Kilford Town Closed Landfill.

Introduction

Below is a worked example of the application of the EPA Code of Practice Matrices to a fictional unregulated closed landfill. This example will show the user how to:

1. Complete a Tier 1 Risk Assessment and
2. Use the Tier 1 Risk Assessment and the EPA Matrices to scope and complete a Tier 2 Risk Assessment,

in compliance with the EPA's Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites 2007. When reading this document prompts to the Code of Practice are in [*square brackets*].

Tier 1 Investigation

History and overview of the site

The closed landfill in Kilford operated as the town dump from 1965 until it closed as a landfill in 1991. The landfill was developed in an old quarry for sand, gravel and soil. The site area is approximately 2 hectares and it is estimated to contain 80-100,000 tonnes of waste. The wastes accepted at this site are reported to have been a mixture of municipal waste, construction and demolition waste and small quantities of industrial waste from a farm machinery factory. It is unknown to what depth the waste is buried. The landfill was reported to be capped with 500mm of topsoil. Currently part of the site is used as a depot for storage of road works materials, machinery etc by the local council. This information has been sourced from council records, aerial photographs and from interviewing of former landfill staff.

The lands adjoining the site include some low intensity agriculture (grazing). To the north and west is a marshy area with small water courses and to the south and west are residential developments, which are approximately 250 and 350 metres from the edge of the waste body.

Walk-over Inspection

The site is currently used as a depot by the council. The southern part and part of the eastern and western perimeters of the site are fenced. The southern part of the site has a hardcore surface and is used for storing road materials and machinery. There is also a shed used for storage and to provide toilet and canteen facilities for staff. The runoff from the landfill and yard area discharges into the marsh via a combination of manmade drains and perimeter ditches. The ditches were dry at the time of the site walkover but it is assumed that during times of rainfall that they will be waterlogged. It is assumed therefore that these ditches form a direct connect between the landfill and the adjacent marsh area. A seep was noticed form the landfill at one location in the perimeter ditch. A completed site walkover survey checklist is included below [*See Appendix 2 of the EPA's Code of Practice, 2007*]

Walkover Survey Checklist		
Information	**Checked**	**Comment (Include distances from the site boundary)**
1. What is the Current Land use?	√	Partially council depot, partially dormant
2. What are the neighbouring land uses?	√	Low intensity agriculture, residential south & west. recent import of soil to south from residential development
3. What is the size of the site?	√	Roughly paced 100m by 200m.
4. What is the topography?	√	Roughly level on the southern half of site. Dips sharply to the marsh in the northern half.
5. Are there potential receptors (if yes give details)?		
Houses	√	Residential units to the south & west
Surface water features (if yes, distance and direction of flow)	√	Surface water drains and drainage ditch network across landfill.
Any wetland or protected areas	√	Marsh and SAC to the North
Public water supplies	?	Will need to check GSI/Council records
Private Wells	?	Door to door survey required.
Services	√	Normal ESB wires
Other buildings	√	Council depot shed.
Other	√	Adjacent agricultural land. Potential future development on land to the south.
6. Are there any potential sources of contamination (if yes, give details)?		
Surface waste (if yes, what type?)	√	Some surface waste in the NW – bits of plastic and wood.
Surface ponding of leachate	X	
Leachate seepage	√	Some to the north of the site
Landfill gas odours	X	
7. Are there any outfalls to the surface water? (If yes, take photographic	√	Manmade surface water drains from depot yard to marsh area. Perimeter ditches to the marsh

evidence)		area.
8. Are there any signs of impact on the environment? (if yes, take photographic evidence)		
Vegetation die off, bare ground	√	Less vegetation in the marsh nearest to the landfill
Leachate seepages	√	Iron staining
Odours	X	
Litter	√	Some windblown
Gas Bubbling through water	X	
Signs of settlement, subsidence, water logged areas	√	Some evidence of surface water percolating into the landfill body. Some evidence of shallow depressions on the surface – not water logged.
Drainage or hydraulic issues	√	(As above)
Downstream water quality appears poorer than upstream water quality	?	No upstream point for comparison.
9. Are there any indications of remedial measures? (Provide details)		
Capping	√	Some evidence of a soil cap.
Landfill gas collection	X	
Leachate Collection	√	Perimeter ditches draining to the marsh area.
10. Describe fences and security features (if any)	√	Fencing, padlock used on the front gate.
Any other relevant information?	√	Marsh drains to a small watercourse from pond (possibly seasonal). Survey was undertaken mid-June after 2 weeks of prolonged dry weather.

Figure 1. Aerial photograph of the site. Outline of landfill shown in red. Note: residential areas to the west and south. Presence of a SAC to the north, shown in beige.

Desk Study: Tier 1 Risk Assessment.

A Tier 1 Risk Assessment was completed in accordance with chapter 3 of the Code of Practice:

- A desk study.
- A completed site inspection (including walk over survey)
- A conceptual site model

The gathering of the above data allows for the Tier 1 Risk Screening and Prioritisation to be completed in accordance with chapter 4 of the Code of Practice.

Tier 1 Risk Screening and Prioritisation

Table 1. Source Scores.

Ref:	Source	Score	Rational
1a	Leachate	7	Waste Body is between 1 and 5 hectares – Mainly municipal
1b	Landfill Gas	7	Waste Body is between 1 and 5 hectares – Mainly municipal

Table 2 Pathway Scores.

Ref:	Pathway	Score	Rational
2a	Groundwater vulnerability	2	Regional mapping incomplete, variable H-L given, assumed high therefore score of 2: GSI data. See Figure 2.
2b	Groundwater flow regime	1	Poor Bedrock Aquifer PL: GSI data. See Figure 3.
2c	Surface water and drainage	2	Landfill drainage system connected to marsh area: confirmed by site walk over survey.
2d	Landfill gas lateral migration	1.5	Workers shed on the landfill, subsoil is predominately sandstone till. See Figure 4.
2e	Landfill gas vertical migration	2	Workers shed on the landfill, subsoil is variety of tills: sandstone till, shale till and quartzite till. See Figure 4.

Table 3 Receptor Scores

Ref:	Receptor	Score	Rational
3a	Human presence (leachate)	3	Workers canteen on landfill with old borehole well supply. Use of mains supply was mentioned in site walk over survey.
3b	Protected areas	1	Designated site within 50 m of the waste body, confirmed by National Parks and Wildlife Service maps (see hatching on aerial photograph).
3c	Aquifer category	1	Poor aquifer PL. See Figure 3.
3d	Public Water Supply	0	Public water supply is greater than 1km (no Karst aquifer). Confirmed by Council Records and GSI data search. See figure 5.
3e	Surface water bodies	3	Surface water within 50 m of site. Confirmed by site walkover survey.
3f	Human Presence (gas)	5	Building on site: (Council Depot). Confirmed by site walkover survey.

Figure 2. Ground Water Vulnerability. Source: Geological Society of Ireland (GSI, 2005). Outline of landfill shown in red.

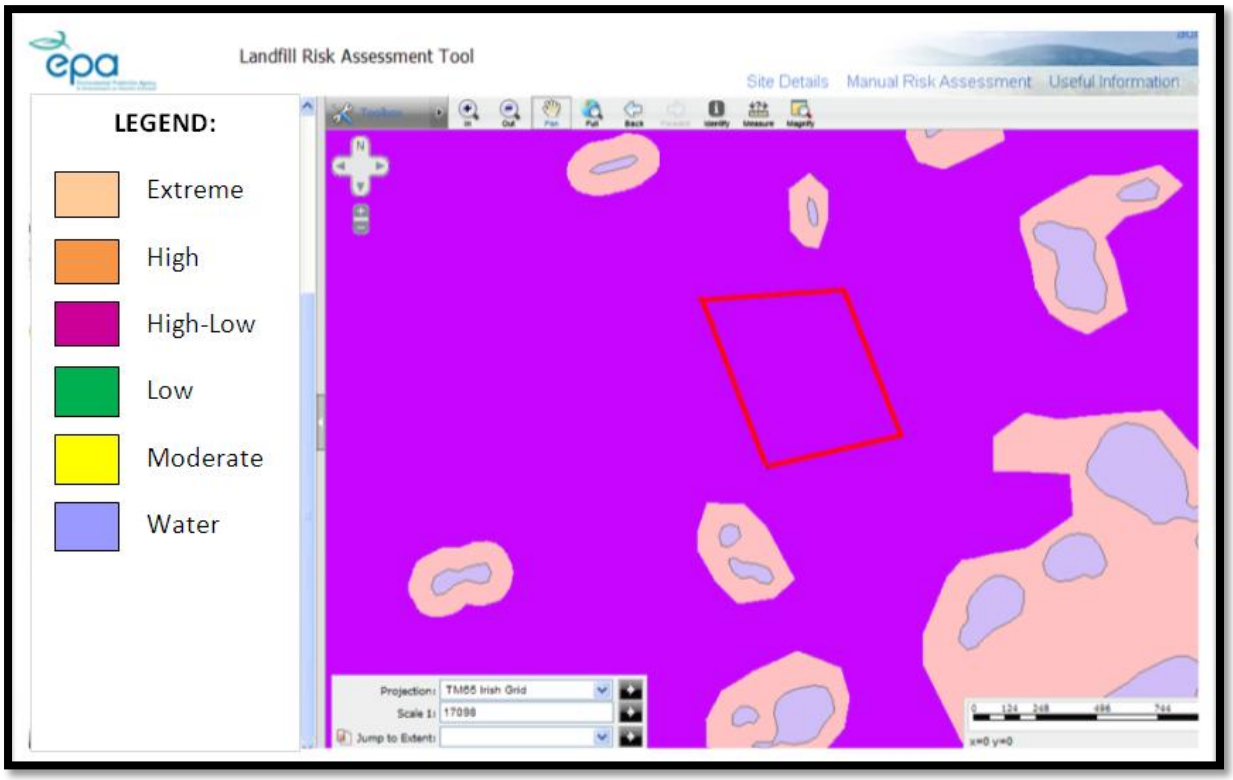


Figure 3. Aquifer Classification. Source: GSI River Basin Districts Management Projects. Outline of landfill shown in red.

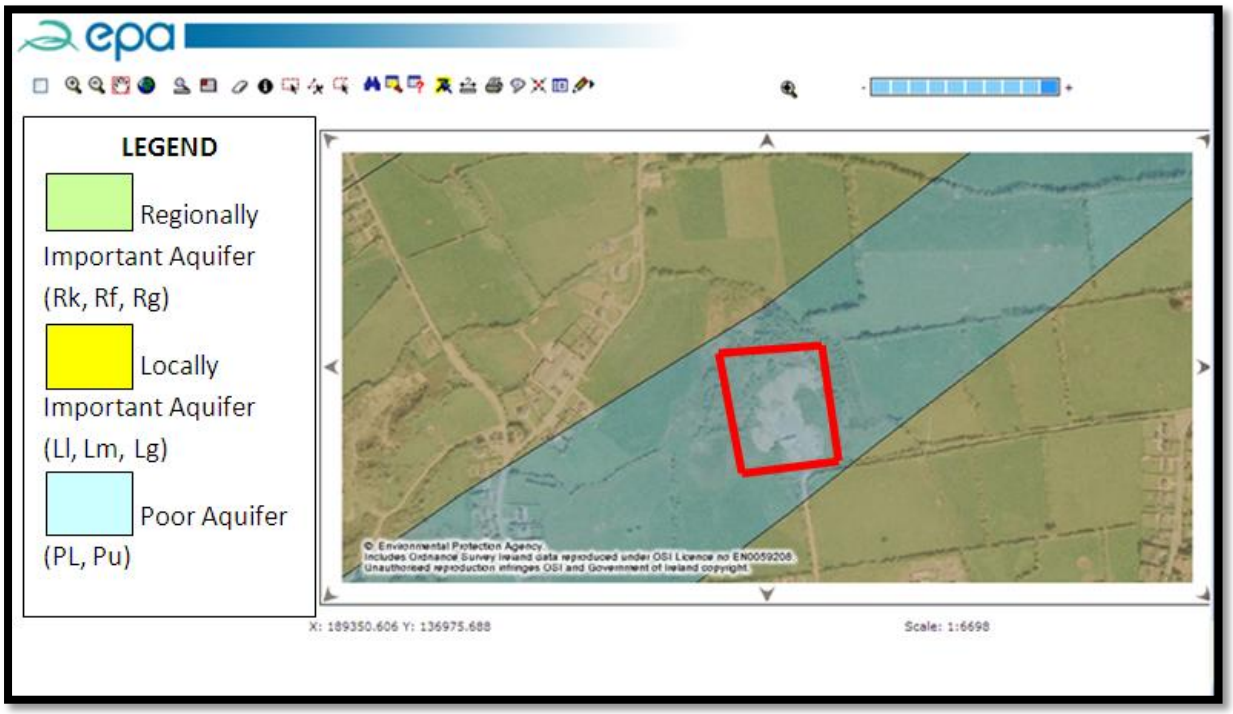


Figure 4. Subsoil Classification. Source: Teagasc Subsoil Map 2006. Outline of landfill shown in red.

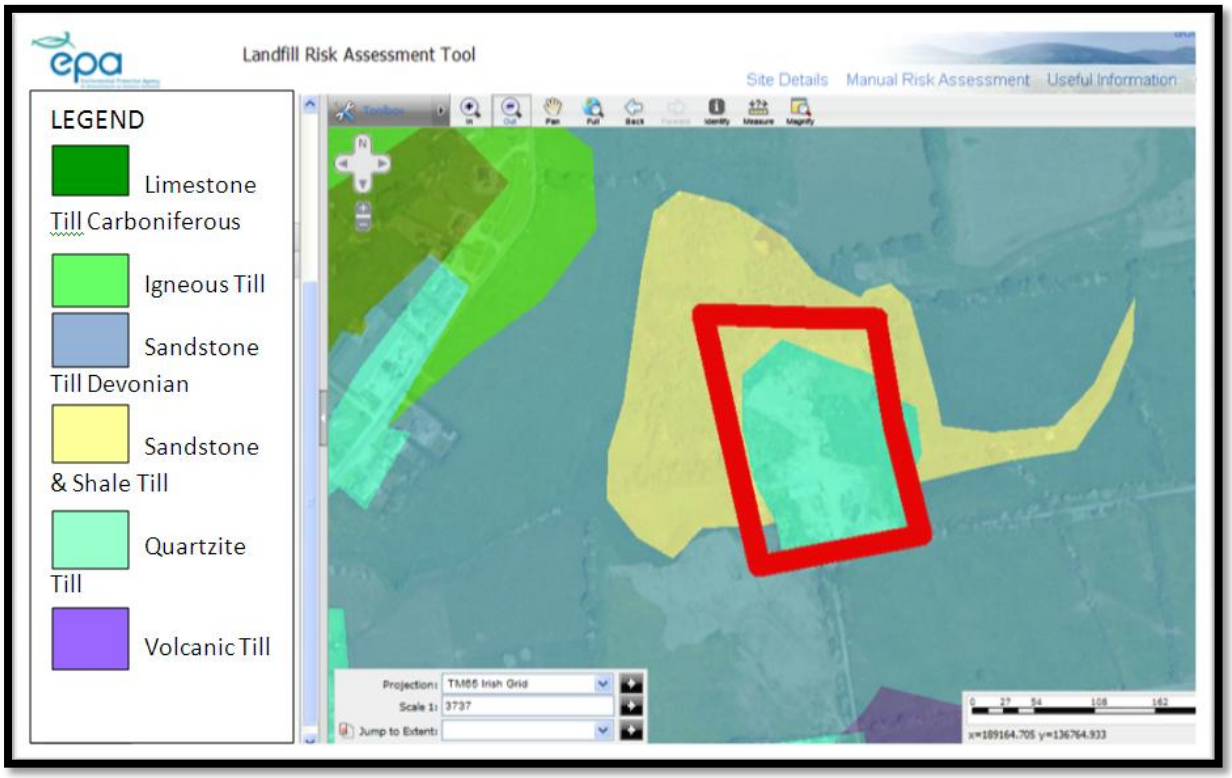


Figure 5. Public Water Supply Search: Council Records. Public water supply shown as a blue triangle. Active drinking water wells are shown as green circles.

Table 4: Tier 1 Risk Calculations and Classification

SPR No.	Equation	SPR Linkage Score (Max Score)	Normalised Score (Calculated score as a % of the max)	Risk Classification
Leachate migration through combined surface water and ground water pathways				
SPR 1 Surface Water Body	1a X (2a+2b+2c) X 3e 7 X (2+1+2) X 3	**105** (300)	35%	C- Low Risk (≤40%)
SPR 2 Protected Area (SWDTE)	1a X (2a+2b+2c) X 3b 7 X(2+1+2) X 1	**35** (300)	12%	C- Low Risk (≤40%)
Leachate migration through ground water pathways				
SPR 3 Human Presence (Private well)	1a X (2a+2b) X 3a 7 X (2+1) x 3	**63** (240)	26%	C- Low Risk (≤40%)
SPR 4 Protected Area (GWPTE)	1a X (2a+2b) X 3b 7 X (2+1) x 1	**21** (240)	9%	C- Low Risk (≤40%)
SPR 5 Aquifer Category	1a X (2a+2b) X 3c 7 X (2+1) x 1	**21** (400)	5%	C- Low Risk (≤40%)
SPR 6 Public Supply (well)	1a X (2a+2b) X 3d 7 X (2+1) x 0	**0** (500)	0%	C- Low Risk (≤40%)
SPR 7 Surface Water Body	1a X (2a+2b) X 3e 7 X (2+1) x 3	**63** (240)	26%	C- Low Risk (≤40%)
Leachate migration through surface water pathways only				
SPR 8 Surface Water Body	1a X 2c X 3e 7 X 2 X 3	**42** (60)	70%	A - High Risk (≥70%)
SPR 9 Protected Area (SWDTE)	1a X 2c X 3b 7 X 2 X 3	**42** (60)	70%	A - High Risk (≥70%)
Landfill gas migration pathways				

SPR 10 Lateral Migration to Human Presence	1b X 2d X3f 7 X 1.5 X 5	**52.5** (150)	35%	C- Low Risk (≤40%)
SPR 11 Vertical Migration to Human Presence	1b X 2e X 3f 7 X 2 X 5	**70** (250)	28%	C- Low Risk (≤40%)

Overall site Risk Classification is high for SPR 8 and SPR 9 and low for all other linkages.

Table 5: Network Diagram for SPR 8

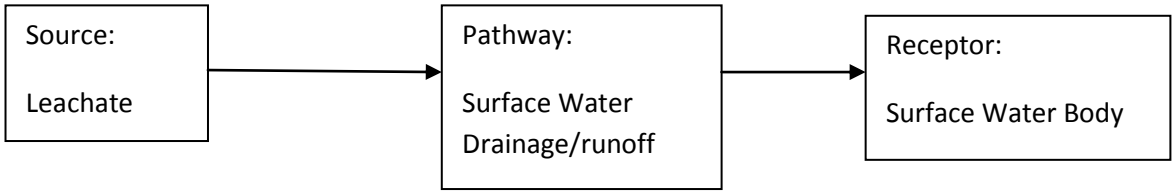
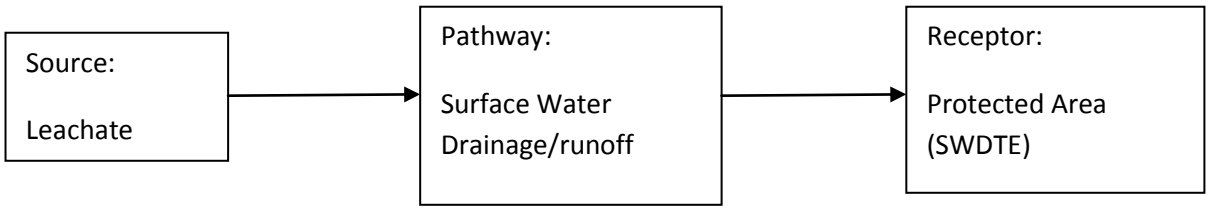
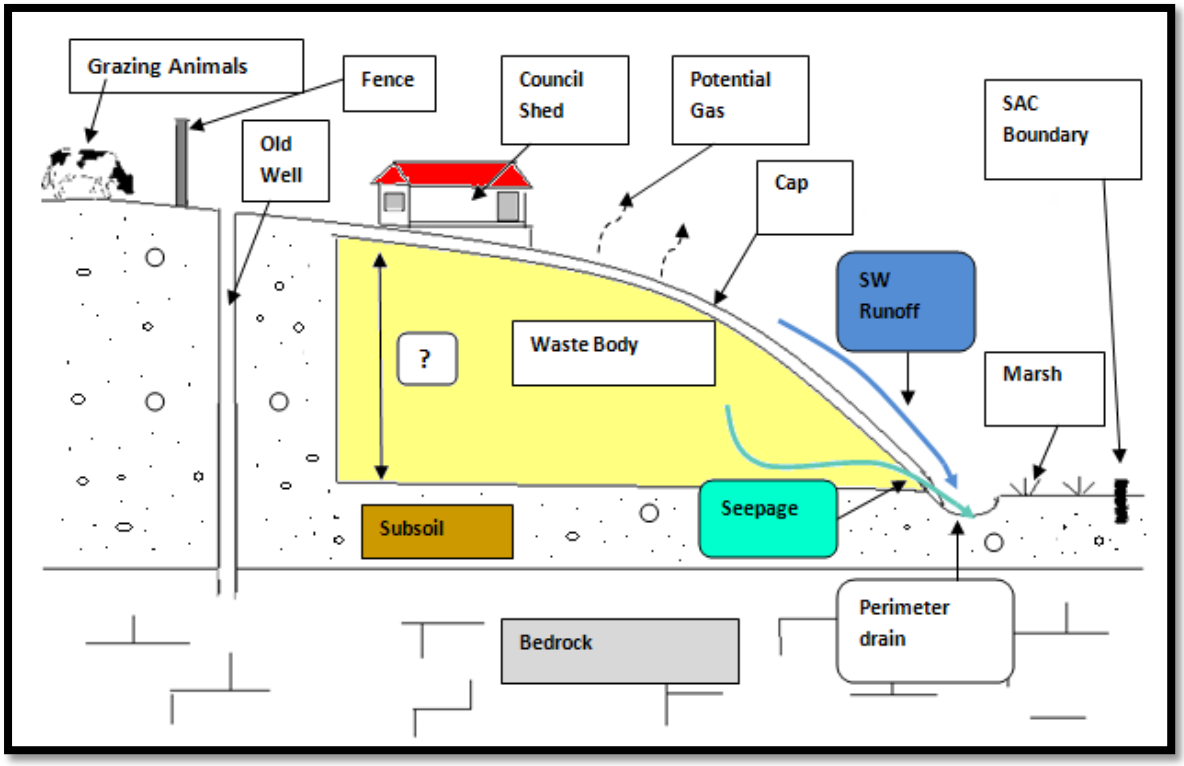


Table 6. Network Diagram for SPR 9.



Initial Conceptual Site Model (CSM)



Matrix Guidance:

Matrix 1 – Guidance for preliminary & exploratory investigations for all unregulated waste disposal sites, under the heading *Tier 1: Preliminary investigation* recommends as mandatory the completion of a desk study, walkover survey and the development of a conceptual site model (CSM). All of these have been completed.

Conclusion

Based on the completion of the SPR scoring as per the COP guidelines the highest risks identified with the closed landfill is associated with the leachate migration to drains and ditches and to the SAC. These are identified as SPR 8 and SPR 9 and it will be these risks that will be the focus of subsequent site investigations conducted as part of Tier 2 work.

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Tier 2 – Exploratory Investigation.

Scope and Goals

The Code of Practice and the EPA's Matrix 1 recommends conducting the Tier 2 Risk Assessment in 2 phases, the first part being an exploratory investigation. The goals of the exploratory investigation are to:

- Refine the Conceptual Site Model
- Confirm Risk Classification from the Tier 1
- Scope the Main site investigation.

Methodology.

Matrix 1 – Guidance for preliminary & exploratory investigations for all unregulated waste disposal sites, under the heading *Tier 2: exploratory investigation & sampling* recommends for SPR 8 & 9 the following:

• Trial Pits & Trenches	Mandatory
• Waste Type	Mandatory
• Waste Sampling	Recommended
• Leachate Sampling	Recommended
• Soil Sampling	Recommended
• Surface or Ground Water Sampling	Recommended/should be considered
• Topographic & GPS Survey	Recommended/should be considered

Trial Pits

The Matrix recommends between 1-2 days of trial pitting. Typically 7-10 trial pits can be completed in 1 day to a depth of 3-5 metres. The trial pitting will confirm the lateral and (depending on the depth) the vertical extent of the waste body. Presence/absence of leachate and odours should be noted for each trial pit. A handheld gas monitor should be used to assess if landfill gas is present during the excavation of the trial pits. Each trial pit should be logged to the BS 5930:1999 standard and the trial pit and waste material should be photographed. Each trial pit should be back filled and cordoned off to allow for settlement. No non hazardous waste should be removed from the site.

Any hazardous wastes encountered during investigative works (e.g. car batteries) should be removed for appropriate disposal/recovery and not re-interred when backfilling trial pits.

Waste type

Waste observed from the trial pits should be assessed to validate the assumptions of the Tier 1 risk assessment [see table 1a and 1b in Chapter 4 of the COP].

Waste Sampling:

Leachability testing is to be conducted on a minimum of 2 samples from the waste[1] dug from the trial pits, the results should be compared to the 2003/33/EC European Waste Acceptance Criteria (WAC) analysis as per the BS 12457 standard. This WAC analysis will also give some data applicable for comparison against accepted target screening values such as the UK CLEA human health soil screening values and the Dutch Standards, thereby allowing assessment of the potential impact on environmental and human health. Other sampling for asbestos or speciated Total Petroleum Hydrocarbons (TPH) should be considered if there are indications are that these types of waste may be present in the soil.

Leachate Sampling

Liquid samples of leachate recovered from trial pits or seepages should be sent to a laboratory for testing. One sample of leachate should be tested to the full suite of parameters in Table C2 of the EPA Landfill Monitoring Manual 2003. Two other samples should be tested for indicator parameters such as; pH, conductivity, temperature, BOD, COD, Ammonia, Chloride, Sulphate, Heavy Metals, Sodium, Potassium and Phosphorus.

Soil Sampling

Soil testing for assessing quality of the existing cap and to assess the nature of adjacent soils should be conducted to assess permeability and composition as per the BS 5930 standard. Two soil samples should be tested for heavy metals and if necessary asbestos or hydrocarbons to quantify the potential for existing contamination.

Surface or Ground Water Sampling

The seepage to the perimeter ditches should be tested for the full suite of parameters in Table C2 of the EPA Landfill Monitoring Manual 2003. The point where the surface drains and perimeter ditches join downstream of the waste body should be sampled, approximately 30 metres before it enters the marshy area. The marsh should also be sampled for indicator parameters at the point where the drainage system discharges into it. Sampling for indicator parameters (as outlined in the EPA COP Matrices) for the small stream and pond should also be completed.

The GSI data base should be consulted to see if any groundwater wells have been recorded within one kilometre of the site (see figure 4). A door to door survey should be conducted in the area where there is potential for any existing wells or active abstraction boreholes in the relevant areas.

Topographic & GPS Survey

A topographic survey should be completed on the site: this will provide a base map for site layout and assist with waste extent and volume calculations. Sampling and investigation points should be accurately recorded and mapped using GPS for presentation on the site layout map.

[1] Samples taken from contaminated soils in the waste body

Exploratory Investigation Findings:

- The depth of waste varied from around 2 metres at the southern end of the landfill to possibly greater than 5 metres at the northern end.
- There appears to be a natural layer of clay under the waste body as identified in some trial pits.
- Waste Characterisation confirmed that the waste was primarily domestic waste although an area of predominately C&D waste was also found. The trial pitting was able to map out the general extent of the waste body. The extent of the landfill was found to be 2.6 hectares.
- The leachate testing showed that the leachate was comparable to an aged leachate (Results showing a pH and a BOD/COD ratio comparable to a methanogenic phase leachate).
- Soil sampling showed that the existing cap is not to the standards in the EPA Landfill Restoration Manual 1999. The cap is too thin and not of low permeability in some areas but it is not contaminated.
- Leachate is seeping in the perimeter ditches at the northern end of the landfill and leachate was also noted in the surface water in the main drain that goes into the marsh.
- No elevated indicator parameters were identified in the stream and the pond.
- There was no ground water encountered during this part of the investigation. A door to door survey of the relevant area identified an old ground water well that is no longer in use. All the nearby buildings and the council depot have their water supplied via the mains network.
- Some methane was recorded by a handheld meter in a few of the trials pits: ranging from 0.1% up to 1.2% v/v.

Refine CSM and confirm Risk Classification.

The Exploratory investigation as outlined in the EPA COP Matrix 1 broadly confirmed the assumptions of the Tier 1 Risk Assessment. Although the area of the landfill has increased from 2 hectares to 2.6 hectares, this increase in size does not change the scoring for Tables 1a and 1b of chapter 4 of the COP.

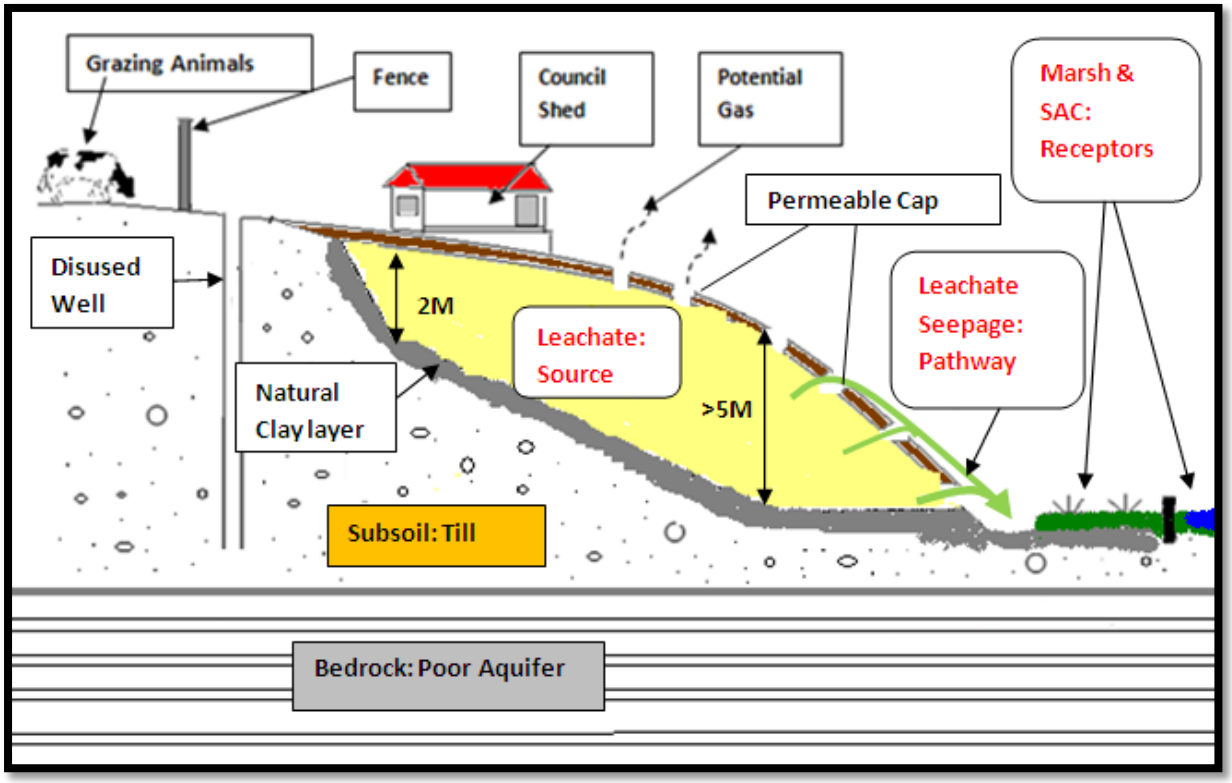
Trial pitting identified an area of C&D waste, however the dominant waste type in the whole landfill is municipal and therefore the scoring for risk source scores [*see tables 1a and 1b in Chapter 4 of the COP*] does not change[2].

Sampling of the surface water drainage showed that it was contaminated by leachate proving the linkage from the landfill source to the water receptor. The leachate itself is an aged leachate which could still pose a risk to human health or the environment.

Although landfill gas was observed in the body of waste, none was recorded in the council shed and canteen. These buildings have a concrete floor which may prevent vertical migration. The trial pitting showed the integrity of the existing cap is not to the standards in the EPA Landfill restoration manual 1999.

[2] If the landfill contains areas of differing wastes, you cannot divide the site into different subunits in order to decrease the landfill area and thus lower the source/hazard score in table1a and 1b in chapter 4 of the COP.

Refined CSM


Grazing Animals
Fence
Council Shed
Potential Gas
Marsh & SAC: Receptors
Permeable Cap
Disused Well
2M
Leachate: Source
Leachate Seepage: Pathway
Natural Clay layer
>5M
Subsoil: Till
Bedrock: Poor Aquifer

Tier 2 Main Investigation.

Scope and Goals

The Code of Practice and the EPA's Matrix 2 recommends the site investigation techniques, sampling and specialist surveys for the main site investigation. The goals of the main investigation are to:

- Refine the Conceptual Site Model
- Confirm Risk Classification[3]
- Provide sufficient information to progress to Tier 3 Quantitative Risk Assessment (QRA) and Remediation Stage.

Methodology

Use the *Matrix 2 – Guidance for main site investigation requirements for moderate risk and high risk for unregulated waste disposal sites*. The SPRs of concern are SPR 8 and SPR 9.

The Matrix 2 identifies that the following are recommended for SPR 8 and SPR 9:

- Geophysics for waste depth, plumes and anomalies.
- Window Sampling and/or Cable Percussion Boring for boreholes
- Leachate Sampling
- Soil Sampling
- Surface Water Sampling
- Ecological Surveys
- Surface Water Surveys

As the SPR 8 and SPR 9 linkages concerns the risk of leachate entering a surface water body and a protected area via seepages or runoff, the matrix does not recommend shallow probes, gas monitoring, bedrock drilling, ground water sampling or assessment, odour or dust surveys. This avoidance of unwarranted investigations represents a considerable saving of time and resources and allows for targeted site investigations focusing on the primary SPRs identified.

Geophysics survey for waste depth, plumes and anomalies

The Geophysics (which should be scoped and completed by a specialist) clearly identified confirms the footprint of the waste body and showed the maximum depth of the waste was to 8 metres at the northern end. It confirmed that a natural lay material underlies the waste and that the bedrock is at depth. One potential leachate plumes was identified towards the northern end of the landfill. There was a large anomaly noticed in an area of landfill that was not trial pitted. This was interpreted to be industrial waste from a farm machinery factory – additional trial pitting subsequently undertaken confirmed this.

[3] Note that all sites with moderate or high SPR's after Matrix 1 must progress to the Tier 3 QRA. If a high/moderate SPR is subsequently found to be low, then the QRA and remediation strategy can be prepared to reflect this [chapters 6 & 7 of the COP].

Window Sampling and/or Cable Percussion Boring for boreholes

The matrix recommends window sampling and/or cable percussion boring. Both these techniques generate boreholes so it may not be necessary to choose both depending on site access and depth of investigation required. On-site conditions will determine which one or combination is most suitable. Three boreholes were completed: two in the waste and one at a down gradient location. Monitoring standpipes were installed to allow leachate/groundwater and (if necessary) gas sampling. Samples of the soil were acquired in the waste and the natural ground. Note that the boreholes in the waste were stopped once they reached the underlying clay to prevent a migration pathway for leachate into the natural ground being formed. Detailed borehole logs with well installation information should be completed and water/leachate ingress and standing levels recorded.

Leachate Sampling

Preliminary leachate testing from the exploratory investigation indicates that this is aged leachate. As SPR 8 and SPR 9 are the high risk and a risk assessment will need to be completed, the COP Matrix 2 recommends that a minimum of two full suite samples are taken at suitable locations on the site – i.e. the new boreholes – one in the waste and one outside it. Indicator parameter analysis will suffice for other locations.

Soil Sampling

Soil sampling from the natural clay at the base of the boreholes will assess its permeability and quality. This assesses its potential for preventing leachate migration through the underlying bedrock. Soil sampling from impacted materials from within the waste body will confirm its contamination potential. Soil sampling of natural material for its quality composition and permeability will assess its suitability for remediation capping works.

Surface Water Sampling

Surface water sampling will require, if possible, a full suite analysis of both upstream and downstream of the landfill. As there is no upstream location on the drainage system, samples will be taken from the ditch and in the marsh. Indicator parameter analysis will suffice for other relevant locations such as other ditches in the vicinity of the site. Given the ecological sensitivity of the downstream, receptor, full suite analysis will be completed on the stream and the pond.

Ecological Survey

An Ecological Survey will be required on the adjacent wetland by a suitably qualified person to assess the potential impact of the leachate on the freshwater ecosystem. This ecological assessment may look at such things Q-Values for water quality or habitat use and potential. The survey and should include screening for Appropriate Assessment (AA) (as per Article 6(3) of the Habitat Directive). AA screening is required in the EPA's Certificate of Authorisation (COA) for all landfills which are within 5KM of a Natura 2000 site.

Surface Water Survey

Not to be confused with the surface water sampling: a surface water survey will be required in order to assess water level, flow rates and assimilative capacity of the nearby drainage network and as far as is practical the marsh and the surface water habitat.

Findings of Main Investigation and discussion

- 2.6 hectare site containing MSW, C&D and some industrial waste.
- The Tier 2 site investigation confirmed that the leachate was impacting the adjacent ditch and nearby marshy area, via the surface water drainage system.
- The main contaminants were ammonia, metals and chloride.
- Additional trial pitting confirmed an area containing machinery and related wastes as identified by the geophysical survey.
- The depth of the waste was confirmed by geophysical survey and boreholes to be 8 metres deep in the northern end of the landfill.
- The natural clay layer was confirmed and was identified to be an impediment to the vertical migration of the leachate.
- Geophysics also accurately identified the area of C&D waste which was less than anticipated based on the initial trial pitting.
- Soil sampling identified that the waste could be generally classified as inert to non-hazardous based on the WAC data [*note this classification is for waste being moved to an engineered and properly planned landfill and does not classify the waste as inert or non-hazardous. It does allow for the contamination potential of the waste to be quantified*]
- Geophysics showed the bedrock to be at depth and there are no receptors identified using the poorly productive aquifer.
- Additional monitoring in the Council shed for methane did not record any elevated concentrations.
- Methane was recorded in several of the trial pits, ranging from 0.1% up to 1.2% v/v. Not considered a significant issue.
- Existing cap is inadequate.
- Suitable material (both quality and volume) exists on site for capping the landfill to the EPA guidance documents.

Discussion and link to Tier 3.

The high risk SPR linkages will have to be broken in the remediation and restoration plan developed for the site.

All Tier 1 and 2 investigation works should be completed with the requirements of the Tier3 and the Certificate of Authorisation in mind with regard to Kilford LF.

A robust remediation strategy should be derived and in this case a key component is an impermeable cap. A proper cap will need to be established over the landfill to limit the potential for rainfall to percolate through the waste. Control and segregation of surface water runoff from the council yard should be undertaken and trenching to limit and collect any seepage at the base of the landfill should be considered. Options such as the interception of the leachate to prevent it from entering the marsh will need to be considered in the Tier 3 Quantitative risk Assessment.