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CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

TIER 2 RISK ASSESSMENT
HISTORIC LANDFILL AT AHASCRA, CO. KERRY

Prepared for: Kerry County Council

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Kerry County Council

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TIER 2 RISK ASSESSMENT

HISTORIC LANDFILL AT AHASCRA, CO. KERRY

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Abstract: This report represents the findings of a Tier 2 risk assessment carried out at Ahascra Historic Landfill, Co. Kerry. The risk assessment was conducted in accordance with the EPA Code of Practice for unregulated landfill sites.

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EXECUTIVE SUMMARY

A Tier 2 environmental risk assessment of Ahascra Historic Landfill was conducted by Fehily Timoney (FT) in accordance with the EPA Cope of Practice for Unregulated Landfill sites.

The study consisted of a desktop study, site walkover, topographical survey, geophysical survey, intrusive site investigation works and environmental monitoring. These works informed the development of the CSM and risk screening model.

The findings of the desk study indicate a network of man-made drainage channels have been excavated north and north-west of the site, likely to assist drainage of the Kiltean Bog. Surface water flow from these land drains are potentially connecting the landfill to the River Feale / Cashen SAC.

A volume calculation based on the geophysical survey's inferred average waste depth of 2.75 m indicate an interred waste volume of approximately 63,250 m^3 (88,550 tonnes) at the site.

Trial pitting confirmed a capping layer comprising shallow topsoil to a depth of 0.1 m and an average clay subsoil depth of 0.7 m across the site. The capping layer does not comply with the capping design specification set out in the EPA's Landfill Design Manual.

The findings of the geophysical survey and trial pitting confirm that municipal type waste material was placed directly on top of the existing blanket peat i.e., a land-raise.

Analysis of waste samples from the trial pits excavated, when assessed against waste acceptance criteria (WAC) for landfill indicated the waste material encountered within the site is typical of domestic non-hazardous waste.

Laboratory analysis of groundwater samples from upgradient and downgradient monitoring wells reported elevated ammonia, chloride, arsenic and mineral oil concentrations above guideline threshold values. These parameters are typical constituents of landfill leachate and may be evidence of localised impact on groundwater quality given the dilute and disperse nature of the landfill.

Analysis of two rounds of surface water sampling from the peatland drainage channel to the east of the site were found to be below the guideline values in all assessments, with the exception of elevated BOD concentrations at the selected surface water sampling locations. High BOD and COD levels are an indirect indicator of the organic content in a waterbody. The detected levels of BOD and COD in combination with the very low flow conditions within the drainage channel may be an indicator of background peatland water quality rather than leachate migration from the landfill. The detected levels of chloride within the waterbody may be an indicator of leachate infiltration from the landfill.

The site is classified as a **High-Risk Classification (Class A)**. The principal risks identified on the site relate to the risk of leachate migration to the surface water drainage channel located along the eastern boundary of the historic landfill and the risk to the groundwater aquifer from the migration of leachate from the waste body.

1. INTRODUCTION

1.1 Background

Ahascra Historic Landfill is in an area of open land located immediately adjacent to an area of peatlands known as the Kiltean Bog. The site is located approximately 4.3 km north-east of Ballyduff village and approximately 8 km north-west of Listowel town, in the townland of Ahascra, Lisselton, Co. Kerry. Available evidence suggests that landfilling ceased, and the site closed in ca. 1990. The closure date is based on a An Foras Forbartha report on National Database on Waste which indicated the site had an annual intake of 1,638 tonnes and 4 years remaining capacity in 1986.

Fehily Timoney (FT) understands that since its closure the site is in the ownership of Kerry County Council (Folio 22510F), with the lands presently leased for agricultural grazing. The site has been capped with a soil cover, and gas ventilation wells have been installed. No other remediation works have been carried out.

Kerry County Council is required to complete a tiered risk assessment of unregulated waste disposal sites in accordance with the Environmental Protection Agency (EPA) code of practice for unregulated waste disposal sites.

A Tier 1 Assessment was completed by KCC in 2007. The site was subsequently registered on the EPA Section 22 Register and given the reference code S22-02664. This assessment determined the site has a risk classification of High (Class A). A subsequent Tier 1 Assessment was completed in 2013. This assessment determined the site has a risk classification of Moderate (Class B). Copies of the assessments are included in Appendix 1.

1.2 Scope of Works

FT's scope of work was to undertake a Tier 2 assessment of the site in accordance with the EPA Code of Practice (CoP) 2007: *Environmental Risk Assessment for Unregulated Waste Disposal Sites*. This approach required the completion of the following:

- Desk Study
- Site Walkover
- Geophysical and surveying to estimate extents and depths of waste
- Intrusive Site Investigation
- Environmental Sampling
- Topographical Survey
- Environmental Risk Assessment (ERA)
- Development of a conceptual site model (CSM)

As part of the initial desk study, a review of available information was undertaken. This was followed-up with a site walkover by FT personnel on the 14th February. The desk study and site walkover were used to determine the locations for the intrusive site investigation.

FT appointed Causeway Geotech Limited (CGL) to conduct the intrusive site investigation which included excavation of trial pits and the installation of two onsite groundwater monitoring boreholes.

A full geotechnical report is included in Appendix 2 of this report.

Minerex Geophysics Limited (Minerex) were appointed by FT to undertake a geophysical survey of the site. Geophysical surveying including EM31 Ground Conductivity, 2D-Resistivity and Seismic Refraction surveying methods.

The full geophysical survey report is included in Appendix 3 of this report.

The purpose of the geophysical study was to attempt to define the vertical and lateral extents of any waste body. Trial pits were excavated to provide a preliminary assessment of the volume, extent and type of waste infilled at the site. The groundwater monitoring boreholes were installed to assess the impact, if any, of the onsite groundwater.

Laboratory analysis of waste samples, surface water and groundwater were conducted to assess and quantify any potential or ongoing environmental impacts. Laboratory reports are presented in Appendix 4 of this report.

The information gathered from the desk study, intrusive site investigation and geophysical survey were used to inform the development of the CSM and the Environmental Risk Assessment (ERA). This report presents the findings of the assessment.

2. DESK STUDY

2.1 Introduction

The desk study included the review of the following literature sources and websites:

- Geological Survey of Ireland, Groundwater Web Mapping: www.gsi.ie
- Environmental Protection Agency Maps: http://gis.epa.ie/Envision
- National Parks and Wildlife Service Map Viewer: www.npws.ie
- DoHPLG/EPA/Local Authority maps: www.catchments.ie
- BS 5930: 1999, Code of Practice for Site Investigations;
- BS 10175: 2000, Investigation of Potentially Contaminated Sites – Code of Practice;
- County Clare Groundwater Protection Scheme, Main Report, GSI 2000.

2.2 Desk Study

This section of the report presents the findings of the desk study.

2.2.1 Site Description & On-Site Conditions

The site is approximately 2.6 hectares. The site is located in a rural setting and the site is accessed via local tertiary roads just off the R551 Ballyduff to Ballybunnion road. A portion of the sites eastern boundary is bounded by a local access road. Bog land exists further east beyond the access road. The site bounded by agricultural land to the north and west and agricultural/bog land to the south.

The most recent Corine, 2018 land use description of the site is agricultural area, pasture.

The site is bounded by steep sloped banks and a metal post and wire fence bounds on all sides. The mounded profile of the site is typical of a land-raise rather than a landfill. There is a small area of hardcore and/or concrete surface located along the south-eastern boundary within the site. This is currently used for agricultural storage use.

The nearest residential dwelling is located approximately 100m north-west of the site and comprises a single bungalow. There are no dwellings located within the site boundary.

The location of the site is shown in Figure 2.1.

2.2.2 Previous Studies

A Tier 1 Risk Assessment was completed by KCC, utilizing the EPAs online Tier 1 Environmental Risk Assessment tool. A site walkover was also conducted in 2007.

The Tier 1 assessment comprised the following:

- Development of a conceptual site model (CSM);
- Identification of contaminant sources, pathways of contaminant migration and potential receptors which may be vulnerable if exposed to those contaminants; i.e., the identification of Source-Pathway-Receptor (SPR) linkages; and
- The priorisation of sites and SPR linkages based on their perceived links.

Based on the available information, the Tier 1 Assessment determined that the overall risk score for Ahascra Landfill was 70%, resulting in a risk classification of **High (Class A)**.

A subsequent Tier 1 Assessment was completed in 2013 by KCC. This assessment determined that the overall risk score for Ahascra Landfill, resulting in a risk classification of **Moderate (Class B)**.

Copies of the assessments are included in Appendix 1.

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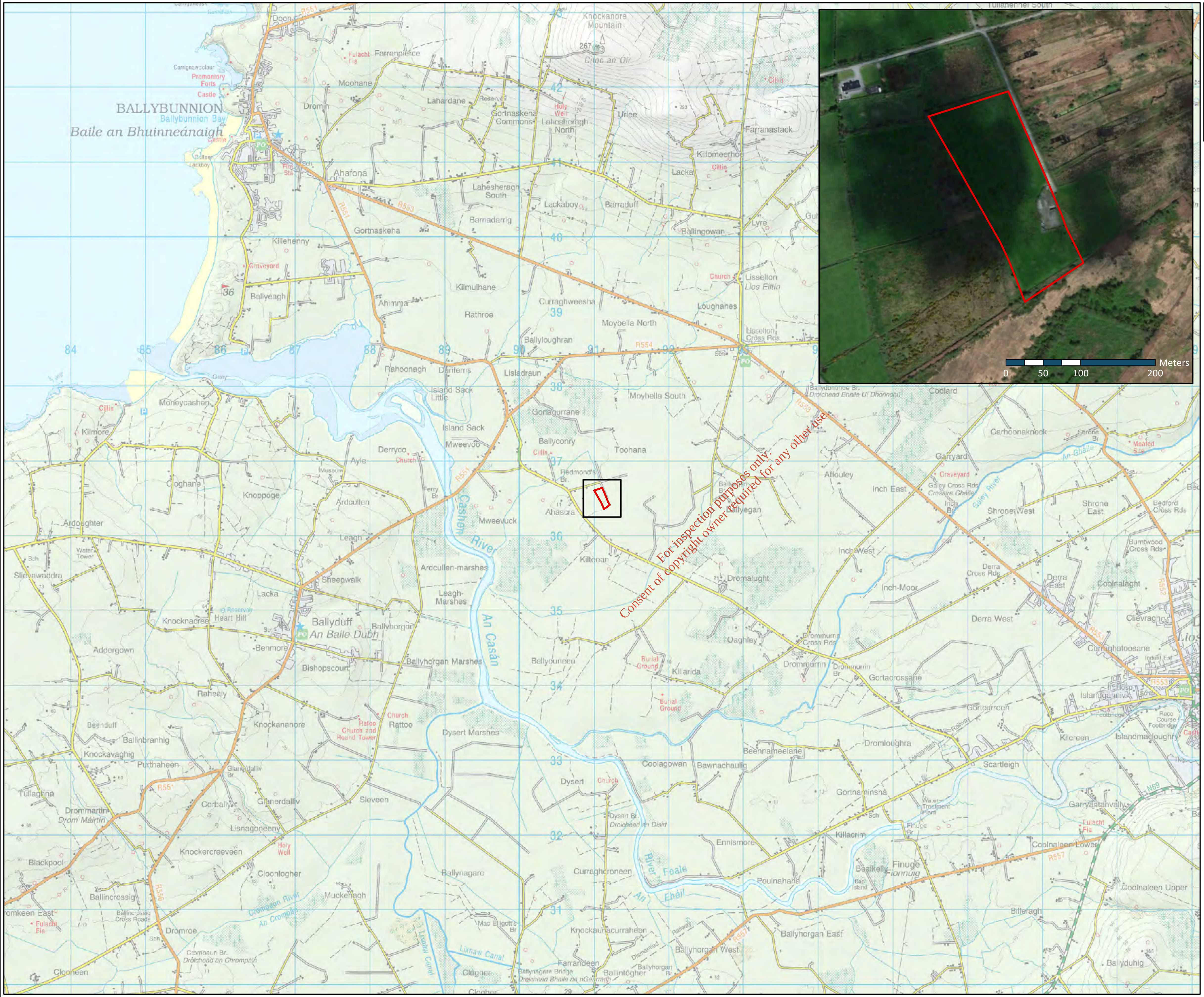

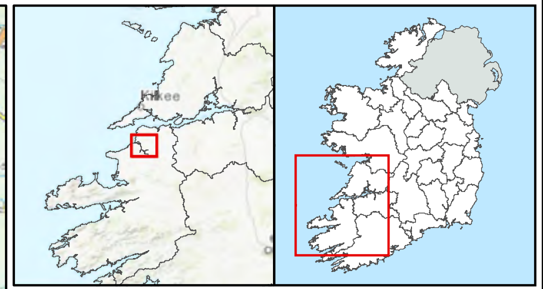

Site Boundary

TITLE: Site Location

PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry

FIGURE NO:	2.1		
CLIENT:	Kerry County Council		
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2.2.3 Topography

The historic landfill is located within a rural setting. Topographically, portions of the site vary with respect to surrounding elevations. The northern half of the site is generally quite flat except for the steep sloped edge which runs along the entire site boundary. A number of depressions were noted during the site walkover with standing water atop the site. The site is raised above the lands immediately surrounding the site and the access road (c.9.3-9.4m AOD). Within the southern half of the site the ground generally slopes towards the concrete, yard area. Elevations within the site range from approximately 12.16 m AOD to 8.80m AOD (base of slope/site boundary). Regarding regional topography, surface elevations decrease north-west of the site towards the River Feale/Cashen while elevations are increasing south and east of the site across the Kiltean peat bog.

2.2.4 Geology

Drift/Quaternary Geology

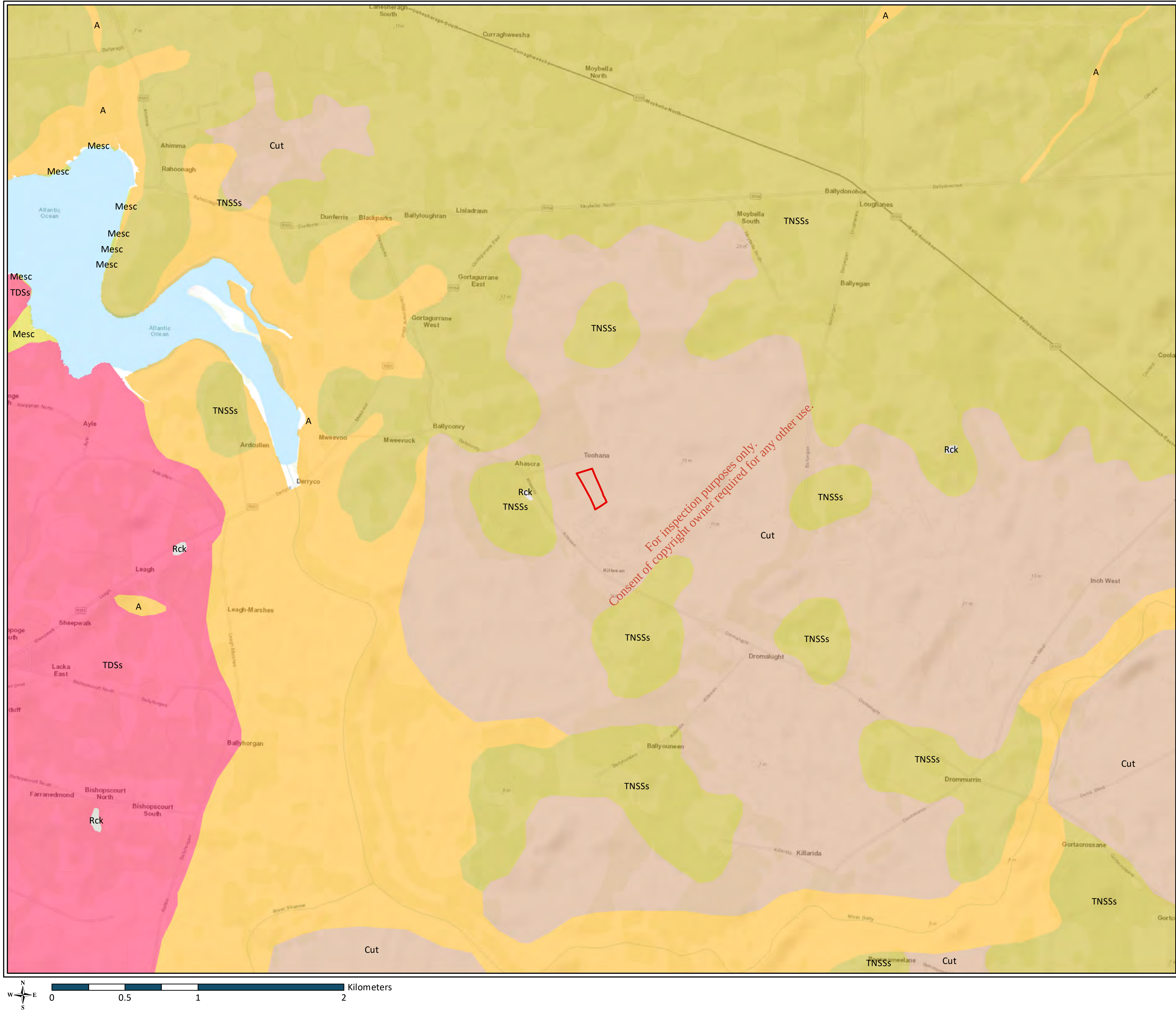
The Quaternary Map provided by GSI Online identifies the quaternary sediments within and surrounding the site as 'Cut over raised peat'. Pockets of sandstone and shale tills surround the adjacent peat bog area. Further west significant alluvium deposits are shown following the Feale/Cashen River. There is no area of bedrock outcrop shown within or immediately adjacent to the site. The GSI mapping does show a small area of outcrop approximately 380m west of the site. Quaternary geology is shown in Figure 2.2.

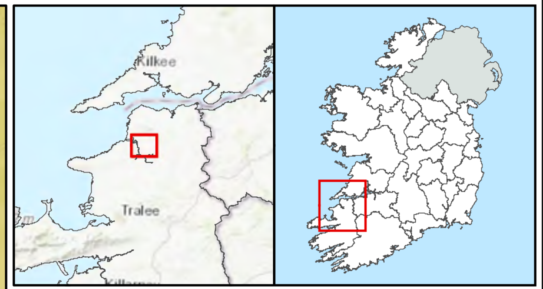
During the installation of boreholes during the site investigation, the presence of peat and sand & gravel tills are described in the driller's logs to a depth of approximately 7.0m BGL at borehole BH01, as referenced in the CGL borehole logs, Appendix 2.

Solid or Bedrock Geology

The GSI online 1:100,000 scale bedrock geology map, shows the bedrock beneath to be found on a single formation. The entirety of the site and surrounding area is underlain by the Waulsortian Limestone formation (CDWAUL) which is generally made up of Dinantian '*massive, unbedded lime-mudstone'.* No bedrock outcrops are shown to be present within the site area. The closest bedrock outcrops recorded by GSI are located approximately 380m west of the site. The bedrock geology is presented in Figure 2.3.

Limestone bedrock was encountered at 7.0m BGL during the installation of borehole BH01 and 2.0m BGL during the installation of BH02, as referenced in the CGL borehole logs, Appendix 2.





Site Boundary

Quaternary Sediments

- A, Alluvium
- Cut, Cut over raised
- Mesc, Esturine silts and clays
- Rck, Bedrock outcrop or subcrop
- TDSs, Till derived from Devonian sandstones
- TNSSs, Till derived from Namurian sandstones and shales

TITLE: Quaternary Geology			
PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry			
FIGURE NO:	2.2		
CLIENT:	Kerry County Council		
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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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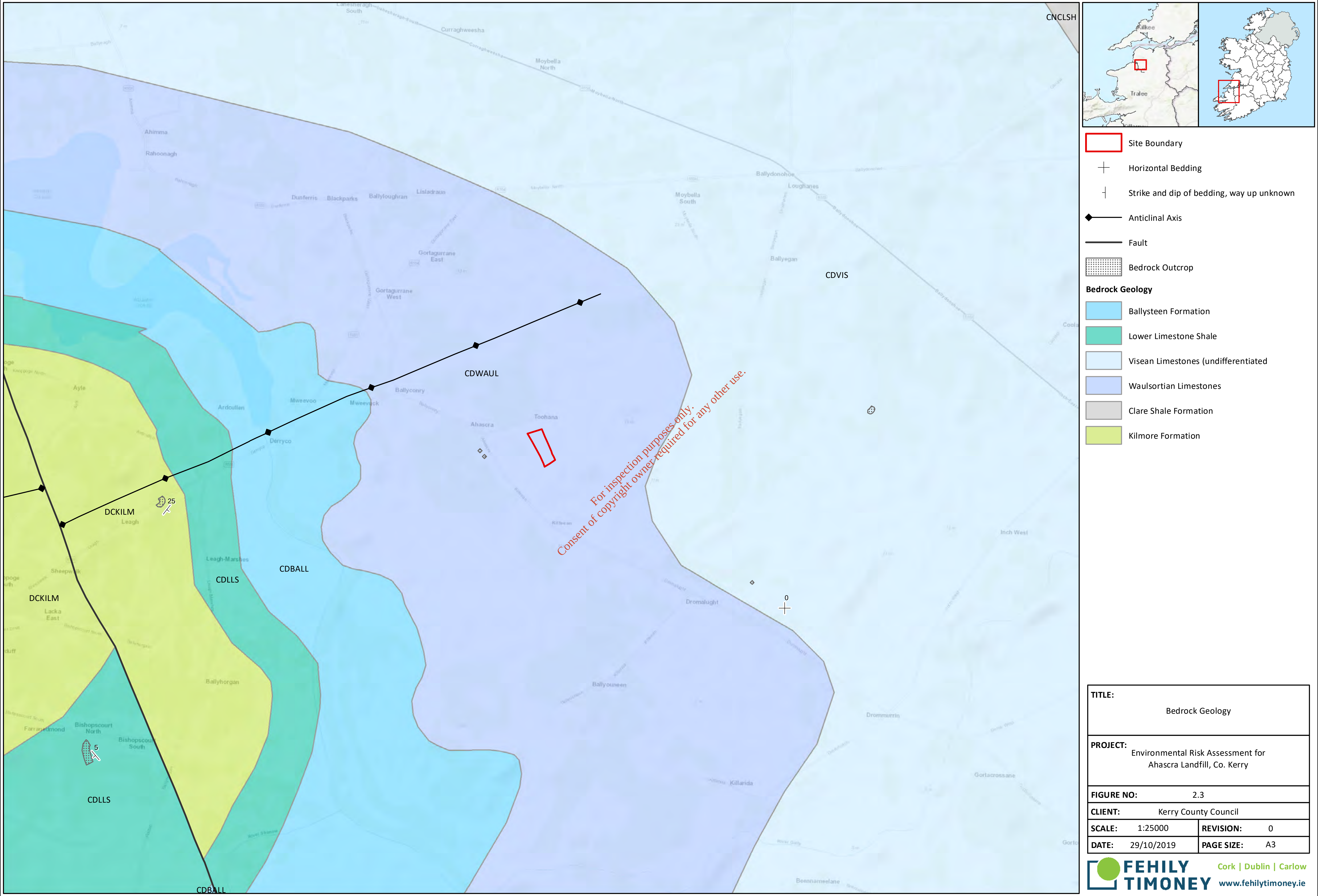

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PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry			
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2.2.5 Hydrogeology

An examination of the national bedrock aquifer map on the GSI online mapping classifies the underlying bedrock groundwater aquifer as a 'Regionally Important Aquifer – Karstified (Diffuse) Bedrock (Rkd). The bedrock aquifer mapping is presented in Figure 2.4.

There are no karst landforms identified within the site boundary or in the immediate vicinity. The nearest karst landforms are a limestone cave and spring located near Lixnaw village approximately 7.5 km south-west of the site boundary.

Historical mapping for the area shows no springs in the immediate vicinity of the site. The closest well shown on historical mapping is located approximately 400m south-west of the site, located adjacent to a stream and farm yard. There are a number of residences relatively close to the site to west, north-west and south where unregistered private wells may be present.

Table 2.1 presents the details of the registered boreholes and springs obtained from the GSI database located within 1km of the site.

Table 2.1: Borehole and Spring Descriptions near the Project Site

BH/Spring	Yield class	Yield (m^3/day)	Use	Depth (m)	Depth to Rock confidence (m)	Distance from site (km)	Drill Date
0813SWW057	-	-	Other	13.7	24.4	0.4	1981
0813SWW054	-	-	Other	24.4	29.3	0.6	1981
0813SWW104	-	-	Other	15.5	257.3	1.1	1981
0813SWW086	-	-	Other	16.8	20.4	1.29	1981
0813SWW071	-	-	Other	7.6	12.5	1.17	1981
0813SWW077	-	-	Other	7.6	12.2	1.20	1981

There are no Groundwater Drinking Water Protection Areas within the site boundaries according to GSI. The nearest groundwater protection zone is located approximately 15.8 km south-west of the site. This groundwater protection zone relates to the Ballyheigue Water Supply Scheme.

The GSI shows that the groundwater body (GWB) is named Ballybunnion GWB and has a karstic flow regime and is defined as being at *Good Status* under the Water Framework Directive (WFD). The risk to groundwater quality is currently under review.

There are no recorded groundwater dependent ecosystems in the area. The nearest groundwater SAC is Kerry Head (IE_SH_G_118) poorly productive bedrock aquifer located approximately 1.6km south-east at its closest point.

GSI mapping shows groundwater recharge to be variable in the region. The GSI national recharge map defined the annual recharge for the site as 30 mm/yr. The effective rainfall for the area is 762 mm/yr, returning a recharge coefficient of 4%. A pocket of land to the west of the site corresponding to sandstone and shale tills displays similar recharge characteristics according to the GSI.

The GSI mapping showing approximate locations of known wells and springs is included in Figure 2.5.

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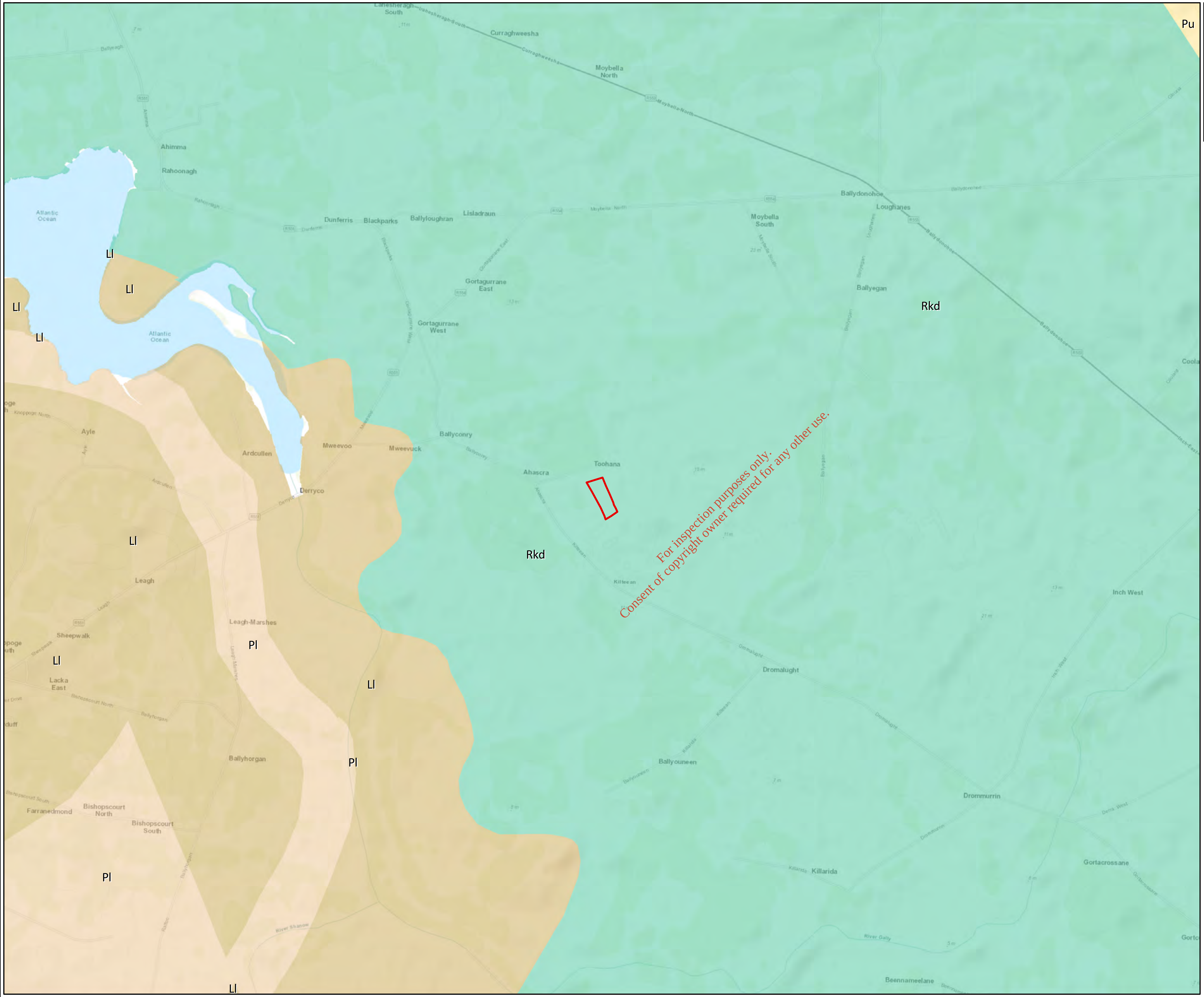

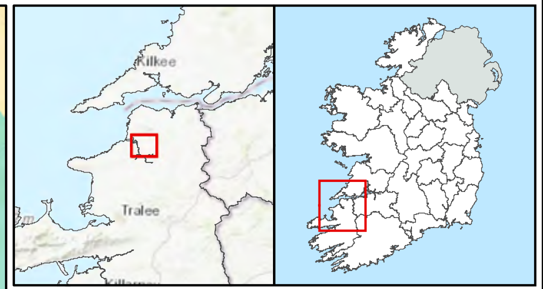

Site Boundary

Bedrock Aquifers

Ll: Locally Important Aquifer - Bedrock Mod Productive Locally

Pl: Poor Aquifer Bedrock Generally Unproductive Except Locally

Pu: Poor Aquifer Bedrock Generally Unproductive

Rkd: Regionally Important Aquifer - Karstified (diffuse)

TITLE: Aquifer Classification			
PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry			
FIGURE NO:	2.4		
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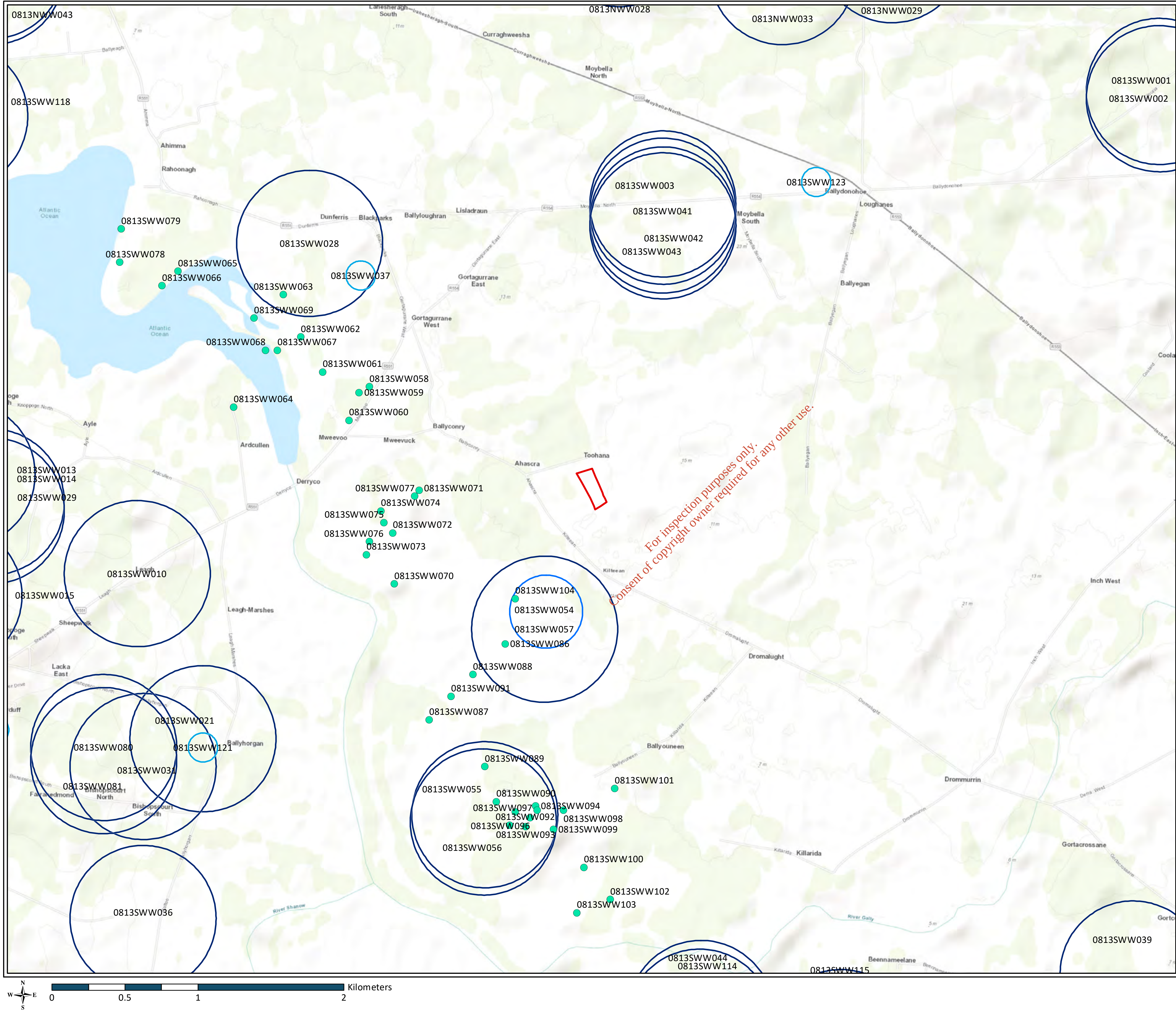

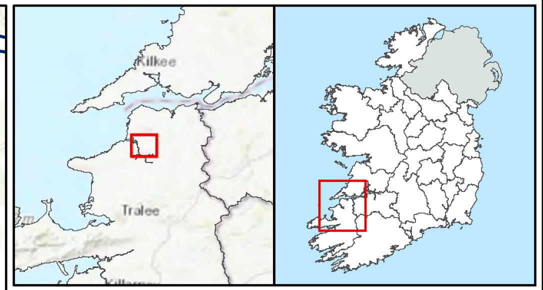

- Site Boundary
- Wells and Springs (10-50m Accuracy)
- Wells and Springs (100-200m Accuracy)
- Wells and Springs (200-500m Accuracy)
- Wells and Springs (500m-1km Accuracy)

TITLE: GSI Wells and Springs

PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry

FIGURE NO:	2.5		
CLIENT:	Kerry County Council		
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2.2.6 Groundwater Vulnerability

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The factors used in assessing groundwater vulnerability include subsoil type and thickness and recharge type as indicated in Table 2.2. The GSI procedure whereby groundwater protection is assessed is outlined in the EPA-GSI publication *Groundwater Protection Schemes* (DELG/EPA/GSI, 1999).

The GSI Online mapping data set identifies the vulnerability of groundwater to contamination immediately underlying the site is classified as moderate vulnerability. Within 400 m of the eastern site boundary, the groundwater vulnerability increases from high to extreme coinciding with the presence of a bedrock outcrop 400 m west of the site and thin overburden cover.

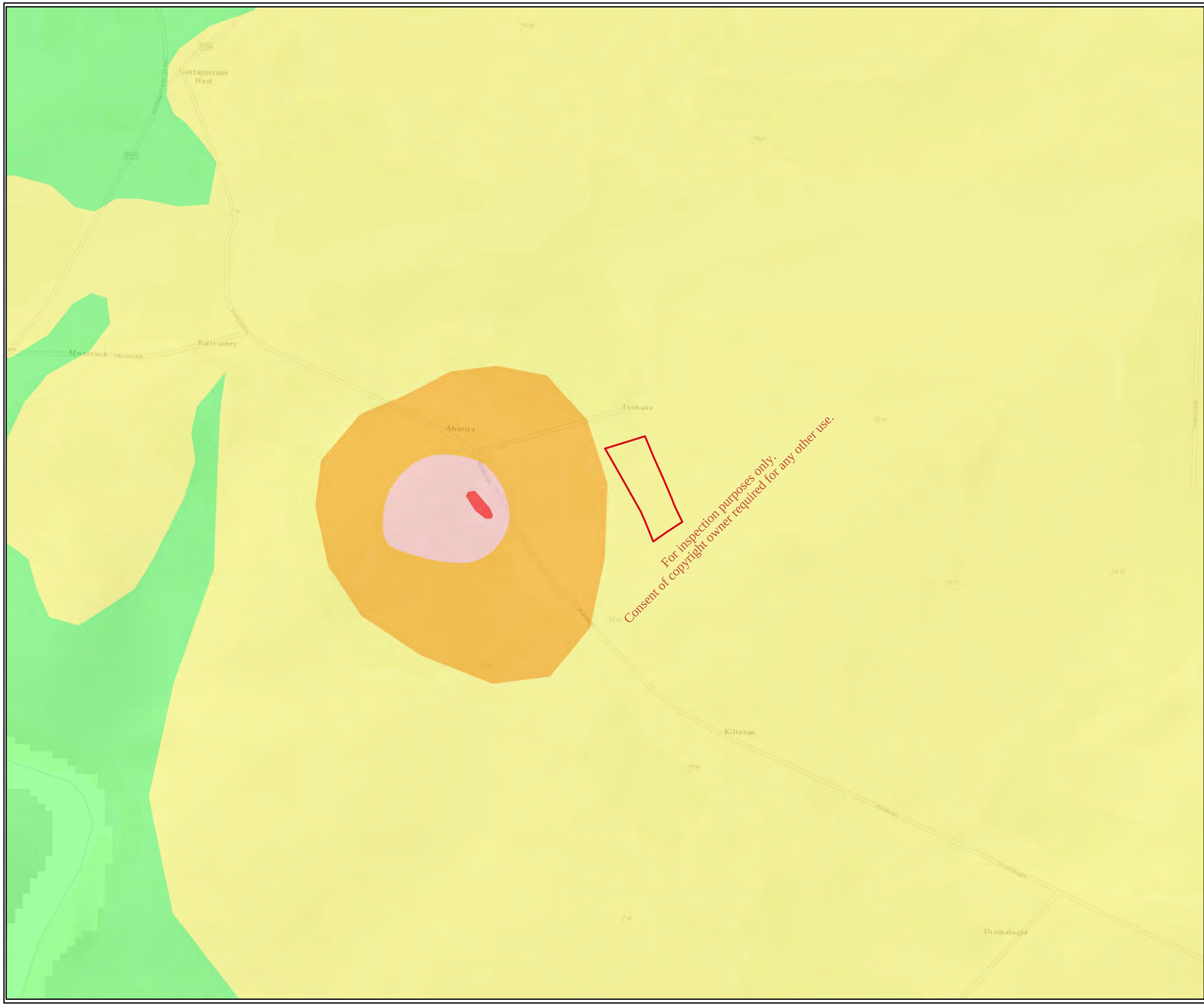
The Groundwater Vulnerability mapping is presented in Figure 2.6.

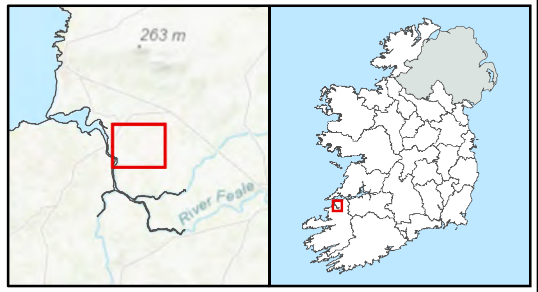
The recharge coefficient associated with the western bedrock outcrop area is 22.5% and the recharge rate is 171 mm/year.

Table 2.2: GSI Guidelines – Aquifer Vulnerability Mapping

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (Shallow Bedrock)	Moderate Permeability (e.g., Sandy soil)	Low Permeability (e.g., Clayey subsoil, clay, peat)
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m
High (H)	>3.0 m	3.0 -10.0 m	3.0 - 5.0 m
Moderate (M)	N/A	>10.0 m	5.0 - 10.0 m
Low (L)	N/A	N/A	>10 m

Notes:
N/A = Not Applicable
Precise permeability values cannot be given at present





Legend

Site Boundary

Groundwater Vulnerability

- E - Extreme
- H - High
- M - Moderate
- L - Low
- X - Rock Near Surface or Karst

TITLE: Groundwater Vulnerability			
PROJECT: Tier 2/3 Assessment for Ahascra Landfill			
FIGURE NO:	2.6		
CLIENT:	Kerry County Council		
SCALE:	1:10000	**REVISION:**	0
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2.2.7 Hydrology

The site is located within the catchment of the Tralee Bay-Feale, sub-catchment Glouria and river sub-basin Glouria_010. The River Feale, first order waterbody, is located approximately 1.5 km south-west of the site at its closest point.

The Glouria River (Glouria_010), second order waterbody, is located approximately 1.11 km south-east of the site and flows in a south-westerly direction before turning west eventually meeting the Rover Feale approximately 2km south-west of the site. Under the water framework directive (WFD), the Glouria waterbody is under review, it's not currently assigned a risk status and its ecological status or potential is unassigned.

Locally, a peatland drainage channel with very low flow rate was identified along north-eastern boundary of site during the site walkover. During periods of increased rainfall, flow direction within the drainage channel is likely south to north. Observations of the localised topography indicate that drainage channels from the surrounding peatlands and field boundaries eventually drain into the River Feale approximately 1.6 km to the west. Review of historical mapping shows a network of man-made drainage channels have been excavated north and north-west of the site, likely to assist drainage of the Kiltean Bog. Surface water flow from these land drains directs flow in a south-westerly course towards the River Feale / Cashen SAC. This is further discussed in section 2.2.9.

2.2.8 Ecology

The site is not within or directly adjacent to any Natural Heritage Area (NHA), proposed NHA (pNHA), Special Area of Conservation (SAC) or Special Protection Area (SPA). The nearest SAC is The Lower River Shannon SAC (Site Code:002165) located approximately 2 km south-west of the site. The SAC includes the Glouria waterbody in its classification extent. This Moanveanlagh Bog SAC (Site Code:002351) and pNHA (Site Code:000374) is located within 13 km east of the site just outside Listowel town.

The River Feale estuary, also known as the Cashen River Estuary, is a designated pNHA and is located within 2 km of the site. The nearest SPA is the Kerry Head coastal region (Site Code: 004189), located approximately 8.5km west of the site.

The ecology protected areas mapping is presented in Figure 2.7.

2.2.9 Site History

The earliest historical map available on the OSI website dates from 1837-1842. The OSI identifies the land within the site boundary was covered in cutover raised peat, with the surrounding area also peatlands. Review of the 1888 – 1913 historical mapping shows that lands to the west of the main local access road was used as a gravel pit, likely used for quarrying sandstone and shale / limestone bedrock.

The OSI Historical Mapping is presented in Figure 2.8.

Review of the OSI 1995 series orthophotography images appears to show landfilling activities were ongoing, as illustrated in Figure 2.10 below this does not correspond with the evidence in the Tier 1 report which suggests waste acceptance having ceased in ca. 1990.

As mentioned previously, a network of assumed man-made drainage channels exists north and north-west of the site likely to assist drainage of the Kiltean Bog. Historical mapping indicates these land drains diverted flow northwards from Kiltean Bog and then diverts westward via Redmond's Bridge where flow follows a south-westerly course before entering the River Feale / Cashen SAC approximately 1.6 km west of the site. Reference to a 'sluice valve' marked on the historical mapping and the uniform nature of the mapped sloped of the channel has been assumed as evidence of a constructed peat drainage network associated with the bog.

Details of the peatland drainage system is illustrated in Figure 2-11 and Figure 2-12 below.

2.2.10 Existing Geological Heritage

The GSI holds no records of areas of Geological Heritage within the site boundary or in the immediate vicinity of the site.

The nearest recorded geological heritage held by the GSI is approximately 6.2km north-west of the site at Ballybunnion. Ballybunnion town is described as underlying *''raised beach deposits, the raised beach sediments are overlain by a geliflucted facies derived from the underlying shale, sandstone and limestone till''.* The bedrock geology at Ballybunnion contains calcareous mudstone, shale and micrite, commonly with chert and some rare fossilised skeletal remains of gonitatites and bivalve species.

Further south, approximately 6.6 km lies Lixnaw Quarry, a working quarry in striped Carboniferous limestone of Visean age. The quarry displays an unusual and distinctive example of the Visean Limestone rock type.

The geological heritage mapping is presented in Figure 2.9.

2.2.11 Existing Geotechnical Stability

The GSI landslides database indicates that there are no recorded geo-hazards within the site boundary or in the surrounding area or region.

2.2.12 Archaeological Heritage

The Ahascra historical landfill site is not within any areas of significant archaeological and historical interest. Review of the archaeological features in the area not three ringforts within 500 m west of the site. The sites are marked on the 1841-42 OSi mapping and no surface trace of them remain today, with the exception of one to the north-west of Ahascra townland.

One univallate ringfort has been incorporated into field banks to the south and east of the ringfort. A drain dug along the southern side, have distorted the ringfort somewhat. The sub-circular area is enclosed by an earthen bank which is very low and wide. The ringfort is ca. 8 m wide and ca. 5 m high. There are two main gaps at the north-east and south-west, measuring 4 m and 1 m respectively.

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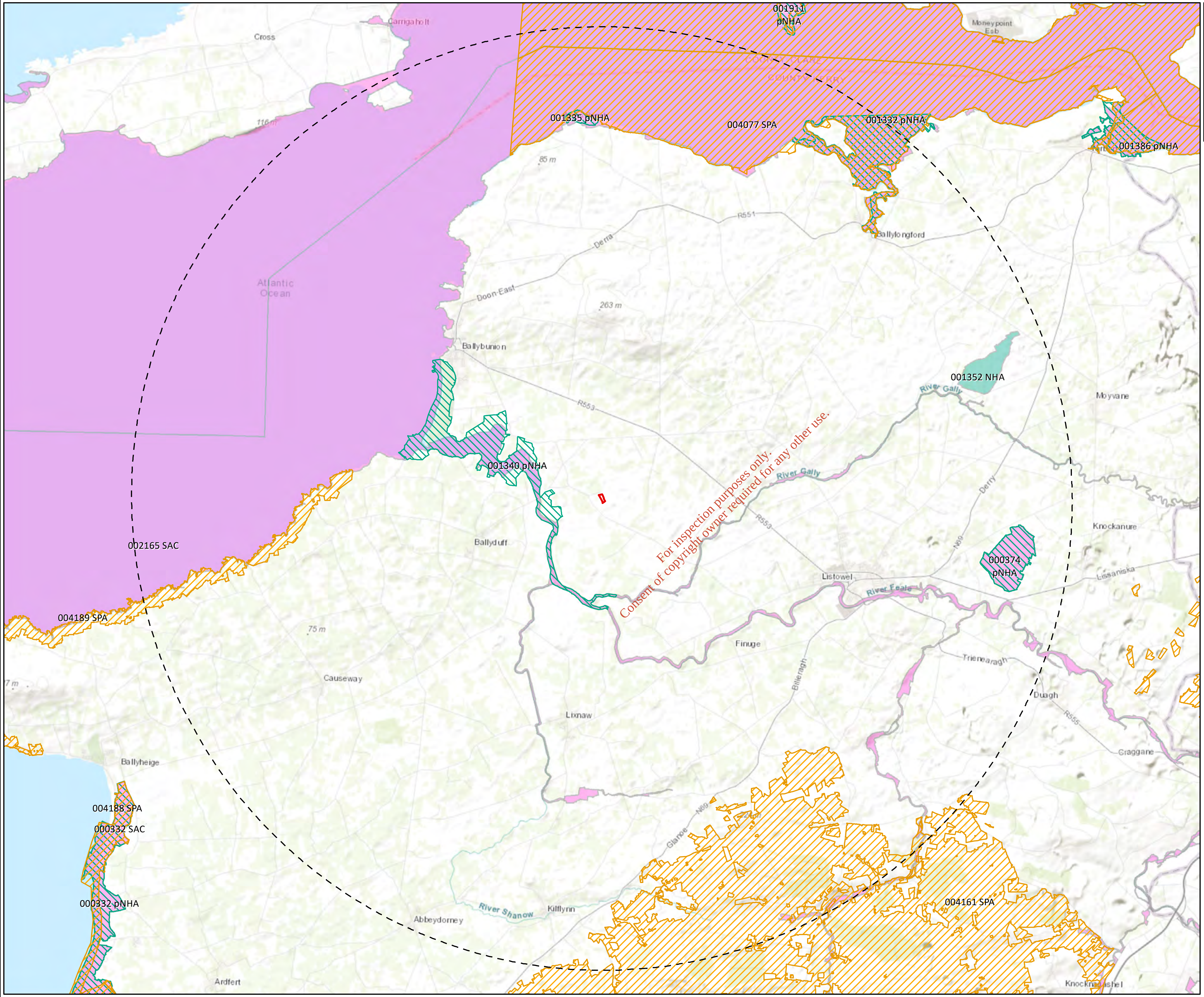

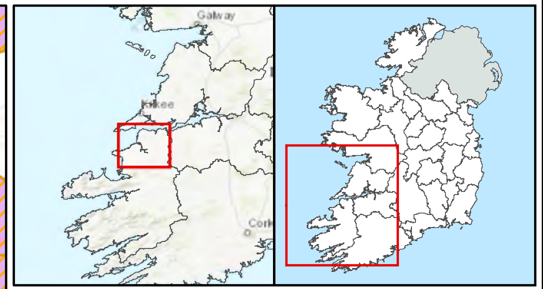

Site Boundary

15km Distance from Site Boundary

Special Protection Area (SPA)

Proposed Natural Heritage Area (pNHA)

Special Area of Conservation (SAC)

Natural Heritage Area (NHA)

TITLE: Ecologically Protected Areas	
PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry	
FIGURE NO: 2.7	
CLIENT: Kerry County Council	
SCALE: 1:120000	**REVISION:** 0
DATE: 29/10/2019	**PAGE SIZE:** A3

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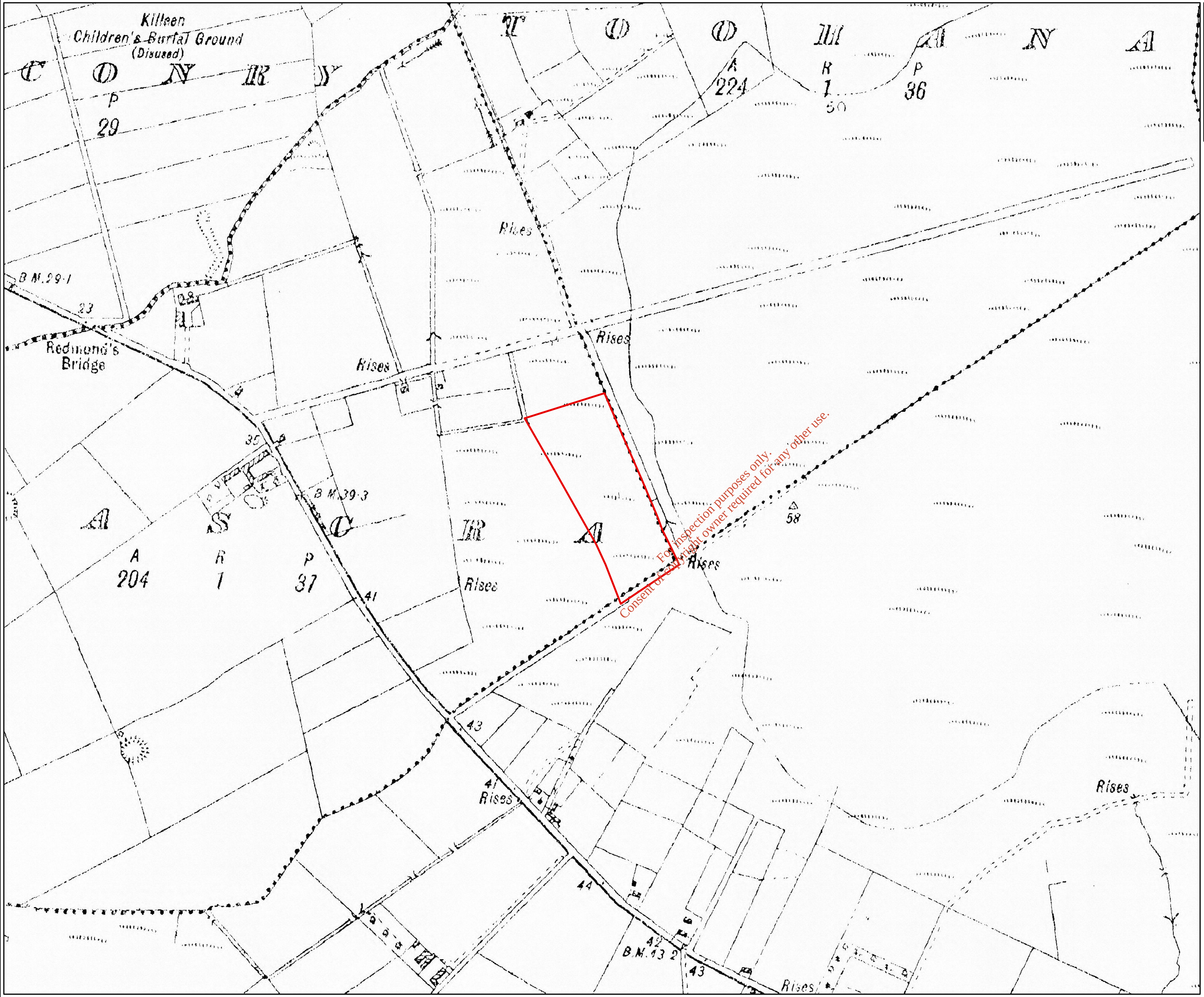

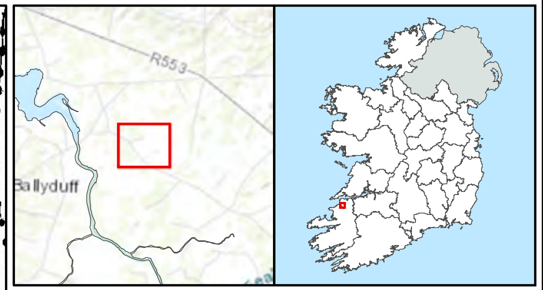

Site Boundary

0 50 100 200 Meters

TITLE:	OSi Historical Mapping
PROJECT:	Environmental Risk Assessment for Ahascra Landfill, Co. Kerry
FIGURE NO:	2.8
CLIENT:	Kerry County Council
SCALE: 1:5000	**REVISION:** 0
DATE: 29/10/2019	**PAGE SIZE:** A3

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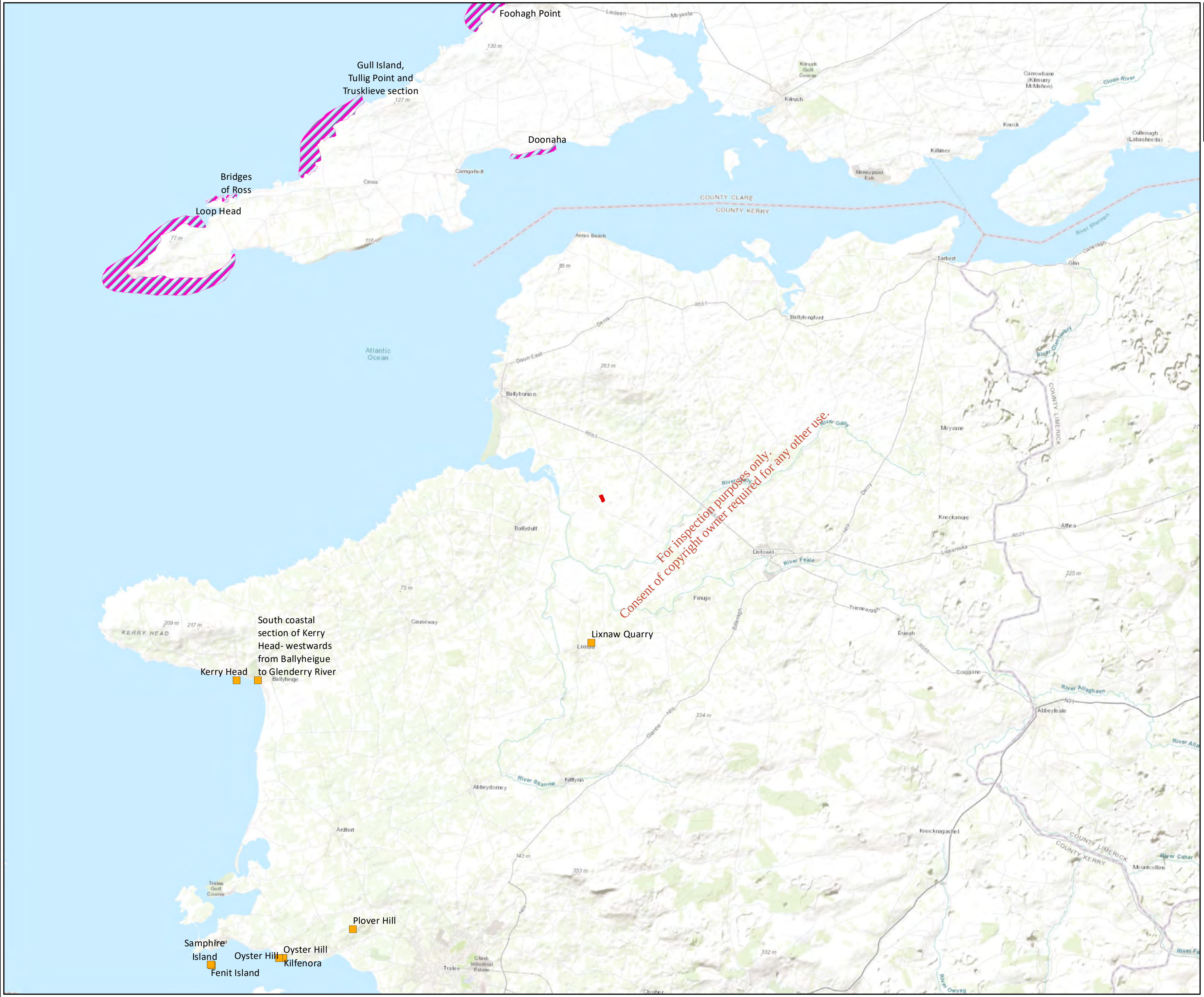

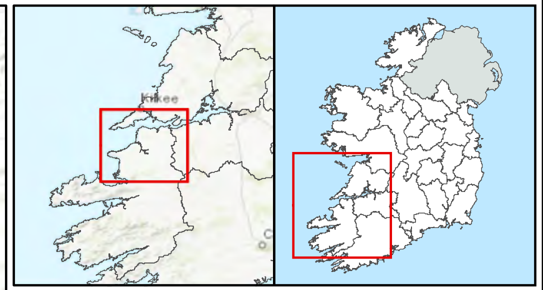

Geological Heritage Sites

Geological Heritage Sites (Audited)

Site Boundary

TITLE: Geological Heritage	
PROJECT: Environmental Risk Assessment for Ahascra Landfill, Co. Kerry	
FIGURE NO: 2.9	
CLIENT: Kerry County Council	
SCALE: 1:175000	**REVISION:** 0
DATE: 29/10/2019	**PAGE SIZE:** A3

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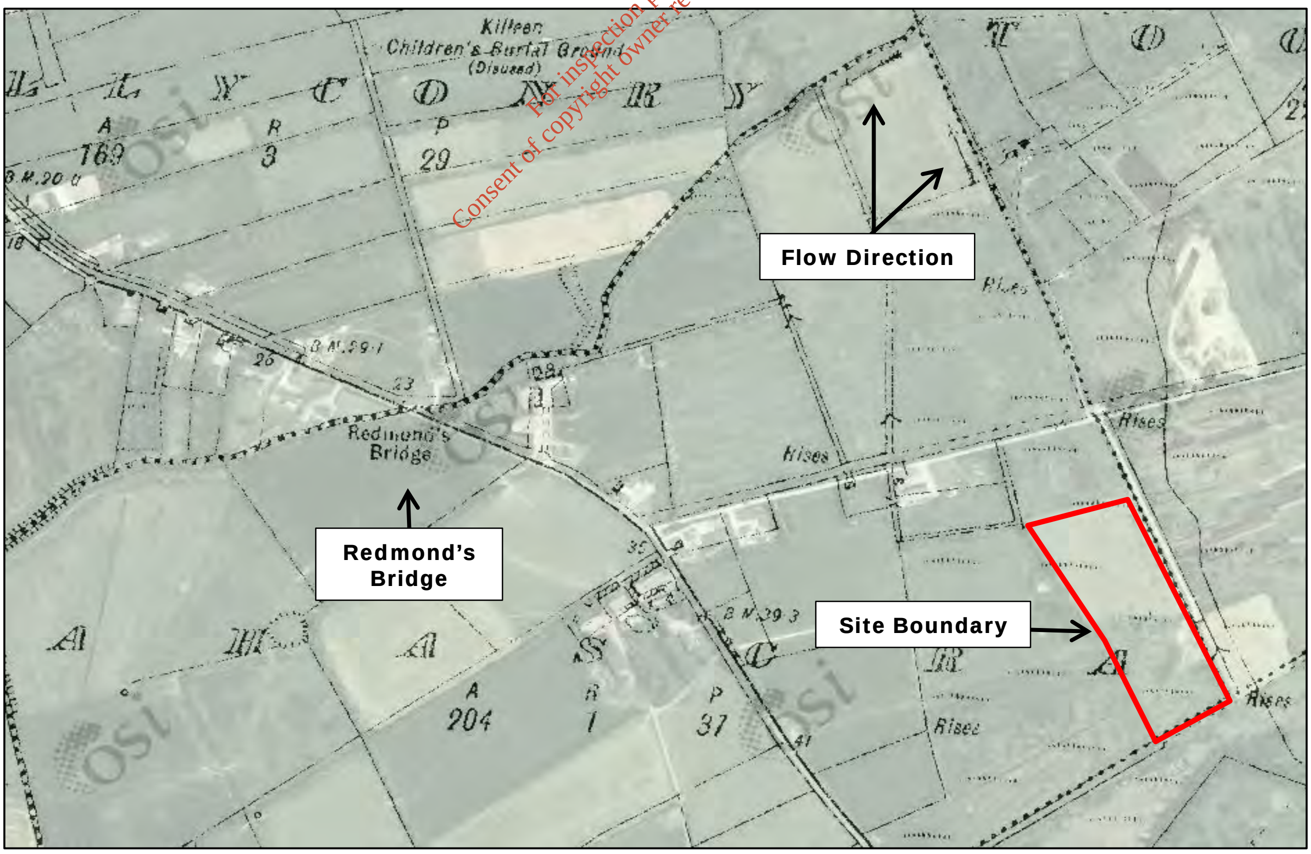
0 1 2 4 Kilometers

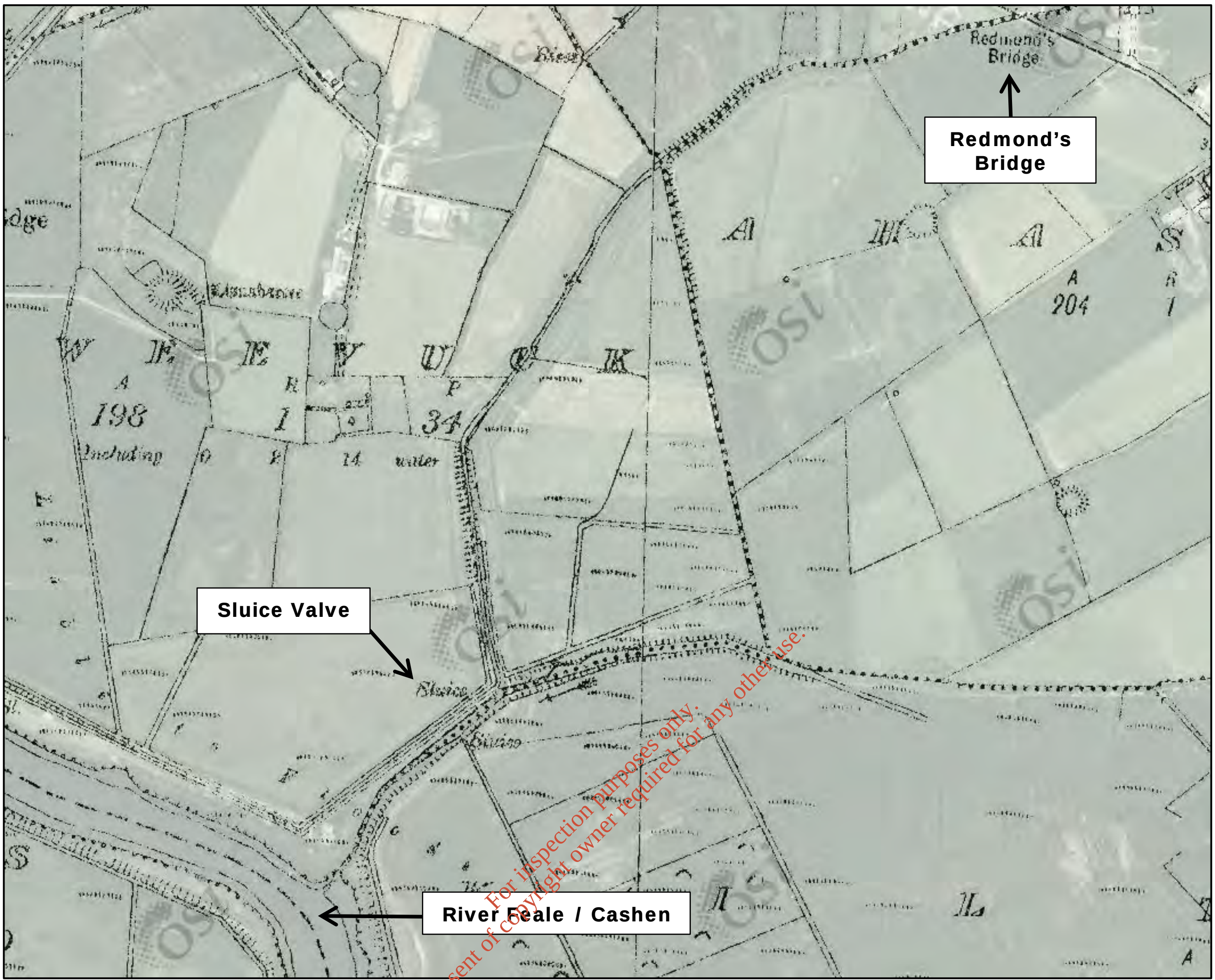
Source: www.map.geohive.ie

Figure 2.10: OSi Aerial Image of Ahascra Historic Landfill (1995)



Source: www.map.geohive.ie

Figure 2.11: Kiltean Bog Upper Peatland Drainage Network



Source: www.map.geohive.ie

Figure 2.12: Kiltean Bog Lower Peatland Drainage Network

3. TIER 2 SITE INVESTIGATION

3.1 Site Investigation Works

A site investigation rationale was devised based on findings of the Tier 1 assessments, site walkover, historical aerial photography and the preliminary risk assessment which formed part of that report.

The scope of site investigation works included:

- Site Walkover
- 1 no. Geophysical survey (2D resistivity and seismic refraction profiling.
- 5 No. Trial pit excavations
- Installation and monitoring of 2 No groundwater boreholes
- Topographical Survey
- Factual reporting.

The locations of the intrusive works at the site are presented in Figure 3.1.

The site investigation included the review of the following literature sources and websites:

- EPA 2003, Landfill Manuals: Landfill Monitoring (2nd Edition)
- EPA 1999, Landfill Manuals: Site Investigations
- BS 5930: 1999, Code of Practice for Site Investigations
- BS 6068 Water Quality: Sampling (parts 6.1-6.6 and 6.11-6.12, 6.14)
- BS 8855 Soil analysis (all parts)
- CLM: Ready Reference 2002, Section 3.1 Soil sampling strategies
- CLM: Ready Reference 2002, Section 3.2 Groundwater sampling/monitoring strategies
- CLM: Ready Reference 2002, Section 3.3 Gas sampling/monitoring strategies

3.1.1 Site Walkover

A site walkover was conducted on the 14th February prior to site investigation works by an FT Engineer. During the site walkover the scope of the site investigative works were determined.

The site walk over checklist and photo log are included in Appendix 5.

Path: R:\Map Production\2019\P1766\Workspace\Ahascra\Tier 2 ERA Report\P1766_Fig3-1_SiteInvestigationLocationPlan_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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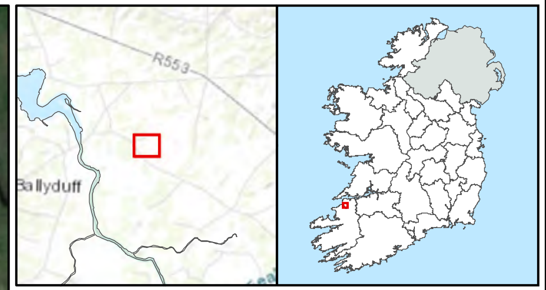

Borehole

Trial Pit

Site Boundary

TITLE: Site Investigation Location Plan	
PROJECT: Ahascra Landfill, Co. Kerry	
FIGURE NO: 3.1	
CLIENT: Kerry County Council	
SCALE: 1:2500	**REVISION:** 0
DATE: 13/11/2019	**PAGE SIZE:** A3

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3.1.2 Geophysical Investigation

A geophysical investigation of the site was carried out on the 8th and 29th of March 2019 by Minerex under instruction from FT.

The geophysical survey consisted of reconnaissance EM31 Ground Conductivity Mapping with follow-up 2D Resistivity and Seismic Refraction profiling methods used to estimate shear-wave velocities (Vs) in the ground material. A total of 297 m of electrical resistivity / seismic profiles were collected.

The geophysical survey was calibrated against the findings of the trial pitting and borehole installations. Information gathered was also used to estimate a general profile of the buried waste above the underlying layers including bedrock.

The geophysical survey delineated the survey area based on two resistivity / seismic profiles and on an interpretation of the ground conditions across the site. The survey succeeded in validating the general location of the waste material. The following conclusions were made:

- The 2D-Reistivity indicated limestone bedrock is between a depth of approximately 7 m - 12 m bgl (i.e., 5 - 0m AOD) across the site.
- The EM31 ground conductivity indicated the landfill material extends throughout the survey area to where the raised ground slopes off towards natural ground surrounding the site. The survey found no waste material exists in the area towards the middle of the site near the eastern access road where a gravel compound exists. The total area covered by the waste body is approximately 23,000 m^2.
- The low 2D-Resistivity data was used to interpret an average waste depth of ca. 2.75m and represents landfill material placed directly onto the existing blanket peat creating a land-raise profile. Low resistivities and seismic velocities measured during the survey inferred the presence of industrial and/or domestic waste rather than C & D type waste and indicated a high organic content.
- The geophysical report inferred the low resistivities detected indicates there is likely leachate present below the landfill. However, this interpretation is likely more representative of saturated peat overburden below the waste body.
- A total volume of 230,000 m^3 for saturated peat overburden was calculated based on the assumption that the peat below the waste body contains a basal saturated depth of ca. 10m.

The modelled profiles and geophysical interpretations are presented in Figure 3.2 and Figure 3.3.

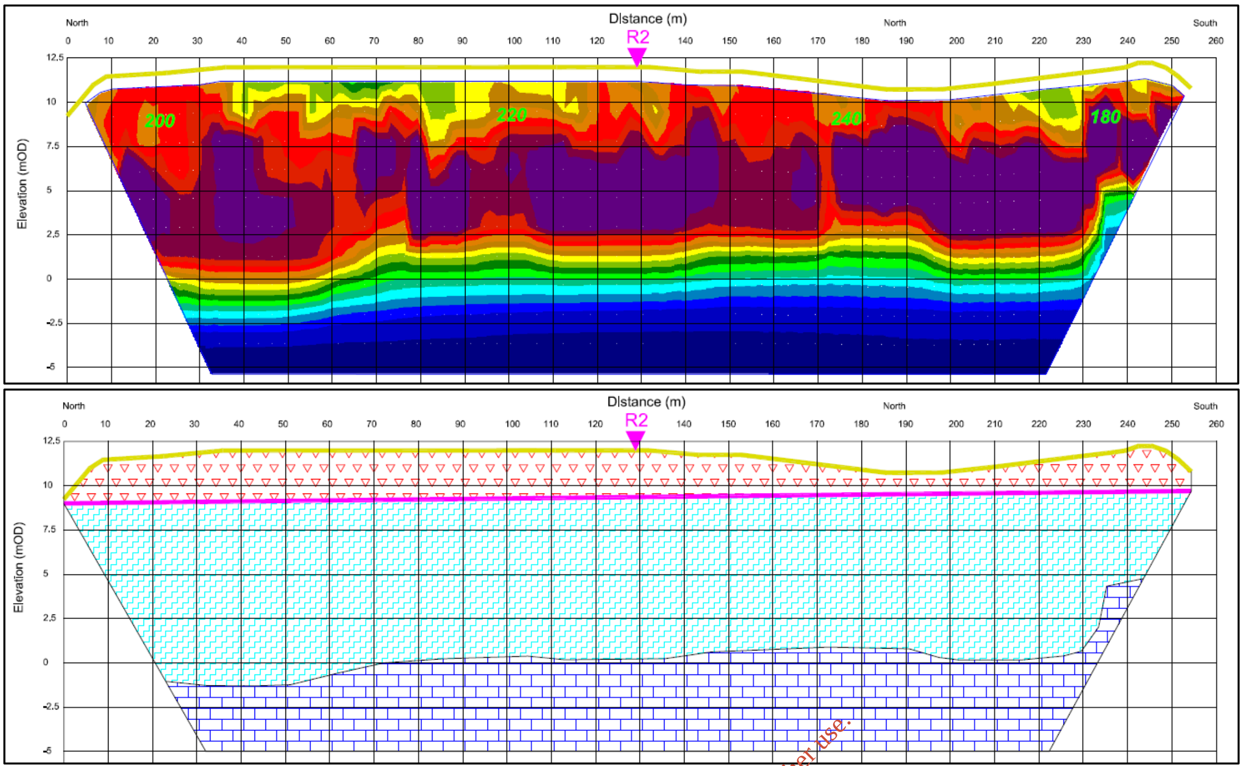

Figure 3.2: ERT Profile R1 Interpreted Cross Section

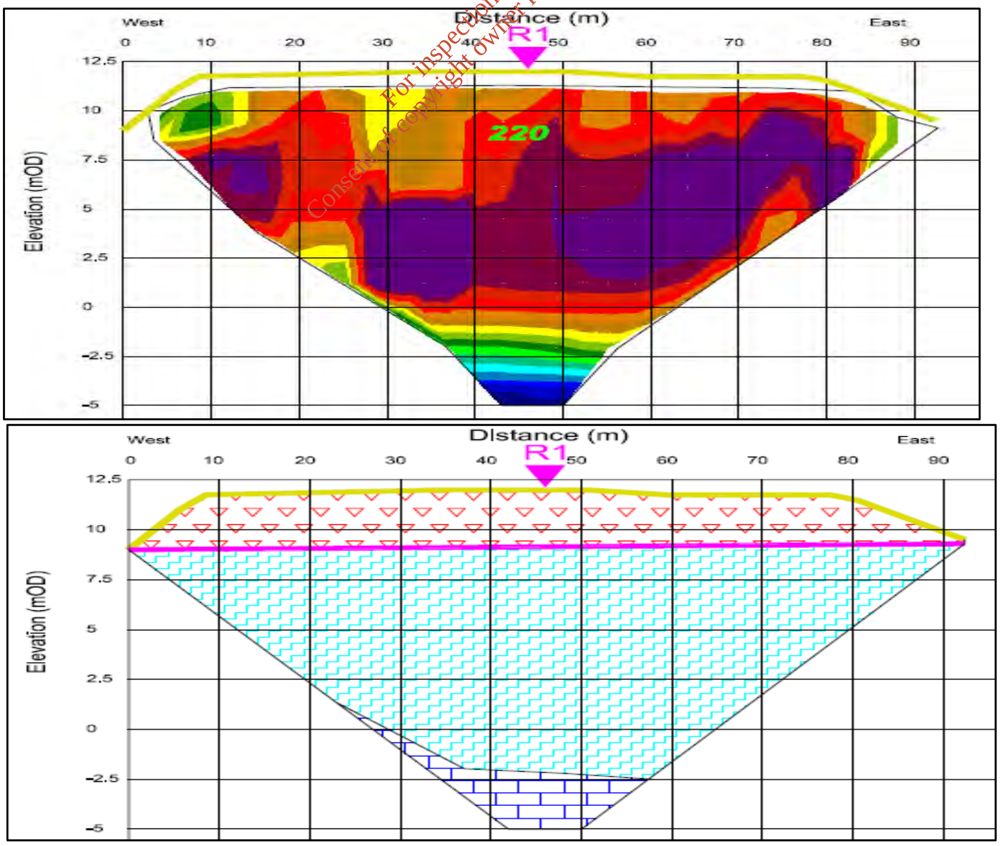

Figure 3.3: ERT Profile R2 Interpreted Cross Section

3.1.3 Trial Pitting

A Causeway Geotech (CGL) Engineering Geologist supervised the advancement of 5 No. trial pits, shown in Figure 3.1, on the 30th May 2019.

The trial pits (TP01 to TP05) were excavated to depths of 1.7m to 2.6m below existing ground level (bgl) using a JCB 3CX back-hoe excavator.

The geophysical survey used in conjunction with the profiles identified during trial pitting provided a picture of the underlying geology of the site and a general profile of the buried waste.

A summary of the ground conditions is presented in Table 3.1 below with photographs and exploratory hole logs provided in the CGL site investigation report, Appendix 2.

Table 3.1: Summary of Ground Conditions

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground/waste (m BGL)	Profile Description
TP01	0.15 (Topsoil) 0.15 – 1.90 (Made Ground)	1.9 (base of excavation)	MADE GROUND: firm dark brownish black slightly sandy slightly gravelly silty CLAY with a high waste content including, block, plastic bags, wire rope, engine parts, glass bottles and fragments, plastic bottles, glass jars and clothing.
TP02	0.10 (Topsoil) 0.10 – 1.70 (Made Ground)	1.7 (base of excavation)	MADE GROUND: Firm dark brown to black slightly sandy slightly gravelly silty CLAY with a high waste content encountered including plastic bags, glass, plastic bottles, wood and cloth.
TP03	0.10 (Topsoil) 0.10 – 1.30 (Silty Clay) 1.3 – 2.6 (Made Ground)	2.6 (base of excavation)	Firm brown slightly sandy slightly gravelly silty CLAY. MADE GROUND: Firm very dark greyish black slightly sandy slightly gravelly silty CLAY with a medium waste content including plastic bags, glass bottles and fragments of cloth, wood and concrete.
TP04	0.10 (Topsoil) 0.10 – 0.70 (Silty Clay) 0.70 – 2.20 (Made Ground)	2.2 (base of excavation)	Firm brown slightly sandy slightly gravelly silty CLAY. MADE GROUND: Firm dark brownish black slightly sandy slightly gravelly silty CLAY with medium – high waste content including plastic bags, glass, wood, saw dust, plastic and glass bottles.
TP05	0.10 (Topsoil) 0.1 – 0.3 (Silty Clay) 0.3 – 2.0 (Made Ground)	2.0 (base of excavation)	Firm brown slightly sandy slightly gravelly silty CLAY.

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground/waste (m BGL)	Profile Description
			MADE GROUND: Firm orangish brown, dark brown and black slightly sandy slightly gravelly silty CLAY with a high waste content including plastic bags, cloth, glass, plastic bottles and wood.

Made ground comprising waste was encountered in all 5 No. trial pits advanced (TP01 – TP05). A shallow cover material was recorded at these trial pit locations and comprised 0.10m to 0.15m of topsoil. Bedrock was not encountered during trial pitting.

Waste material comprising mainly plastic bags, glass bottles, fragments of cloth, wood and concrete was encountered to the base of the excavation of between 1.7m – 2.6m in all 5 No. trial pits. Groundwater was not encountered during trial pitting.

Trial pitting shows the existing soil cover is also not uniform across the entire landfill and therefore is unlikely preventing rainfall percolation into the waste body and minimising leachate generation, as inferred in the Minerex Geophysical report and referenced in Causeway trial pitting logs (TP01 and TP02).

The Minerex geophysical survey stated ''*near the surface the resistivities are higher, particularly near the start of profile R1 which indicates drier landfill material or a thicker layer of topsoil covering the landfill in this area*". Causeway's trial pitting logs confirm this interpretation where deeper topsoil and subsoil is recorded at TP03 – TP05 advanced at fringe locations near the landfill boundary.

3.1.4 Waste Sampling

A total of 2 No. samples of the made ground / waste at the site was collected from trial pits TP03 and TP04 advanced in the southern and western portions of the site.

All samples were submitted for Waste Acceptance Criteria (WAC) testing to Chemtest Ltd, a UKAS/MCERTS approved laboratory. Samples were collected from site under Chain of Custody procedures.

The results are provided in Appendix F of the CGL Ground Investigation report, see Appendix 2 of this report. The results are discussed in Section **Error! Reference source not found.**

3.1.5 Evidence of Contamination

The trial pit excavation works identified waste material tending north-west to south-east across the entire site with thicknesses ranging from 0.10 – 2.6 m BGL. Evidence of waste material was identified in 5 No. trial pits locations (TP01 to TP05). The waste encountered was typically described as black/organic waste with plastic bags, clothing, glass bottles, fragments of wood, wire rope, engine parts and saw dust. The waste material description as described by CGLs Engineering Geologist is very typical of MSW material.

3.1.6 Waste Delineation

The combined findings of the geophysical survey and intrusive site investigation were used to interpret the aerial extent of the waste mass.

The geophysical survey succeeded in validating the general location of the waste material. Both the elevated EM conductivity readings in combination with the trial pit logs show the waste to be present throughout the entire survey area.

The findings of the site investigation work suggest the waste material is deposited in a single infill area tending north-west to south-east across the site and between approximately 250m in length and 92m in width. The total area covered by the waste body is approximately 23,000 m^2.

Considering the areas and an average waste depth of 2.75m, the volume of waste material has been calculated as 63,250 m^3, 88,550 tonnes (at an assumed waste density of 1.4 tonne/m^3).

Minerex interpreted the low resistivities and seismic velocities measured were consistent with commercial and domestic waste rather than C & D type waste.

An extract from the Minerex geophysical report (Appendix 3) showing a delineation of the identified waste body is presented in Figure 3.4. The map shows the EM31 ground conductivity contours. The low (blue) conductivities indicate drier waste and thinner material / natural ground. The middle range (green) values indicate interred waste material. The high (red) values indicate the presence of metal or highly conductive landfill material and the negative readings (blank) in the south-east indicate buried metal.

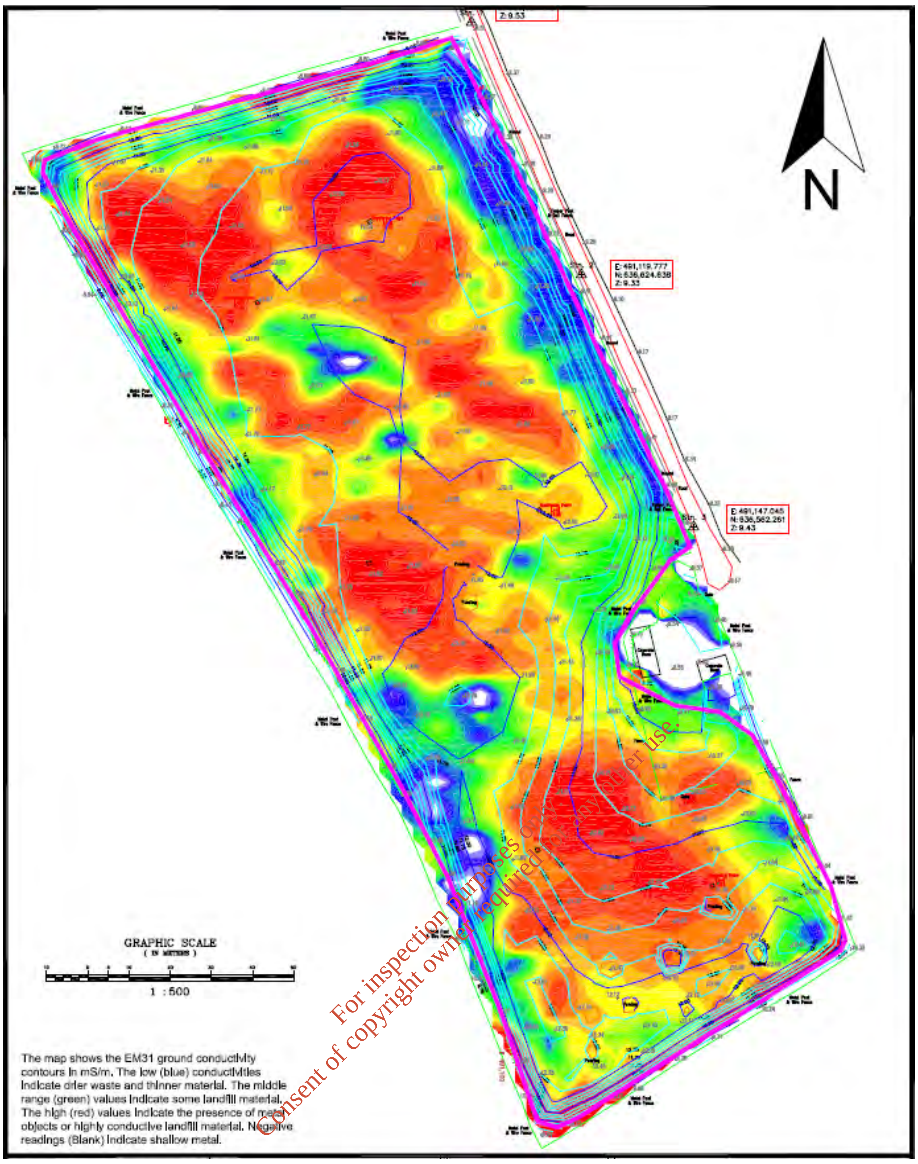

Figure 3.4: Delineation of the Waste Profile

3.1.7 Borehole Installation and Groundwater Sampling

Two boreholes (BH01 and BH02) were drilled to a total depth of 8.5 m bgl at the site on the 20th June 2019. The boreholes were drilled and installed for groundwater monitoring purposes.

Exploratory hole BH01 was advanced at a location ca. 50m beyond the northern boundary of the site and screened within the limestone bedrock. Exploratory hole BH02 was advanced at a location adjacent to the gravel compound beyond the eastern site boundary and screened within the limestone bedrock. The purpose of borehole BH02 was to act as an upgradient monitoring well.

Groundwater monitoring was undertaken at monitoring wells BH01 and BH02 on 16th July and 3rd September 2019. Prior to sampling, the standpipe wells were purged and developed with Waterra groundwater sampling pipework / foot valves and gas caps installed by CGL on the 20th June 2019 in preparation for groundwater monitoring to be undertaken by FT.

All samples were appropriately bottled (using prepared laboratory bottle ware) and packaged for submission to the laboratory. The samples were submitted for laboratory testing to ALS Global Ltd. The analytical results are contained in Appendix 4 and are further discussed in the proceeding sections.

3.2 Geotechnical Analysis

3.2.1 In-situ Capping Permeability Testing

One bulk disturbed soil sample from TP03 was submitted for geotechnical analysis by Causeway Geotech Ltd for analysis of moisture content and permeability testing by triaxial compression. The results of the geotechnical analysis are included in Appendix E of the intrusive Site Investigation Report prepared by Causeway Geotech, see Appendix 2 of this report.

This testing was undertaken to assess the ability of the existing capping material to minimise rainfall infiltration and leachate generation from the waste body.

The k-value calculated for sample TP03 classified the existing capping material as a brown gravelly very sandy very silty CLAY.

Details of permeability for sample TP03 at 0.5m bgl calculated using an 11-day triaxial compression test is shown in Table 3.2.

Table 3.2: Permeability by Triaxial Compression

Sample ID	B-Value (%)	Mean Flow Rate (ml/min)	K (m/s)
TP03	0.96	0.0033	3.5×10^{-10}

In accordance with the EPA Landfill Site Design Manual an engineered capping material should have a permeability less than or equal to 1×10^{-9} m/s to minimise infiltration of rainwater into the waste body. The permeability estimated for sample TP03 analysed at the Ahascra site is below the EPA guidance and is technically suitable as a low permeability capping material.

Despite the above findings, the shallow topsoil depth of 0.1 m and an average clay subsoil depth of 0.7 m do not fully comply with the capping design specification set out in the EPA's Landfill Design Manual.

4. ENVIRONMENTAL ASSESSMENT

The results of the environmental assessment at the Ahascra Historic Landfill site are presented in the following sections.

4.1 Chemical Assessment Criteria

Results were assessed against the following criteria:

- Council Decision 2003/33/EC – Waste Acceptance Criteria
- European Communities, Environmental Objectives (Groundwater)(Amendment) Regulations, 2010 (S.I. No. 9 of 2010) as amended in 2011, 2012 and 2016
- Interim Guideline Values (IGV) set out in the EPAs Groundwater Towards Setting the Guideline Values for the Protection of Groundwater in Ireland.
- European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations, 2012 (S.I. No. 327 of 2012)
- European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I No. 272 of 2009) as amended in 2015 and 2019.
- European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 (S.I. No. 294/1989).

4.2 Waste / Made Ground Assessment

The soil / made ground samples analysed during this assessment have been compared against Waste Acceptance Criteria (WAC) to determine the appropriate waste classification rating associated with the interred waste. WAC screening is chosen for this assessment to suitably categorise the interred waste as being either inert, non-hazardous or hazardous material.

4.2.1 Chemical Results for Waste Samples

The soil samples analysed from the site investigations were assessed against the Waste Classification Assessment Criteria. A summary of the results for Ahascra Landfill is outlined in Table 4.1 below, while the laboratory reports are presented in Appendix F of the CGL site investigation report. See Appendix 2 of this report.

Table 4.1: Waste Sampling Results – Solid Waste Analysis

Parameter	Units	Inert Waste Acceptance Criteria	Non-Hazardous Waste Acceptance Criteria	Hazardous Waste Acceptance Criteria	Sampling Results - Sample ID	
					TP03 (at 2.10 m)	TP04 (at 2.20 m)
Total Organic Carbon	%	**3**	**5**	**6**	**8.3**	**4.1**
Loss on Ignition	%	--	--	**10**	**11**	6.9
Total BTEX	mg/kg	**6**	--	--	< 0.010	< 0.010
Total PCBs (7 Congeners)	mg/kg	**1**	--	--	< 0.10	< 0.10
TPH Total WAC (Mineral Oil)	mg/kg	**500**	--	--	**1500**	< 10
Total (of 17) PAH's	mg/kg	**100**	--	--	< 2.0	< 2.0
pH		--	**>6**	--	8.0	8.2
Acid Neutralisation Capacity	mol/kg	--	--	--	0.024	0.036
Arsenic	mg/kg	**0.5**	**2**	**25**	< 0.050	0.056
Barium	mg/kg	**20**	**100**	**300**	< 0.50	< 0.50
Cadmium	mg/kg	**0.04**	**1**	**5**	< 0.010	< 0.010
Chromium	mg/kg	**0.5**	**10**	**70**	< 0.050	< 0.050
Copper	mg/kg	**2**	**50**	**100**	< 0.050	< 0.050
Mercury	mg/kg	**0.01**	**0.2**	**2**	**0.026**	**0.017**
Molybdenum	mg/kg	**0.5**	**10**	**30**	0.36	0.19
Nickel	mg/kg	**0.4**	**10**	**40**	0.057	< 0.050
Lead	mg/kg	**0.5**	**10**	**50**	< 0.010	< 0.010
Antimony	mg/kg	**0.06**	**0.7**	**5**	**0.068**	0.032
Selenium	mg/kg	**0.1**	**0.5**	**7**	0.022	0.015
Zinc	mg/kg	**4**	**50**	**200**	< 0.50	< 0.50
Chloride	mg/kg	**800**	**15000**	**25000**	35	55
Fluoride	mg/kg	**10**	**150**	**500**	3.1	1.5
Sulphate	mg/kg	**1000**	**20000**	**50000**	**2300**	**1400**
Total Dissolved Solids	mg/kg	**4000**	**60000**	**100000**	**4800**	3100
Phenol Index	mg/kg	**1**	-	-	< 0.30	< 0.30
Dissolved Organic Carbon	mg/kg	**500**	**800**	**1000**	130	190
Moisture	%				< 0.050	0.056

* Hazardous Waste Landfill Criteria: >6% TOC
* Items in **bold** are in exceedance of the Inert WAC limit value
* Items shaded in **green** are in exceedance of the Non-Hazardous WAC limit value
* Items shaded in **orange** are in exceedance of the Hazardous WAC limit value

4.2.2 Waste Classification

As can be seen in Table 4.1, based on the results of 2 No. soil samples submitted for laboratory waste acceptance criteria (WAC) testing, analysis of waste samples from the trial pits excavated indicate that the waste material encountered within the site is typical of non-hazardous waste.

The WAC testing indicates the waste material has a high organic content as indicated by the total organic carbon and loss on ignition levels which is most likely due to the degradation of organic fractions within the MSW.

Given the nature of the waste encountered during trial pitting, the results of the WAC analysis for TP03 are within the expected range for non-hazardous MSW.

4.3 Groundwater Analysis

Two rounds of groundwater quality monitoring were undertaken at the site on the 16th July and 3rd September 2019. The findings from the monitoring and an interpretation of the results is presented in the following sections.

4.3.1 Groundwater Depth Analysis

Groundwater depth analysis was undertaken during both rounds of monitoring at monitoring wells BH01 and BH02. The average static groundwater level from both monitoring rounds is calculated below.

Table 4.2: Groundwater Depth Analysis

Borehole ID	Location Gradient	Ground Level (mAOD)	Depth to Water (m bgl)	Groundwater Level (mAOD)
BH01	Downgradient	8.558	1.360	7.198
BH02	Upgradient	9.648	1.515	8.133

*Note: Location gradient is in reference to the identified waste deposition area.

Based on the above field survey measurements, groundwater was present at relatively shallow levels below the surface at ca. 1.5 m below ground level (m bgl). Based on the groundwater level measurements and the geophysics interpretation that the inferred base of the waste body lies at approximately 9.0 m AOD, the depth assessment from July and September indicates that the potentiometric groundwater surfaces do not intersect the waste body.

The approximate 1.0m difference in groundwater hydraulic head levels suggests that the groundwater flow direction is tending north/north-west. A potentiometric map illustrating the hydraulic gradient and the direction of groundwater flow is presented in Figure 4.1.

4.3.2 Groundwater Borehole Position

The location of the groundwater boreholes installed at the site where based on the anticipated groundwater flow direction. A desktop analysis of the site in tandem with a site walkover estimated that the likely groundwater flow direction was west/north-west based on the topography of the site and location of the River Feale further west.

The combination of lower groundwater levels at monitoring well BH01 compared to BH02 and a review of the GSI groundwater flow contours indicates flow direction is due west/north-west. BH01 is therefore considered to be down of the waste mass identified.

4.3.3 Groundwater Quality Monitoring

The results of groundwater samples analysed from borehole BH01 to the west of the site have been assessed against the EPAs Interim Guideline Values (IGVs) and the European Groundwater Regulations (2010) (as amended) assessment criteria. A summary of the results reported for each parameter is outlined in Table 4.3.

Only results that were shown to be above the limit of detection are shown in Table 4.3, all other results obtained were found to be below the limit of detection and therefore below the relevant groundwater quality thresholds. The complete laboratory reports with all results are presented in Appendix 4 of this report.

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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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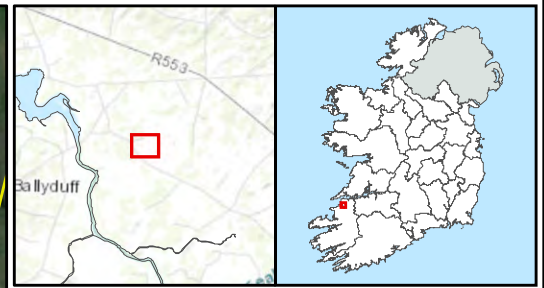

Borehole Locations

Groundwater Flow Direction

Site Boundary

1m Contours

TITLE: Groundwater Flow Direction			
PROJECT: Ahascra Landfill, Co. Kerry			
FIGURE NO:	4.1		
CLIENT:	Kerry County Council		
SCALE:	1:2500	**REVISION:**	0
DATE:	31/10/2019	**PAGE SIZE:**	A3

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Table 4.3: Groundwater Sampling Results

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2010 Standards [2]	BH01		BH02	
				03/09/2019	16/07/2019	03/09/2019	16/07/2019
Inorganics							
Ammoniacal Nitrogen as N	mg/l	**0.15**	**0.065 - 0.175**	**2.38**	**2.43**	**2.38**	**1.89**
Conductivity @ 20 deg.C	mS/cm	**1**	**1.875**	0.552	0.516	0.634	0.652
Total Dissolved Solids	mg/l	**1000**		434	442	484	500
Fluoride	mg/l	**1**		<0.5	<0.5	<0.5	<0.5
Dissolved Oxygen	mg/l		**NAC**	7.1	5.59	9.08	8.57
pH	pH Units	**6.5-9.5**		7.99	8.17	7.67	7.57
Phosphate (Ortho as PO4)	mg/l		**0.03**	<0.05	<0.05	<0.05	<0.05
Chloride	mg/l	**30**	**24-187.5**	**37.4**	**44.1**	**37.4**	**35.7**
Total Cyanide	mg/l	**0.01**	**0.0375**	<0.05	<0.05	<0.05	<0.05
Total Alkalinity as CaCO3	mg/l		**NAC**	309	471	348	350
Total Suspended Solids	mg/l			-	-	-	-
Total Oxidised Nitrogen as N	mg/l			<0.1	<0.1	<0.1	<0.1
Sulphate (soluble) as S	mg/l	**200**	**187.5**	<1	<1	<1	<1
Total Organic Carbon	mg/l			4.04	3.44	3.29	4.64
Dissolved Metals (Filtered)							
Mercury (diss.filt)	µg/l	**1**	**0.75**	<0.01	<0.01	<0.01	<0.01
Arsenic (diss.filt)	µg/l	**10**	**7.5**	**65.6**	**39.2**	**19.2**	**14.4**
Barium (diss.filt)	µg/l	**100**		24.8	29	42.8	53.3
Boron (diss.filt)	µg/l	**1000**	**750**	18.2	23.6	16.6	11.7
Cadmium (diss.filt)	µg/l	**5**	**3.75**	<0.08	<0.08	<0.08	<0.08

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2010 Standards [2]	BH01		BH02	
				03/09/2019	16/07/2019	03/09/2019	16/07/2019
Chromium (diss.filt)	µg/l	**30**	**37.5**	<1	<1	<1	<1
Copper (diss.filt)	µg/l	**30**	**1500**	<0.3	<0.3	0.464	<0.3
Lead (diss.filt)	µg/l	**10**	**7.5**	<0.2	<0.2	<0.2	0.241
Manganese (diss.filt)	µg/l	**50**		**376**	**341**	**1250**	**1280**
Nickel (diss.filt)	µg/l	**20**	**15**	0.972	1.32	1.32	1.36
Phosphorus (diss.filt)	µg/l			<10	<10	19.6	<10
Selenium (diss.filt)	µg/l			<1	<1	<1	<1
Thallium (diss.filt)	µg/l			<2	<2	<2	<2
Zinc (diss.filt)	µg/l	**100**	**75**	2.19	2.07	3.3	3.88
Sodium (Dis.Filt)	mg/l	**150**	**150**	31.4	35.9	29.6	31.2
Magnesium (Dis.Filt)	mg/l	**50**		8.25	9.06	10.3	10.8
Potassium (Dis.Filt)	mg/l	**5**		1.78	2.52	2.28	2.12
Calcium (Dis.Filt)	mg/l	**200**		80.2	87.7	102	109
Iron (Dis.Filt)	mg/l	**0.2**		**2.79**	**0.798**	**4.13**	**2.23**
Mineral Oil / Oils & Greases							
Mineral oil >C10 C40 (aq)	µg/l	**10**		<100	**251**	<100	<100

[1] IGV-Interim Guideline Values, from EPA, Towards Setting Guideline Values for the Protection of Groundwater in Ireland, 2003.
[2] OTV-Overall threshold value, European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010) as amended in 2011, 2012, 2016.
* Items shaded in **bold** are in exceedance of the EPA IGV Standards
* Items shaded in **orange** are in exceedance of the Drinking Water Regulations

4.3.4 Groundwater Analysis Discussion

The results of two rounds of groundwater monitoring from BH01 (downgradient) and BH02 (upgradient) have reported several exceedances of the IGVs and European Groundwater (OTV) limit values.

Samples recovered from monitoring wells BH01 and BH02 reported ammoniacal nitrogen concentrations ranging from 1.89 mg/l to 2.43 mg/l, which exceed guideline threshold values. Results indicate very little difference in ammonia concentrations upgradient and downgradient of the landfill. Given the presence of peat soils surrounding the site, ammoniacal N levels are likely going to be naturally high. Despite the presence of peat soils and the lack of background water quality data for the area, the ammoniacal N levels detected at BH01 and BH02 may also be an indication of impact from the landfill.

Chloride levels ranging from 35.7 mg/l to 44.1 mg/l at both BH01 and BH02 during the monitoring period exceeded the OTV limit value. The concentration differences between both monitoring wells is considered negligible.

Arsenic concentrations ranged from 39.2 mg/l to 65.6 mg/l at downgradient BH01 and from 14.4 mg/l to 19.2 mg/l at upgradient BH02. Levels of arsenic detected at both monitoring wells exceed guideline threshold limit values. The notable differences in arsenic concentrations between upgradient well BH02 and downgradient BH01 may be an indication of a leachate plume migration in the direction of BH01.

Iron and manganese concentrations detected during the monitoring period exceeded the IGV limit. Iron levels ranged from 0.798 mg/l to 2.79 mg/l at BH01 (downgradient) and 2.23 mg/l to 4.13 mg/l at BH02 (upgradient).

Results show notable differences in manganese levels between BH01 and BH02. An assessment of the average concentrations over the monitoring period show a concentration difference of 907 mg/l between each location. The difference in manganese concentrations is likely evidence of water quality changes between overburden and bedrock geology locally. Boreholes logs show BH01 has been installed into predominantly overburden peat and clay material, whereas BH02 is installed within mostly limestone bedrock where potential for higher levels of manganese during abstraction will be greater.

The GSI[1] described high iron and manganese concentrations are caused mainly by the natural conditions in the ground and the natural chemistry of the groundwater. Such conditions often occur in areas underlain by peat and mudstone where reducing conditions result in solution of iron and/or manganese from the bedrock. The Ahascra historic landfill is underlain by peat and mudstone and is likely giving rise to the levels of iron and manganese detected at BH01 and BH02, and therefore are representative of background groundwater hydrochemistry.

Mineral oil concentrations of 0.251 mg/l were detected at downgradient well BH01 during the July monitoring round and exceeded the IGV threshold of 0.01 mg/l. Results show mineral oil levels were below the limit of detection (LOD) at BH02 in July and below the LOD at both wells in September.

The results of groundwater monitoring when assessed List 1 and List 2 substances – SVOCs, pesticides, herbicides, organics) shows all results are below the laboratory limit of detection in all assessments at both sampling locations. The lack of detection of these substances indicates that no hazardous waste material was disposed at the historic landfill.

[1] County Clare Groundwater Protection Scheme, Main Report (GSI 2000).

The presence of elevated ammonia, chloride, arsenic and mineral oil concentrations typically present in landfill leachate may be evidence of impact from the landfill given the position of the monitoring wells adjacent to the landfill. The levels detected at borehole BH02 indicate the landfill is likely impacting water quality locally at these locations.

4.4 Landfill Gas Monitoring

FT carried out one round of landfill gas (LFG) monitoring at each monitoring borehole location (BH01 and BH02) as indicated on Figure 3.1. In accordance with the EPA CoP, methane, carbon dioxide, oxygen and atmospheric pressure were analysed at the 2 No. groundwater monitoring wells located outside the waste body using a geotechnical instrument GEM5000 Landfill Gas analyser.

4.4.1 Monitoring Results

In accordance with the CoP, the trigger level for methane outside the waste body is 1% v/v and for carbon dioxide is 1.5% v/v. The monitoring results for methane, carbon dioxide and oxygen levels for the perimeter borehole are summarised in Table 4.4.

Table 4.4: Perimeter Well Monitoring Results October 2019

Date: 23-10-2019						
Sample Station	CH_4	CO_2	O_2	Atmospheric Pressure	Staff Member	Weather
	(% v/v)	(% v/v)	(% v/v)	(mbar)		
BH01	0.2	0.1	21.3	1005	Emily Archer	Overcast, heavy rain, showers, 12°C
BH02	0.5	0.3	21.6			

As can be seen in Table 4.5, concentrations of both carbon dioxide (CO_2) and methane (CH_4) at monitoring boreholes BH01 and BH02 were below the threshold values set by the CoP during the October monitoring round.

4.5 Surface Water Monitoring

4.5.1 Monitoring Locations

In the absence of a free-flowing surface waterbody near the site, surface water monitoring locations were selected within a man-made peatland drainage channel adjacent to the landfill footprint, as shown on Figure 4.2. Very low flow conditions were observed within the land drain during both monitoring rounds.

Monitoring location SW1 was selected as the furthest upstream location and samples a localised drainage channel on the eastern side of the access road to the landfill. A second location SW2 was selected approximately 50m further south along the same eastern drainage channel. SW2 is not downstream of the landfill.

Two surface water monitoring rounds were carried out on the 19th July and 6th September 2019. The surface water sampling locations at the site are presented in Figure 4.2.

4.5.2 Monitoring Parameters

The results of surface water sampling analysed from the 2 No. sampling locations (SW1 and SW2) at the site have been assessed against the Maximum Admissible Concentration (MAC) Regulations (1989) and the Environmental Quality Standard (EQS) for Surface Waters Regulations (2009) (as amended) assessment criteria based on the presence of the River Feale.

A summary of the results reported for each parameter from the two monitoring rounds is outlined in Table 4.5. Only results that were shown to be above the limit of detection are shown in Table 4.5, all other results obtained were found to be below the limit of detection and therefore below the relevant surface water quality thresholds. The complete laboratory reports with all results are presented in Appendix 4 of this report.

Table 4.5: Surface Water Sampling Results

Parameter	Units	MAC [1]	EQS [2]	Upstream SW01 16.07.2019	Downstream SW02 16.07.2019	Upstream SW01 03.09.2019	Downstream SW02 03.09.2019
Inorganics							
Ammoniacal Nitrogen as N	mg/l	--	**≤0.140 (95%ile)**	<0.2	<0.2	<0.2	<0.2
Conductivity @ 20 deg.C	mS/cm	--	--	0.0973	0.0926	0.17	0.17
Fluoride	mg/l	--	**0.5**	<0.5	<0.5	<0.5	<0.5
Dissolved Oxygen	mg/l	--	**95%ile>80% saturation, 95%ile<120% saturation**	9.73	9.04	8.63	8.88
pH	pH Units	--	**6.0-9.0**	6.14	6.08	6.29	6.39
Phosphate (Ortho as PO4)	mg/l	--	--	<0.05	<0.05	<0.05	<0.05
Chloride	mg/l	--	--	21.2	21.1	32.6	42.8
COD, unfiltered	mg/l	--	--	179	167	183	183
Total Cyanide	mg/l	--	**0.01**	<0.05	<0.05	<0.05	<0.05
BOD, unfiltered	mg/l	--	**≤2.6 (95%ile)**	**8.2**	**10**	**4.5**	**3.6**
Total Alkalinity as CaCO3	mg/l	--	--	9	12.7	16	11
Total Suspended Solids	mg/l	--	--	35.1	46	24	41.8
Total Oxidised Nitrogen as N	mg/l	--	--	<0.5	<0.5	<0.1	<0.1
Sulphate (soluble) as S	mg/l	--	--	<5	<5	<5	<5
Total Organic Carbon	mg/l	--	--	63.6	63.5	51.7	51.6
Dissolved Metals (Filtered)							
Mercury (diss.filt)	µg/l	**0.07**	**0.05**	<0.01	<0.01	0.0102	<0.01
Arsenic (diss.filt)	µg/l	--	**25**	<0.5	0.683	<0.5	0.578
Barium (diss.filt)	µg/l	--	--	2.41	2.76	2.42	2.52
Boron (diss.filt)	µg/l	--	--	16.7	16	11	12.6

Parameter	Units	MAC [1]	EQS [2]	Upstream SW01 16.07.2019	Downstream SW02 16.07.2019	Upstream SW01 03.09.2019	Downstream SW02 03.09.2019
Cadmium (diss.filt)	µg/l	--	**0.08**	<0.08	<0.08	<0.08	<0.08
Chromium (diss.filt)	µg/l	**32**	**4.7**	<1	<1	<1	<1
Copper (diss.filt)	µg/l	--	**30**	3.11	2.41	2.2	2.29
Lead (diss.filt)	µg/l	**14**	**7.2**	1.26	1.22	1.15	1.14
Manganese (diss.filt)	µg/l	--	--	79.8	85.2	89.7	88.5
Nickel (diss.filt)	µg/l	**34**	**4**	0.854	0.915	1.11	1.27
Phosphorus (diss.filt)	µg/l	--	**0.075**	12.2	12.1	20.1	18.7
Selenium (diss.filt)	µg/l	--	--	<1	<1	<1	<1
Thallium (diss.filt)	µg/l	--	--	<2	<2	<2	<2
Zinc (diss.filt)	µg/l	--	**100**	41.1	39.6	32.4	32.2
Sodium (Dis.Filt)	mg/l	--	--	12	11.8	22.7	22.8
Magnesium (Dis.Filt)	mg/l	--	--	2.63	2.9	3.96	3.93
Potassium (Dis.Filt)	mg/l	--	--	0.281	0.372	0.65	0.667
Calcium (Dis.Filt)	mg/l	--	--	6.33	7.48	7.93	7.67
Iron (Dis.Filt)	mg/l	--	--	1.19	1.13	0.801	0.774
Volatile Organic Compounds (VOCs)							
Dichloromethane	µg/l	--	**20**	<3	<3	4.26	8.28

Notes:

[1] Maximum Admissible Concentration (MAC), as classified by European Communities (Quality of Surface Water intended for abstraction of drinking water) Regulations 1989 (S.I No. 294 of 1989)

[2] Environmental Quality Standard (EQS), European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I No. 272 of 2009)

* Items shaded in **bold** are in exceedance of the European Communities MACs

* * Items shaded in **orange** are in exceedance of the 2009 EQS Regulations

** * NAC – no abnormal change

4.5.3 Surface Water Analysis Discussion

The results of the surface water laboratory analysis as presented in Table 4.5, when assessed against the MAC (1989) and EQS (2009) quality standards were found to be below the guideline values in all assessments, with the exception of BOD concentrations at upstream and downstream locations.

BOD levels ranged from 4.5 mg/l to 8.2 mg/l (upstream) and 3.6 mg/l to 10 mg/l (downstream) during both monitoring rounds in July and September. High BOD and COD levels are an indirect indicator of the organic content in a waterbody. The detected levels of BOD and COD (167 mg/l – 183 mg/l) in combination with the very low flow conditions within the waterbody may be an indicator of background peatland water quality rather than leachate migration from the landfill.

Results from the second round of sampling indicate an increase in chloride concentrations at upstream and downstream locations. Chloride levels of 42.8 mg/l at downstream SW02 were two times greater during the second round compared to first round results in July. The chloride level increases at both sampling locations may be an indicator of leachate migration from the landfill. Similar chloride levels were detected in the waste samples retrieved as referenced in Table 4.1.

Results overall, show very little variation in parameter levels was observed between upstream and downstream sampling locations.

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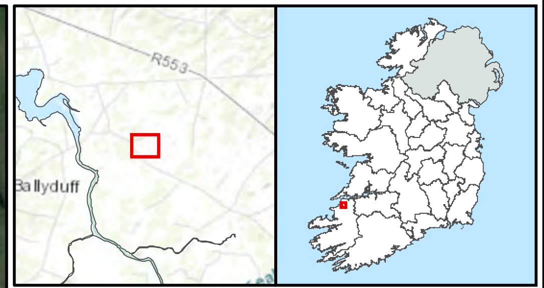

Surface Water Sampling Locations

Site Boundary

TITLE: Surface Water Sampling Locations	
PROJECT: Ahascra Landfill, Co. Kerry	
FIGURE NO: 4.2	
CLIENT: Kerry County Council	
SCALE: 1:2500	**REVISION:** 0
DATE: 31/10/2019	**PAGE SIZE:** A3

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5. RISK ASSESSMENT

5.1 Introduction

Risk assessment considers the likelihood of occurrence and the consequence of occurrence of an event (Royal Society, 1992[2]). ERA (Environmental Risk Assessment) is based on the development of a Conceptual Site Model (CSM) which is used to determine the potential exposure of a vulnerable receptor to a contaminant. The CSM is used as the basis for the risk assessment. It is used to identify all possible sources (S), pathways (P) and receptors (R) as well as the processes that are likely to occur along each of the source-pathway-receptor (S-P-R) linkages and uncertainties.

Based on the desktop investigation and completed site investigation, this CSM assumes the source to be the made ground containing waste deposit, the pathway to involve the migration of landfill gas, surface water and groundwater and the ultimate receptors to be the surface water features, groundwater, groundwater abstraction well and all human presence near the waste material.

5.2 Potential Pathways and Receptors

A pathway is a mechanism or route by which a contaminant encounters, or otherwise affects, a receptor. Contaminants associated with deposited waste may include leachate generated from groundwater/rainwater infiltration into the waste material and/or the lateral or vertical migration of landfill gas to human receptors.

The potential pathways associated with the Ahascra site are:

- Groundwater migration; and
- Surface water infiltration;

5.2.1 Leachate Migration leading to Surface Water Infiltration

According to the EPA CoP, there are three main pathways for leachate migration. These are:

- Vertically to the water table or top of an aquifer, where groundwater is the receptor
- Vertically to an aquifer and then horizontally in the aquifer to a receptor such as a well, spring, stream or in this case, the adjacent coastline
- Horizontally at the ground surface or at shallow depth to a surface receptor

The migration and attenuation of leachate from the site depends on the permeability and thickness of subsoil and on both the bedrock permeability value and type. These elements are encompassed in groundwater vulnerability, groundwater flow regime and surface water drainage.

[2] Royal Society 1992, Risk: Analysis, Perception and Management. The Royal Society, London (ISBN 0-85403-467-6).

The main receptors to leachate migration from this site are:

- Aquifer;
- Surface water features; and
- Human presence nearby the site

5.2.2 Landfill Gas Migration

According to the EPA CoP, there are two main pathways for landfill gas migration. These are:

- Lateral migration via subsoil
- Vertical migration via subsoil

The migration of landfill gas from the site depends on the nature of the material deposited and the nature, permeability and thickness of the surrounding subsoil or bedrock.

The main receptors to potential landfill gas migration from this site are:

- Human Presence/Buildings nearby the waste body

5.3 Conceptual Site Model

Based on the review of the Tier 1 assessments and site investigation works undertaken for Ahascra Historic Landfill, an assessment of the risk is made to confirm the source – pathway – receptor (S-P-R) linkages identified in the preliminary investigation. The results and analysis of the investigation has enabled a revised conceptual model to be produced for the site, which is presented in Figure 5.1, overleaf.

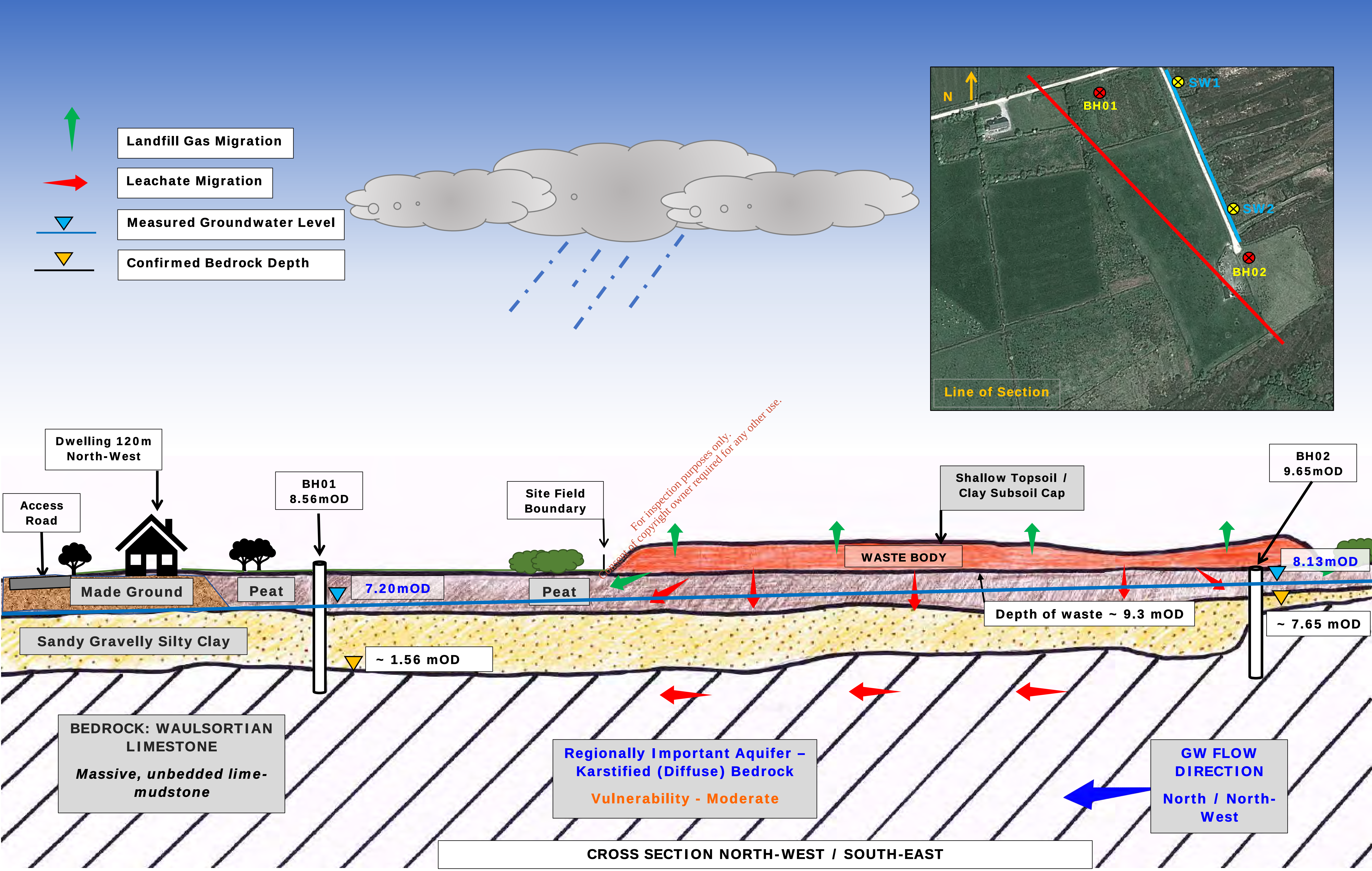

FIGURE 5.1 AHASCRA HISTORIC LANDFILL

CONCEPTUAL SITE MODEL

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5.4 Risk Prioritisation

Risk prioritisation enables resources to be prioritised on the highest risk facilities and on the highest source – pathway – receptor linkage potential.

The risk prioritisation process assigns a score to each linkage and the overall score is the maximum of the individual linkages for the site. The higher the score a site/linkage receives the higher the risk.

To classify the risk, scores will be applied to the information obtained during the site investigation of Ahascra Historic Landfill. Where there is insufficient information available (i.e., where there is a high degree of uncertainty) the highest score is assumed.

In accordance with the EPA CoP (2007) the scoring matrices are as follows:

- Leachate: Source/hazard scoring matrix, based on waste footprint
- Landfill gas: Source/hazard scoring matrix based on waste footprint
- Leachate migration: Pathway (Vertical)
- Leachate migration: Pathway (Horizontal)
- Leachate migration: Pathway (Surface water drainage)
- Landfill gas: Pathway (Lateral migration potential)
- Landfill gas: Pathway (Upwards migration potential)
- Leachate migration: Receptor (Surface water drainage)
- Leachate migration: Receptor (Human presence)
- Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/groundwater dependent terrestrial ecosystems)
- Leachate migration: Receptor (Aquifer category – Resource potential)
- Leachate migration: Receptor (Public water supplies – other than private wells)
- Leachate migration: Receptor (Surface water bodies)
- Landfill gas: Receptor (Human presence)

Table 5.1 calculates the points awarded to each of the headings listed above.

Table 5.1: Risk Classification Calculation – Ahascra Landfill

EPA Ref	Risk	Points	Rationale
1a	Leachate; source/hazard scoring matrix, based on waste footprint.	7	Based on a waste footprint of 2.3 ha and the assumption of municipal and domestic waste the score should be 7.
1b	Landfill gas; source/hazard scoring matrix, based on waste footprint.	7	Based on a waste footprint of 2.3 ha and the assumption of municipal and domestic waste the score should be 7.
2a	Leachate migration: Pathway (Vertical)	1	GSI describes the groundwater vulnerability as moderate across the entire site. The geophysical site survey inferred the presence of a thick peat layer (ca. 7m) underlying the waste body.
2b	Leachate migration: Pathway (Horizontal)	5	The site is underlain by a Regionally Important Aquifer – Karstified (Rkd).
2c	Leachate migration: Pathway (Surface water drainage)	2	A shallow peatland drainage channel is present along the eastern perimeter of the site. This drainage channel is connecting the landfill to the Kiltean Bog man-made drainage network which directs flow south-west towards the River Feale / Cashen SAC.
2d	Landfill gas: Pathway (Lateral migration potential)	1	The geophysical survey in combination with desktop study has identified the presence of peat underlying the landfill and site perimeter.
2e	Landfill gas: Pathway (Upwards migration potential)	0	Based on no buildings, structures or other enclosed spaces present directly above the waste body, a score of 0 is being applied.
3a	Leachate migration: Receptor (Human presence)	2	One residential dwelling is located between 50m and 250m to the north-west of the site boundary.
3b	Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/ groundwater dependent terrestrial ecosystems)	0	The nearest groundwater protection zone is located approximately 15.8 km south-west of the site.
3c	Leachate migration: Receptor (Aquifer category – Resource potential)	5	The underlying bedrock groundwater aquifer as a 'Regionally Important Aquifer – Karstified (Diffuse) Bedrock (Rkd).
3d	Leachate migration: Receptor (Public water supplies – other than private wells)	0	The nearest groundwater protection zone is located approximately 15.8 km south-west of the site.
3e	Leachate migration: Receptor (Surface water bodies)	3	Shallow drainage channel is present along the eastern perimeter of the site within 50m.
3f	Landfill Gas: Receptor (Human presence)	3	Residential dwelling located within 50m to 250m north-west of the waste body.

Table 5.2: Normalised Score of S-P-R Linkage

Calculator		S-P-R Values	Maximum Score	Linkage	Normalised Score
Leachate migration through combined groundwater and surface water pathways					
SPR1	1a x (2a + 2b + 2c) x 3e	**168**	300	Leachate => surface water	56%
SPR2	1a x (2a + 2b + 2c) x 3b	**0**	300	Leachate => SWDTE	0%
Leachate migration through groundwater pathway					
SPR3	1a x (2a + 2b) x 3a	**84**	240	Leachate => human presence	35%
SPR4	1a x (2a + 2b) x 3b	**0**	240	Leachate => GWDTE	0%
SPR5	1a x (2a + 2b) x 3c	**210**	400	Leachate => Aquifer	53%
SPR6	1a x (2a + 2b) x 3d	**0**	560	Leachate => Surface Water	0%
SPR7	1a x (2a + 2b) x 3e	**126**	240	Leachate => SWDTE	53%
Leachate migration through surface water pathway					
SPR8	1a x 2c x 3e	**42**	60	Leachate => Surface Water	**70%**
SPR9	1a x 2c x 3b	**0**	60	Leachate => SWDTE	0%
Landfill gas migration pathway (lateral & vertical)					
SPR10	1b x 2d x 3f	**21**	150	Landfill Gas => Human Presence	14%
SPR11	1b x 2e x 3f	**0**	250	Landfill Gas => Human Presence	8%
Site maximum S-P-R Score					**70%**
Risk Classification					**A – High Risk**

Table 5.2 shows the maximum S-P-R scoring for the site is **70%.**

The following are the risk classifications applied:

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

Based on this, the site can be classified as a **High-Risk Classification (Class A)**. The principal risks identified on the site relate to the risk of leachate migration to the surface water peatland drainage channel located along the eastern boundary of the historic landfill and the risk to the groundwater aquifer from the migration of leachate from the waste body.

6. CONCLUSION

A Tier 2 study was conducted by FT in accordance with the EPA CoP for Ahascra Historic Landfill. The study consisted of a desktop study, geophysical survey, intrusive site investigation and environmental sampling works. These works informed the development of the CSM and risk screening model.

The findings of the site investigation work and geophysical surveying show that waste material is deposited in a single infill area tending east to west in the centre of the site and between approximately 250m in length and 92m in width. The total area covered by the waste body is approximately 23,000 m^2.

A volume calculation based on the geophysical survey's inferred average waste depth of 2.75 m indicate an interred waste volume of approximately 63,250 m^3 (88,550 tonnes) at the site.

The findings of the geophysical survey and trial pitting were used to interpret an average waste depth of ca. 2.75m and confirmed the landfill material was placed directly on top of blanket peat creating a land-raise profile. Low resistivities and seismic velocities measured during the survey were consistent with industrial and/or domestic waste rather than C&D type waste and indicated a high organic content.

Trial pitting confirmed a capping layer comprising shallow topsoil to a depth of 0.1 m and an average clay subsoil depth of 0.7 m across the site. The capping layer does not comply with the capping design specification set out in the EPA's Landfill Design Manual. The existing soil cover is also not uniform across the entire landfill and therefore is unlikely preventing rainfall percolation into the waste body and minimising leachate generation.

The findings of the desk study indicate a network of peatland drains excavated north and north-west of the site are potentially connecting the landfill to the River Feale / Cashen SAC.

Analysis of waste samples from the trial pits excavated, when assessed against waste acceptance criteria (WAC) indicated the waste material encountered within the site is typical of non-hazardous waste. The WAC testing indicates the waste material has a high organic content which may be due to the degradation of organic fractions within the MSW. Given the nature of the waste encountered during trial pitting, the parameter concentrations detected in the waste samples are within the expected range for MSW.

Groundwater depth analysis undertaken in July and September has inferred an average groundwater level of 8.13 m (AOD) upgradient and 7.20 m (AOD) downgradient of the landfill. Based on these measurements, it is assumed that the potentiometric groundwater surface does not intersect the assumed average waste body depth of 9.30 m (AOD). Given the waste material has been deposited to form a land-raise from the natural ground level (ca. 9.30 mAOD), groundwater levels intersecting the waste body is considered unlikely.

Analysis of groundwater samples from upgradient monitoring well BH02 and downgradient monitoring well BH01 reported elevated ammonia, chloride, arsenic and mineral oil concentrations above guideline threshold values. The parameters detected are typical constituents of landfill leachate and may be evidence of localised impact on groundwater quality given the dilute and disperse nature of the landfill.

Landfill gas monitoring from perimeter wells indicated concentrations of both carbon dioxide and methane at BH01 and BH02 were below the threshold values set by the CoP during the October monitoring round.

Analysis of two rounds of surface water sampling from the drainage channel to the east of the site were found to be below the guideline values in all assessments, with the exception of BOD concentrations at upstream and downstream locations.

BOD levels ranged from 4.5 mg/l to 8.2 mg/l upstream and 3.6 mg/l to 10 mg/l downstream during both monitoring rounds in July and September. The detected levels of BOD and COD in combination with the very low flow conditions within the waterbody may be an indicator of background peatland water quality rather than leachate migration from the landfill. Chloride levels of 42.8 mg/l at downstream SW02 were two times greater during the second round compared to first round results in July. The detected levels of chloride within the waterbody may be an indicator of leachate infiltration from the landfill.

Based on the above findings, the site can be classified as a **High-Risk Classification (Class A)**. The principal risks identified on the site relate to the risk of leachate migration to the surface water peatland drainage channel located along the eastern boundary of the historic landfill and the risk to the groundwater aquifer from the migration of leachate from the waste body.

6.1 Recommendations

Based on the results of the initial Tier 2 assessment the site is classified as High Risk. For a high-risk site, the CoP indicates that a Tier 3 Environmental risk assessment be undertaken including a Detailed Quantitative Risk Assessment (DQRA).

It is therefore recommended by FT that a Tier 3 DQRA be undertaken for the site in conjunction with an application for a Certificate of Registration for this site.

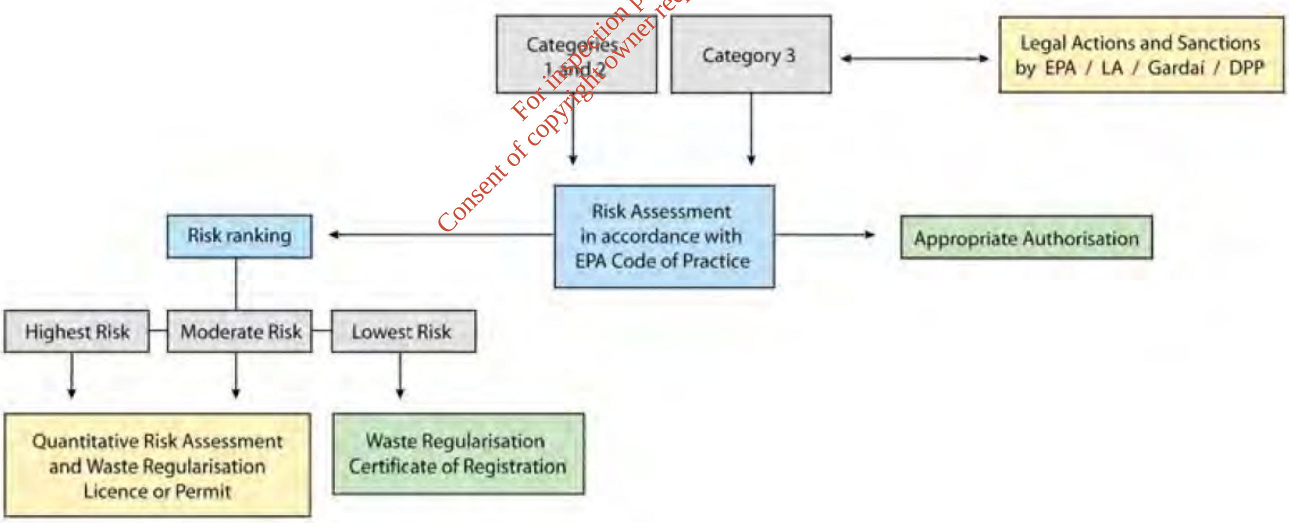

Figure 6.1: Extract from Section 1.3 of the EPA Code of Practice