TIER 2/3 ENVIRONMENTAL RISK ASSESSMENT

FOR

ILLEGAL LANDFILL SITE

BACK FIELD REAR OF ST MUNCHIN'S ST

ST MARYS PARK

LIMERICK CITY

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1.0 EXECUTIVE SUMMARY

Verde Environmental Consultants (Verde) was requested to undertake a Tier 2/3 Risk Assessment for an illegal landfill site in St Mary's Park Limerick City under the EPA Code of Practice (Environmental Risk Assessment for Unregulated Waste Disposal Sites), hereafter referred to as the EPA COP.

The subject site is located in a sensitive location on the northern half of Kings Island with the waste area bordering a special area of conservation (SAC) and an established residential housing estate. Tier 1 and Tier 2 assessments have already been undertaken at the site.

A scope of works for the Tier 2/3 Assessment was agreed following consultation with Limerick City Council. Additional site investigation data was required to supplement the information gathered in Tier 1 and Tier 2 assessments and to refine the conceptual site model. Additional information was also gathered for the benefit of designing and costing remediation options for the site.

In accordance with the EPA COP a Detailed Quantitative Risk Assessment (DQRA) is normally required where the site is deemed to pose a high or moderate risk to the environment or human health. Verde considered that the DQRA exercise may not be required given that Ministerial Direction (WIR 04/04) states that sites proximate to residential development and SAC should at all times be remediated. The EPA COP also states that it is to be *"assumed that the waste shall be removed from the site except only where it can be shown that an alternative solution provides greater protection to the environment and the health of the local population."*

A DQRA was not undertaken therefore this report is being referred to as a Tier 2/3 Assessment. In accordance with EPA guidelines, and considering the site specific requirements, the following scope of works was devised:

- Geophysical survey
- Trial pit survey,
- Collection and analyses of waste and sub-soil samples,
- Collection and analyses of groundwater samples for evidence of leachate,
- Collection and analysis of surface water samples
- Landfill gas examination
- Reporting according to the EPA Code of Practice

The risk assessment at St Mary's was undertaken for the site in accordance with the procedure described in the EPA CoP, 2007 and follow on from findings from the Tier 1 and Tier 2 assessments undertaken previously. Findings are summarised as follows:

- The results of the waste and soil analysis indicate that contamination is present in soils which are in direct contact with the waste.
- Results suggest that the waste material encountered is not having a significant impact on underlying natural soils.
- Groundwater quality is generally quite good at the site. There is the potential for leachate from waste material to potentially impact upon groundwater and also surface water. The severity of this risk is likely to increase as the volume of the waste body increases.
- Surface water results did not indicate any significant difference between water quality upstream and downstream of the site. This is consistent with previous assessments at the site.
- There was no evidence of landfill gas on site apart from some evidence of low level landfill gas in deeply buried waste mainly at the southern end of the site.

Although current impacts are low, there is a high potential risk associated with the site. According to the EPA COP risk matrix the site should be re- categorised a Class A – Highest Risk site due to the direct linkages between the waste body with surface water and the SAC.

It is recommended that the site will need to be remediated due to its Class A rating. Remediation of the site will first require the segregation and removal of all mixed waste items such as plastic, wood, metal, electronic items etc. Once these are removed, it is considered that much of the remaining soils may be suitably categorised as inert fill if a diligent segregation process is undertaken. This however will require further verification during the remediation process including consultation with the EPA.

Before undertaking any remediation programme a full ecological assessment will also need to be undertaken at the site according to requirements in relation to protection of the SAC. This ecological assessment will need to be undertaken in conjunction with the design of the remediation plan for the site.

2.0 INTRODUCTION

Verde Environmental Consultants (Verde) was requested to undertake a Tier 2/3 Risk Assessment for an illegal landfill site in St Mary's Park Limerick City under the EPA Code of Practice (Environmental Risk Assessment for Unregulated Waste Disposal Sites), hereafter referred to as the EPA COP.

The subject site is located in a sensitive location on the northern half of Kings Island with the waste area bordering a special area of conservation (SAC) and an established residential housing estate. A summary of the Tier 1 and Tier 2 assessments completed for the site are introduced in Section 2.1 below.

2.1 Summary of Tier 1 and Tier 2 Findings

A summary of Tier 1 and Tier 2 Risk Assessment findings is given as follows:

- Soils affected by waste materials were visually examined and were determined to be generally aerobic with some darker anaerobic conditions below the surface.
- Surface water was visually examined on site and there was no significant evidence of contamination of drainage channels leading to the Abbey River and River Shannon. This is supported by physicochemical analysis of surface water as undertaken in the Tier 1 Assessment.
- There is no significant ecological evidence of any alteration in the existing wet grassland vegetation in the SAC arising from the dumping.
- Groundwater leachate sampling has identified some potential concerns in relation to Total Oxidised Nitrogen (TON). Total phosphorous concentrations at the site are also quite variable. Phosphorous is a major nutrient of concern in determining the trophic status of groundwater-fed surface water features. Reasonably elevated concentrations were exhibited for some metals, in particular Calcium, Magnesium, Sodium, Manganese, and Chromium. Arsenic is elevated in one borehole. None of the list I metals were present in high concentrations. The mobility of metals will vary depending on the degradation status of the waste.
- Based on the findings of the Tier 1 and Tier 2 assessments, and in accordance with the EPA COP, the site has been assigned as Class B (moderate risk) due to the SPR linkage of leachate migration through groundwater and surface water to a surface water body and the SAC.
- Landfill gas measurements were not taken at site as there were no landfill gas odours evident at the site.

2.2 Tier 2/3 Risk Assessment – Scope of Works

A scope of works for the Tier 2/3 Assessment was agreed following consultation with Limerick City Council. Additional site investigation data was required to supplement the information gathered in Tier 1 and Tier 2 assessments and to refine the conceptual site model. Additional information was also gathered for the benefit of designing and costing remediation options for the site.

In accordance with the EPA COP a Detailed Quantitative Risk Assessment (DQRA) is normally required where the site is deemed to pose a high or moderate risk to the environment or human health. Verde considered that the DQRA exercise may not be required given that Ministerial Direction (WIR 04/04) states that sites proximate to residential development and SAC should at all times be remediated. The EPA COP also states that it is to be *"assumed that the waste shall be removed from the site except only where it can be shown that an alternative solution provides greater protection to the environment and the health of the local population."*

In accordance with EPA guidelines, and considering the site specific requirements, the following scope of works was devised:

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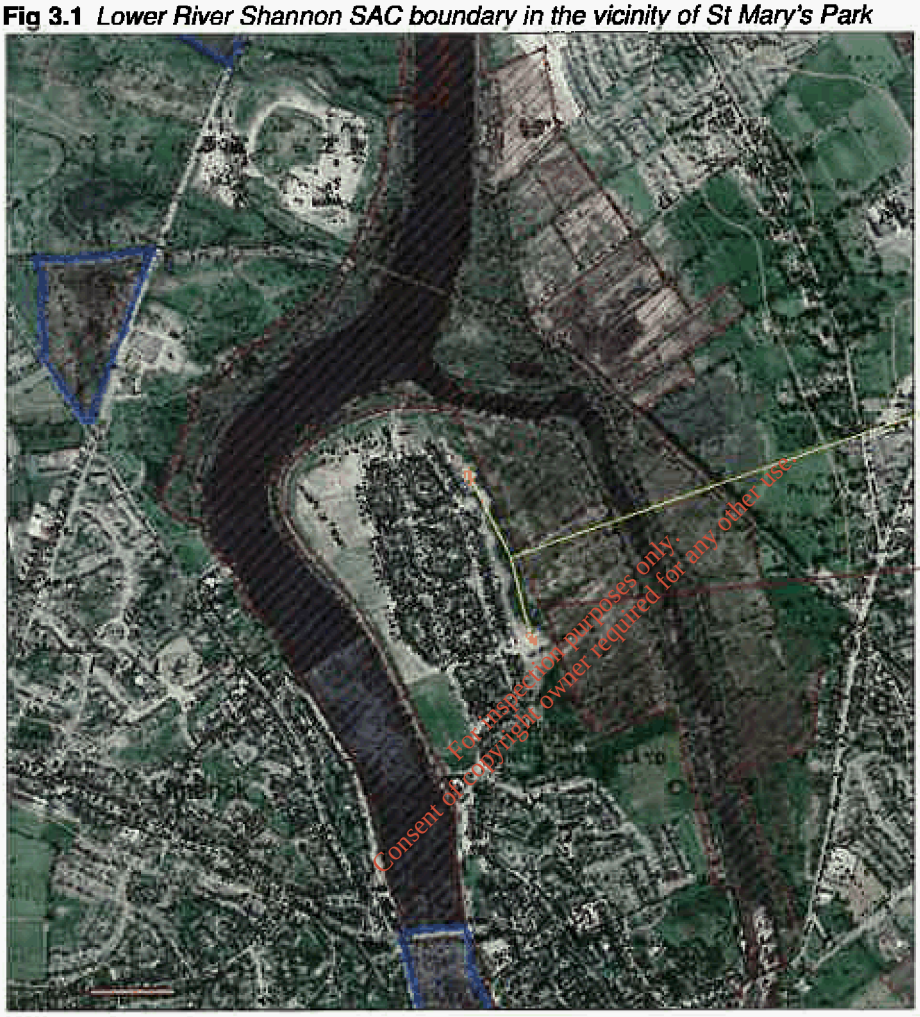
3.0 DESCRIPTION OF SITE

The subject site is approximately 13.5 hectares, owned by Limerick City Council and located in St Mary's Park on the northern half of Kings Island. The island is formed by the River Shannon to the north and west and the Abbey River to the east and south. A 3.5 hectare section of the site has been defined as the portion of the site extending outwards from the rear of the houses on St Munchin's Street and containing the illegal landfill area. The land borders onto the Lower River Shannon Special Area of Conservation (SAC) as seen in Fig 3.1 overleaf.

Fig 3.1 *Lower River Shannon SAC boundary in the vicinity of St Mary's Park*



The landfill lies to the east of an established residential housing estate and forms a linear feature approximately 600m in length along the edge of an extensive area of wet grassland. A gravel access track runs along the rear of the houses from the gate in the north to a bulbous shaped raised area in the south. The nearest dwelling is less than 5m from the waste body.

3.1 Historical Site Use

The primary sources were used to research the history of the site and the surrounding area were available extracts of historical Ordnance Survey of Ireland (OSI) maps, which were viewed on-line and anecdotal information from discussions with Limerick City Council staff and local residents.

Historical information from 1830's OSI mapping indicates that there was a Cromwell's fort located approximately where the housing estate is presently and there were military exercising grounds encroaching onto the current site. The land to the east is a flood plain and OSI mapping suggests that the lands most liable to flooding are the mid to southern areas of the site and bordering onto the waste body. Information from local residents suggests that the flood plan sometimes partially covers some of the waste body.

Based on information provided by Limerick City Council, St Mary's Park was built in the 1930's and intermittent disposal of waste occurred in an area known locally as the "Back Field". An extensive local authority clean up took place in 2001 where waste material was excavated to a depth of up to 3 metres. It is understood that over the years, inert fill was backfilled to raise levels of the site in areas closest to the rear of the houses.

There is a rail line approximately 250m east of the site, running parallel to the Abbey River and records indicate that this was also used as a rail tram historically. According to OSI information from 1830's mapping, five quarries and two lime kilns were located approximately 800m west of the site, consistent with the presence of limestone bedrock in the area.

3.2 Geology

Overburden:

According to Teagasc soils and subsoils data obtained from the GSI public files, subsoil in the area consists of Marine/ Estuarine silts & clays in land liable to floods.

Solid Geology:

The geology beneath the site is indicated by the GSI to comprise of Dinantian Pure Bedded Limestones. Geophyical data indicates that bedrock levels are approximately 6 metres below ground level.

3.3 Hydrology & Hydrogeology

Regional Classification:

According to the national draft bedrock aquifer map, the underlying aquifer is described as a locally important aquifer – bedrock with is generally moderately productive.

Vulnerability:

According to the GSI National Vulnerability Data from 1996, the vulnerability of the site is rated high to low. An examination of the national vulnerability map for the site (presented in Appendix 1 - Maps), the majority of the site particularly on the northern side is considered of low vulnerability and beyond the southern boundary of the site is considered of high vulnerability.

Site investigation findings confirm that there is at least presence of at least 3-4m of adequate soil overburden. The presence of flood plain will however increase the vulnerability area of the site.

Well Search:

A well search for the area indicates that there are no groundwater wells on site or within 500m of the site. There are a number of historical wells listed in OSI data for land beyond 500m east of the site. According to local enquiries, water to the residential areas is supplied via a mains water system.

Surface Water Courses and Drainage:

The River Shannon is located north, flowing in a westerly direction. The Abbey divides out from the River Shannon, approximately 100m north of the landfill area and flows south easterly and then southerly, parallel to the landfill site at a distance of 200m. The Abbey River eventually surrounds the perimeter of Kings Island and meets the River Shannon again. A number of drains run across site from a west to east direction towards the Abbey River.

The special area of conservation (SAC) which is included in the Lower River Shannon runs along the eastern edge of the Island, fronting on to the Abbey River, including lands on both sides of the Abbey river and adjacent to the illegal landfill site. The SAC comprises fresh water wetland which floods in winter and slowly drains during spring and summer.

The Site Map in Appendix 1 outlines all the major features of the site.

4.0 METHODOLOGIES

The Tier 2/3 Risk Assessment is undertaken in accordance with the Code of Practice (Environmental Risk Assessment for Unregulated Waste Disposal Sites), EPA 2007 (EPA CoP, 2007). The detailed components of the scope of works were generated based on the findings of the Tier 1 and Tier 2 risk assessments, the recommendations of the EPA COP and also The EPA Site Investigation Matrices. These matrices were published as a supplementary guidance tool for the assessment of unregulated waste disposal sites. Verde subsequently implemented a site investigation programme that included:

- Geophysical survey
- Trial pit survey,
- Collection and analyses of waste and sub-soil samples,
- Collection and analyses of groundwater samples for evidence of leachate,
- Collection and analysis of surface water samples,
- Landfill gas examination
- Reporting according to the EPA Code of Practice

4.1 Geophysical Survey

The geophysical survey was completed by Minerex Geoservices Ltd between 8th to 10th June 2011. The full Geophysical Survey is presented in Appendix 2 and summarised herein. The main objectives of the geophysical survey were:

- To determine the ground conditions under the site
- The delineate the horizontal and vertical extent of the waste body
- To check for possible leachate plumes
- To determine the depth to rock and overburden thickness
- To determine the type of overburden and rock
- To detect lateral changes within the geological layers

The geophysical methods employed were:

EM31 Conductivity mapping: to determine the bulk conductivity of the subsurface and thereby investigate the lateral extent of landfill material. The measurements also indicate the presence of metal and other conductive objects within the range of the instrument.

2-D Resistivity Profiles: to investigate the lateral and vertical extent of the landfill material, evidence of any leachate plume and the depth to rock.

Seismic Refraction Profiles: determines the depth to horizontal or near horizontal layers where the compaction/strength/rock quality changes. This provides information on landfill and overburden thickness and the depth to rock.

4.2 Trial Pit Survey

The trial pit survey was carried out on the 16 June 2011. Areas of overgrown vegetation, as shown on Photograph 1, were cleared before the start of the survey. The trial pits were excavated using a track mounted excavator, capable of travelling on variable terrain and with a reach of 6 mbgl. The locations are shown on Figure 3.1.

The excavation was supervised by a Verde Environmental Scientist and each pit was logged in accordance with BS5930. The trial pit logs are included in Appendix 3.

4.3 Waste Sampling

Waste sampling was undertaken on the 16th June 2011. A waste analysis suite was generated with consideration for the findings of the Tier 1 & 2 investigations and also to undertake waste testing in accordance with Council Decision of 19th December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC.

Analysis parameters are examined against reference concentrations for inert waste, stable non-reactive hazardous waste and hazardous waste. Specific limit values apply for the total content of the solid portion of the waste and also, limit values apply for the composite of eluate produced during leachability testing of the waste.

Limit values apply for waste acceptable at landfills is calculated at liquid to solid ratios (L/S) of 2 l/kg and 10 l/kg for total release and directly expressed in mg/l for C0 (the first eluate of percolation test at L/S = 0,1 l/kg).

4.4 Soil Sampling

Verde conducted investigations in accordance with BS 10175:2001 Investigation of Potentially Contaminated Sites-Code of Practice. The intrusive works were supervised by experienced Verde environmental scientists who were also responsible for all field monitoring and the collection of the soil samples.

Soil sampling was then undertaken throughout the entire landfill to identify possible hot-spots or localised contamination areas. Individual soil layers were tested to examine for the potential mobility of contamination into underlying soils.

Soils were tested for a range of parameters; all samples were tested for list I and list II metals, phosphates, nitrates, and parameters specifically chosen as indicator parameters of landfill contamination. A smaller selection of samples were taken to provide a cross sectional representation of soil condition. Full details of analysed parameters and results are given in Appendix 4.

4.5 Groundwater/ Leachate Sampling

Groundwater was examined for the presence of leachate according to standard practice for the parameters listed in the EPA Landfill Monitoring Manual 2nd Edition, 2003 as follows. Sampling was undertaken at four of the six boreholes that were previously installed at the site; two of the monitoring wells were damaged and could not be sampled.

Test parameters were chosen the same as those tested in the previous Tier 2 investigations in December so that trends could be observed. Samples were sent to an independent accredited laboratory for analysis. Full details of analysed parameters and results are given in Appendix 4.

4.6 Surface Water Sampling

Surface water sampling was undertaken at three locations to examine surface water quality in the River Shannon and Abbey River. Samples were taken on 17th June 2011 and brought directly to an independent accredited laboratory for analysis.

Sample locations are presented in Figure 1 in the Figures and Tables section of this report. Sampling locations are described as follows:

SW1 was taken at the point where the Abbey River divides out from the Shannon River. This point is upstream of the landfill and therefore is seen as a representative upstream sample for both the River Shannon River and Abbey River.

SW2 was taken at a point on the Abbey River which is downstream of the larger surface water drains that lead out from the landfill body.

SW3 was taken at a point on the river Shannon which is downstream of the landfill area

Full details of analysed parameters and results are given in Appendix 4.

4.7 Gas Monitoring

Gas monitoring was undertaken at across the surface of the site to examine ambient conditions and also gas monitoring was undertaken at each of the available boreholes which were retrofitted with gas monitoring valves. Sampling was undertaken using a Rae Systems Multi Gas Monitor PGM-50. This allowed testing of Methane , Oxygen, Carbon Dioxide.

Landfill gas was monitored in accordance with methodologies described in the EPA Landfill Monitoring Manual 2003. Results are assessed against the Department of the Environment (DOE) publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

Additional monitoring was undertaken using a Mini Rae photoionisation detector (PID) to examine for the presence of volatile organic compounds (VOCs).

4.8 Meteorological Conditions

Meteorological data was recorded on site and also referenced against data from nearby meteorological station information from Shannon Airport.

5.0 ON SITE INVESTIGATIONS

Field works were commenced on 8th June 2011 and the geophysical survey was completed on the 10th June. Data from this survey was then used to provide a guideline for the trial pit sampling. The remainder of site investigations was completed during 16th and 17th June 2011. A summary of works undertaken is given in Table 5.1 below.

Table 5.1 *Summary of Objectives and Works Completed*

DESCRIPTION OF WORKS	OBJECTIVES
Geophysical Survey	• Provides detail on waste composition • Assists in choice of trial pit locations • Assess subsurface geology and hydrogeology to supplement the information gathered in trial pitting • Provides information on depth to rock, stratification of sub-soils and waste layers
Trial Pitting and Soil Sampling x 14 locations	• Provides information regarding waste/ soil type and profiles • Provides information regarding contamination levels in the soils beneath the waste body and mobility potential of contamination found. • Identifies significant pollutants • Provides an examination of leachability of soils • Information on soil composition and characteristics.
Waste sampling x 5 locations	• Identifies significant pollutants • Provides information on waste composition & classification ▪ Provides essential information required for scoping, quantifying and costing of any remediation works.
Gas monitoring x 5 locations	• Undertake at this site due to the close proximity to residential dwellings to assess risk from landfill gas.
Surface Water x 3 locations	• Additional sampling to supplement information gathered in Tier 1 & 2 assessments. • Provides information on the vulnerability of receiving surface water bodies.
Groundwater/ Leachate x 4 locations	▪ Re-examination of groundwater/ leachate to observe trends with previous sampling at site.

5.1 Geophysical Survey

The resistivity and seismic survey delineated five layers that represent waste at the top and rock at the bottom of the profile sections.

The ground conductivity survey outlines areas of mainly domestic waste, high metal concentration and possible leachate into the marshy ground to the East (into the SAC). The full survey is contained in Appendix 2 and summarised as follows:

- The northern portion of the site (Locations 1 – 3 of the geophysical survey) contains the thickest domestic waste within the site, generally in the region of 0.5 – 1m thick.
- Locations 4 and 5, centrally along the landfill, show the highest conductivity outside the domestic waste area. This can possibly indicate lateral spread of leachate from the domestic waste or also could indicate higher clay content in the overburden.
- Locations 6 and 7 are in the bulbous shaped area in the south. Geophysical information indicates that conditions are predominantly created by fill of rock, boulders, sand, gravel and clay with possible some building waste but not large amounts of domestic waste other than what is scattered on the surface. Subsequent trial pitting confirmed the presence of decomposed mixed waste buried centrally beneath this raised area of land.
- Generally the outline of the domestic waste and made ground is shown within the red area on Map 4, this area measures 17000m^2.
- The underlying natural geology is mainly cohesive soils like clay overlying weathered rock and rock at depth.
- There are no leachate plumes visible in the resistivity data, at least not strong leachate plumes as would be typical from landfills. The main locations for possible leachate are at locations 4 and 5 above.

5.2 Physical Examination of Waste

A site excavator was used to examine the waste mound in areas to confirm the depth and composition of waste across the surface and also below ground level. Fourteen trial pits were examined across the landfill site and waste profiles were examined. This provided the information in relation to waste type and quantities. A physical examination of the waste was undertaken, a summary of which is given in Table 5.2 below.

Table 5.2 *Main Waste Types*

WASTE TYPE	DETAIL
Mixed Municipal Waste	Kitchen waste Paper and cardboard Clothes & textiles Metal containers, Furniture, leisure equipment Waste glass Wood Wastes from chimney sweeping Electrical goods Ash from domestic fires
Horse Manure Sawdust and Bedding Material	Manure in particular is extensively visible across site from horses that are housed in the rear of the adjacent dwellings and grazing on site
Construction & Demolition waste	Soil and stones Concrete Metals
Possible Hazardous Waste Components	Discarded electrical and electronic equipment Fluorescent tubes and other mercury-containing waste Discarded equipment containing CFCs Paint, inks, adhesives and resins containing dangerous substances Asbestos

Average waste thickness has been generated from information gathered from trial pitting logs, a summary of which is given in Table 5.3 overleaf.

Table 5.3 *Summary of waste layers*

Trial Pit No	Surface Waste Layer, m	Buried Waste Layer, m	Total Waste Thickness, m
1	0	0.6-1.8	1.2
2	0.1	0.6-1.0	0.5
3	0.1	0.45-0.9	0.55
4	0.1	0.1-0.55	0.55
5	0.55	0.55-0.75	0.75
6	1.1	1.1-1.5	1.5
7	1.95	1.95-2.3	2.3
8	1.2	1.2-1.6	1.6
9	0.5	0.5-1.2	1.2
10	0.6	0.6-1.5	1.5
11	1	1.0-1.5	1.5
12	0.55	0.55-1.5	1.5
13	0.6	0.6-0.7	0.7
14	0	0	0
Average Thickness	0.60	0.50	1.10

The total area of waste is calculated from the Tier 3 Geophysical mapping as 17,000m^2 comprising mixed municipal waste and also inert fill used for raising the site. The topographical survey of the Tier 2 study had calculated the surface area of the mixed municipal waste as 0.95 hectares of this total. During trial pitting, additional waste was however found buried in areas where no surface waste was visible.

Based on the trial pitting survey, the average waste thickness is 1.1m, with an average of 0.6m above ground level and an average of 0.5m waste thickness buried. Taking an average density of soil at 1.5 tonnes per m^3, his equates to a total of 30,600 tonnes of waste of which 16,691 tonnes is on the surface and 13,909 tonnes is buried.

5.3 Waste and Soil Sampling

In most cases, the soil and waste was mixed together therefore sample analysis was primarily based on analytical parameters specified in the EU Council Decision establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC.

5.3.1 *Waste categorisation*

The waste acceptance criteria tests are based on the analysis of a solid sample of waste and also an analysis of leachate eluate generated from the waste according to Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC.

For the St. Mary's site, the solid portion of the samples, tested for total content were all within acceptable levels for inert classification. In the case of the leachate generated from these samples, the majority of test parameters are below the waste acceptance criteria (WAC) criteria for inert waste set in the Council Decision apart from a few elevations described below:

Trial Pit 1 (0.6-1.5m portion): Mixed soil and waste had elevated soluble sulphate concentrations in the waste eluate of 2,130mg/kg; higher than the WAC of 1,000mg/kg. However the Council Decision states that *"if the waste does not meet these values for sulphate, it may still be considered as complying with the acceptance criteria if the leaching does not exceed either of the following values: 1,500 mg/l as C0 at L/S = 0,1 l/kg and 6,000 mg/kg at L/S = 10 l/kg.*

Trial Pit 7 (2.0-2.3m portion): Mixed soil and waste in had elevated soluble sulphate concentrations in the waste eluate of 1,140mg/kg: higher than the WAC of 1,000mg/kg. The same derogation may apply as above.

Trial Pit 14 (upper 0.2m portion): Mixed soil and waste in had elevated dissolved organic carbon in the waste eluate concentrations of 609mg/kg, above the WAC of 500mg/kg. This sample was taken the extreme north of the site, in an area where no waste was present.

Trial pits 10, 11, 12, 13 Composite Sample: The composite sample generated from the of mixed soil and waste layers had 3 somewhat elevated results as follows:

- Antimony 0.0882mg/kg against a WAC of 0.06mg/kg in the waste eluate.
- Sulphate 2,950 mg/kg against a WAC of 1,000 in the waste eluate. The same derogation for sulphate may apply as noted above.
- Total Dissolved solids 5,130mg/kg against a WAC of 4,000 in the waste eluate.

It is important that although the waste analysis suggests that the waste can be classified as inert in most cases, the Council Decision states that "*if the listed wastes are contaminated or contain other material or substances such as metals, asbestos, plastics, chemicals, etc. to an extent which increases the risk*

associated with the waste sufficiently to justify their disposal in other classes of landfills, ***they may not be accepted in a landfill for inert waste.****"*

This note is important in that the waste cannot be classified as inert in this case due to the observed presence at the St. Mary's site of large quantities of metals, plastics, and also some observed asbestos and potential chemicals. Based on laboratory results, it is suggested that once these items are segregated out and removed that the waste may be regarded as inert (following further verification).

5.3.2 Soil and Waste Analysis Results

The previous section deals with the categorisation of the waste and additional soil sampling was then undertaken at representative locations throughout the site to identify possible hot-spots or localised contamination areas. Sampling objectives also focused on identifying any impact on the natural ground underlying the waste.

In order to assess the human health and environmental risks posed by potential contaminants within the underlying soils and groundwater, Verde undertook a comparison of the laboratory analysis for soil samples using generic assessment criteria (GAC). Generic assessment criteria are contaminant concentration values used for comparison purposes to assess the risk associated with contaminant concentrations found on site and are derived using non-site-specific information. In the absence of generic assessment standards, Verde have adopted UK CLEA methodology for the assessment of risks.

Following the UK CLEA methodology, generic assessment criteria have been used to highlight contaminants present at the site which pose a risk to human health. For the St. Mary's Park site, the GACs applicable to residential with plant uptake have been used for assessment of the risk for the site.

The following rationale was chosen in sample choice:

1. Sampling of made ground/ soils mixed with waste - results summarized in Table 5.4
2. Sampling of soil in natural ground - results summarized in Table 5.5

Table 5.4 *Analysis of made ground and soil mixed with waste*

Trial Pit No:	2B	4A	8B	11B	GENERIC ASSESSMENT CRITERIA
Sample ID	20476-1-002B	20476-1-004A	20476-1-008C	20476-1-011B	
Depth	0.55-1.0	0-1.0	1.2-1.6	1.25-1.5	
Arsenic (As)	10.3	23.6	10.3	33.4	32
Cadmium (Cd)	1.27	1.53	0.774	10.2	10
Total Chromium (Cr)	33.2	43.1	23.2	1.36	3,000
Copper (Cu)	46.4	51	33.8	31.4	200
Lead (Pb)	135	694	78.5	46.7	200
Mercury (Hg)	< 0.14	< 0.14	< 0.14	187	170
Nickel (Ni)	25.1	31.6	27.3	< 0.14	130
Selenium (Se)	2.1	3.71	< 1	25.1	350
Zinc (Zn)	134	82	118	1.49	450
Sulphate	1810	1210	1010	1170	2,400
Phenol	< LOD	0.0172	< LOD	< LOD	180
Total Organic Matter	ND	5.88	ND	ND	NS
Phosphate, PO4	< 1	< 1	< 1	< 1	NS
Total Oxidised N	5.52	< 1	< 1	2.55	NS
pH, pH units	6.55	7.23	7.82	7.03	NS

NOTE

- All results are in mg/kg dry substance.
- Generic Assessment Criteria for all metals based are on Soil Guideline Values (CLEA) for residential land use with plant uptake apart from Chromium & Copper which are derived from LQM / CIEH values

One elevated results was observed Trial Pit 4 where a lead concentrations of 694mg/kg was found in the upper 0.8m of waste mixed with soil. The representative GAC for lead is 200mg/kg.

Analysis results for natural soils are presented in Table 5.5 overleaf.

Table 5.5 *Analysis of natural ground*

TRIAL PIT NO:	1C	4B	7C	9B	11B	GENERIC ASSESSMENT CRITERIA
Sample ID	20476 1 001C	20476 1 004B	20476 1 007C	20476 1 009B	20476 1 011B	
Depth	2.5-3.0	1.2-1.5	2.3-2.5	1.5-2.0	0.8-1.0	
Arsenic (As)	12.9	6.35	5.86	11.6	3.76	32
Cadmium (Cd)	0.896	0.549	0.439	0.698	0.318	10
Total Chromium (Cr)	30.8	24.1	23.5	23.1	33	3,000
Copper (Cu)	5.55	19.2	16	18.3	16.9	200
Lead (Pb)	44	41	38	42.4	46.3	200
Mercury (Hg)	< 0.14	< 0.14	< 0.14	< 0.14	< 0.14	170
Nickel (Ni)	31.3	34.8	29.1	34.2	26.8	130
Selenium (Se)	1.16	< 1	< 1	< 1	< 1	350
Zinc (Zn)	44.9	59.6	47.6	58.1	37.5	450
Sulphate	119	50.7	106	78.9	274	2,400
Phenol	< LOD	< LOD	< LOD	< LOD	< LOD	180
Total Organic Matter	ND	< 0.35	ND	ND	ND	NS
Phosphate, PO4	< 1	< 1	< 1	< 1	< 1	NS
Total Oxidised N	< 1	< 1	< 1	< 1	< 1	NS
pH, pH units	8.03	8.18	8.22	8.1	7.84	NS

NOTE

- All results are in mg/kg dry substance.
- Generic Assessment Criteria for all metals based are on Soil Guideline Values (CLEA) for residential land use with plant uptake apart from Chromium & Copper which are derived from LQM / CIEH values

The results for natural ground are significantly lower than the results for waste samples analysed. No elevated results were found in natural ground therefore results suggest that there is no significant impact to the natural ground underlying the landfill.

5.4 Groundwater Sampling

Groundwater at the site was tested for the presence of leachate. Six wells had been drilled during the Tier 2 site investigation and of these wells two had been found damaged.

In order to assess the groundwater analyses results with regard to potential risks to human health and/or environmental receptors, Verde have compared the groundwater results with Threshold Values listed in the European Communities Environmental Objectives (Groundwater) Regulations 2010 (SI No 9 of 2010). These regulations have been developed for the purposes of responding further to the requirements of The Water Framework Directive (2000/60/EC) and The Groundwater Directive (2006/118/EC). Where no threshold value exists, comparisons are made with the older EPA Interim Guideline Values (IGVs) for the protection of groundwater.

It is noted that the comparison of groundwater analytical results with the Groundwater Regulations is not representative of actual risk and is used as a guide to the potential risks posed. It is also noted that background levels may already be influenced by the sites close proximity to a residential area. The limit values are therefore primarily being used to identify any potential groundwater issues and observation of any trends across the site. Results of the remaining four monitoring wells are summarised below.

5.4.1 *In Situ Measurements*

A summary of *in-situ* analysis and laboratory analysis are given in Tables 5.6 and 5.7 below.

Table 5.6 *Summary of groundwater in situ measurements*

Well ID	Casing Height (m)	Water Level (m)	Well Depth (m)	pH	Temperature (°C)	Conductivity (µS/cm)
BH1	0.38	0.90	4.17	6.91	13.0	960
BH2	0.25	0.75	3.65	7.02	12.8	800
BH3	0.19	1.23	3.54	7.00	13.4	760
BH4	Borehole damaged					
BH5	0.28	0.54	4.58	7.09	12.4	740
BH6	Borehole damaged					
Reference Limit Value :				6.5 - 9.5	NS	800-1,875

Notes

- Casing Height = height of steel casing above ground level
- Water Level = distance measured between top of steel casing and top of water level
- Well depth = distance measured between top of steel casing and base of well

Table 5.7 – *Groundwater Analysis Results*

PARAMETER	UNITS	BH1	BH2	BH3	BH5	Reference Limit Value
		20476-1-MW1	20476-1-MW2	20476-1-MW3	20476-1-MW5	
Organic Carbon, Total	mg/l	20.4	10.5	8.48	7.7	no abnormal change *
Ammoniacal Nitrogen as NH3	mg/l	11.5	<0.2	1.7	<0.2	0.15
BOD, unfiltered	mg/l	2.38	<1	<1	<1	ns
COD, unfiltered	mg/l	88.8	286	123	248	ns
Cyanide, Total	mg/l	<0.05	<0.05	<0.05	<0.05	0.01*
Nitrate as NO3	mg/l	<0.3	2.49	3.37	<0.3	37.5
Nitrite as NO2	mg/l	<0.05	0.07	<0.05	<0.05	375
Oxygen, dissolved	mg/l	9.04	8.67	8.38	8.64	ns
pH	pH Units	8.44	7.88	7.96	8.07	6.5-9.5 *
Phosphate (ortho) as PO4	mg/l	<0.05	<0.05	<0.05	<0.05	0.03*
Sulphate	mg/l	130	206	29.1	35.5	187.5
Sulphide	mg/l	<0.05	<0.2	<0.1	<0.1	ns
Arsenic (diss.filt)	µg/l	4.69	0.768	1.05	1.49	7.5
Boron (diss.filt)	µg/l	181	203	73.8	172	ns
Cadmium (diss.filt)	µg/l	<0.1	<0.1	0.141	0.101	3.75
Chromium, Hexavalent	mg/l	0.032	<0.03	0.042	<0.03	0.03*
Copper (diss.filt)	µg/l	3.26	3.4	4.77	5.55	1,500
Lead (diss.filt)	µg/l	0.185	0.074	0.156	0.222	18.75
Mercury (diss.filt)	µg/l	<0.01	<0.01	<0.01	<0.01	0.75
Nickel (diss.filt)	µg/l	13	7.3	7.08	6.81	15
Zinc (diss.filt)	µg/l	8.88	1.66	2.24	2.22	100 *
PAHs	µg/l	0.287	none detected	none detected	none detected	0.075
Phenols, Total monohydric	mg/l	none detected	none detected	none detected	none detected	0.5*

Notes

Reference Limit Values are according to threshold values listed in the European Communities Environmental Objectives (Groundwater) Regulations 2010 (SI No 9 of 2010). In any case where a threshold value is not available, comparison is made with the older EPA Interim Guideline Values (IGVs) for the protection of groundwater, these are marked with an asterix *

Normal groundwater temperatures in Ireland vary between 9.5 and 10.5 degrees Celsius and based on this, groundwater temperature at this site may be somewhat elevated. This however may be explained by the presence of groundwater close to the surface at the site (average water level less that 1m from the surface), but also may be contributed to by microbial activity in soils due to waste breakdown. Conductivity readings and pH readings appear normal for the site.

Ammoniacal Nitrogen concentrations are elevated at BH1 and this may be as a result of horse manure or decomposition products of other municipal wastes on site. PAHs are also elevated at this location. Borehole 1 is located close to the entrance gates of the landfill and waste deposition is thickest in this region.

Sulphate has a threshold value of 187.5 mg/l quoted in SI No 9 of 2010; all samples comply with this value apart from BH 2 where a concentration of 206 mg/l was found. Sulphate may be a direct indicator of leachate contamination but natural background levels can be related to underlying sedimentary rock or areas influenced by sea water.

Apart from the results outlined above, general groundwater at the site is considered reasonably good and no significant variations have been observed from comparisons with analysis undertaken during previous sampling at site.

5.5 Surface Water Sampling

Surface sampling was undertaken at three locations; one upstream location (SW1) where the Abbey river divides away from the river Shannon and two other samples representing downstream on the Abbey River (SW2) and downstream on the River Shannon (SW3). The laboratory test report is contained in summarised below and presented in full in Appendix 4.

Table 5.8 - *Surface Water Results*

PARAMETER	UNITS	SW1 (Upstream)	SW2 Abbey R. Downstream	SW3 R. Shannon Downstream	Reference Limit Value
Organic Carbon, Total	mg/l	11.3	9.81	9.7	ns
Ammoniacal Nitrogen as NH3	mg/l	<0.2	<0.2	<0.2	0.2
BOD, unfiltered	mg/l	1.08	<1	<1	4
COD, unfiltered	mg/l	22.5	21.6	21	40
Cyanide, Total	mg/l	<0.05	<0.05	<0.05	10
Nitrate as NO3	mg/l	3.53	3.48	3.39	50
Nitrite as NO2	mg/l	0.05	0.05	<0.05	0.05
Oxygen, dissolved	mg/l	10.2	9.96	10.3	ns
pH	pH Units	8.68	8.68	8.67	6 to 9
Phosphate (ortho) as PO4	mg/l	<0.05	<0.05	<0.05	0.5
Sulphate	mg/l	10.4	10.4	12.9	200
Sulphide	mg/l	<0.01	<0.01	<0.01	ns
Arsenic (diss.filt)	µg/l	0.715	0.941	0.756	25
Boron (diss.filt)	µg/l	15.2	20	17	2000
Cadmium (diss.filt)	µg/l	<0.1	<0.1	<0.1	< 0.08
Chromium (diss.filt)	µg/l	5.04	4.94	5.25	32
Chromium, Hexavalent	mg/l	<0.03	<0.03	<0.03	3.4
Copper (diss.filt)	µg/l	1.32	1.23	1.28	30
Lead (diss.filt)	µg/l	0.027	0.049	0.04	7.2
Mercury (diss.filt)	µg/l	<0.01	<0.01	<0.01	0.05
Nickel (diss.filt)	µg/l	2.4	2.37	2.47	20
Zinc (diss.filt)	µg/l	0.492	0.887	1.23	50
Phenols, Total monohydric	mg/l	none detected	0.12	none detected	8
Benzo(a)pyrene (aq)	µg/l	<0.009	<0.009	<0.009	0.05
Benzo(b)fluoranthene (aq)	µg/l	<0.023	<0.023	<0.023	0.03
Naphthalene (aq)	µg/l	0.175	0.105	0.321	2.4

Notes

Reference limit values included for comparison are derived from values quoted in SI 272 of 2009, European Communities, Environmental Objectives (Surface Waters) Regulations 2009. For parameters where no EQS is available, comparison is made with selected values from Parameters of Water Quality, Interpretation and Standards, EPA 2001.

Based on laboratory results, no adverse impacts to surface water were observed and the existing water quality and capacity within the Abbey River and River Shannon is good.

5.6 Landfill Gas Sampling

During this investigation, gas valves were retrofitted to the monitoring wells installed previously during Tier 2 investigations. Some of the wells were damaged, details of which are included below. The monitoring programme included the measurement of methane, carbon dioxide, oxygen and also volatile organic compounds VOCs.

The monitoring results are presented in Table 5.6.1 and are examined against guideline limits from the Department of the Environment (DOE) publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994). The guidelines stipulate that, where carbon dioxide or methane are present in a landfill at 0.5% v/v and 1% v/v respectively, then housing should not be erected within 50 m of the landfill and private gardens should not be allowed within 10 m.

Table 5.9 *Summary of in landfill gas measurements*

Well ID	Methane %	Carbon Dioxide %	Oxygen %	VOCs ppm
BH1	< 0.1	0.058	20.9	1.9
BH2	< 0.1	0.061	20.9	5.8
BH3	< 0.1	0.058	20.9	< 1
BH4	< 0.1	0.058	20.9	5.0
BH5	Damaged	Damaged	Damaged	Damaged
BH6	< 0.1	0.08	20.9	< 1
Reference Limit :	0.5	1.0	NS	NS

Notes

Borehole 5 was damaged and therefore not suitable for sampling. Boreholes 4 and 6 were also partially damaged with steel bars etc. in the boreholes. Although it was possible to install gas monitoring valves on the monitoring wells, it was not possible to confirm if the wells were allowing free flow of gas from beneath.

A screening examination of landfill gas was also done across the landfill surface and no landfill gas was recorded. No landfill gas of significance was recorded in the landfill monitoring points installed on site. Decomposition odours were detected in Trial Pit 1 and therefore a temporary gas monitoring well was installed in the soils prior to backfilling. Low level landfill gas was detected at this point, a reading of 0.015% methane was measured and CO_2 was measured at 0.35%. Both of these levels are below the relevant limit values. This trial pit was installed at the south of the site where evidently historical dumping was undertaken and then covered over with inert fill. It is important to point out that this was only installed as a temporary sampling point and is not may not be a representative sample. The presence of low level landfill gas in this area however highlights the potential for landfill gas production at the site due to older decomposed wastes.

5.7 Meteorological Conditions

Weather conditions were mild on both days with moderately heavy occasional rain. Environmental conditions during 16 to 17 June 2011 are summarised in table 5.7.1 below.

Table 5.10 *Summary of meteorological conditions*

Date	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	Atmospheric Pressure (mBar)
16/6/2011	5.2	15.6	8.9	1006.7
17/6/2011	15.1	16.1	9.6	997.4

(Data obtained from historical weather station data for Shannon Airport www.met.ie and www.wunderground.com).

6.0 REVISED SITE CONCEPTUAL MODEL

The EPA COP requires the Conceptual Site Model (CSM) developed during Tier 1 and Tier 2 should be refined after completion of the Tier 3 Assessment. Contamination sources within the waste body are very variable and the site is an unregulated landfill there is a high degree of uncertainty about the wastes present. Investigations undertaken to date indicate that the soils or water bodies have not been significantly affected by the presence of the waste material to date; however, the waste is considered to be a significant potential contamination source. Verde consider the same pollutant linkages to exist as were defined in the Tier 2 risk assessment. A brief summary of the pollutant linkages in provided below.

In the context of defining the pollutant risks for the site, the following are defined:

- Source – a substance that is in, on or under the land and has the potential to cause harm or to cause pollution of environmental media or risk to environmental receptors
- Pathway – a route or means by which a receptor can be exposed to, or affected by, a contaminant source.
- Receptor – in general terms, something that could be adversely affected by a contaminant, such as people, an ecological system, property, or a water body, and

The risk assessment methodology outlined in the EPA CoP is based on a risk prioritisation scoring system whereby the system evaluates the potential pollutant linkages at a site and produces an overall site score based on the maximum individual linkages for the site. The scoring system used allocates a higher value to higher risk elements thus allowing a meaningful comparison to be made between different sites. Ultimately the system ranks the site in terms of whether it is Class A (high), Class B (medium) or Class C (low risk).

Full details of the S-P-R linkage scores are presented in Appendix 5. The revised conceptual model highlights the plausible pollutant linkages, considering all identified sources, pathways and receptors.

Source contamination is summarised as follows:

- Solid waste material and residual reduced quality made ground/overburden containing waste.
- Reduced quality leachate potentially containing a variety organic & inorganic contaminants.
- Landfill gases being generated within waste body ground

Pathways identified for the contaminants outlined include:

- Potential leaching of components of the waste to the groundwater aquifer.
- Possibility for vertical and lateral migration of contamination to the Abbey River and River Shannon.
- Potential contact with the public and County Council employees with the waste material through dermal contact, inhalation of gases and dusts or ingestion.

The primary potential receptors identified to be at risk from the on-site contamination comprise of the following:

- Risks to humans in particular nearby residents.
- Risks to wildlife visiting the site and within the wetland.
- Risks to grazing horses.
- Groundwater in the aquifer beneath the site.
- Risks to groundwater dependent terrestrial ecosystems (GWDTE).
- The River Shannon and Abbey River surround the site and are potential receptors.
- Risks to surface water dependent terrestrial ecosystems (SWDTE) specifically the Lower River Shannon Special Area of Conservation.

6.1 Conceptual Model

A conceptual model is generated based on the nature of the source, the existence of the receptors within defined distances from the source and the pathways available between the source and the receptors. Major source contaminant – pathway – receptor linkages may be summarised as follows:

Table 6.1 *Conceptual Model Linkages*

SOURCE CONTAMINANT	PATHWAY	RECEPTOR
Solid waste material and residual reduced quality made ground/overburden containing waste. Potential variety of organic & inorganic contaminants.	Direct dermal contact Inhalation of dust Ingestion	Public Animals/ wildlife on site Future site users Site workers
	Drainage / Runoff	Abbey River and River Shannon SAC Underlying aquifer
Reduced quality groundwater leachate potentially containing a variety organic & inorganic contaminants.	Direct dermal contact Ingestion	Public Animals/ wildlife on site Future site users Site workers
	Vertical migration (GW Vulnerability) Horizontal Migration (GW flow regime)	Abbey River and River Shannon SAC Underlying aquifer
Ground gases being generated within made ground	Inhalation of landfill gases	Public Future site users Site workers
	Accumulation & explosion of methane within buildings	Building receptors on adjacent lands Possible future on-site buildings

6.2 Risk Scoring System

The scoring system is specified in the CoP. The highest individual linkage scores obtained from the Risk Assessment for St Mary's are summarised below Individual S-P-R linkage scores are normalised to a rating of 100. This is done by representing the linkage score as a percentage of the maximum possible score for each individual linkage. The overall site score is considered to be the maximum of the individual normalised S-P-R linkage scores.

Table 6.2 *Risk Scoring Matrix*

Table Number	Max Points	Points Available	Comment
1a	10	10	Type: Municipal Area 1 to 5 ha
1b	10	7	Type: Municipal Area 1 to 5 ha
2a	3	1	Moderate Vulnerability
2b	5	3	Productive Fissured Bedrock Groundwater Body (Lm)
2c	2	2	Direct connection between drainage ditches & surface water body
2d	3	1	Clay, Alluvium, Peat. No capping layer present.
2e	5	1	Clay, Alluvium, Peat. No buildings, structures or enclosed spaces above the waste body.
3a	3	3	On or within 50m of the waste body
3b	3	3	SWDTE/ GWDTE within 50m of the waste body
3c	5	3	Locally Important Aquifer, Lm
3d	7	3	Public water supply greater than 1km (no karst aquifer)
3e	3	3	Surface water bodies within 50m of site boundary
3f	5	5	Human presence on site or within 50m of site boundary. Includes housing for livestock & poultry

The waste deposited covers a wide area and is in close proximity to surface water drains, in close proximity to adjacent houses and also bordering onto the SAC. For the purposes of this assessment, the surface area of the waste body was mapped found to cover 1.7 hectares. This is higher than the area estimated in the Tier 2 investigations due to the discovery of significant additional volumes of waste buried close to or beneath the surface.

Table 6.3 *Calculation of Risk*

SPR No.	Max Score	Site Score	Normalised Score	Calculation
SPR1	300	180	60	1a x (2a + 2b + 2c) x 3e
SPR2	300	180	60	1a x (2a + 2b + 2c) x 3b
SPR3	240	120	50	1a x (2a + 2b) x 3a
SPR4	240	120	50	1a x (2a + 2b) x 3b
SPR5	400	120	30	1a x (2a + 2b) x 3c
SPR6	560	120	21	1a x (2a + 2b) x 3d
SPR7	240	120	50	1a x (2a + 2b) x 3e
SPR8	**60**	**60**	**100**	1a x 2c x 3e
SPR9	**60**	**60**	**100**	1a x 2c x 3b (SWDTE)
SPR10	150	35	23	1b x 2d x 3f
SPR11	250	35	14	1b x 2e x 3f

Results of investigations at this site indicate that there does not appear to be any significant negative current impact to receptors (groundwater, surface water, flora, fauna or human beings) however by strictly enforcing the scoring system of the COP, it is suggested that the landfill should now be increased to a High Risk (Class A) site. Based on linkages SPR8 and SPR9 relating to linkages between the source waste material and surface water and surface water dependent terrestrial ecosystems (SWDTE).

Risk classification is assigned as follows:

Table 6.4 *Risk Classification*

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

7.0 CONCLUSIONS

The risk assessment at St Mary's was undertaken for the site in accordance with the procedure described in the EPA CoP, 2007 and follow on from findings from the Tier 1 and Tier 2 assessments undertaken previously. Findings are summarised as follows:

- The results of the waste and soil analysis indicate that contamination is present in soils which are in direct contact with the waste.
- Results suggest that the waste material encountered is not having a significant impact on underlying natural soils.
- Groundwater quality is generally quite good at the site. There is the potential for leachate from waste material to potentially impacting upon groundwater and also surface water. The severity of this risk is likely will increase as the volume of the waste body increases.
- Surface water results did not indicate any significant difference between water quality upstream and downstream of the site. This is consistent with previous assessments at the site.
- There was no evidence of landfill gas on site apart from some evidence of low level landfill gas in deeply buried waste mainly at the southern end of the site.

Although current impacts are low, there is a high potential risk associated with the site. According to the EPA COP risk matrix, the site should be categorised a Class A – Highest Risk site due to the linkages defined as follows:

SPR-8: Direct linkages between the waste body (1.7 hectares) and surface water.

SPR-9: Direct linkages between the waste body and with the SAC.

These linkages will be most evident in times of flood when surface water may be in direct contact with a large portion of the landfill. Should waste volumes increase, anaerobic conditions may become evident in underlying wastes. Such conditions would result in changes in soil chemistry, the production of methane and other landfill gases, increased mobility of metals and the generation of sulphides and other waste leachates associated with a typical landfill.

7.0 RECOMMENDATIONS

It is recommended that the site will need to be remediated due to its Class A rating. The EPA COP also references the Ministerial Direction (WIR 04/04) stating that sites proximate to residential development and SAC should at all times be remediated; it is to be *"assumed that the waste shall be removed from the site except only where it can be shown that an alternative solution provides greater protection to the environment and the health of the local population."*

It is suggested that remediation of the site will first require the segregation and removal of all mixed waste items such as plastic, wood, metal, electronic items etc. Any waste electronic and electrical equipment (WEEE), asbestos and other dangerous substances will require separation and disposal according to relevant specific legislation. Segregation of other waste streams such as metal and wood etc. will facilitate the recycling recovery and reuse of the waste and will also minimise any disposal costs.

Once the mixed waste streams are removed, laboratory results suggest that much of the remaining soils may be suitably categorised as inert fill (if a diligent segregation process is undertaken) and may be left on site. This however will require further verification during the remediation process including consultation with the EPA.

- Before undertaking any remediation programme, a full ecological assessment will need to be undertaken at the site according to requirements specified in the Habitats Directive 92/43/EEC in relation to protection of the SAC. This includes:
  - Preparation of habitat map defining principle habitat types in vicinity of landfill and wet grassland east to the Abbey River based on field survey.
  - Consultation with National Parks & Wildlife Service regarding proposed remediation works and potential impacts and mitigation requirements during the remediation process.
  - Preparation of Screening Report for Appropriate Assessment (AA) with Natura Impact Statement as required assessing potential impacts on the Natura 2000 network in general and on the Lower River Shannon SAC in particular, including cumulative impacts with other plans or projects.
  - Development of plan to re-vegetate all disturbed land to tie in with existing marsh vegetation and to avoid the establishment of weed species or invasive alien species that could compromise the integrity of the SAC in the vicinity of the works. This element will need to be addressed as part of the AA process.
  - Mapping of habitats will be undertaken in the first phase as this will be required as part of the AA process. This will include mapping of invasive alien species which would present a risk of accidental transfer during remediation works.

- Defining of working area to avoid unnecessary disturbance to adjacent wet grassland habitats Avoidance of direct site run-off to the Abbey River which may carry elevated loads of suspended solids or pollutants.
- Monitoring of run-off water quality.
- Establishment of vegetation efficiently following removal of waste and final re-profiling of ground
- Any soil imported to the site (if required) will need to be screened to be certified free of invasive alien species.

9.0 REFERENCES

- Tier 1 Environmental Risk Assessment Report – Limerick City Council 2010
- Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites" EPA, 2007
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- Code of Practice for Site Investigations, BS 5930:1999.
- "Model Procedures for the Management of land Contamination" Contaminated Land Report 11 (CLR 11), published by the UK environment Agency & DEFRA.
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