	Scunthorpe Borough
Enforcement Area	South
Geology	Sand overlying Frodingham ironstone and mudstone – The floor of the pit probably consists of Scunthorpe mudstones.
Geological Bore Logs	None
Landfill Gas Information	Yes
Waste Permitted By	Not Licensed
Other wastes taken at source	A) Pulverised refuse (Planning permission dated 14/8/1962) Appendix 4.9.C B) Scrap metal (collection skip on site) C) Excavation and construction waste D) Building waste (untreated domestic waste)
Depth of quarry	6m
Area	22.4 Acres
Total Volume	433,000m^3
Original site use	Sand Quarry
Year of Filling	1961
Site Closed	1978
Site Restored	1978/79

4.9.4 Landfill Gas Survey at Midland Road Industrial Estate, Scunthorpe, November 1990 Ref AEA-EE-0071 prepared by The Environmental Safety Centre, Harwell Laboratory

The report detailed above**,** provides maps indicating the extent and years of fill although the origin of this information is unknown. Table 4.9.4 below presents this information.

Table 4.9.4

Appendix	Map	Year of fill	Extent of Fill
4.9 E	Figure 2	1944-48	Brigg Road/East Common Lane and
4.9 E	Figure 2	1949-54	Inside quarry to south of Brigg Road
4.9 E	Figure 2	1954-58	Infill moved north westerly
4.9 D	Figure 1 a	1963	Active area between Cottage Beck Road, Colin Road Nostell Road and the railway line/Brigg Road. Area beyond Nostell Road completed.
4.9 D	Figure 1 b	1965	Active filling around Cottage Beck Road Depot (1963-1965)
4.9 D	Figure 1 c	1967	Filling on extension to the west of Midland Road
4.9 D	Figure 1 d	1971	Filling abuts gardens on Lilac Avenue and Warwick Road to the west of the site

Using the information from table 4.9.4 a map has been produced which shows the location of the youngest waste placed in areas of the site. The map can be found in Appendix 4.9 F.

4.9.4 Photographs of the landfilling:

Historic photographs of the landfilling are attached at Appendix 4.9. (1) to 4.9. (15). The photographs are of unknown date and origin but are retained by North Lincolnshire Council with their records. Pictures that are of particular interest are detailed in Table 3 below.

Table 3

Reference	**Description**
4.9.(2)	Shows the landfill operation taking place with residential properties along Lilac Avenue in the close background
4.9.(5)	Illustrates the shredded waste being bulldozed during operations
4.9.(10)	Illustrates vegetation growth over the waste
4.9.(15)	Appears to show piles of earth which may have been a form of capping for that area.

4.10 Utilities

Severn Trent Water was contacted to ascertain what sewer systems traversed across the site. Appendix 4.10.A indicates the sewer system for the area. Severn Trent has advised that the depth of the sewers is between 1.6 to 2.3 metres.

Anglian Water was contacted to ascertain the location of drinking water supplies. Appendix 4.10.B indicates supply routes. Anglian Water has advised that the expected depth of the water supply pipes is expected to be about 750 to 900 millimetres. The mains water supply pipes are constructed of cast iron with the exception of a small section of Midland Road (south of Nostell Road) which has been replaced with high density poly ethylene pipe approximately 10 years ago. No assessment of ground conditions took place prior to the replacement of the pipework.

4.11 Archaeological Information/ Monument Structures

It is considered unlikely that any relic structures will remain below ground on the actual landfilled area due to the excavation of iron ore. There may however be archaeological information in the 250m buffer area adjacent to the site which may need to be taken into consideration in terms of any future site investigation. The following information has been provided by the Council's Historic Monuments Officer

The boundary of the Midland Road landfill site is within the recorded area of the ironstone workings 1885 – 1936 (hatched in brown and lilac on the plan provided in Appendix 4.11 A. Some archaeological material was recorded in this area during the quarrying but it is not expected that there will be any existing survival of archaeological remains.

Within the 250m boundary of the site, which extends beyond the ironstone workings on the north west and south west sides, there are a number of recorded archaeological finds including a Romano-British settlement at (MLS 1873). A full list of the monuments is presented in identified on the site and within 250m of the site is presented in Appendix 4.11. B.

4.12 Environmental Information

4.12.1 Environmental Permitting Regulations

The following information was provided by the Environmental Protection Unit at North Lincolnshire Council and the Environment Agency. Environment Agency response to request for information is presented at Appendix 4.3.3.

On site: Table 4.12.1 below summarises regulated processes that are, or have been present on areas of the site that have been tipped/infilled, the locations of which are shown on the map at Appendix 4.12.1a.

Table 4.12.1

Company Name	Address	Process Type	ID Number	Permit Ref	Part A/Part B
George Kamita	Plot 50 Colin Road Scunthorpe	Extraction of non-ferrous metal from scrap	223	P223/2.1/05	Part B
GPS Mobile Crushing Services	36-38 Midland Road Scunthorpe	Mobile crushing and screening	263	P263/3.16/05	Part B
Lou's Tyres	Brigg Road Scunthorpe	Waste oil burner 0.4 MW	226	P226/1.1/04	Part B
AMS Bobcat	Brigg Road Scunthorpe	Waste oil burner 0.4 MW	236	P263/1.1/05	Part B
Steel Centre 4	Midland Road Scunthorpe	Metal coating	266	P266/6.23.09	Part B
Jack Tighe Ltd	East Common Lane Scunthorpe	Coating of metal and plastic	65	P65/6.23/05	Part B
Lafarge	Nostell Road Scunthorpe	Cement batching	60	-	Part B - Revoked 2005
Cottage Beck Civic Amenity Site	Cottage Beck Road	Civic Amenity Site		43122	Civic amenity site
Cottage Beck Transfer Station	Cottage Beck Road	Transfer Station		43128	Transfer station
LAS Metals Ltd	Banbury Road	Metal Recycling		43105	Metal Recycling

Off-site: Table 4.12.1b below summarises the regulated processes that are present within the 250m Buffer Zone, the locations of these processes are shown on the map at Appendix 4.12.1b

Table 4.12.1b

Company Name	Address	Process Type	ID Number	Permit Ref	Part A/Part B
Carbon International	Brigg Road Scunthorpe	Coal coke, coal products	28	P28/3.5/05	Part B
Cemex UK Materials Ltd	East Common Lane, Scunthorpe	Cement batching	6	P6/3.1/04	Part B
Tata Steel UK Ltd	Brigg Road Scunthorpe	Iron and steel works	-	EA Permit BL38381W	A1
Caparo Merchant Bar plc				EA Permit BR88321K	

4.12.2 Petrol Filling Stations - On Site and within 250m

There are no known active petrol filling stations at present on site.

Historical maps record 14 former fuel storage sites within the boundary of the former landfill. The locations and available details of former fuel storage on the site are presented on a map and a table presented in Appendix 4.6s and 4.6t.

4.12.3 Control of Major Accident Hazard Sites (COMAH)

There are no COMAH sites on the site of the former landfill or within the 250m buffer zone. A map showing the nearest COMAH sites is presented at Appendix 4.12.3 together with comments from the HSE at Appendix 4.12.3(a).

4.12.4 Notification of Installations Handling Hazardous Substances (NIHHS) 1984 amended 2002

There are no known premises relating to the above act on site.

4.12.5 Planning Hazardous Consents

There have been no planning permissions relating to hazardous substances on site.

4.12.6 Radon

Radon is a natural radioactive gas. You cannot see, hear, feel or taste it. It comes from the minute amounts of uranium that occur naturally in all rocks and soils. Radon is present in all parts of the UK, although the gas disperses outdoors so levels are generally very low. The Action Level for radon inside domestic properties is 200 Becquerel's per cubic meter. The Action Level for radon inside commercial premises is 400 Becquerel's per cubic meter.

Geological conditions in certain areas can lead to higher than average levels. Midland Road and, indeed, much of the Scunthorpe area have low levels of radon with an average of about 20 Becquerel's per cubic meter. To ensure health protection, North Lincolnshire Council's Building Control Team has advised that development within this area would require a suitable radon protective damp proof membrane to offer adequate protection.

The map at Appendix 4.12.6 A indicates that the area of Scunthorpe, including the Midland Road landfill area, requires basic protection from Radon. The map at Appendix 4.12.6 B is taken from BR 211-2007 'Guidance on protective measures in new buildings' and indicates shaded areas requiring basic or full radon protection.

4.12.7 Invasive Species

The site walkover of the site carried out by council staff did not indicate the presence of any invasive species such as Japanese Knotweed.

4.12.8 Ecological Receptors

Checks made with the councils Environment Team have confirmed that the area of Midland Road former landfill site does not have any ecological receptors as defined in Table 4.12.8 below. There are, however, two areas designated as Local Wildlife Sites selected for their botanically rich grassland beyond the site but within the 250m buffer zone of this report. A map indicating these sites (shaded pink) is attached at Appendix 4.12.8.2A

Table 4.12.8 Designated Ecological Receptors: Source Annex 3, Table A Row 2 of Defra Circular 01/2006 Environmental Protection Act 1990: Part 2A Contaminated Land

Any ecological system, or living organism forming part of such a system, within a location which is:
• an area notified as an area of special scientific interest under section 28 of the Wildlife and Countryside Act 1981;
• any land declared a national nature reserve under section 35 of that Act;
• any area designated as a marine nature reserve under section 36 of that Act;
• an area of special protection for birds, established under section 3 of that Act;
• any European Site within the meaning of regulation 10 of the Conservation (Natural Habitats etc) Regulations 1994 (i.e. Special Areas of Conservation and Special Protection Areas);
• any candidate Special Areas of Conservation or potential Special Protection Areas given equivalent protection;
• any habitat or site afforded policy protection under paragraph 6 of Planning Policy Statement (PPS 9) on nature conservation (i.e. candidate Special Areas of Conservation, potential Special Protection Areas and listed Ramsar sites); or
• any nature reserve established under section 21 of the National Parks and Access to the Countryside Act 1949.

5 PLANNING HISTORY OF PERMITTED DEVELOPMENT ON MIDLAND ROAD LANDFILL

With reference to the Environment Agency guidance, Contaminated Land Capital Grants Guidance Note - April 2012-2013, Annex 1, Eligibility Criteria for Local Authority Programme no. 6, states "If the site has been granted planning permission since 1994 (the date PPG23 Planning and Pollution Control was published) for its current use, the proportion of the site to which the planning permission relates will not be eligible".

The following information provides details with regard to the planning history of the of the site itself and development within the 250m buffer zone and includes an analysis of planning permissions granted both pre-1994 and post 1994 in order that it is clear what proportion of the site was granted pre and post 1994.

This information has been taken from historical maps presented at Appendices 4.6a to 4.6i dated 1887-1995, summarised in the tables at Section 4.6.1 and 4.6.2, information provided by North Lincolnshire Council's Development Control department presented at Appendices 5.3a and 5.7a, summarised in the Table 1 at Section 5.4 below, and from information provided by North Lincolnshire Council's Property Assets Team and from the Local Land and Property Gazetteer.

5.1 Planning History and Development on Site

The majority of the commercial development on the Midland Road Industrial Estate took place prior to 1994. Contaminated land was not considered in granting of these permissions.

Records show that between 1994 and 2002 North Lincolnshire did not consider land contamination when granting planning permissions on or within 250m of the site.

5.2 Pre-1994 Development on Site

There are a total of 136 business premises on Midland Road Industrial Estate on top of the historic landfill; historical maps and planning records show the majority of commercial development of Midland Road Industrial Estate took place between 1960 and 1991.

Development of commercial premises started between 1960 and 1971 in the south, with Banbury Road being developed in the north between 1962 and 1993. Further commercial development took place between 1966 and 1991 when Midland Road was extended from the south to meet with Banbury Road. The north west of the site was developed between 1970 and 1980.

Searches of the planning archives have confirmed that approximately 133 of the 136 business premises were developed prior to 1994. **This equates to 98% of the business premises on site being established prior to 1994.**

5.3 Development 1994 to Present on Site

Ninety planning permissions were granted on the site between 1994 and 2010, a full list is presented at Appendix 5.3a.

Thirty-nine of these permissions were for structures such as buildings and extensions these have been summarised on a table presented at Appendix 5.3b and are plotted on a map presented at Appendix 5.3c. The remaining fifty-one were for irrelevant applications i.e. removal of conditions, change of pitch of roof.

Of the thirty-nine relevant applications for buildings, extensions etc, eleven planning applications were for new buildings, 8 on existing sites, 3 on new sites. This information indicates that approximately 133 of business premises were established prior to 1994. The remainder of the applications were for extensions and alterations to existing business premises.

The Environmental Protection Team sent memos to planners recommending contaminated land conditions or warning of the potential for landfill gas for nine of the thirty-nine applications, memos presented at Appendix 5.3d.

Seven of the thirty-nine permissions granted had contaminated land conditions, information provided at Appendix 5.3e, leaving thirty-two premises with no relevant conditions on the decision notices. Of the seven with contaminated land conditions, two of the applications had the conditions discharged through the planning process, information from Planning Enforcement presented at Appendix 5.3g.

5.4 Discussion/Table

The above information and figures taken from the table presented at Appendix 5.3b which lists the thirty-nine relevant applications post 1994, has been summarised on the table 5.4 below: Post 1994 approximately 2.0 % of new premises have not had contaminated land conditions applied to decision notices (this equates to two permissions granted in 1995 by Scunthorpe Borough Council and in 1998 granted by North Lincolnshire Council). These two premises will not influence the cost design and scope of the proposed site investigation.

Table 5.4

Approximate number of business premises	136
No. of planning applications post 1994	90
Relevant planning applications post 1994 - i.e. buildings, extensions, plus any structures requiring enclosed areas or intrusive work such as telecommunications works and associated kiosks. NB Some of these applications were for the same business premises	39
Irrelevant applications i.e. removal of conditions, change of pitch of roof	51
Of the 39 applications above - the number of applications relating to new buildings on site since 1994	11
Of the 11 new buildings built on site since 1994, the number of applications for new buildings relating to new business premises - the remainder of the new buildings post 1994 were on existing premises	3
Of the 39 granted - the number of those granted with contaminated land conditions	7

Number of premises with contaminated land conditions which have been discharged through the planning process	2
Memos sent to planners from Environmental Health recommending conditions or warning of the potential for landfill gas for the 39 granted	9

5.5 Planning History and Development within 250m Buffer Zone

The majority of the development in the buffer zone around Midland Road Industrial Estate took place prior to 1994 and land contamination was not considered when granting permission for development.

5.6 Pre 1994 Development within 250m Buffer Zone

Historical maps show the majority of the development of the buffer zone of Midland Road Industrial Estate took place in the 1950's and 1960's. Up until this time the majority of the buffer zone was open undeveloped land.

Development of the north east of the buffer zone began in the early 1900's with the Chemical Works associated with the steel works further north, road and rail networks were also developed in this area. The remainder of the buffer zone was developed during the 1950's with residential and commercial premises. The far south of the site was developed later during the 1960's.

5.7 Development 1994 to present within 250m Buffer Zone

One hundred and sixty-six planning permissions were granted in the buffer zone between 1994 and 2010, a full list of these is presented at Appendix 5.7a. Of these seventy-six were for structures such as buildings and extensions, these are summarised on a table presented at Appendix 5.7b and plotted on map presented at Appendix 5.7c. The remainder were for irrelevant applications i.e. installation of security gate, drop kerbs etc.

Of the seventy-six relevant applications, nineteen applications were for new structures/buildings. Of the nineteen applications, one was for ten link houses on one site; the remainder were for additional buildings on existing sites. The remaining fifty-seven applications were for extensions and alterations to existing businesses and residential premises.

The Environmental Protection Team sent a memo to planners recommending contaminated land conditions for one of the applications, memo presented at Appendix 5.7d. Contaminated land conditions were placed on the decision notice for this premise; there was no formal discharge of conditions through the planning process, information from Planning Enforcement presented at Appendix 5.7e. None of the remaining applications were granted with contaminated land conditions.

5.8 Discussion/Table

The above information and figures taken from the table presented at Appendix 5.7b which lists the relevant applications post 1994, has been summarised on the table 5.8 below:

Table 5.8

Total number of premises in the buffer zone	unknown
Number of planning applications post 1994	166
Relevant planning applications post 1994 - i.e. buildings, extensions, plus any structures requiring enclosed areas, or intrusive work NB Some of these applications were for the same premises	76
Irrelevant applications i.e. drop kerb	90
Of the 76 applications above - the number of applications relating to new buildings since 1994	19
Of the 19 new buildings built since 1994, the number of applications for new buildings relating to new sites - the remainder of the new buildings post 1994 were on existing sites	1
Of the 76 granted - the number of those granted with contaminated land conditions	1
Number of premises with contaminated land conditions which have been discharged through the planning process	No record
Memos sent to planners from Environmental Health recommending conditions or warning of the potential for landfill gas for the 39 granted	1

6. SITE OWNERSHIP

The site covers an area of approximately 39.8 hectares. Eighty percent of the site is used for commercial/industrial premises; the remaining 20% of the site is currently public open space.

The map presented at Appendix 6 shows North Lincolnshire Council owned land in blue.
Details of the properties owned by North Lincolnshire Council on and off site are presented at Appendix 6a and 6b respectively.

6.1 Site Ownership by North Lincolnshire Council

Of the 39.8 hectares, North Lincolnshire Council owns approximately 22.7 hectares, which equates to approximately 57% of the site. Thirty-five percent of the land owned by North Lincolnshire Council is public open space. A number of plots under North Lincolnshire Council ownership are leased or rented out to private companies.

6.2 Private Site Ownership

Approximately 17 hectares, which is approximately 43% of the site is under private ownership.

7 SUMMARY OF PREVIOUS GROUND INVESTIGATIONS

7.1 General

Whilst North Lincolnshire Council holds some records of investigations on the former Midland Road landfill, it is likely that much of the information held by the now dissolved Humberside County Council will have been lost during its transition to a Unitary Authority in 1996.

There are four reports summarised at Section 7.2 below. Two of the reports relate to the Council's Cottage Beck Road Depot which is located on the northern most boundary of the site and the other two reports involve site investigations which culminated in the construction of the vent trench on the west boundary of the site which borders residential properties on Warwick Road and Lilac Avenue.

7.2. Ground Investigation Report, Cottage Beck Road Council Depot, Scunthorpe

The Fleet Management Organisation, which was part of Humberside County Council (HCC), engaged the HCC Materials Testing Laboratory to carry out an intrusive site investigation to provide factual information on ground conditions to facilitate types of appropriate foundations for any future development on site. The following report was produced: *Ground Investigation Report, Cottage Beck, Scunthorpe dated December 1990, prepared by Humberside County Council, Technical Services Department-Materials Testing Laboratory*. Referenced 84/12/3/MFW/SAR

Two light percussive shell and auger boreholes were sunk at locations presented in Appendix 4.2.A. No groundwater was encountered in either borehole and the strata encountered are set out in Table 7.2 below. No chemical testing or ground gas monitoring was undertaken, but the logs provide a useful indication of the nature of the underlying ground at Cottage Beck Road Depot.

Table 7.2 Borehole Strata

Strata BH1	**Depth BH1**	**Strata BH2**	**Depth BH2**
Made ground, black & grey mottled clayey, silty sand with fine to course fragments of brick, concrete, glass, wood, coal and glacial gravel.	4.0m	Made ground - tarmac	0.30m
		Made ground, black & grey mottled clayey, silty sand with fine to course fragments of brick, concrete, glass, wood, coal and glacial gravel.	3.2 m
Orange brown silty fine to medium sand with occasional fine to medium gravel of predominantly limestone	4.00-5.1m	Orange brown silty fine to medium sand with occasional fine to medium sub rounded gravel	3.2-3.7 m
Dark grey thinly laminated slightly to moderate weathered calcareous mudstone – Scunthorpe Mudstone weathered with depth	5.1-5.8m	Dark grey thinly laminated slightly to moderate weathered calcareous mudstone – Scunthorpe Mudstone	3.7 -4.30m

7.3 Landfill Gas Survey Midland Road Industrial Estate

Scunthorpe Borough Council initiated an investigation of the Midland Road Industrial Estate in 1990; the main purpose of the assessment was to:

- Assess the risks posed to and recommend risk management measures for properties on and around the Midland Road Industrial Estate.
- Provide a specification for appropriate risk management measures at the site

The following reports were produced:

Report on a Landfill Gas Survey at Midland Road Industrial Estate, Scunthorpe – dated November 1990, referenced AEA-EE-0071 and prepared by The Environmental Safety Centre, Harwell Laboratory.
Report on a Landfill Gas Survey At Midland Road Industrial Estate Scunthorpe Part 2

The report consisted of a desk top study, a gas survey of industrial properties and a site investigation.

The report identified 3 main areas for investigation:-

1. A large portion of the site occupied by industrial premises forming the Midland Road Industrial Estate
2. An open area containing rough land, designated for further industrial development and a similar ‘cut grass’ area used as a playing field/open space.
3. Land bordering the site which includes domestic housing to the west, further industrial premises to the north-west and south-east, and a railway line, trunk road (Brigg Road) and the Steel Works.

A plan of the areas is presented in Figure 3 attached at Appendix 7.2.2.A

Much of the area containing industrial premises is covered by concrete hard standing, paving and tarmac roads. There is a history of problems with the industrial premises, such as cracking of floors and walls, together with roadways and pavement damage probably due to settlement. There are no recorded incidents arising from landfill gas although during the 1990 field survey some occupants of premises complained of odour problems and occasional headaches, this, however, is not substantiated.

7.3.1 Thumper Bar Survey 1 January 1989

A thumper bar gas survey to assess levels of methane and oxygen was undertaken by Scunthorpe Borough Council between April 1989 and October 1990 at 54 locations, details of which are presented in Figure 5 Appendix 7.2.2.B. The results of the thumper bar survey are recorded in Table 5 at Appendix 7.2.2.C.

All of the sample points taken in residential gardens on Lilac Avenue showed elevated levels of methane and depleted levels of oxygen. The maximum levels of methane recorded in the garden areas on Lilac Avenue were 78% and 66% Vol methane. The majority of samples taken on the industrial estate also demonstrated elevated levels of methane with maximum recorded levels of 70% Vol methane being recorded at a property on Midland Road. Lower levels of methane were recorded to the south east of Nostell Road which is thought to have older waste deposits dating from the 1940's to perhaps the 1960's.

The Council's Cottage Beck Road Depot gave a methane reading of 58% Vol.

7.3.2 Scunthorpe Borough Council Internal Gas Survey 1 April 1989-October 1990

A gas survey was undertaken internally inside commercial properties on the industrial estate and one residential property on Midland Road. The type of instrument used is not known but anecdotal evidence suggests the monitoring was carried out using staff that were unfamiliar with this type of equipment and method of monitoring and the equipment used was not calibrated.

Scunthorpe Borough Council carried out an indoor monitoring exercise at 27 commercial properties on the site between April 1989 and October 1990. Results can be seen in Table 4 at Appendix 7.2.2.D of this report.

Monitoring took place in drains and service entries measuring total flammable gases. The one residential location showed no elevated levels of gases. Plots 29 and 33 on Midland Road showed the maximum recorded levels of flammable gases at 70% and 45% LEL respectively. Other properties showed low to negligible levels of flammable gases.

It is unclear how frequently the monitoring was undertaken.

7.3.3 Thumper Bar Survey 2 April 1989- October 1990

A further thumper bar survey was undertaken by Scunthorpe Borough Council at 51 locations details of which are presented in Figure 5 Appendix 7.2.2.B. It is unclear how frequently the monitoring was undertaken during this period and results presented possibly show maximum recorded levels only. The type of instrument used is not known but anecdotal evidence suggests the monitoring was carried out using staff that were unfamiliar with this type of equipment and method of monitoring and the equipment used was not calibrated.

The residential properties on Lilac Avenue showed no elevated levels of methane. Eighteen industrial premises showed elevated levels of methane with a maximum value of 50% Vol.

7.3.4 Trial Pits and Probes 1990

Eleven Trial pits were excavated with a JCB to identify the nature of the underlying deposits and allow installation of gas monitoring pipes prior to back filling. “Aquapipe” of 50mm diameter and 1.5 m length were used in the boreholes. The report stated that the top 1.5 m of the tube was non perforated.

An additional five locations had a 30 cm perforated narrow steel tube inserted to act as further gas monitoring locations; these were connected to 25mm mild steel tubing. The depth of the tubing is unknown.

The locations of the trail pits and probes are presented on Figure 6 Appendix 7.2.2.E. No chemical testing was undertaken and no gas sampling was undertaken for trial pit 4 and 5. The arisings from the trial pits are set out in Table 7.3.4 below. No water strikes were recorded in the trial pits apart from borehole 1 at 2.6m.

Gas monitoring was undertaken on 2-3 occasions the results of which are set out in table 7.3.4a below. No weather conditions, flow rates or atmospheric pressure was recorded. Elevated levels of methane were identified on the recreational ground area and the industrial estate area. Low levels of gases were identified in the 5 probes with a maximum value of 2000ppm being identified adjacent to residential properties on Lilac Avenue. Results are presented in Table 7.3.4b below.

Table 7.3.4 Waste Arisings Found

Trial Pit	arisings found during 25/10 & 1/11/90 intrusive works
TP1	**Between 0 and 3.0m** Dry blackened domestic refuse with wood, bricks, rubber tubing, paper, concrete blocks. Water ingress at 2.6m
TP2	**0m** Thick grass, **0.3m** Very dry sand, **0.5 to1m** Dry domestic refuse, plastics, paper, bricks & bottles. **1 -3m** Ash burnt bricks, wood, very dry
TP3	**0.1 -0.3m** Topsoil, **0.3 – 2m** Sandy soil, **2m** Waste, plastic, plastic sacks, domestic waste with small quantity of paper., hard rock infill : hole abandoned
TP4 No pipe inserted	**0 – 0.2m** Topsoil, **1m** Sand, hole abandoned
TP5 No pipe inserted	**0.0-0.1m** Topsoil, **0.1 – 2m** Shale/Sand no waste
TP6	**0.0-0.1m** Topsoil **0.1 – 2.5m** waste, brick, plastic, general industrial waste, no paper , **2.5 – 3m** Clay
TP7	**0 – 0.1m** top soil, **0.1-3.0m** waste-ash, sand, bottles, no organic degradable material
TP8	**0.0 -0.5m** Sandy soil, **0.5-2.5m** pulverised waste – newsprint (no date, but still in £.s.d), **2.5-3.0m** soil/clay some brick waste
TP9	**0-0.1m** Soil/rubble, **0.1-0.2m** Waste (HV Mains Cable), **0.2-2.8m** Waste – some pulverised (magazines still readable)
TP10	**0-0.1m** Topsoil, **0.1 – 1.6m** Waste –bricks/rubble, very little plastic., **1.6 -2.5m** Sand – site base
TP11	**0 – 1.5m** made ground, hardcore, **1.5m** hard concrete ? old road ? floor slab

Table 7.3.4a Trial Pits

Trial Pit Number	25/10/90			1/11/90		
	% CH4	% Vol O_2	% VolCO_2	% CH4	% O_2	% CO_2
TP1	80%LEL	17		26%LEL	<1	8
TP2	60 % Vol	<1.0		44 % Vol	0	40
TP3	48 % Vol	<3.0		12 % Vol	0	27
TP6	2%LEL			11 % Vol	6	12
TP7	8%LEL			4%LEL	4	7
TP8	50 % Vol	<0.5		4-30%LEL	4-15	1
TP9	6 % Vol	<0.1	6.0%	4.5%LEL	2	12
TP10	Trace	18		0.5%LEL	15-20	3.5
TP11	8%LEL	10		1%LEL	9	5

Table 7.3.4b Probes

Probe Number	25/10/90		1/11/90		2/11/90	
	% CH4 (ppm)	% CO_2 (ppm)	% CH4 (ppm)	% CO_2 (ppm)	% CH4 (ppm)	% CO_2 (ppm)
P1	1000		60	0.5	0	2.0
P2	2000		800	0.5	100	0.2
P3					0	2.0
P4					0	3.0
P5					0	0

7.3.5 Thumper Bar Survey 3 October –November 1990

Twenty six thumper bar measurements were taken in the gardens of 23 residential properties and 3 locations on Banbury Road and Colin Road. Locations can be seen in Figure 7 at Appendix 7.2.2.F and results in Table 8 at Appendix 7.2.2.G. The results showed negligible levels of methane and CO2 with the exception of LAS Metals on Banbury Road which presented a maximum reading of 45% Vol methane.

7.3.6 Internal Gas Survey 2 October – November 1990

Further indoor gas monitoring took place at 96 commercial premises by testing service ingress points and inspection pits etc although properties along East Common Lane, Grange Lane North, Colin Road, Banbury Road and Cottage Beck Road were investigated at a later stage and reported in the Part 2 report.. Results of testing are presented in Table 9 Appendix 7.2.2.H of this report. The maximum level of flammable gases recorded for this monitoring was 6% LEL and 32% LEL.

7.3.7 Recommendations of Report

Based upon the findings of the site investigation and monitoring the report put forward the following recommendations:

- All properties to be fitted with flammable gas and carbon dioxide alarms.
- All properties to be surveyed annually for evidence of subsidence
- All properties to be sealed where cracks have been seen.
- Permanent gas monitoring locations to be put in place.

- A gas vent trench to be constructed along the boundary of the landfill and gardens of Warwick Road/Lilac Avenue.
- All service providers to the premises to be advised of potential for flammable, noxious and asphyxiant gases below ground/structures.
- Any new planning application/approval should be subject to a detailed assessment of gas quality/production, together with any requirement to control/remediate a site.

7.4 Annex to Report AEA-EE-0071 Tender Specifications

Specifications for the following were included in the annexe report:

- Fixed methane and carbon dioxide alarm meters in premises as detailed in annex.
- Installation of 7 permanent gas monitoring boreholes both within and beyond the site boundary.
- Installation of a gas venting trench along the western boundary adjacent to residential properties along Warwick Road/Lilac Avenue, one within the grassed area and at two locations within the site. Figure B at Appendix 7.4.1 indicates locations.

7.5 Site Investigation Report – LAS Metals, Midland Road, Scunthorpe dated 1 August 2006, and prepared by T.L.P. Ground Investigations in support of a planning application 2008/1404.

The purpose of the report was to identify the soil, ground gas and groundwater conditions for the development site which was to erect a workshop and offices.

Gas testing took the form of 5 spike bars to a depth of 1.5m which were monitored on one occasion in 2006. Methane, carbon dioxide and oxygen were measured and the worst case values are presented in table 7.5 below.

Table 7.5

Max % vol CH4	Max % vol CO2	Lowest % vol O2
48	15	10

Five trial pits were dug to a maximum depth of 4.0m, one groundwater seepage was noted at 3.85m. The depth of the waste deposits were only found in one of the trial pits which identified the depth of the waste at 4.0m. Waste was identified as plastic, timber, scrap metal, fabric, sacking, strapping, wire and ash mixed in with a silty and clayey sand which contained stones and gravel. The depth of the Scunthorpe Mudstone was found to be 4.0m.

Limited surface soil sampling was undertaken at a depth of 0.5 - 1.0m, including pH, phenols, cyanides sulphate, metals and semi metals, speciated poly-aromatic hydrocarbons, speciated total petroleum hydrocarbons and volatile and semi volatile organic compounds. The levels identified did not indicate a risk to human health based upon a commercial end use. The site was not assessed in terms of risk to controlled waters.

The report was not accepted by the Council as being adequate and further work/information was requested. This site has now been developed and the contaminated land conditions placed on the decision notice are still in place.

7.6 Risk Management Measures Undertaken following 1990 Site Investigation

Tenders were put out to companies with regard to the installation of a gas venting trench and 7 permanent monitoring boreholes.

7.6.1 Venting Trench

Work on the trench commenced on 13 December 1993.

The specifications for the trench were as follows:-

Length -Approximately 494 metres between 54 Lilac Avenue & 85 Warwick road
Depth To 0.5m into underlying mudstone formation or 5m whichever was the lower depth.
Width 1 metre.

Geotextile Required to separate the membrane from the course granular fill – Life expectancy 120 years. Overlap a minimum of 300mm.

GeoMembrane A high density polyethylene impermeable membrane liner with a design life of 30 years as a minimum and not less than 1.0mm thick. Joint overlap to be a minimum of 500mm. All drains. Sewers and pipes to be sealed.

Photographs were taken during construction and two are attached as Appendix 7.6.1.A illustrating the process. A diagram of the vent trench construction and location is provided in Appendix 7.6.1 B and 7.6.1 C

7.6.2 Construction of Boreholes

Following the recommendations of the AEA report to install permanent gas monitoring boreholes, tenders for those works were received by Scunthorpe Borough Council in late 1991 and shortly thereafter 7 permanent gas monitoring boreholes were located at the points shown in Appendix 7.6.2 A. Boreholes 1A, 2A and 3A whilst being recorded as having been constructed on the map were not accounted for in the tender documents referred to above.

The boreholes were constructed with 50mm slotted standpipes with push on end caps, monitoring valves, bentonite seals and metal covers. The last metre of each pipe being of 50mm solid pipe. Boreholes 1 to 4 were installed to a depth of 6 metres in virgin ground and 5 to 7 in areas of known waste to a depth of 4 metres. Appendix 7.6.2.B shows the construction of the wells installed, 7.6.2.C shows the monitoring head installed and 7.6.2.D shows the cover type. Borehole log records can be seen at Appendix 7.6.2.E.

Boreholes 1 to 4 continue to be monitored by North Lincolnshire Council but 5, 6 and 7 have been lost due to changes in development and in the case of 5 (central on the recreational field) due to lack of use and overgrowth of vegetation.

7.6.3 Industrial Estate Properties

Scunthorpe Borough Council wrote to businesses that were the subject of internal gas monitoring and advised them of the results. They were advised whether or not levels found exceeded Health and Safety at Work limits and were provided with generic safety advice. They were also advised to ensure that fixed gas monitoring alarms were fitted in buildings.

7.7 Review of Previous Ground Investigations

The thumper bar testing used to assess ground gas conditions in the AEA report will not reflect deeper gas concentrations and the single instant readings are unlikely to provide a reliable and robust analysis of the ground gas regime on the site. Soil gas might be diluted if the surface is not sealed adequately or driving the spike can reduce permeability and inhibit ingress of soil into the hole and loose earth or water may clog the hole. Therefore where no ground gas has been identified using this method it cannot be assumed that there is an absence of ground soils gases underneath the testing area. Shallow driven probes used in the AEA investigation also suffer from similar problems and where the shallow driven probes identify low or absent levels of gases, sole reliance on this type cannot be used to draw conclusions about the ground gas regime on the site. Further investigation would always be required by installing permanent gas monitoring wells.

The trial pit gas installations are also not viewed as a robust method of ground gas analysis, as the results are often unreliable due to issues such as backfilled waste arisings allowing venting of gas, backfilling of material altering the ground gas regime and ground conditions can as a result take a long time to stabilise. The depth of the monitoring is also restricted to shallow depths and does not reflect the deeper gas regime on the site. In this instance the trial pits reached a depth in the order of 3.0 m whilst the waste is thought to be at a depth of 6.0 m or more.

The internal gas monitoring undertaken may have suffered interference from other materials such as solvents used at industrial processes and as such cannot be relied upon to identify the source of the flammable gases identified. The absence of gas concentrations cannot be used to prove the absence of gas but this data provides information on potential gas ingress routes that might require immediate attention.

The ground gas monitoring locations on the Midland Road landfill lack detail in terms of the number and spatial positioning of trial pit and probe gas monitoring locations and the temporal resolution in which the data was collected to be able to draw any robust conclusions about the site. It is important when assessing the ground gas regime on a site that sufficient gas monitoring readings are taken over time and at an appropriate frequency. However the number frequency and duration of monitoring does not comply

with current guidance contained in CIRIA C665 (2007). There is an absence of critical information such as gas flow rate data, atmospheric pressure readings, weather data, water level within monitoring locations, ambient temperature and ground conditions.

There is also a lack of information about migration of ground gases from the site including both the industrial and residential areas adjacent to the former landfill.

It is clear however that the data collated demonstrated that the site was producing significant % volumes of methane and carbon dioxide including the industrial area, and the recreational field. Table 7.7 below shows the maximum methane and carbon dioxide levels on the recreational and industrial areas of the site. Horizontal and vertical migration of the gas identified is possible but gas concentration is a poor indicator of migration and surface emission risks. However the data collated does not allow a mathematical assessment of gas migration potential.

Table 7.7

	Max % Vol CH4	**Max % Vol CO2**	**Lowest % vol O2**
Industrial Area 1990	50	12	<0.1
Recreational Area 1990	78	40%	<1.0
Off site migration	No data	No data	No data
Plot 44 Midland Road 2006	48	15	10

The data collected in the AEA report did not consider risks posed to controlled waters by the landfill waste, as chemical testing of the underlying waste, leachate and groundwater analysis was not undertaken. Risks posed to human health from underlying waste was also not considered.

The site investigation carried out on behalf of LAS Metals in 2006, suffered from similar issues in terms of lack of robust ground gas data. However the results obtained seem to indicate that significant % volumes of methane and carbon dioxide were still being produced, as identified in table 7.7a. below. Chemical testing of the surface deposits on site appeared to indicate that levels of contamination were acceptable, however the nature of the testing suite and the depth of the samples taken do not provide a robust analysis of the site conditions in terms of risks to human health and controlled waters.

Table 7.7a Results of Gas Analysis

	% v/v CH4	**% v/v CO2**	**% v/v O2**
Borehole1	16.0	4.9	13.6
Borehole 2	9.0	3.4	13.9
Borehole 3	8.0	4.0	12.6
Borehole 4	48.0	15.0	10.0
Borehole 5	12.0	2.1	14.6

8 GROUND GAS MONITORING DATA

8.1 Ground Gas Data Collection 1991 to 1995 and 2006 to Present

Following installation of the vent trench on the Midland Road site Scunthorpe Borough Council undertook gas monitoring from ten boreholes on the site from 1991 to 1996. Council staff monitored the following parameters: Methane, carbon dioxide, oxygen and barometric pressure. On occasions the weather conditions were noted. The Council had no facility to monitor gas flow rates.

The location of the boreholes monitored during this period can be found in Appendix7.6.2 A. Seven of the boreholes were located on the eastern boundary of the vent trench, the remaining three locations were located on the centre of the recreation field, on an industrial site located on the eastern boundary of the landfill and an industrial unit located approximately 200m from the southern boundary of the site. Staff who undertook the monitoring had not undertaken any formal training and the transposing of results onto spreadsheets often resulted in inconsistent data capture. When Scunthorpe Borough Council became part of North Lincolnshire Unitary Authority in April 1996 gas monitoring on the site ceased.

In 2006 North Lincolnshire Council attempted to relocate the boreholes and re-initiate gas monitoring. By this time however the majority of the boreholes were either lost or broken and current gas monitoring therefore takes place on 4 remaining borehole locations (Borehole 1, 2, 3, and 4).

Monitoring for the period 2006 to present has been undertaken by outside contractors Veolia using a Geotechnical Instrument Gem2000. Their protocol for monitoring can be found in Appendix 8.1. The following parameters have been monitored by the council: methane, carbon dioxide, oxygen, hydrogen, hydrogen sulphide, carbon monoxide and atmospheric pressure. Flow rate has been intermittently monitored by the contractors from 2006 until March 2011 and after this date flow rate monitoring has been undertaken for each monitoring round.

8.2 Gases Monitored

Methane, carbon dioxide, hydrogen sulphide, carbon monoxide and hydrogen have been monitored on the site. Details of their toxic and explosive characteristics can be found in Appendix 8.2.

8.3 Ground Gas Monitoring Results Obtained 1991-1995

The gas data collected and associated gas plots are presented in Appendix 8.3 summary of the data showing peak and mean gas levels are tabulated in Appendix 8.3A.

8.3.1 Methane

Borehole 7 (offsite) did not demonstrate elevated levels of methane but did show one occasion of elevated levels of carbon dioxide (15% Vol) with the remaining measurements being around 5% Vol.

Borehole 6 (eastern boundary of the site) showed three occasions of elevated levels of methane (80%, 20% 15% Vol) over the four year monitoring period.

Borehole 5 (centre of the recreational field and landfill site) showed consistently elevated levels of methane (above 30% Vol) with a peak of 61% and depleted levels of oxygen.

The boreholes located on the perimeter of the vent trench all demonstrated elevated levels of methane with peak values all above 10% Vol. Borehole 2 and borehole 4 had highest methane levels with both boreholes having peak values of 80% Vol and mean values of 26 % and 27 % Vol respectively.

As no flow rates are available for this period of monitoring no methane gas screening values have been calculated for this period.

8.3.2 Carbon Dioxide

Maximum carbon dioxide levels were seen in borehole 2A (peak 44% Vol) with borehole 7 at (peak 15% Vol) , borehole 1A (peak 16% vol) borehole 1 (peak 12% vol) and borehole 2A (peak 8.87 % Vol). The remaining boreholes produced peak levels around 5% Vol.

As no flow rates are available for this period of monitoring no carbon dioxide gas screening values have been calculated for this period.

8.3.3 Barometric Pressure

The barometric pressure measurements noted during this period were obtained from a office wall mounted barometer. The results transposed onto spreadsheets appear inconsistent and unreliable. However periods of high (1028 mb) and falling pressure appear to have been monitored during this four year period.

8.4 Ground Gas Monitoring Results Obtained 2006-2011

The gas data collected and associated gas plots are presented in Appendix 8.3. A summary of the data showing peak and mean gas levels are presented below in Table 2 below.

8.4.1 Methane

Borehole 1 has produced no methane over the 5 year monitoring period with zero or no recorded flow rate. Borehole 3 produced a peak level of 4.2% Vol in 2008 with zero or no recorded flow rates. Borehole 4 produced a peak level of 1% Vol in 2007 but had zero or no recorded flow rate. Borehole 2 has the highest levels of methane with a peak value of 72.1% Vol in 2007 and the borehole has a maximum flow rate of 4.7 l/hr.

Using the worst credible approach a GSV has been calculated for each set of readings in order to identify and assign the site with the maximum value GSV methane for borehole 2. The results are presented in Table 8.4.1 below

This method gives a GSV (CH4) of 3.1 in 2007. If more recent 2010 data is used in isolation then a GSV (CH4) of 0.15 could be assigned. The lack of robust flow rate data does not however provide confidence that these values can be relied upon as being representative.

Using the worst possible approach to calculate the GSV (CH4) the highest flow rates and highest gas concentration have been combined for borehole 2 and are presented in Table 8.4.1 below.

8.4.2 Carbon Dioxide

Borehole 1 produced a peak level of 10.5% Vol in 2006 but had zero or no recorded flow rate. Borehole 3 produced a peak level of 8.1% Vol in 2009 with zero or no recorded flow rate. Borehole 4 produced a peak value of 10.7% vol in 2007 but had zero or no recorded flow rate. Borehole 2 produced the highest level of carbon dioxide with a peak value of 28.6% Vol in 2008 with a maximum flow rate of 4.7 l/hr.

GSV's for carbon dioxide in borehole 2 have also been calculated where flow rates were available and are presented in Table 8.4.2 below. Using the worst credible approach a GSV has been calculated for each set of readings in order to identify and assign the site with the maximum value GSV for carbon dioxide. This provides a GSV (C02) of 0.95 in 2007. If more recent 2010 data is used then a GSV of 0.15 could be assigned as a GSV (CO2). The lack of robust flow rate data does not however provide confidence that these values can be relied upon as being representative.

Using the worst possible approach to calculate the GSV (CO2) the highest flow rates and highest gas concentration have been combined for borehole 2 and are presented in Table 8.4.2a below.

Table 8.4.1 Worst Credible Approach Gas Screening Values for Methane and Carbon Dioxide

Borehole 2 GSV CH4	Date	Borehole 2 GSV CO2	Date
0.75	14/09/2006	0.35	14/09/2006
1.55	19/10/2006	0.66	19/10/2006
2.45	03/07/2007	0.69	03/07/2007
3.1	16/07/2007	0.95	16/07/2007
2.13	23/07/2007	0.68	27/07/2007
0.71	09/08/2007	0.33	09/08/2007
0.15	03/03/2010	0.15	03/03/2010
0.04	16/03/2010	0.06	16/03/2010

Table 8.4.2 Worst Possible Approach GSV Methane

Borehole 2 Maximum flow rate l/hr	Borehole 2 Maximum CH4 %Vol	GSV
4.7	72.1	3.38

Table 8.4.2a Worst Possible Approach GSV Carbon Dioxide

Borehole 2 Maximum flow rate l/hr	Borehole 2 Maximum CO2 % Vol	GSV
4.7	28.6	1.34

8.4.3 Hydrogen Sulphide

Peak levels of hydrogen sulphide have been identified in borehole 2 at 18 ppm, which would typically be associated with a strong offensive odour. These levels exceed current Occupational Exposure Limits (OEL's) presented in Appendix 8.2 but are well below the Lower Explosive Limit of hydrogen sulphide at 4,500 ppm.

Adverse health effects from hydrogen sulphide gas exposure occur at a number of orders of magnitude below the LEL. There is currently no evidence to suggest that residents adjacent to the landfill site on Lilac Avenue and Warwick Road have ever had cause to complain about odours that might be associated with hydrogen sulphide gas.

8.5 Factors Influencing Ground Gas Emissions at Midland Road

Table 8.5 below sets out the main influencing factors on landfill site degradation and the associated gas and leachate production. The fundamental influencing factors of ground gas emissions are discussed below.

8.5.1 Seasonal Variation

Seasonal variation can influence landfill gas migration. Frozen soil over the landfill may provide a barrier to upward landfill migration and can retard the microbial process of degradation due to reduced temperatures and moisture. Freeze/thaw cracks might cause landfill gas to migrate upwards or horizontally, whilst warmer summer months tend to increase gas diffusion. The results do not present obvious seasonal variation, however during the last 2 years (2009 and 2010) of monitoring in Borehole 2, methane levels have peaked in the winter months and reduced during the summer months. This

might be due to an increased dryness in the waste during the summer months which might have retarded methane production.

8.5.2 Atmospheric Pressure

The difference between soil gas pressure and barometric pressure allows gas to move either vertically or laterally depending on whether the barometric pressure is higher or lower than the soil gas pressure. When barometric pressure is falling, landfill gas will tend to migrate out of the landfill into surrounding areas. The data gathered seems to demonstrate that peak gas emissions correspond to periods of low or falling pressure as can be seen on the scatter plots of methane v's atmospheric pressure plotted for borehole 2 presented in Appendix 8.3.

However no data is available for the barometric pressure two days preceding that identified on the day of monitoring and therefore it is difficult to make robust interpretations about the ground gas data.

8.5.3 Groundwater Levels

Gas movement is influenced by variations in the groundwater table. If the water table is rising into an area it will force the landfill gas upwards. However no data has been collected on groundwater levels within the landfill area during the period of ground gas monitoring and therefore no inferences have been drawn on this aspect.

8.5.4 Temperature

Increases in temperature stimulate gas particle movement and gas diffusion. Although the landfill itself might maintain a stable temperature, surface air temperature can be related to the surface emission rate. Due to the absence of borehole temperature and air temperature data it has not been possible to draw any conclusions about this potential relationship.

8.5.5 Moisture

Soil water content influences both the permeability and diffusivity of the soil. Therefore the amount of precipitation and moisture in the soil has an effect on landfill gas migration. Increased soil moisture can reduce the available pore space for gaseous transport and reduce diffusion. However it is also possible that soil moisture may seep through pore spaces to push out gases into these spaces. The presence of a certain amount of water in a landfill increases gas production as the moisture encourages bacterial growth and transports nutrients and bacteria to all areas of the landfill. Suggested moisture content for waste degradation ranges from 25-40 % volume. At levels below 20% biological reactions would stop.

Weather conditions during monitoring have not been fully recorded and therefore it is difficult to draw any definite conclusions about the relationship between moisture and ground gas emissions at the site. The moisture content of the waste is at present unknown; however it is possible that the waste is quite dry in areas due to the amount

of hard surfacing on the industrial estate. The recreational area is not thought to have a properly constructed clay cap so it is possible that the rainfall has been allowed to infiltrate the waste in this area thereby producing moisture levels that are preferable for landfill degradation.

8.5.6 Waste Composition

The higher the organic content of waste the more landfill gas is produced during bacterial decomposition. Large quantities of chemicals disposed to landfill are more likely to produce non methane organic carbons (NMOC) and other gases either through volatilisation or chemical reactions.

The site accepted construction and demolition waste which will increase the likelihood of hydrogen sulphide emissions and NMOC emissions at the site. Any increase in hydrogen sulphide emissions can lead to decreases in methanogenesis. The site also accepted untreated domestic waste, the organic content of which can be assumed to be quite high including items such as food, garden waste, street sweepings, textiles and wood and paper products. Pictures taken of tipping at the site presented (date unknown) in Appendix 4.2 E (1-15) appear to show high levels of paper waste.

The site also accepted mechanically treated pulverised waste this is known to increase the homogeneity of the waste by size reduction and mixing. These smaller waste particles decompose quicker due to their high surface area and mass ratio and the shredding aids to remove moisture barriers caused by impermeable materials. The water content distribution through this type of waste is also improved. These latter factors are thought to speed up methane production.

However shredded waste is also thought to have a negative effect on degradation of waste due to promoting excessive initial hydrolysis and acid formation (phase II acid phase of landfill gas generation) which prevents or postpones the start of CH_4 formation and the methanogenic environment of Phase III. It is possible therefore that the shredded waste retarded methane production, though the timeframe associated with this potential delay is unknown. Buffering of the waste is known to help establish methanogenic conditions.

8.5.7 Age of Refuse

Peak gas production usually occurs in the order of 7-10 years after the waste is buried with gas production continuing for a period of 40 years or more. The wastes deposited at the Midland Road site are expected to span a time epoch in the order of 30 years or more from approximately 1948 -1978. Due to the fact that different wastes were deposited in the site at different times and under differing conditions, different phases of landfill gas production may be occurring simultaneously on the site at any one time.

Table 8.5. Summary of Influencing Factors on Landfill Degradation (Source STS Yuen 2001)

Influencing factors	Criteria / Comments	References
Moisture	Optimum moisture content : 60% and above (by wet mass)	Pohland (1986) ; Rees (1980)
Oxygen	Optimum redox potential for methanogenesis: -200mV - 300mV below -100mV	Farquhar and Rovers (1973) Christensen and Kjelden (1989) Pohland (1980)
pH	Optimum pH for methanogenesis: 6 to 8 6.4 to 7.2	Ehrig(1983)/ Farquhar and Rovers(1973)
Alkalinity	Optimum alkalinity for methanogenesis : 2000mg/l Maximum organic acids concentration for methanogenesis : 3000mg/l Maximum acetic acid/alkalinity ratio for methanogenesis : 0.8	Farquhar and Rovers (1973) Farquhar and Rovers (1973) Ehrig (1983)
Temperature	Optimum temperature for methanogenesis : 40o 41o 34—38oC	Rees (1980) Hartz et al. (1982) Mata-Alvarez et al. (1986)
Hydrogen	Partial hydrogen pressure for acetogenesis: below 10-6 atm.	Barlaz et al. (1987)
Nutrients	Generally adequate in most landfill except local systems due to heterogeneity	Christensen and Kjelden (1989)
Sulphate	Increase in sulphate decreases methanogenesis	Christensen and Kjelden 1989)
Inhibitors	Cation concentrations producing moderate inhibition (mg/ l) : Sodium 3500-5500 Potassium 2500-4500 Calcium 2500-4500 Magnesium 1000-1500 Ammonium(total) 1500-3000 Heavy metals : No significant influence Organic compounds : Inhibitory only in significant amount	McCarty and McKinney (1961) Ehrig(1983) Christensen and Kjelden(1989)

8.6 Quality of Ground Gas Data Collected

8.6.1 Spatial Resolution

The boreholes placed on the site were poorly resolved spatially when installed in the early 1990's. This issue has been further compounded by the loss of six boreholes during the period of ground gas monitoring. Therefore the remaining 4 boreholes on the site only provide data about ground gas emissions on the western boundary of the site adjacent to the vent trench. To improve the spatial resolution for the site a greater number of boreholes would be necessary.

8.6.2 Temporal Resolution

The results obtained provide a good temporal resolution of approximately 9 years. However the robustness of the inferences that can be drawn from this data is reduced by the lack and/or absence of flow rate data throughout the nine year period of ground

gas monitoring. The first five years did not provide any flow rate data and the last 4 years has provided sporadic unreliable flow rate data. The Council has been advised that flow rate data has only been gathered on a regular basis from March 2011 onwards. It can therefore be inferred that flow rate data inputted before this date may not be reliable.

9 COMPLAINTS / INCIDENTS

9.1 Council Offices Cottage Beck Road Scunthorpe

The Cottage Beck Road site is occupied by the council's Fleet Management Services and consists of council office buildings and a large external area used for storage and washing of domestic refuse and recycling vehicles. Next-door to this site is the Council's Household Recycling Site. Maps of the site are presented in Appendix .4.15 a & b. The site is thought to be located on top of the former Midland Road landfill site, and is not thought to have any gas protection measures in place. The building construction is a ground bearing floor slab.

On the 10th February 2010, National Grid was called out to attend and investigate smells of gas inside council offices at Cottage Beck Road, Scunthorpe. The call was made in response to number of members of staff being able to smell gas inside their offices.

National Grid attended and tested the site internally and externally for flammable gases. As a result they identified 13% LEL of flammable gases in a store cupboard which was directly adjacent to the offices where the complaints had initially arisen.

National Grid tested their mains gas supply and concluded that the flammable gas levels were not associated with any fault or leak on the main supply system. National Grid then dug a trench outside and adjacent to the cupboard where the elevated gas concentrations had been identified. As a result of this excavation National Grid advised the council that flammable gas levels in the cupboard dropped to 3% LEL.

Prior to and during this incident the council was in the process of upgrading the external storage and washing areas for the council's fleet of vehicles. Historically the exterior of the site was a mixture of soft and poorly maintained areas of hard landscaping. The upgrading resulted in the laying of new surface water drainage and a new concrete pad to cover the whole of the site. Any areas of soft landscaping and or cracks in hard surfaced areas were therefore sealed preventing the escape of any potential ground gas emissions. This work might have had an impact upon any underlying ground gas regime.

As part of the investigation of this incident it came to light that employees in these council offices had at times over the years complained of smells of gas and had suffered headaches. Anecdotal evidence suggests that the complaints were restricted to the same area/offices of the building.

Following this incident the council carried out the gas monitoring the details of which are presented in Table 9.1 below. In June 2011 the council installed a fixed gas monitoring system.

Table 9.1 Gas Monitoring Carried out at Cottage Beck Road Council Depot

Monitoring Type/Location	**Dates**	**Outcome**
Portable flammable gas monitor used by National Grid in Store cupboard	11-02-10	Identified 13%LEL flammable gas in a store cupboard at the front of the building
Gas monitoring using portable gas analyser borrowed from SITA (GA2000), placed in cupboard to log CH4/CO2/O2/H2S a 24 hour basis.	22/02/10 – 26-02-10 01/03/10 – 05/03-10	No gas detected
Perimeter gas survey using a portable Gas Tech Analyser	11-03-10	40-50 ppm detected adjacent in flower bed opposite entrance door and adjacent to drain
Gas Alert Micro 5 used to intermittently monitor the workspace environment generally first thing in the morning.	01/04/10 – 01/06/2011	No elevated levels detected
Detective Plus left in cupboard/adjacent office and corridor on a rotating 24 hour basis.	13-10-10 – 02-11-10	Alarmed in corridor on 22-10-10 @ 10% LEL methane. Corridor ventilated. National Grid called out pressure tested gas pipe in front of building and found no evidence of flammable gases anywhere.
Fixed continuous gas monitoring system installed in the building	01/06/11	Not alarmed since installation.

9.2 National Grid Call Outs to Residential Properties

An enquiry was made with National Grid regarding how many call outs have been made by residents of Lilac Avenue and Warwick Avenue Scunthorpe. The addresses that formed part of the enquiry were those that bordered the Midland Road landfill site and vent trench on the western boundary.

The results of the enquiry are presented in Table 9.2 below.

Table 9.2 National Grid Call Outs for Lilac Avenue and Warwick Avenue

Address	Date	Report
54 Lilac Ave	06/05/06	Internal gas escape
55 Lilac Ave	05/07/10 & 15/07/10	Internal gas escape
64 Lilac Ave	06/10/07 & 27/09/07	Internal gas escape
68 Lilac Ave	26/08/08	Internal gas escape
73 Lilac Ave	02/11/11	Internal gas escape no trace
80 Lilac Ave	20/07/05	Internal gas escape
96 Lilac Ave	30/06/09 & 29/06/09	Internal gas escape
96 Lilac Ave	01/02/09	Smell of gas in shed
98 Lilac Ave	02/02/08	Internal gas escape
110 Lilac Ave	08/12/06	Internal gas escape
114 Lilac Ave	22/05/10	Internal gas escape
120 Lilac Ave	17/04/07	Outside escape no trace other than propane bottle
49 Warwick Ave	08/04/10	Smell of gas at backdoor
57 Warwick Ave	25/01/07	Smell of gas at backdoor
79 Warwick Ave	08/04/10	Smell of gas at bus stop
92 Warwick Ave	30/09/10	Smell of gas on drive
98 Warwick Ave	08/04/10	Smell of gas at excavation
103 Warwick Ave	23/05/10	Internal gas escape
108 Warwick Ave	10/04/07	Internal gas escape
111 Warwick Ave	23/04/10 & 24/12/07	Internal gas escape
116 Warwick Ave	29/05/07	Carbon monoxide alarm

10 PRELIMINARY RISK ASSESSMENT

This section formulates and develops the site conceptual model for the former Midland Road landfill in accordance with Model Procedure CRL 11 (EA 2004).

10.1 Context and Objectives Of Preliminary Risk Assessment

The context and objectives of the preliminary risk assessment for Midland Road landfill are presented in section 10.11 and 10.12 below.

10.1.1 Context

The context of the preliminary risk assessment:

a) Is defined by the “suitable for use approach” as set out in the definition of contaminated land under the Environmental Protection Act 1990 Part 2A

b) Will assess unacceptable risks to human health and the environment defined under Part 2A of The Environmental Protection Act 1990 taking into account the current use and circumstances of the land

c) Is to consider the use of the land that is likely to be made and which is consistent with any existing planning permission or is lawful under town and country planning legislation.

d) Will enable North Lincolnshire Council to identify whether or not it is necessary to make a bid to Defra to obtain funding to investigate “the site” further. Any future funding indentified as being required, will enable the council to identify whether or not the site meets the statutory definition of contaminated land as defined under the Environmental Protection Act 1990 Part 2A.

e) Enables North Lincolnshire Council as the enforcing authority to exercise its powers under the framework of the Environmental Protection Act 1990 Part 2A, namely that of inspection, identification and remediation of contaminated land.

10.1.2 Objectives

The objectives of the preliminary risk assessment are to:

a) Identify potential contaminants and or radioactivity associated with the former Midland Road landfill with the potential to cause harm to designated Part 2A receptors and/or pollution of controlled waters

b) Identify designated Part 2A receptors which could be at risk of harm from contaminants and radioactivity and controlled waters which could be polluted by contaminants.

c) Identify pathways/routes and/or means by which the designated Part 2A receptors and controlled waters could be exposed to or affected by a contaminant and or radioactivity.

d) Identify plausible pollutant linkages where each of the following have been identified: a contaminant, a receptor and pathway capable of exposing a receptor to the contaminant

e) Identify significant pollutant linkages by considering the degree or likelihood of the occurrence of significant harm, pollution of controlled waters or significant harm attributable to radioactivity.

f) Identify what potential risks to designated Part 2A receptors and controlled waters are associated with Midland Road former landfill

g) Identify the level of each identified risk in terms of the probability or frequency of the occurrence

h) Identify the magnitude of the consequences of the occurrence

i) Identify whether potential unacceptable risks defined by Part 2A of the Environmental Protection Act 1990 are likely to exist

j) Identify what further action is required to assess and or manage these potential unacceptable risks.

10.2 Broad Characteristics of the Site

The broad characteristics of the site have been summarised in Table 10.2 below.

Table 10.2

Characteristic	Description
Ironstone quarry	Worked iron ore band 3m thick. Overburden thickness 1m – 2.5 m depth of waste circa 4.0 m.
Landfill construction	No liner, engineered cap (surface cap 0.1 – 0.3 m) or leachate/gas control systems in place.
Waste	1945-1979 Younger waste deposits (domestic waste and construction and demolition wastes) will present an increased gas generation potential
Waste decomposition	Should be in maturation stage below peak levels of gas generation. Dry wastes in areas of the site may give rise to large scale gas production
Current uses on site	Commercial/industrial estate and public open space
Uses adjacent to the site	Residential housing estate and commercial/industrial premises.
Geology	Ironstone and Mudstone with Blown Sand deposits to the west.

Vent Trench 2.5 – 3.0m depth	Located on western boundary to protect residential development from lateral migration. Effectiveness depth/location and extent of the vent trench is not proven.
Complaints	Occupants of commercial/industrial premises located over the top of the landfill have complained of headaches/odours etc that have not been effectively resolved.
Monitoring	Internal air space monitoring has identified elevated levels of volatile gases internally and in service pits. Up to 70% methane concentrations have been recorded in boreholes. There is evidence of gas migration into buildings. All of the above have not been effectively resolved.
Settlement	There is evidence of settlement across the landfill associated with decomposition. Many industrial/commercial premises show evidence of settlement cracks
Controlled Waters	Secondary A Aquifers and poor quality surface waters adjacent to the site
Archaeological and Ecological Systems	None

10.3 Scope of Site Conceptual Model

The model will concentrate on wastes within the former landfill site and any contamination and ground gases that could be associated with the wastes. It is recognised that sources of contamination and ground gases might be associated with both the adjacent made ground and potential spillages associated with current and historical operational practices at commercial and industrial premises. However these sources of potential contamination will not form the focus of the site conceptual model.

The model will concentrate on both on site and off site receptors relevant to Part 2A and it will consider pathways which are relevant to these receptors. At this stage the off site receptors being considered are within 250m of the former landfill site boundary.

10.4 Hazard Identification

The main source of hazards have been identified as landfill/ground gas (bulk and trace components) at the site associated with wastes deposited as part of the landfilling process between 1945 and 1979. Based upon guidance provided by the Chartered Institute of Environmental Health (CIEH 2008) the landfill waste streams can be broadly divided into two categories set out below:

a. Landfill waste tipped 1945 – 1960's; and
b. Landfill waste tipped mid 1960's to 1990's (municipal landfill sites)

The different areas of fill based upon the above criterion are shown in Appendix 4.9F. The drawings and table in Appendix 10.4 show the locations of trial pits that have been excavated on the site and areas where there are clear descriptions of domestic type waste along with premises that have experienced odours/headaches and subsidence.

Areas of known methane production are associated with these locations where gas monitoring boreholes have been sunk.

Settlement of the waste has occurred and evidence suggests that at least some of the waste has decomposed. The following gas generation potential, level of risk to potential development and level of risk from lateral migration are summarised in Table 10.4 below.

Table 10.4

Source	**Generation potential**	**Level of risk for an on site development**	**Risk of lateral migration**
Landfill 1945-1960's	Low/moderate	Low/moderate	Low
Landfill mid 1960's to early 1990's	Moderate to very high	Moderate to very high (depends on current nature of fill and whether waste is dry or wet and also on type of floor slab)	Moderate to very high (reflecting fractured rock in surrounding solid geology which could provide migration pathway)

The greatest gas risk will be posed by the waste which was deposited during the latter part of the operational period of the landfill, from the mid 1960's to 1979. The depth of the waste is relatively shallow (less than 5m) and therefore aerobic degradation of the waste is likely to be a dominant process in areas that have not been capped by development. Atmospheric air is able to percolate into the waste system during changes of atmospheric pressure to maintain aerobic conditions. One result is that decomposition occurs faster and produces mainly carbon dioxide.

The available gas data indicates that higher gas concentrations are associated with exploratory hole locations which recorded higher volumes of putrescible waste (borehole 2 on the western site boundary has produced a maximum value of 70% methane).

There is evidence to demonstrate that gas migration into buildings has occurred in the past but this has never been resolved in a satisfactory manner.

10.4.1 Gases Associated with the Waste Deposits

The process of hazard identification for gases has taken into account the advice and guidance contained in the following documents:

- Waste Management Paper 26A Landfill Completion (DOE 1993) Table 3.2 and 3.3
- Guidance for monitoring trace components in landfill gas (EA V3 2010)

Table 10.4.1 below sets out bulk and trace gases which have the potential to be present on and off site.

Table 10.4.1

Bulk Gases:	Methane (CH4), Carbon Dioxide (CO2)
Trace Gases:	1,2-dichloroethane 1,1-dichloroethane, 1,2-dichloroethene, 1,1-dichloroethene1-butanethiol, 1-pentene, 1-propanethiol, 2-butoxyethanol, 1,1,2,2-tetrachloroethane, Antimony, Arsenic, Benzene, Butyric Acid, Carbon Disulphide, Chloroethane, Dichloromethane, Chloroethene (vinly chloride), Dimethyl disulphide, Dimethyl sulphide, Ethanal (acetaldehyde), Ethanethiol, Ethyl butyrate, Furan (1,4-epoxy-1,3-butadiene), Hydrogen sulphide, Methanal (formaldehyde), Methanethiol, Styrene, Tetrachlorethene, Tetrachloromethane, Trichloroethene, Trimethylbenzene, Toluene, Mercury, PCDD's and PCDF's, Carbon Monoxide

10.4.2 Waste, soils and sludge's

No sampling of waste or near surface soils has been completed on the site. However due to the historic use of the site there is the potential for elevated levels of contaminants to be present in these materials/substrates. Full details of contaminants associated with wastes, soils and sludge's can be found in Appendix 10.4.2.

10.4.3 Groundwater/surface water/ leachate

No sampling of waste or near surface soils has been completed on the site. However due to the lack of a properly constructed cap and liner, controlled waters relevant to the site have the potential to be impacted by contaminants in the waste, which are able to mobilise and form leachate and migrate horizontally or laterally along preferential pathways. Full details of contaminants associated with groundwater's/surface waters and leachate can be found in Appendix 10.4.3

10.5 Hazard Assessment

The process of hazard assessment requires analysing the potential for unacceptable risks to be present on the site. This involves identifying what pathways and receptors are present on the site, along with the identification of pollutant linkages which have a reasonable possibility of existing. Pathways, receptors and pollutant linkages have been considered both on site and within 250m of the site boundary.

10.5.1 Pathway Characterisation

Gas emissions are considered to be the main risk driver for the site and the principal mechanisms for gas migration include diffusion and pressure differential (advection) flow. These mechanisms could allow gas migration into buildings on site via a number of ingress routes, but the main ones are considered to be:

A. Cracks in the ground bearing floor slab (as identified in the structural review of the buildings which noted numerous settlement cracks); and
B. Through gaps around service penetrations which penetrate the floor slab

The risk of gas migration will be reduced into buildings over the landfill site where they are provided with gas protection measures.

Off site migration out of the landfill could occur via the following routes:

C. Preferential migration along utility service trenches
D. Migration through drift geology (notably Blown Sand if it is present); and
E. Preferential migration along fractures or bedding in the surrounding. This is considered to be the most likely route.

The absence of an engineered cap and the limited thickness of subsoil/topsoil (typically 0.1-0.3 m) will permit the waste deposits to naturally vent to atmosphere in the area that is open space. This together with the shallow depth of waste (less than 5m) and the presence of a vent trench on the western boundary of the open space will limit off site migration. If off site migration does occur the driving mechanism is likely to be diffusion and the distance and rate of migration will be limited.

The main pathways for the site are considered to be those associated with gas migration as described above. However other pathways are present on site, which need to be considered in the overall site conceptual model. Non gas pathways are presented in Appendix 10.5.1 Tables 1 and 2

10.5.2 Receptors Characterisation

Receptors on this site are primarily at risk from ground gas migration and can be broadly divided into two:

a) On site (occupants of commercial/industrial units and maintenance workers in the ground); and
b) Off site (notably of the residential dwellings to the west and immediately adjacent commercial/industrial properties.

Whilst there is a theoretical risk of gas migration to distant off site receptors such as the bowling green/golf club etc, it is considered improbable that circumstances would arise whereby significant harm was likely. Similarly the likelihood of significant harm arising from the outdoor inhalation pathway is low for public open space receptors.

Secondary risks to receptors on the site are those associated with contaminants in the surface soils and shallow waste deposits. Receptors associated with these secondary risks can be broadly divided into three:

c) On site (occupants of commercial/industrial units and maintenance workers in the ground); and
d) On site users of the public open space (adults, children and pets); and
e) Controlled waters (controlled waters: underlying secondary aquifer and surface waters)

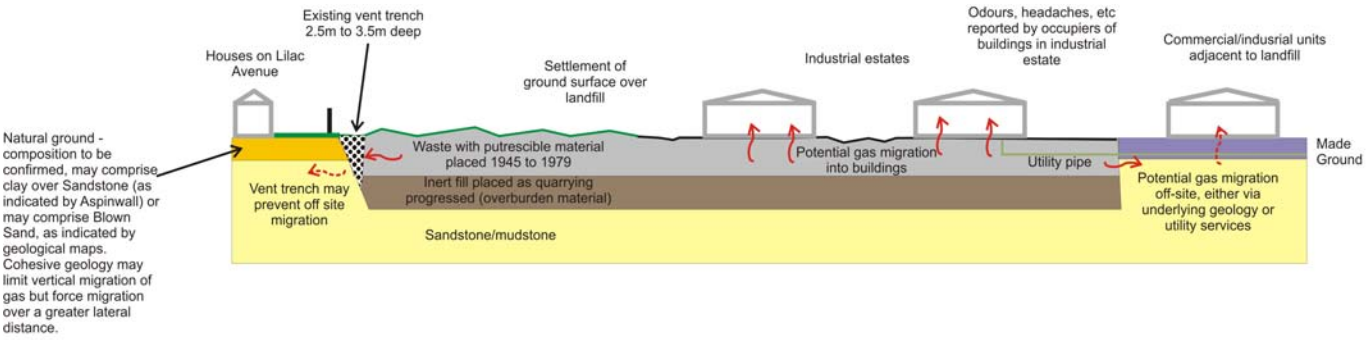
Appendix 10.5.2 summarises designated receptors identified in the current Contaminated Land Statutory Guidance April 2012 for on and off site receptors.

10.6 Site Conceptual Model and Pollutant Linkages

Using information gathered on contaminants, pathways and receptors relevant to the site a site conceptual model has been produced which has assisted in the identification of pollutant linkages which have a reasonable possibility of existing.

A simplified site conceptual model for landfill gas is presented below in Figure 10.6. Appendix 10.4 presents collated information about the site that includes the different waste deposits (pre and post 1960), locations of trial pits (where domestic waste has been identified) locations of receptors, and premises which have reported problems of headaches/odours/subsidence.

Figure 10.6



Three additional cross sectional diagrams of the site have been produced which show primary gas and secondary non gas pollutant linkages and are presented in Appendix 10.6 a.

- A north to south cross section which does not include the vent trench or residential property adjacent to the site
- An east to west cross section which includes the vent trench which is designed to protect residential properties on the western boundary.
- A north east to north west section at the northern most end of the site which shows residential housing not thought to be protected by the vent trench.

Primary potentially complete pollutant linkages associated with ground gases can be found in Table 10.6 below. Other secondary non gas potentially complete pollutant linkages can be found in Appendix 10.6b.

Table 10.6 Human Health Pollutant Linkages On and Within 250m of the Site Associated with Bulk and Trace Gases

No	Source	Pathway	Receptor	Likelihood	Consequence	Risk/Justification
1	Landfill Waste	Cracks/penetrations in floor slabs, resulting in ingress and accumulation of gas	Occupants of commercial/industrial premises	High	High	HIGH Occupants have reported odour nuisance and headaches. Internal space monitoring has identified locally elevated concentrations of volatiles gases. This is anecdotal information and has not been substantiated via robust data collection. Further the validity of the monitoring data is unclear notably as it was most likely collected using un-calibrated monitoring equipment by untrained personnel.
2	Landfill Waste	Accumulation in service pits	Occupants of commercial/industrial premises	High	High	HIGH On-site monitoring has identified locally elevated concentrations of volatile gases in service pits. The validity of the monitoring data is unclear, notably as it was most likely collected using un-calibrated monitoring equipment by untrained personnel.
3	Landfill waste	Lateral migration via diffusion flow in drift deposits	Occupants of residential dwellings off site	Low	High	MEDIUM The potential for high methane concentrations has been noted within the landfill where monitoring has recorded up to 70% methane. The effectiveness of the vent trench installed along the western boundary of the site is not known although the possibility of it being completely ineffective is low.
4	Landfill waste	Lateral migration via pressure driven flow in bedrock	Occupants of residential dwellings	Low	High	MEDIUM The intrusive works completed to date have not assessed the potential for pressure driven preferential migration via rock strata.
5	Landfill waste	Lateral migration via preferential pathways- notably utility infrastructure	Off site residents/site users	Low	High	MEDIUM The investigation completed to date has not assessed the potential for preferential migration via utility services

10.7 Risk Estimation and Evaluation

Risk estimation involves predicting the magnitude and probability of the possible consequences (what degree of harm or pollution might result and to what receptors and how likely is it) that may arise as a result of a hazard. Risk evaluation involves deciding whether or not the risk is unacceptable.

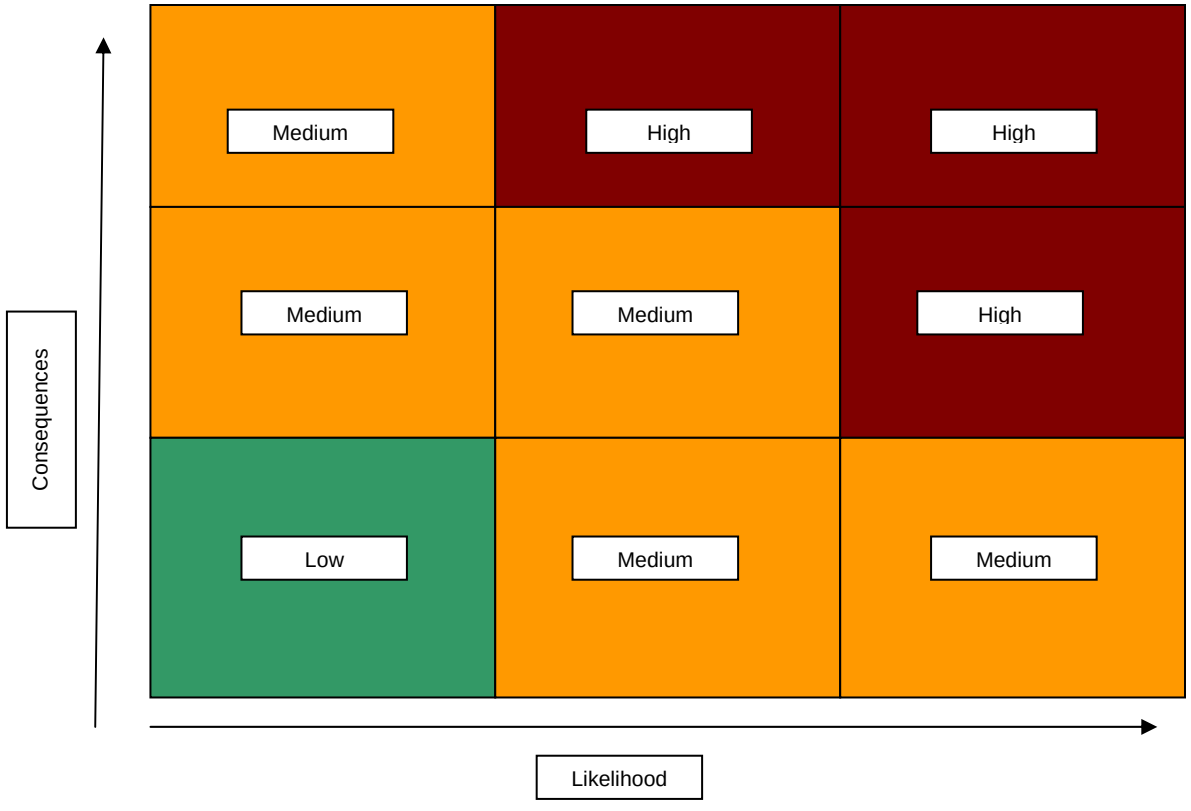
In carrying out this risk estimation and evaluation process the significance of pollutant linkages are considered by assessing:

- the degree of the occurrence of significant harm and or significant possibility of such harm (with reference to Table A and B Annexe 3 of Circular 01/2006 (EA 2004)
- pollution of controlled waters
- significant harm attributable to radioactivity.

In carrying out this process reference has been made to *Guidelines for Environmental Risk Assessment and Management Green leaves III* Defra November 2011. This document identifies that "assessing risk involves an analysis of the consequences and likelihood of a hazard being realised. In decision making low consequence and low risk are typically perceived as acceptable and therefore only require monitoring. Whilst high consequence/high probability risks (red) are perceived as unacceptable and a strategy is required to manage risk. Other risks (amber may require structured risk assessment to have a better understand the features that contribute most to the risk." Figure1 below represents this decision making process.

High risk pollutant linkages are considered to require urgent investigation and medium risked pollutant linkages are thought to require further investigation to clarify the predicted risk, whilst low risked pollutant linkages are thought not to require any further investigation.

Figure 1 (Source Green leaves III 2011)



10.7.1 Risk estimation and evaluation of bulk and trace gas pollutant linkages, which present a risk to human health

Section 10.6 and Table 10.6 summarised potentially complete pollutant linkages associated with bulk and trace gases that might be present on the site and/or off site and which present a risk to human health. The evidence and justification for the predicted risk estimation and evaluation for each pollutant linkage can be found below.

SPL 1 Migration of bulk and trace gases through cracks and penetrations in floor slabs of on site commercial and industrial premises

a) There is clear evidence gathered from the site walkover survey of existing and continued subsidence and cracking to commercial and industrial buildings on the site providing a preferential pathway for gas migration.

b) Anecdotal evidence from companies and staff collected during site walk over's suggests that gas is smelt on some premises and occupants of industrial and commercial properties have complained of headaches and odour nuisance. During periods of heavy rainfall bubbling in puddles has been seen regularly on some premises.

c) Internal space monitoring has identified locally elevated concentrations of volatile gases. The validity of the internal monitoring is unclear as it was most likely collected using un-calibrated monitoring equipment by un-trained personnel.

d) Flammable gas levels of 13% LEL have been identified in an enclosed space of a building which is thought to be located on top of the landfill (see section 9.0 for further details). There is low confidence and certainty that this reading is associated with flammable landfill gases as there could have been interferences with other gases commonly found in an office environment. A landfill gas technical discussion note by The Environmental Protection Group Limited dated May 2011 (EPG 2011) identifies that whilst this level of gas is unacceptable the poor confidence in the data gathered requires that further assessment takes place. At present robust data collection to substantiate this event has not taken place.

e) Limited gas monitoring of the younger waste deposits (Post 1961) have identified a maximum Gas Screening Value (GSV) of 3.38 for methane and 1.34 for carbon dioxide which would categorise the site as Characteristic Situation 3 (moderate risk) when compared against Wilson and Card (1999) which is referenced in CIRIA C665. Parts of the industrial/commercial premises are located on waste deposits placed between 1961 and 1979. Whilst it is recognised that these GSV's do not represent a robust interpretation of the gassing regime on the site and required risk management measures, they provide evidence to support the fact that this pollutant linkage requires further urgent investigation.

f) Information gathered from the site walk over's and desk top study has identified that the majority of the industrial and commercial units on the Midland Road landfill have no gas management measures in place.

g) Many of the units carry out hot or spark creating activities that will give rise to an increased risk of explosion.

Based on the above lines of evidence it is considered that the likelihood of an explosive, and asphyxiation event associated with accumulation of gases in industrial/commercial premises is HIGH.

Due to the potential explosive and asphyxiation risks associated with the pollutant linkage it is considered that such an event presents a short term (acute) risk to human health likely to result in significant harm defined by Part 2A of the Environmental Protection Act 1990. Therefore the consequence has been assessed as HIGH risk.

<u>The overall risk classification of for this pollutant linkage is therefore HIGH requiring urgent investigation.</u>

SPL 2 Accumulation of gases in service pits located on industrial and commercial premises

a) The site walkover survey identified the presence of a number of service pits located on commercial/industrial premises, which can be used to carry out work activities.

b) On site monitoring has historically identified locally elevated levels of volatile gases in service pits, however the validity of the monitoring data is unclear, as it was most likely collected using un-calibrated monitoring equipment by untrained personnel.

c) Limited gas monitoring of the younger waste deposits (Post 1961) have identified a maximum Gas Screening Value (GSV) of 3.38 for methane and 1.34 for carbon dioxide which would categorise the site as Characteristic Situation 3 (moderate risk) when compared against Wilson and Card (1999) which is referenced in CIRIA C665. Parts of the industrial/commercial premises are located on waste deposits placed between 1961 and 1979. Whilst it is recognised that these GSV's do not represent a robust interpretation of the gassing regime on the site and risks associated with the use of service pits, they provide evidence to support the fact that this pollutant linkage requires further urgent investigation.

Based on these lines of evidence it is considered that the likelihood of an explosive and asphyxiation event associated with gas accumulation in the service pits is HIGH.

Due to the potential explosive and asphyxiation risks associated with the pollutant linkage it is considered that such an event presents a short term (acute) risk to human health likely to result in significant harm defined by the Environmental Protection Act 1990. Part 2A. Therefore the consequence has been assessed as HIGH.

<u>The overall risk classification of for this pollutant linkage is therefore HIGH requiring urgent investigation.</u>

SPL 3 Lateral migration of gases via diffusion flow in Blown Sand drift deposits to off site residential dwellings and adjacent industrial/commercial buildings

a) Gas monitoring of the younger waste deposits has identified the potential for high methane concentrations with borehole monitoring recording 70% methane adjacent to the landfill sites western boundary. There is a residential housing estate immediately adjacent to the site on its western boundary where the high methane concentrations have been identified.

b) Geological maps indicate the presence of Blown Sand drift deposits on the western boundary of the site which underlie the residential housing estate. Drift deposits are also thought to be present on the south western boundary of the site underlying adjacent commercial/industrial premises. The presence of the Blown Sand may allow lateral migration of gases via diffusion flow to off site residential housing located on the western boundary.

c) There is a vent trench located along the boundary between the edge of the tipped site and the residential housing located on the western boundary, which will limit the potential for off site gas migration. This trench runs from 87 Warwick Road and along Lilac Avenue to number 54 (See appendix 7.6.1B and 7.6.1C for diagram of the vent trench location). Whilst the vent trench will allow gases to escape vertically to atmosphere, it is not clear how effective the trench is at performing this function as there are no gas monitoring boreholes located on the housing side of the trench. Further, there are no detailed ‘as-built’ drawings to show the actual depth of the vent trench in relation to the adjacent waste deposits, depth to groundwater and/or identified thickness of Blown Sand drift material. The vent trench has not been maintained over the years and is overgrown with vegetation in the form of grasses/bushes and trees which may reduce its effectiveness. However the probability of the vent trench being completely ineffectual is considered to be low.

d) There is some uncertainty as to whether or not the vent trench runs the full length of the waste deposits on the western boundary, as the area that might have been tipped could extend beyond 87 Warwick Road to Gladstone Drive. This leaves approximately 20 residential properties which are directly adjacent to the site unprotected in terms of gas migration. To the south of the vent trench the waste is also thought to extend further and therefore properties on the southern end of Lilac Avenue waste are also unprotected.

e) The absence of a properly engineered cap in the public open space area will allow waste deposits to “vent” naturally to atmosphere and therefore off site migration will be further limited.

f) The houses and adjacent industrial/commercial premises built in the 250m buffer zone are not thought to have any gas protection measures incorporated into their building design.

g) It is unclear at this stage whether or not the gas generation has the driving force to migrate long distances. However due to the age of the waste it is expected that gas

generation should be well below peak levels and the driving force will be low. However there is evidence of drier less well decomposed areas of waste which could give rise to large scale gas generation if the waste became wet.

Based on the above lines of evidence it is considered that whilst the there is a potentially complete pollutant linkage, the likelihood of an explosive and asphyxiation event associated with gas accumulation in residential houses and/or adjacent industrial/commercial premises via diffusion flow in drift deposits LOW.

Notwithstanding the above due to the potential explosive and asphyxiation risks associated with the pollutant linkage it is considered that such an event presents a short term (acute) risk to human health likely to result in significant harm defined by the Environmental Protection Act 1990. Part 2A. Therefore the consequence has been assessed as HIGH.

<u>The overall risk classification of for this pollutant linkage is therefore MEDIUM requiring further investigation to robustly assess the risks.</u>

SPL 4 Lateral gas migration via pressure driven flow in the bedrock to residential housing and adjacent commercial/industrial premises

a) The permeability of the surrounding soil/bedrock has not been investigated and therefore site investigations carried out to date have not evaluated the effect of the surrounding geology upon pressure driven flow.

b) Fractures and or bedding that are expected to be present in the underlying geology will present preferential pathways for gas migration via this route.

c) The presence of the vent trench on the western boundary is expected to reduce the likelihood of gas migration via this route. At present the depth of the vent trench is not proven.

d) Residential and commercial/industrial properties located adjacent to the landfill are not known to have any gas protective measures in place.

e) It is unclear at this stage whether or not the gas generation has the driving force to migrate long distances however due to the age of the waste it is expected that gas generation should be well below peak levels and driving force will be low. However there is evidence of drier less well decomposed areas of waste which could give rise to large scale gas generation if the waste became wet.

Based on the above lines of evidence it is considered that whilst there is a potentially complete pollutant linkage, the likelihood of an explosive / asphyxiation event (associated with gas accumulation in residential houses and/or adjacent industrial/commercial premises via pressure driven flow through bedrock) is LOW.

Notwithstanding the above, due to the potential explosive and asphyxiation risks associated with the pollutant linkage it is considered that such an event presents a short term (acute) risk to human health likely to result in significant harm defined by the Environmental Protection Act 1990. Part 2A. Therefore the consequence has been assessed as HIGH.

The overall risk classification of for this pollutant linkage is therefore MEDIUM requiring further investigation to robustly assess the risks.

SPL 5 Lateral migration via preferential pathways (utilities) to off site residents and adjacent commercial/industrial premises

a) The backfill in which service runs are laid can create a preferential pathway for gas migration if there is a sufficient volume of gas and driving force. Plans of water and sewerage utilities have been obtained and these indicate that services run from north to south. Relic/private sewers appear to be present on the areas of public open space.

b) Site investigations carried out to date have not assessed the potential for preferential gas migration via this pathway.

c) It is unclear at this stage whether or not the gas generation has the driving force to migrate long distances however due to the age of the waste it is expected that gas generation should be well below peak levels and the driving force will be low. However there is evidence of drier less well decomposed areas of waste which could give rise to large scale gas generation if the waste became wet.

Based on the above lines of evidence it is considered that whilst there is a potentially complete pollutant linkage, the likelihood of an explosive / asphyxiation event (associated with preferential migration of gas via utility services and accumulation in residential houses/industrial/commercial premises) is LOW.

Notwithstanding the above, due to the potential explosive and asphyxiation risks associated with the pollutant linkage it is considered that such an event presents a short term (acute) risk to human health likely to result in significant harm defined by the Environmental Protection Act 1990. Part 2A. Therefore the consequence has been assessed as HIGH.

The overall risk classification of for this pollutant linkage is therefore MEDIUM requiring further investigation to robustly assess the risks.

10.7.2 Risk estimation and evaluation for human health risk pollutant linkages associated with contaminants contained in soils and landfill waste.

Risk estimation and evaluation of potentially complete pollutant linkages associated with contaminants that might be present in the near surface soils/waste and which might present a risk to human health are presented in Appendix 10.7.2 Table 9. Justification and lines of evidence for each potentially complete pollutant linkage is set out in detail in Appendix 10.7.2. A brief summary of this assessment is provided below.

The majority of the pollutant linkages are considered to be a medium risk due to the lack of a proper cap on the landfill site, the poor quality external surfacing on many of the industrial estate sites and the presence of sensitive receptors (children) on the recreation field area. At present there is no evidence in the form of sampling to support the predicted risk estimation and evaluation.

10.7.3 Lines of Evidence and Justification for Risk Analysis of Radioactivity Pollutant Linkages Associated With Risks to Human Health

Risk estimation and evaluation of potentially complete pollutant linkages associated with radioactivity, which might present a risk to human health are presented in Appendix 10.7.3 Table 10. Justification and lines of evidence for each potentially complete pollutant linkage is set out in detail in Appendix 10.7.3. A brief summary of this assessment is provided below.

The overall risk associated with pollutant linkages presented in Appendix 10.7.3 Table 10 has been assessed as low for all routes of exposure. The pollutant linkages are considered to be of a low risk due to the lack of direct historical evidence of radioactive waste deposits and due to the known low risks associated with historical practices that might have feasibly occurred throughout the life of the landfill site. Advice has been sought from the Environment Agency Non Nuclear Radioactive Substances Team (Midlands Region) in order to reach this conclusion. There is no evidence in the form of sampling to support the predicted risk estimation and evaluation.

10.7.3.1 Local history associated with potential radioactive waste that might have been disposed of in the landfill

As the landfill site is known to have been in operation prior to 1963 when the Radioactive Substances Act came into being it is likely to have the potential for unrecorded radioactive contamination. Prior to the Control of Pollution Act 1974 (CoPA) materials were not segregated before disposal and therefore these type of landfill sites also have the potential for unrecorded radioactive contamination. Materials such as cottage luminising industries may have existed where home-workers used luminous paints to paint instruments, watches and clocks. These types of waste will have arisen from the 1900’s onwards and will have been disposed of along with domestic refuse.

Following the introduction of CoPA it is still possible that radioactive materials could have been deposited in the landfill as articles such as smoke detectors and certain luminescent materials were not thought of as radioactive by members of the public and

could have been disposed in domestic refuse. **The Defra Industry Profile identifies that landfill sites that pre-date formal arrangements for disposal of low level radioactive waste and which are in close proximity to industrial sites which have generated radioactive wastes are capable of giving rise to an effective dose of 3 millisieverts/year above natural background levels.**

The following industries have been identified which have the potential to have generated radioactive wastes and which were in close proximity to Midland Road landfill site prior to 1963.

- **Metals Mining:** Iron ore has been mined widely in Scunthorpe and Midland Road landfill itself is a former iron ore open cast mine. Metalliferous mining wastes can contain higher than normal concentrations of naturally occurring radioactive materials (NORM). However the Defra Industry profile suggests that such elevated concentrations of NORM are unlikely to be capable of giving rise to an individual effective dose of 3 millisieverts/year above local natural background levels.

- **Ferrous Metal Production**: Scunthorpe town is based around iron and steel production which started in the 1850's. The Lysaght's Iron and Steel works directly adjacent to the Midland Road landfill was built in 1912. The sintering process of iron and steel making results in the volatilisation of components of the ore including lead-210 and polonium-210. The Defra Industry Profile advises that **concentrations of radioactivity in the sinter dusts are likely to be above levels set out in the Radioactive Substances Act at levels of 11.3 and 99.8 Becquerel's/gram (Bq/g) for lead-210 and polonium-210 respectively.** These dusts were sent to landfill or disposed of on site**.** The Midlands Region Non Nuclear Radioactive Substances Regulation Team have provided the view that the sinter dusts from the steel works site which might have been deposited in the landfill site prior to 1963 are unlikely to be capable of giving rise to an individual effective dose of 3 millisieverts/year above local natural background levels.

  The slag associated with iron and steel production contains low levels of naturally occurring radioactive material which are thought to be unlikely to be capable of giving rise to an individual effective dose of 3 millisieverts/year above natural background levels.

- **Incinerators**: Scunthorpe General Hospital opened in 1929 with 72 beds and by the end of the 2nd world war this had increased to 204 beds. The hospital extended again in 1966 with an additional 192 beds. Historic maps do not show the existence or location of an incinerator stack, however due to the size of the hospital it is likely that incineration of waste took place on the site. The waste ash from the incinerator is likely to have contained heavy metals and radionuclides. The ash was normally sent to landfill. The Defra Industry Profile suggests that discharges from incineration are unlikely to be capable of giving rise to an individual effective dose of 3 millisieverts/year above natural background levels. The Midlands Region Non Nuclear Radioactive Substances Regulation Team concurs with this advice.

- **Medical Establishments**: Information obtained from the League of Friends of The Scunthorpe Hospital suggests that x-ray equipment was installed in Scunthorpe General Hospital in 1931. In 1932 a school of nursing was also set up. It is therefore likely that radionuclide's were used for diagnostic investigations and possibly therapeutic procedures. The Defra Industry Profile suggests that concentrations of radioactive contaminants in waste streams from former medical establishments are unlikely to be capable of giving rise to an individual effective dose of 3 millisieverts/year above the local natural background levels under any reasonable scenario. The Midlands Region Non Nuclear Radioactive Substances Regulation Team concurs with this advice.

- **Military Sources:** Whilst North Lincolnshire has a number of military airfields that operated during the 2nd World War and can be associated with radium used for paints/instrument dials. There were a number of decoy burning sites surrounding Scunthorpe during the 2nd World War that were used to divert attention from the steel works. The Midlands Region Non Nuclear Radioactive Substances Regulation Team advised that these types of decoy sites and the waste associated with them would only be a risk if RAF waste was burnt. The RAF airfields were some distance from Midland Road landfill site and therefore it is considered unlikely that deposition of military RAF waste took place.

- **Miscellaneous Small Users**
  Gamma radiography was often used to assess castings and welds. As Scunthorpe has an industrial legacy based upon iron and steel production it is likely that this type of activity took place in the town prior to 1963 when the Radioactive Substances Act came into being. The Defra Industry Profile suggests that premises which used radioactive substances prior to regulation under the Radioactive Substances Act are capable of giving rise to an individual effective dose of 3 millisieverts/year above local natural background levels if the practice involved an open source and disposal in waste pits was known to have been practised.

  It is likely that the steel works site and other casting industries in Scunthorpe prior to 1963 used gamma radiography, however as the radiation was always a sealed source this should not pose a significant risk if disposed of at the landfill site . Based on this information it has therefore been assessed that gamma radiography sources prior to 1963 are not capable of giving rise to an individual effective dose of 3 millisieverts/year above the local natural background levels. The Midlands Region Non Nuclear Radioactive Substances Regulation Team concurs with this assessment.

10.7.4 Risk estimation and evaluation for controlled waters pollutant linkages associated with contaminants contained in the landfill waste.

Risk estimation and evaluation of potentially complete pollutant linkages associated with contaminants that might impact upon controlled waters are presented in Appendix 10.7.4 Table 11. Justification and lines of evidence for each potentially complete pollutant linkage is set out in detail in Appendix 10.7.4. A brief summary of this assessment is provided below.

The overall risk associated with pollutant linkages presented in Appendix 10.7.4 Table 11 has been assessed as medium. The pollutant linkages associated with controlled waters are considered to be of a medium risk due to the lack of a cap, liner and leachate management system, the presence of preferential flow paths on site (old drains) and the low sensitivity of the groundwater (Secondary A aquifer) and adjacent surface waters (poor to bad quality). The Environment Agency Groundwater Team (Midlands Region) was consulted in order to reach this view about the site. There is no evidence in the form of sampling to support the predicted risk estimation and evaluation.

10.7.5 Risk estimation and evaluation of building effects

Risk estimation and evaluation of potentially complete pollutant linkages associated with the building effect along with justification and lines of evidence are presented in Appendix 10.7.5.

The overall risk of buildings ceasing to be capable of being used for the purpose for which they were intended is considered to be low. This assessment has been based upon evidence gathered from the site walkover which made an initial assessment of the structural integrity of buildings and the likelihood of further significant subsidence occurring taking into account the age of the landfill and likely decomposition that has already taken place.

10.8 Degree of Confidence and Uncertainties in Site Conceptual Model

The prediction of risk introduces uncertainty into the understanding of the actual risks and as such it is beneficial to identify the uncertainties in order that the information collected is refined to reduce these levels of uncertainty.

Identification of a lack of knowledge about specific factors in the conceptual site model and risk assessment will assist in directing and influencing the proposed site investigation in order that robust data is collected for the site. This in turn will provide a robust basis for decision making within the Part 2A framework.

The main uncertainties associated with landfill gas risks are:

A. Condition of the floor slabs
B. Precise dimensions and internal layout of buildings
C. The level of confidence that can be assigned to internal detection of landfill gas in some buildings

Other uncertainties associated with landfill gas include:

D. Detailed geology of the surrounding area (drift and solid)
E. Existing groundwater levels
F. The permeability of the strata
G. The depth/location/extent of the vent trench
H. The current state of decomposition of the waste
I. The future potential of the site to generate gas

At present due to the high degree of uncertainty about the site, there is not sufficient information to allow a robust assessment of risk to be made about the site and to confirm whether gas migration into buildings is occurring.

Detailed uncertainties and levels of confidence associated with all primary and secondary pollutant linkages identified in the site conceptual model are presented in Appendix 10.8.

10.9 Potential Unacceptable Risks

The primary potentially unacceptable risks are considered to be those associated with landfill gas. The assessment has predicted a number of HIGH risk potentially complete pollutant linkages which are capable of resulting in “significant harm” as defined by EPA 1990 Part 2A. These are:

A. Migration of landfill gas through cracks and service penetrations and accumulation in on site commercial/industrial units
B. Migration and accumulation of landfill gas in service pits located in on site commercial/industrial units

The above risks require urgent investigation in order to be able to robustly evaluate the acute risks associated with the site.

Other landfill gas MEDIUM risks have been predicted which are capable of resulting in “significant harm” these are:

C. Lateral migration via diffusion flow in drift deposits to off site residential and commercial/industrial premises
D. Lateral migration via pressure driven flow in bedrock to off site residential and commercial/industrial premises
E. Lateral migration via preferential pathways (utilities)

The above risks require investigation in order to clarify the predicted risks associated with these pollutant linkages.

Secondary MEDIUM risks to human health from shallow surface soils/waste and to controlled waters from leachate production have also been identified. At present these pollutant linkages have not been investigated and in isolation are not considered to be of sufficient priority to warrant bringing the site forward for Part 2A detailed inspection. However it is considered that there are potentially complete pollutant linkages that are capable of meeting the statutory definition of Contaminated Land and therefore require further investigation in order to be able to robustly evaluate the predicted risks. Full details of the secondary pollutant linkages can be found in Appendix 10.9.

10.10 Requirements for Detailed Inspection

A robust assessment of the risks posed by the site is required in order to determine whether or not the site or parts of it meet the statutory definition of Contaminated Land as defined by EPA 1990 Part 2A. The primary risk drivers for the proposed site investigation are those associated landfill gas.

The main information required to provide a robust assessment of the risk associated with landfill gas is:

A. The state of decomposition of the waste
B. The future gas generation potential of the waste
C. Detailed geology of the area
D. Permeability of strata
E. Details regarding groundwater levels
F. The depth and location of vent trench
G. The condition of floor slabs
H. The precise dimensions and internal layout of buildings

The data gathered from the site investigation will provide sufficient information to allow a robust assessment of the gas risk on the site. There should be no need for further site investigation works as it should provide sufficient information to be able to design remedial measures if required.

Secondary risks to human health from shallow surface soils/waste and risks to controlled waters from leachate production have also been identified. Sampling of surface soils and potable water supplies is required to be able to robustly evaluate the predicted risks. The data gathered will allow the risks to be evaluated using generic assessment criteria in order to decide whether or not further risk assessment is required or whether the site meets the definition of "Contaminated Land".

10.10.1 Greenhouse Gas Emissions

Local authorities, with enforcing duties under Part 2A EPA 1990, are able to use Defra funding to measure total site Greenhouse Gas (GHG) emissions where closed historic landfill (CHL) sites are being investigated & remediated under Part 2A (Defra, 2008). The main contributor to these emissions is methane, which is a relatively potent greenhouse gas, and present in high concentrations in landfill gas.

Additionally, a range of other gases have been linked with climate change. Some of these gases are more potent climate change agents, and may also be present in landfill gas, albeit at lower levels. It is important to understand the contribution that all these gases could make to the total site GHG emissions.

The site investigation proposes to investigate the effect of landfill gases upon climate change.

10.11 Scope of Site Investigation

In order to gather sufficient information about the site that will allow a robust assessment of the risks to be made the site investigation will:

A. Characterise the waste bodies to allow assessment of the gas risks and targeting of monitoring locations.
B. Locate targeted boreholes and well response zones to assess all potential gas migration pathways relevant to the site.
C. Implement a robust system of gas monitoring (flow rates/in ground pressure/bulk gas and volatile organic concentrations/and groundwater and leachate conditions.
D. Monitor gas levels outside the waste mass during variable weather conditions using high frequency monitoring where appropriate.
E. Target chemical testing and vapour monitoring at locations where a "strong chemical odour" has been noted.
F. Undertake a Ground Penetration Radar, topographical and structural survey of 10% commercial premises to assess condition and nature of floor slabs and internal dimensions.
G. Undertake a geophysics resistivity survey and locate targeted trial pits to confirm the vent trench depth/location and dimensions.
H. Carry out internal air space monitoring in all commercial premises on site for a period of 1 year during periods of low/falling atmospheric pressure using an FID combined with GC-MS if available.
I. Undertake on site surface sampling and potable water supply testing to assess human health pollutant linkages associated with inhalation/ingestion and dermal contact.
J. Undertake leachate and groundwater sampling in order to inform the gas risk assessment and provide data on controlled waters.
K. Total greenhouse gas emission monitoring (see section 10.12 below)
L. Interpret and assess the risks posed by the site.

10.12 Climate Change Mitigation Assessment

The site investigation will also assess the affect of greenhouse gases and therefore the Climate Change Mitigation Assessment (CCMA) will involve landfill gas monitoring that will allow a measure of the total amount of GHG emissions from the landfill site. The investigation will take the form of:

1) Walkover survey and Flame Ionisation Detector (FID) monitoring;
2) Measurement of methane flux using flux boxes; and
3) Measurement of trace components within landfill gas.

The above CCMA has been devised based upon advice provided by Shaun Robinson (Technical Advisor Geoscience at the Environment Agency).

10.13 Costs of Detailed Inspection

The risks associated with landfill gas are the primary risk drivers for the site and are the reason this site is being brought forward for detailed inspection through the securing of Grant Funding. As part of the preliminary risk assessment other secondary risks to human health (non gas) and controlled waters have been identified. Whilst in isolation these secondary risks are not seen as a high priority for detailed Part 2A inspection they require further investigation in order to be able to evaluate the predicted risks robustly.

The details and costs of inspection have therefore been itemised into 3 separate costed components as detailed below:

1 Details and costs associated with the investigation and assessment of ground gas pollutant linkages (Urgent investigation required to assess acute risks to human health).

2 Details and costs associated with the climate change mitigation assessment (Non essential aspect of detailed inspection).

3 Details and costs associated with the investigation and assessment of secondary non ground gas pollutant linkages (investigation required to clarify the predicted chronic risks to human health and risks to controlled waters).

The costs have been itemised in this way in order that the council's bid for grant funding is not prejudiced in terms of value for money", as the lower risk and non essential items of the site investigation (items 2 and 3) can be easily removed if funding is not available for all aspects of the proposed detailed inspection.

A detailed costed scope of works is presented in Appendix 10.13

11. References

AEA Environment and Energy. *A report on a landfill gas survey at Midland Road Industrial Estate, Scunthorpe*. Report reference AEA-EE-0071

AEA Environment and Energy. *A report on a landfill gas survey at Midland Road Industrial Estate, Scunthorpe*. Report reference AEA-EE-0094

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