ENVIRONMENTAL PERMIT VARIATION APPLICATION
HYDROGEOLOGICAL RISK ASSESSMENT

SKELBROOKE QUARRY EXTENSION
STRAIGHT LANE
SKELBROOKE
DONCASTER
SOUTH YORKSHIRE
DN6 8LY

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ENVIRONMENTAL PERMIT (REF.: CP3994ZR) VARIATION APPLICATION

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1.0 INTRODUCTION

1.1 Scope & Background

1.1.1 Sirius Environmental Limited (Sirius) has been commissioned by Darrington Quarries Limited ('DQL'), part of the FCC group of companies, to prepare an Environmental Permit Variation Application for the Environmental Permit: EPR/CP3994ZR to support a revised scheme of restoration for the former quarry at Skelbrooke Landfill Extension, Skelbrooke, Doncaster. DQL are seeking to commence an alternative restoration scheme for the extension area (primarily in response to safety concerns) which will bring the ground levels within the flooded area to above that of current water levels within the void. This will also aid in surface water management for the wider restored quarry and landfill.

1.1.2 The original Hydrogeological Conceptual Model and Risk Assessment were prepared in April 2000 (SLR, 2000) and consisted of a Hydrogeological (Regulation 15) Risk Assessment. Subsequent to the 2000 Hydrogeological Risk Assessment (HRA), a separate HRA was prepared in June 2003 (SLR, 2003) to support the original PPC application for the adjacent Skelbrooke Landfill facility (Cells 1-6).

1.1.3 Due to the fact that infilling operations never commenced in the Skelbrooke Landfill Site Extension Area, that authorisation to accept material for deposition in the Skelbrooke Extension Area was removed in 2007 and that the Skelbrooke Quarry Extension Area was varied into Closure in 2015 no subsequent Hydrogeological Risk Assessment Reviews (HRARs) have been undertaken. However, periodical reviews of the HRA have also been carried in August 2007 (SLR, 2007), 2013 (FCC, 2013) and September 2019 (TerraConsult, 2019). All periodic HRA reviews were supported by a detailed review of the hydrogeological regime surrounding the Skelbrooke Landfill Site (including the Skelbrooke Extension Area), the assessment of leachate, groundwater and surface water quality, and the derivation of new/revised groundwater compliance points and leachate levels (where appropriate).

1.1.4 This HRAR builds upon the existing conceptual model to incorporate the proposed deposit of selected suitable wastes within the quarry void. The wastes to be deposited within the void will be of a quality in which there is sufficient dilution within the aquifer to prevent the discernible discharge of hazardous substances and limit the discharge of non-hazardous pollutants to prevent pollution. The primary source of material to be deposited will be non-hazardous materials with a low pollution potential, including soils from local greenfield or low-risk brownfield development sites will also be considered. In order protect local ground water quality, site specific waste acceptance criteria (WAC) has been derived for wastes to be placed below the water table and up to 2m form final levels, with acceptance criteria for restoration soils to be deposited within the final 2m based on Soil Screening Values (SSVs) derived using ATRISK Guidance prepare by Atkins.

2.0 UPDATE AND REVIEW OF CONCEPTUAL SITE MODEL

2.1 Source

Site Design and Construction

2.1.1 The Skelbrooke Landfill Extension is located in an area in which extensive mineral extraction has taken place. It is developed within a historic Permian Magnesian Limestone quarry approximately 7.5km northwest of Doncaster and approximately 1km to the west of the A1(T). Extraction operations in the area extend through the Magnesian Limestone and into the Permian Marl with basal void elevations ranging from 16mAOD to 20mAOD.

2.1.2 Planning consent for mineral extraction and restoration of the Skelbrooke Extension Area was originally granted by Doncaster Metropolitan Borough Council in 1998 (Ref.: 96/50/1641/9/MIN). The original scheme of restoration allowed for the landfilling of “controlled wastes, but excluding special wastes”, and allowed for 25% settlement.

2.1.3 In 2005, planning consent (Ref.: 03/7149/P) was issued approving a revised scheme of restoration for the extension area. This revised scheme incorporated a low-level restoration profile that would be completed with suitable non-degradable fill materials.

2.1.4 Following the issuing of planning consent in 1998, the Skelbrooke Extension Area obtained authorisation for the disposal of biodegradable wastes in engineered cells under the Waste Management Licensing Regulations 1994 in July 2001 (Licence Ref.: EAWML65052) which was subsequently updated to Environmental Permit EPR/CP3994ZR. However, no cells have been engineered within the Skelbrooke Extension area to date and therefore no wastes have been deposited.

2.1.5 In 2007, the permit/licence was modified to remove conditions allowing the acceptance of waste at the site, with the exception of waste to support landfill restoration activities (where appropriate), subject to prior written agreement with the Environment Agency. No such agreements were requested, and no wastes were therefore deposited at the site.

2.1.6 In January 2015, an EA initiated variation to the permit was determined to close the facility since when no wastes have been permitted for disposal at the site. A Closure Plan (Doc. Ref.: 1776/R/025/1) dated October 2014 was incorporated into the permit as part of this variation.

2.1.7 Due to the absence of waste deposition activities and the associated development of engineered cells within the Skelbrooke Extension Area, it is considered that the base and sidewall of the Skelbrooke Extension Area consists of exposures of the surrounding country rock which consist of Magnesian Limestone and Permian Marl and that no leachate collection infrastructure or capping system has been installed.

2.1.8 Furthermore, the material for deposition within the Skelbrooke Extension area is to be of a nature that presents a pollution potential that is less than, or equal to, the natural quality of the surrounding geology/groundwater, it is considered that pollution containment engineering (including basal/sidewall lining systems, leachate collection infrastructure and capping systems are not required.

Leachate Management

2.1.9 As previously indicated, no waste deposition activities have been undertaken in the Skelbrooke Quarry Extension Area between the issuing of EAWML65052 (subsequently EPR/CP3994ZR) in 2001 and the definite closure of the landfill operations that were previously permitted at the Skelbrooke Quarry Extension Area in January 2015. Accordingly, there is no leachate to manage within the flooded quarry void or an existing leachate source term to consider against background groundwater quality.

2.1.10 Under the revised development proposals, the infilling of the Skelbrooke Quarry Extension Area will now be achieved by means of the deposit of suitable non-biodegradable, non-hazardous wastes, with a large portion tipped directly into the flooded quarry void without the installation of a geological barrier. Full details of the wastes to be deposited to achieve final levels are presented in **Appendix SS1** to the Supporting Statement (*Doc. Ref.: WR7640/04.R2*) submitted in support of the application.

2.1.11 For deposits that will sit below the water table DQL propose to limit the non-hazardous wastes to those with a relatively low pollution potential, including quarry materials (overburden, fines etc), soils from local greenfield or low-risk brownfield development sites which meet the requirements of site-specific Waste Acceptance Criteria (WAC), with all waste sources subjected to verification testing to minimise the risk of the deposit of a rogue load. Waste deposited above the groundwater table will be extended to also include other suitable fill materials, such as construction and demolition waste that meet inert WAC for landfill. All wastes to be accepted at the site will not undergo any significant biological, chemical or physical transformation.

2.1.12 Site specific waste acceptance criteria has been derived for wastes materials to be tipped directly into the flooded quarry and which accounts for the dilution available within the limestone aquifer in order to prevent the discernible discharge of hazardous substances and limit the input of non-hazardous pollutants to prevent pollution, taking into to account baseline groundwater quality of the aquifer. Restoration soils located above the water table within 1m of final ground levels will be accepted based on Soil Screening Values (SSVs) derived by Atkins and their ATRISK Guidance.

2.1.13 It is important to highlight that hazardous wastes are excluded from the list of permitted wastes and that infill materials shall consist of a small list of materials that would always qualify as non-hazardous under the Waste Framework Directive. Moreover the waste will also be deemed to be inert in nature on the following criteria:-

- Does not undergo any significant physical, chemical or biological transformations;
- Does not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health; and
- The total leachability, pollutant content and the ecotoxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water or groundwater.

2.1.14 The proposed waste for recovery within the Skelbrooke Quarry Extension Area have been adopted from the list of wastes which the waste producer may not need to test presented in the Environment Agency's Waste Acceptance

Procedures for Deposits for Recovery[1]. However, it is appreciated that as the proposed infilling operations involves the deposition of material into the flooded quarry void without the presence of an engineered lining system between the infill materials and aquifer unit a set of WAC stating the upper threshold of materials which can be accepted for use in the proposed recovery operation has been determined accounting for the dilution available in the aquifer and baseline groundwater concentrations of key substances.

2.1.15 The aforementioned review and comparison of existing groundwater quality data recorded as part of ongoing monitoring of the adjacent Skelbrooke Landfill Site (Cells 1-6) and the published regional Upper Magnesian Limestone groundwater geochemistry presented in Bearcock and Smedley (2009) and identified both the key parameters for consideration and appropriate Liquid Equivalent WAC values.

2.1.16 To ensure that the derived Liquid Equivalent WAC values did not result in the degradation of the surrounding groundwater quality, these values were also compared to their corresponding Environment Assessment Levels, as derived in **Section 2.3.**

2.1.17 As discussed within **Section 2.3** of the accompanying ESSD (*Doc. Ref.: WR7640/05*), it is considered that the proposed Liquid Equivalent WAC values represent the worst-case pollution source term for the proposed waste recovery activity. Accordingly, the pollution source term associated with the proposed waste recovery operations is presented in **Table HRA1.**

Table HRA1: Pollution Source Term Data for Proposed Materials for Deposition below the water table within the Skelbrooke Extension Area Quarry Void

Parameter	Proposed Waste Acceptance Criteria (L/S 10:1 mg/kg)	Worst-Case Pollution Concentration (mg/l)	EAL (mg/l)	Risk Factor
Arsenic	0.5	0.05	0.05	1
Cadmium	0.04	0.004	0.0004	10
Chromium	0.5	0.05	0.0047	11
Copper	2	0.2	0.015	13
Lead	0.5	0.05	0.0002	250
Mercury	0.01	0.001	0.00001	100
Nickel	0.4	0.04	0.008	5
Phenol	1	0.1	0.0077	13
Zinc	4	0.4	0.075	5
Chloride	2,400	240	250	1
Fluoride	30	3	1.5	2
Sulphate	3,000	300	1,560	<1

2.1.18 The WAC listed in **Table HRA1** are largely set at the inert landfill threshold specified in the Council Decision of 19th December 2002. The thresholds for chloride, fluoride and sulphate set at 3 times the standard WAC threshold to

[1] https://www.gov.uk/government/publications/deposit-for-recovery-operators-environmental-permits/waste-acceptance-procedures-for-deposit-for-recovery

account for the lower risk factors associated with these non-hazardous pollutants.

2.1.19 Once waste levels in the void have been raised above that of the water table in the limestone aquifer, the initial waste deposits will be deemed to act as artificially established geological barrier that will prevent direct contact between the wastes and groundwater.

2.1.20 The final 1m of the restoration profile will be above the water table and, therefore, it is proposed to use Soil Screening Values (SSVs) derived by Atkins and their ATRISK guidance. The Atkins ATRISK SSVs are calculated by using the appropriate Contaminated Land Exposure Assessment Protocol (CLEA). The proposed 'generic' end-use of the restoration is that of grassland and trees/shrubs which are planted on the restoration area and maintained throughout the aftercare period specified in the planning permission.

2.2 Pathways

2.2.1 A Hydrogeological (Regulation 15) Risk Assessment was prepared and submitted in support of the 1999 Waste Management Licence Application and identified two potential pollution pathways; leakage through the proposed sidewall seals and basal leakage through the underlying Permian Marl (Edlington Formation). The sidewall leakage pathway considered the migration of leachate generated by the then proposed waste inventory (domestic, industrial and commercial) through a substantial thickness of Permian Marl (proven to be approximately 35m thick) prior to reaching the underlying Lower Magnesian Limestone; identified as a possible receptor. The side wall leakage pathway considered the lateral diffusion of generated leachate into the adjacent Upper Magnesian Limestone during the operational and post-operational periods of Skelbrooke Quarry Extension Area. The 1999 Hydrogeological (Regulation 15) Risk Assessment concluded that the risk posed by the fully developed 1999 Skelbrooke Quarry Extension Area proposal to surrounding water resources were negligible.

2.2.2 As previously discussed, the landfill development proposal presented in the 1999 Waste Management Licence Application and discussed in the accompanying Hydrogeological (Regulation 15) Risk Assessment was never developed and the Skelbrooke Landfill Area has remained undeveloped. Accordingly, there has been no requirement to undertake periodic review of the original Hydrogeological Risk Assessment to confirm it validity. However, the development of the adjacent Skelbrooke Landfill Site (Cells 1-6); which was subject to a PPC Permit Application in 2003, has proceeded and as such a contemporary account of the current hydrogeological conceptual site setting is available for review.

2.2.3 The Hydrogeological Risk Assessment Review which accompanied the 2003 PPC Permit Application for the adjacent Skelbrooke Landfill Site (Cells 1-6); subsequently authorised under EPR/BV1470IE, examined the location of the proposed development in relation

2.2.4 As previously discussed, in light of the revised development proposals for the Skelbrooke Quarry Extension Area, and the deposition of selected materials which will be of a quality that will not result in the degradation of the surrounding hydrogeological environment, it was proposed that the Conceptual Site Model (CSM) for the Skelbrooke Quarry Extension Area be revised. It was considered that this revision examined the potential pathways through which the surrounding hydrogeology and the proposed infill material could interact. In order to visually depict this, a CSM section line transecting previously infilled (and permanently capped) Skelbrooke Landfill Site (Cells 1-6) and the proposed void to be infilled within the Skelbrooke Quarry Extension Area. This CSM Section Line and its corresponding route are both presented in **Drawing No. WR7640/10/HRA1**.

2.2.5 To ensure that a complete picture of the surrounding hydrogeological environment could be obtained and the potential interactions between the proposed Skelbrooke Quarry Extension Area development and the existing environment could be identified, the current leachate compliance levels within the adjacent Skelbrooke Landfill Site (Cells 1-6) and recorded groundwater range within the adjacent Upper Magnesian Limestone were incorporated into **Drawing No. WR7640/10/HRA1**.

2.2.6 This revised CSM indicated that the same potential pollutant pathways identified in the 1999 Hydrogeological (Regulation 15) Risk Assessment and the subsequent Hydrogeological Risk Assessment; and Risk Assessment Reviews, of the adjacent Skelbrooke Landfill Site still exist for the revised infilling proposals. It was identified that the primary interaction between the proposed infilling material with the surrounding hydrogeological environment is the lateral migration of groundwater through the void sidewall (particularly the Upper Magnesian Limestone). A second potential interaction pathway was also observed and consists of the basal migration of liquid through the low permeability Permian Marl (Edlington Formation), however, due to the proven vertical thickness of this lithological unit (35m) it is considered that the potential of basal leakage from the void area into the underlying Lower Magnesian Limestone is severely limited.

2.2.7 The base levels of the extensions will continue to be located within the underlying low-permeability Permian Marl, which will provide adequate attention to the downward movement of any potential pollutants that could leach from the waste deposits to deeper aquifer systems.

2.2.8 It is further identified that the proposal to infill the proposed quarry void without the installation of an engineered lining system or dewatering of the void means that a large portion of the restoration waste materials will be tipped directly into groundwater. Wastes placed above the upper boundary fo the Permian Marl will subsequently be in direct contact with the saturated zone associated with the overlying Magnesian Limestone aquifer. However, as indicated in **Section 2.1**, in order to ensure that the infilling operations do not result in the degradation of the surrounding groundwater quality the Waste Acceptance Criteria for the development proposal have been derived to prevent the discernible discharge of hazardous substances and limit the discharge of non-hazardous pollutants to groundwater, taking into account the dilution factors and baseline quality of the limestone aquifer.

2.2.9 For waste deposits to be placed above the groundwater table, the initial waste deposits will subsequently form an attenuating barrier that prevent the direct contact between the subsequent deposits of and groundwater. Whilst the underlying waste are likely to be saturated, they will be offer very limited groundwater resources potential. Consequently, the deposits will offer attenuation to any pollutants that leach from the waste deposits above the water table.

2.2.10 Due to the potential for lateral interactions between the infill material and the Upper Magnesian Limestone aquifer it is considered prudent to examine potential pollution pathways associated with the Magnesian Limestone Aquifer.

Geology

2.2.11 The geology of Skelbrooke Landfill Extension is taken from:

- British Geological Survey 1:50,000, Sheet No. 87 Barnsley Solid and Drift (1976);
- British Geological Survey 1:50,000, Sheet No. 78 Wakefield Solid and Drift (1978);
- British Geological Survey 1: 63,360, Sheet No. 88 Doncaster Solid and Drift (1969);
- British Geological Survey 1:63,360, Sheet No. 79 Goole Solid and Drift (1971);
- British Geological Survey 1:50,000, Sheet No. 87 Barnsley (2008);
- Institute of Geological Sciences 1:100,000 Hydrogeological Map of Southern Yorkshire and Adjoining Areas (1982); and
- National Rivers Authority (now the Environment Agency), Policy and Practice for the Protection of Groundwater - Regional Appendix Yorkshire Region. 1991.

2.2.12 These geological maps have been supplemented by site specific information, details of which include:

- Logs of fifteen boreholes advanced in 1991 within the extension area as part of a mineral evaluation exercise; and
- Logs of three boreholes (SB Series) advanced by SECOR (now SLR) in March 1998 to further characterise the nature of the deposits in the extension area and provide permanent groundwater monitoring installations.

2.2.13 Borehole logs from both these investigations are presented in **Appendix ESSD2** and **Appendix ESSD3** of the accompanying ESSD *(Doc. Ref.: WR7640/05)*.

2.2.14 The BGS Onshore Viewer and BGS Map Sheet 87 (1:50 000, Barnsley, 2008) indicates only limited superficial deposits are present in the area. Where present, they are confined to local drainage channels. It was reported in the 2007 HRAR that there were no superficial deposits at the existing Skelbrooke Landfill.

2.2.15 From review of British Geological Survey 1:50,000 scale geology maps, publicly available borehole records and borehole logs prepared following site investigations undertaken at and around the Skelbrooke Landfill Site and the installation of monitoring infrastructure, the underlying geological succession in the vicinity of the site can be determined and summarised. A summary of this geological succession (including unit thicknesses) is presented in **Table HRA2**.

Table HRA2: Geological Sequence at Skelbrooke Landfill Complex

Geological Unit	Thickness	Description
Upper Permian Marl (Roxby Formation)	<6	Red shaley clays and mudstones with gypsum and anhydrite seams
Upper Magnesian Limestone (Brotherton Formation)	<20	Compact and flaggy dolomitic limestone with thin beds of mudstone
Middle Marl (Edlington Formation)	<35	Red brown and grey green mudstone with interbedded sulphates (gypsum and, at depth, anhydrite)
Lower Magnesian Limestone (Cadeby Formation)	N/A	Composed of two lithological groups. The upper division contains minutely cellular and highly porous dolomite, characterised at or near surface

Geological Unit	Thickness	Description
		by solutional features. The lower division comprises regularly bedded dolomitic and oolitic limestones.
Basal Permian Sands and Breccia	N/A	Outcrops as a discontinuous layer of loosely cemented sand succession, resting unconformably on the Carboniferous rocks.

2.2.16 The base of the Skelbrooke Quarry Extension Area extends to a elevation of ~17mAOD. Borehole logs for installation located along the western edge of the quarry confirm that the Upper Permian Marl is not present around the extension area, with quarry extension extending through ~10m of the Upper Magnesium Limestone (Brotherton Formation) and a ~5m thickness of the underlying Middle Permian Marl (Edlington Formation).

Hydrogeology

Physical Characteristics

2.2.17 The Environment Agency classifies the Upper Magnesian Limestone (Brotherton Formation) and Permian Middle Marl (Edlington Formation) as aquifer units with the following paragraphs summarising their assigned aquifer classifications and the physical characteristics of each lithology.

2.2.18 The Upper Magnesian Limestone (Brotherton Formation) is classified by the Environment Agency as a Primary aquifer unit which consists of compact and flaggy dolomitic limestones. This lithological fabric results in a relatively low primary intergranular porosity and permeability; indicated by Allen et al., (1997) to be in the region of 5.5×10^{-4}m/d, however, the Upper Magnesian Limestone has a the potential for a high secondary permeability due to the presence of macro and micro fractures which have been enhanced by subsequent karstic weathering. The total porosity of this lithological unit is estimated by Allen et al., (1997) be vary between 6 to 30% with an interquartile range of 9.4% to 16%. Groundwater flow through this unit it predominantly achieved through fracture flow, with a permeability range of between ~0.01 and ~165m/d (a mean of ~37m/d was confirmed by SLR (2004) from rising head tests performed in various boreholes installed around the periphery of the main Skelbrooke landfill facility. The lowest permeability value was deemed to be influenced by the proximity of the landfill sidewall which impinged on the cone of depressions. Excluding this permeability value, the mean permeability equates to ~41 m/d. These compare to estimated permeability ranges of between 10 and 100 m/d specified by Allen et al., (1997).

2.2.19 The Permian Middle Marl (Edlington Formation) is classified by the Environment Agency as a as a Secondary B lithology primarily consists of red brown and grey green mudstone with interbedded sulphates (gypsum and, at depth, anhydrite); as indicated in **Table HRA2**. Site specific hydrogeological data for both the engineered and in-situ Permian Marl were identified as part of the 2003 HRA completed for the adjacent Skelbrooke Landfill Site with a permeability range between 1×10^{-10}m/s (min) and 1×10^{-9}m/s (max) with a mode of 1×10^{-9}m/s. These permeability values were derived using CQA testing and characterisation information obtained during the construction of landfill cells (including packer tests in the marl and triaxial permeability test results on remoulded and compacted clay samples).

Groundwater Flow

2.2.20 Groundwater levels have been monitored around the perimeter of the adjacent Skelbrooke Landfill Site since 1996 through a total of 15 monitoring boreholes, all of which monitoring groundwater within the underlying Magnesian Limestone and remain active.

2.2.21 A statistical summary of the recorded groundwater levels in the Magnesian Limestone Lincolnshire between November 1996 and December 2023 in the vicinity of the Skelbrooke Quarry and landfill complex is presented in **Table HRA3**, whilst groundwater hydrographs are presented in **Appendix HRA1**.

Table HRA3: Statistical summary of monitored groundwater levels in the vicinity of the Skelbrooke quarry and landfill complex

BH ID	1996 – 2023 Groundwater Levels (mAOD)			
	Minimum	Mean	Maximum	95%ile
Upgradient (of Skelbrooke Landfill)				
SK06	33.96	36.34	40.64	37.87
SK07	32.26	36.75	40.15	38.25
SK09	34.82	37.09	38.50	37.91
SK10	35.81	37.53	38.93	38.32
SK11	34.87	37.24	40.99	38.71
SK12	40.51	42.15	42.73	42.56
Cross-Gradient (of Skelbrooke Landfill)				
SK04	30.42	33.06	34.70	34.14
SK05	27.74	34.37	37.43	35.38
SK08	27.76	32.99	42.59	37.93
SK21	27.95	29.62	34.92	31.24
Downgradient (of Skelbrooke Landfill)				
SK01	21.83	24.68	31.58	29.10
SK02	23.57	26.09	31.05	27.61
SK03	23.12	27.99	30.31	29.02

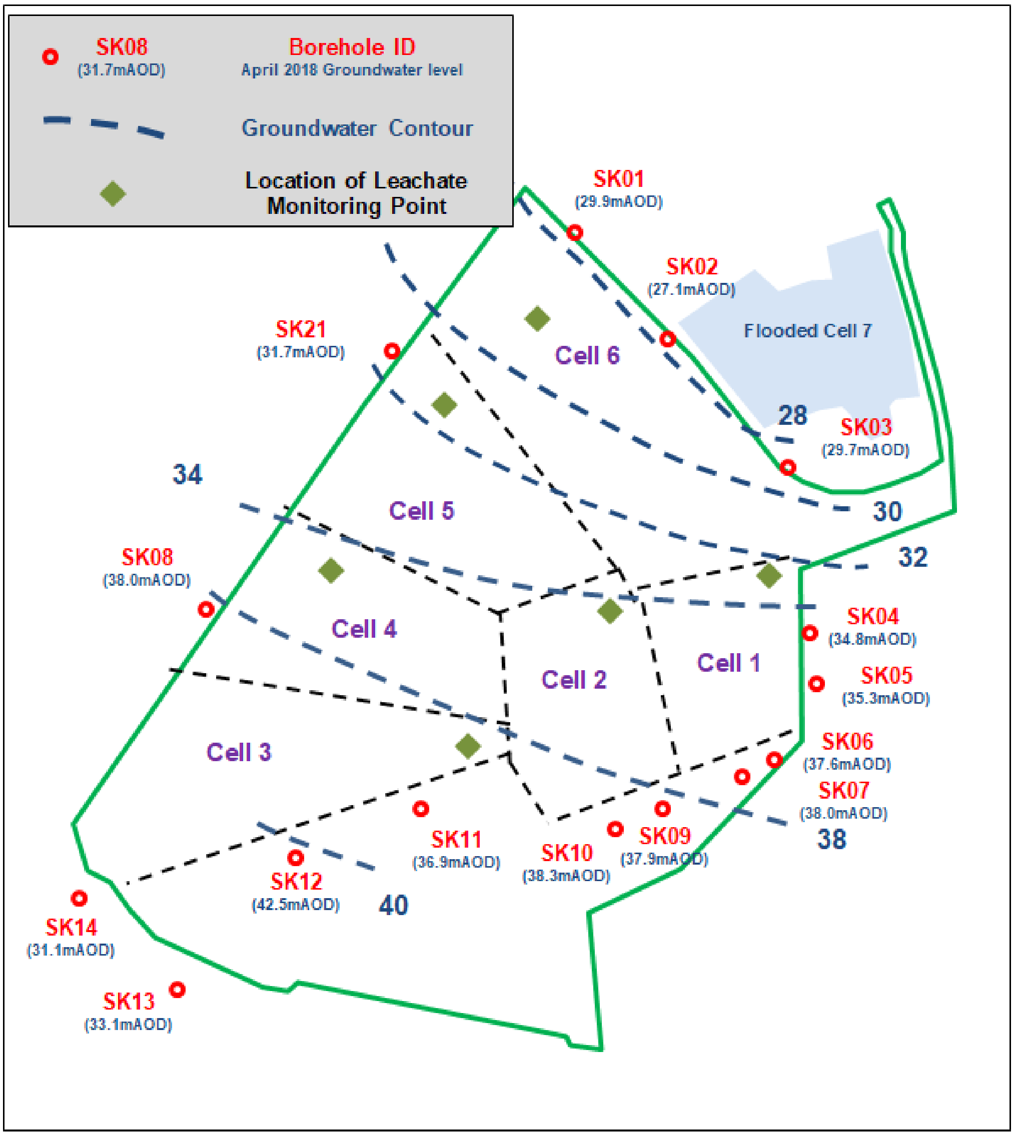
2.2.22 A review of the groundwater timeseries plots presented in **Appendix HRA1** and the statistical analysis presented in **Table HRA3** demonstrate that groundwater levels in the vicinity of the south-western edge of Skelbrooke Quarry Extension Area have shown some high groundwater range, which has largely been influence by groundwater management practices operated at the site to support the development of the adjacent landfill facility. This influence can also be observed in SK01, where water levels were largely maintained below 22mAOD to support landfill operations within Cell 6 until 2012. Post-2012 groundwater levels have been typically managed above ~23.5mAOD.

2.2.23 Groundwater levels in SK02 are significantly influenced by water levels within the flooded quarry extension area, which are actively managed in lieu of the extension areas use to support the management of surface run-off from the adjacent capped landfill. Since 1996 water levels have largely varied between ~25mAOD and ~28mAOD with intermittent short lived spikes Water levels have largely attributed to flash responses to storm events, inbetween which the water levels are general managed below the invert level of the outfall from the landfill drainage network into the extension area, which is currently set at ~26.5mAOD. Since 2021 water levels in the extension area have largely been managed between ~23.5mAOD and ~25mAOD. As part of the restoration scheme the inflow network will be redesigned so that the surface waters from the adjacent landfill flow through open ditch networks constructed across the restored surface to the constructed attenuation pond/wetland.

2.2.24 Based on the water levels being recorded in borehole SK03, natural groundwater levels along the southwestern edge of the extension area are most likely to vary between ~27mAOD and ~29mAOD.

2.2.25 When the groundwater levels presented in **Table HRA3** are transposed onto a site location plan of the adjacent Skelbrooke Landfill Site, the resulting groundwater contour plot confirms an overall north-easterly hydraulic gradient of 0.032 towards the Skelbrooke Quarry Extension Area. Such a hydraulic contour plot was prepared as part of the 2019 HRA undertaken for the adjacent Skelbrooke Landfill Site (Cells 1-6) and is presented in **Figure HRA1**. Please note that the Skelbrooke Quarry Extension Area is represented in this groundwater contour plot and it referred to as "Flooded Cell 7".

Figure HRA1: Groundwater Contour Plot of Skelbrooke Landfill Site



(Reproduced from 2019 Hydrogeological Risk Assessment Review (Report No. 4485/R/01/01))

2.2.26 However, it was noted in the 2019 HRAR for Skelbrooke Landfill Site that a variance in recorded groundwater levels is observed in SK12, SK13 and SK14. A review of the relevant Ordnance Survey Maps indicate the presence of a topographical divide (~52mAOD) near to southern boundary of Cell 3, this in conjunction with the in-situ (up-thrown Middle Permian Marl) and or presence of quarry fines may be responsible for variance in groundwater levels expressed at SK12 and to the southwest at SK13 and SK14.

2.2.27 Alternatively, the juxtaposed relative positions of the stratigraphically older Cadeby Limestone against the younger Brotherton Formation along the north-westerly facing site boundary (and or presence of the quarry 350m to the southwest) may also explain the lower water table on the southwest corner of Cell 3.

2.2.28 Based on the current understanding of groundwater levels surrounding the site, there is a single aquifer system adjacent to the sidewall of Skelbrooke Quarry Extension Area, the Upper Magnesian Limestone (Brotherton Formation) Aquifer.

2.3 Receptor

2.3.1 The Site is not located within a Source Protection Zone, however, the Environment Agency classifies the Upper Magnesian (Brotherton Formation) Limestone Aquifer strata adjacent to the site as a Principal Aquifer; which is capable of supporting water supplies on strategic scale, and the Permian Middle Marl (Edlington Formation) as a Secondary B Aquifer (a lower permeability layer which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering).

2.3.2 Due to the absence of superficial deposits in the vicinity of the proposed Skelbrooke Quarry Extension Area Development, the primary receptor to the proposed infilling activity has been identified to be the Upper Magnesian Limestone.

2.3.3 Springs and hydraulically connected fluvial networks associated with The Skell are located ~250m to north/northeast of the application site, to which the limestone aquifer is the source of baseflow to these features. These surface water features are Secondary Receptors to the proposed waste recovery activity.

Compliance Points

2.3.4 The primary receptor to the discharge of pollutants from the landfill relate to groundwaters in the immediately surrounding Upper Magnesian Limestone (Brotherton Formation).

2.3.5 The following compliance points have been identified:

Hazardous Substances

2.3.6 In line with current EA guidance, the point of compliance for Hazardous Substances is the down-gradient boundary of the site relative to the direction of groundwater flow within the vertical mixing depth of limestone aquifer surrounding the site.

Non-Hazardous Pollutants

2.3.7 As with previous HRAs examining the adjacent Skelbrooke Landfill Site (Cells 1-6), the compliance point for Non-Hazardous Pollutants remains groundwater in the aquifer horizon at the down-gradient boundary of the site.

Groundwater Quality

2.3.8 Due to the absence of infilling activities and subsequent closure of the Skelbrooke Quarry Extension Area in 2015 no dedicated groundwater monitoring schedule has been developed for the Skelbrooke Quarry Extension Area. However, groundwater monitoring schedules specified to the adjacent Skelbrooke Landfill Site (Cells 1-6) have allowed for a review of local groundwater quality.

2.3.9 Groundwater quality in the vicinity of Skelbrooke Landfill Site (Cells 1-6) is currently monitored routinely around the perimeter of the site in a total of 13 perimeter monitoring boreholes (SK01, SK02, SK03, SK04, SK05, SK06, SK07, SK08, SK09, SK10, SK11, SK12, SK21) and two monitoring points, SKSW01 and SKSW03 record the quality of groundwater in the backwall drainage sump and the backwall drainage discharge point to the surface water lagoon respectively. As discussed previously, each groundwater monitoring borehole monitors the Upper Magnesian Limestone (Brotherton Formation).

2.3.10 These monitoring boreholes provide an indication of downgradient (SK01, SK02 and SK03), cross-gradient (SK04, SK05, SK08 and SK21) and upgradient (SK06, SK07, SK09, SK10, SK11 and SK12) groundwater quality.

2.3.11 Statistical analysis of all the background groundwater quality monitoring data recorded in all monitoring boreholes between 1996 and 2023 has been undertaken as part of this HRA in order to identify the baseline concentrations of the matrix and metallic ions within the surrounding groundwater which have been identified as the main parameters of inert waste 'leachate' quality, which corresponds to the type of materials proposed for deposition within the Skelbrooke Quarry Extension Area. A summary of monitored groundwater quality around the periphery of the existing Skelbrooke Landfill Site for these determinands is presented in both **Table HRA4** and **Table HRA5** with individual datasets and associated timeseries plots presented in **Appendix HRAR2.**

2.3.12 Examination of the timeseries charts and analysed monitoring data (presented in **Table HRA4**) from the upgradient boreholes indicate that background concentrations of all matrix and metallic indicator species do not show any increasing trends since 1996. Furthermore, with concentrations for all determinands remaining stable of improving throughout the monitoring period. This stability in background groundwater quality is depicted in the timeseries plots prepared for all metallic indicator species which visually demonstrate consistent concentrations the monitoring period.

2.3.13 Two additional up-gradient monitoring boreholes have been installed during the operational lifecycle of Skelbrooke Landfill Site (Cells 1-6), namely SK11 and SK12 which commenced monitoring in 2004 and 2007 respectively. Review of the groundwater monitoring records for these more recent up-gradient monitoring boreholes strongly correlate to the pre-existing monitoring boreholes.

2.3.14 Examination of the peripheral boreholes monitoring the cross-gradient groundwater regime also in indicate that the concentrations of groundwater quality indications have has remained at consistently low concentrations throughout the monitoring window. As with upgradient groundwater monitoring records, further statistical analysis demonstrated that apart from rare elevated concentrations (subsequently identified as statistical outliers) concentrations of all determinands have either remained stable or demonstrate a decreasing trend throughout the monitoring period. This stability of groundwater quality depicted for this borehole in the timeseries plots is further represented in the datasets contained within the statistical summary presented in. Review of the analysed datasets indicated that the mean and most frequent recorded values for all parameters strongly correlate to one another, further indicating that concentrations within these boreholes have remained stable throughout the monitoring period.

2.3.15 It is noticed that chloride concentrations recorded in SK08 and the additional cross-gradient monitoring borehole SK21 installed in 2003 are higher relative to SK04 and SK05, with chloride concentrations within SK08 and SK21 recorded at approximately ~60-140mg/l compared to the ~30-60mg/l within SK04 and SK05.

2.3.16 A review of groundwater quality records for monitoring boreholes located downgradient of Colsterworth Landfill Site indicate that groundwater quality downgradient of the Site strongly correlates to recorded groundwater quality upgradient for the site. This strong correlation is depicted in **Table HRA4** where there is a visible similarity between the mean determinands concentrations including chloride cadmium, copper and zinc with a significant number of detections either at or below corresponding limit of detection values.

2.3.17 Upon review of all groundwater monitoring boreholes, it is noted that sulphate concentrations are noticeably higher than the other determinands discussed above. Due to the presence of relatively elevated sulphate concentrations upgradient, cross-gradient and downgradient of the existing Skelbrooke Landfill Site (Cells 1-6), it is considered that the recorded sulphate concentrations are representative of natural background conditions. Subsequent, review of published information relating to the Upper Magnesian Limestone including Bearcock and Smedley (2009) confirmed that the groundwater contained within the Upper Magnesian Limestone is naturally elevated in sulphate due to the presence of sulphate compounds (e.g. ZnSO4).

2.3.18 Additionally, it was noted that groundwater concentrations for cadmium, chromium, nickel and lead all indicated periods of relatively elevated concentrations during the monitoring periods (i.e. between 1996 and 2021). Upon closer inspection, it was identified that these periods of elevated concentrations were not limited to a single monitoring borehole or direction from the existing Skelbrooke Landfill Site (Cells 1-6). Short-lived elevated concentrations of similar values were recorded in the same rounds of monitoring for all upgradient, cross-gradient and downgradient boreholes for cadmium, nickel and lead. Visual depictions of these events are presented in **Appendix HRA2.** It considered that these events either reflect short lived changes in natural background groundwater chemistry due to changes in Redox conditions or are indicators of subsequent contamination of the samples following abstraction. Whilst it is important that a full groundwater monitoring history is reviewed as part of this Hydrogeological Risk Assessment, it is considered prudent that the Environmental Assessment Levels (and by definition site-specific WACs) are derived from a period of the where such irregularities are not observed. Accordingly, the derivation of conservative Environmental Assessment Levels for these determinands will be undertaken from the point that the monitoring records no longer display these short-lived elevated concentrations (i.e. from July 2011 onwards).

2.3.19 It is appreciated that whilst cadmium, nickel and lead display a number of short-lived (one round of monitoring) elevated concentrations during the monitoring period, the monitoring records for chromium indicate a sustained period of elevated concentrations around the Skelbrooke Landfill Site (Phases 1-6). As observed in the cadmium, nickel and lead monitoring records the elevated concentrations of similar magnitudes were recorded in all monitoring boreholes (upgradient, cross-gradient and downgradient). As depicted in the chromium time-series plot presented in **Appendix HRA2**. However, unlike the short-lived pollution events observed for cadmium, nickel and lead, the elevated chromium concentrations appeared suddenly and persisted for an extended period until January 2016. Due to all perimeter groundwater monitoring boreholes at Skelbrooke Landfill Site recording this elevated chromium concentration it is considered that the recorded chromium concentrations were released from an external source and migrated to the Skelbrooke Landfill (where it was subsequently detected). It is considered that the release of these chromium concentrations continued until approximately January 2016 at which point the source was removed. Subsequently recorded chromium concentrations around the perimeter of the Skelbrooke Landfill Site immediately responded and reduced to Limit of Detection Levels, where they have remained. To ensure that a conservative EAL (and associated WAC value) is selected for the site, it is considered prudent to derive these values from groundwater chromium concentrations recorded from January 2016 onwards.

2.3.20 To summarise, the recorded concentrations of the key matrix and metallic determinands relating to the proposed material for deposition recording within the groundwater upgradient, cross-gradient and downgradient of the existing Skelbrooke Landfill Site (Cells 1-6) strongly correlate to one another. This indicates that the pollution prevention measures employed at the existing Skelbrooke Landfill Site (Cells 1-6) are operating appropriately and it can be considered that the recorded determinand concentrations are representative of natural baseline conditions.

2.3.21 Further verification that the recorded groundwater concentrations are indicative of natural geochemical baseline conditions is obtained upon comparison of the recorded perimeter groundwater concentrations against published regional groundwater quality data as presented in Bearcock and Smedley (2009) which presented a statistical summary of the key major and minor constituent geochemical species within the Magnesian Limestone of County Durham and North Yorkshire. **Table HRA6** includes a reduced summary table of this this statistical data, focussing on the determinands identified in **Section 2.1**.

2.3.22 Comparison of this published regional dataset against the site-specific geochemical record for Skelbrooke Landfill Site (Cells 1-6) indicates that the recorded upgradient background concentrations (mean + 2σ) recorded at the Skelbrooke Landfill Site correlate favourably to the concentrations of the corresponding parameter presented in **Table HRA6**.

Table HRA4: Summary of Monitored Groundwater Quality in Upgradient and Cross Gradient Monitoring Boreholes around Skelbrooke Landfill Site (Cells 1 – 6) between 1996 – 2023

Parameter	Statistic	Upgradient Monitoring Boreholes					Cross-Gradient Monitoring Boreholes				
		SK06	SK07	SK09	SK10	SK11	SK12	SK04	SK05	SK08	SK21
Ammoniacal Nitrogen (mgN/l)	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	0.2	0.1	0.1	0.1	0.1	0.1	0.13	0.11	0.38	0.06
	Maximum	2.70	0.90	1.20	1.20	1.14	1.40	1.30	1.10	13.1	0.55
	St Dev	0.4	0.2	0.2	0.2	0.1	0.2	0.2	0.2	1.5	0.1
	Count	166	219	216	218	180	143	217	216	197	196
Cadmium (mg/l)	Minimum	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
	Mean	0.0003	0.0003	0.0003	0.0004	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003
	Maximum	0.001	0.001	0.0013	0.0021	0.0022	0.0014	0.0012	0.0014	0.0018	0.0014
	St Dev	0.0003	0.0002	0.0003	0.0003	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003
	Count	70	88	86	88	81	66	88	87	84	85
Chloride (mg/l)	Minimum	6	2	13	17	22	17	28	19	26	73
	Mean	34.5	30.8	30.9	48.6	51.3	40.9	44.9	35.3	94.9	100
	Maximum	106	87	101	123	80	58	84	77	200	140
	St Dev	19.5	14.3	14.2	18.1	14.2	11.7	11.5	9.5	24.4	12.3
	Count	163	219	218	218	181	143	218	217	196	197
Chromium (mg/l)	Minimum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	0.0033	0.0037	0.0039	0.0042	0.0035	0.0029	0.0038	0.0037	0.0033	0.0037
	Maximum	0.0112	0.0241	0.0205	0.0245	0.0214	0.0189	0.0239	0.0162	0.0145	0.0274
	St Dev	0.0025	0.0037	0.0039	0.0046	0.0040	0.0034	0.0040	0.0031	0.0029	0.0044
	Count	70	88	85	86	80	66	88	87	84	84
Copper (mg/l)	Minimum	<0.001	<0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	0.0075	0.0068	0.0055	0.0062	0.0039	0.0043	0.0047	0.0038	0.0036	0.0028
	Maximum	0.029999999	0.029999999	0.0387	0.02	0.009	0.009	0.02	0.02	0.013	0.009
	St Dev	0.0056	0.0048	0.0054	0.0036	0.0019	0.0018	0.0040	0.0037	0.0030	0.0019

Parameter	Statistic	Upgradient Monitoring Boreholes					Cross-Gradient Monitoring Boreholes				
		SK06	SK07	SK09	SK10	SK11	SK12	SK04	SK05	SK08	SK21
	Count	70	87	85	85	81	66	88	87	83	83
Lead (mg/l)	Minimum	<0.0001	<0.0001	<0.0001	<0.0001	0.000037	0.000032	0.000044	0.00002	0.000039	0.000052
	Mean	0.0029	0.0029	0.0032	0.0025	0.002587	0.001855	0.003169	0.00236	0.002900	0.002788
	Maximum	0.0200	0.043	0.0545	0.033	0.030000	0.010000	0.049000	0.01300	0.044000	0.030000
	St Dev	0.0034	0.0053	0.0069	0.0040	0.003948	0.001759	0.006498	0.00245	0.005920	0.004721
	Count	58	75	73	74	76	66	76	75	76	76
Nickel (mg/l)	Minimum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0009	0.0009	<0.001	<0.001
	Mean	0.0039	0.0041	0.0034	0.0050	0.0041	0.0032	0.0044	0.0036	0.0032	0.0026
	Maximum	0.018	0.038	0.02	0.025	0.0211	0.0142	0.014	0.0171	0.025	0.0222
	St Dev	0.0028	0.0053	0.0035	0.0051	0.0035	0.0025	0.0023	0.0030	0.0034	0.0030
	Count	60	79	77	78	76	67	78	77	76	76
Sulphate (mg/l)	Minimum	90	96	238	364	379	260	300	165	176	120
	Mean	312	276	356	683	989	697	478	1136	293	190
	Maximum	857	669	547	1510	1910	1140	940	2040	462	330
	St Dev	163	127	72	235	377	236	110	376	56	43
	Count	59	78	75	77	76	67	76	77	76	76
Zinc (mg/l)	Minimum	<0.002	<0.002	<0.002	0.002	0.00128	<0.002	<0.002	<0.002	<0.002	0.0013
	Mean	0.016	0.016	0.010	0.012	0.00671	0.017	0.009	0.010	0.0063	0.0061
	Maximum	0.160	0.080	0.063	0.062	0.04300	0.106	0.049	0.089	0.033	0.0486
	St Dev	0.022	0.013	0.010	0.013	0.00706	0.017	0.009	0.013	0.0055	0.0065
	Count	70	87	85	86	80	67	88	86	82	83

[1] - Where concentrations are below the laboratory reporting limit, a value equal to 100% the reporting limit has been used for statistical analysis
[2] - Statistical outliers for period removed

Table HRA5: Summary of Monitored Groundwater Quality in Downgradient Monitoring Boreholes around Skelbrooke Landfill Site (Cells 1 – 6) between 1996 - 2023

Parameter	Statistic	Downgradient Boreholes		
		SK01	SK02	SK03
Ammoniacal Nitrogen (mgN/l)	Minimum	<0.01	<0.01	<0.01
	Mean	0.87	0.11	1.00
	Maximum	7.97	1.10	32.8
	St Dev	1.5	0.2	3.8
	Count	124	160	201
Cadmium (mg/l)	Minimum	<0.00002	<0.00002	<0.00002
	Mean	0.0002	0.0003	0.0003
	Maximum	0.0011	0.001	0.0029
	St Dev	0.0002	0.0002	0.0004
	Count	57	68	88
Chloride (mg/l)	Minimum	37	51.8	33
	Mean	83.1	115.7	58.5
	Maximum	166	378	365
	St Dev	26.4	53.9	47.8
	Count	127	163	201
Chromium (mg/l)	Minimum	<0.001	<0.001	<0.001
	Mean	0.0027	0.0036	0.0033
	Maximum	0.01	0.0163	0.0208
	St Dev	0.0024	0.0028	0.0031
	Count	57	68	87
Copper (mg/l)	Minimum	<0.001	<0.001	<0.001
	Mean	0.0145	0.0044	0.0038
	Maximum	0.138	0.016	0.029
	St Dev	0.0245	0.0026	0.0046

Parameter	Statistic	Downgradient Boreholes		
		SK01	**SK02**	**SK03**
	Count	57	68	87
Lead (mg/l)	Minimum	<0.001	0.00036	0.000041
	Mean	0.0020	0.0026	0.0029
	Maximum	0.016	0.015	0.033
	St Dev	0.0025	0.0024	0.0047
	Count	55	61	75
Nickel (mg/l)	Minimum	<0.001	<0.0009	<0.0009
	Mean	0.0056	0.0042	0.0054
	Maximum	0.017	0.016	0.023
	St Dev	0.004	0.002	0.004
	Count	55	61	78
Sulphate (mg/l)	Minimum	234	285	1050
	Mean	600	462	1555
	Maximum	1400	902	2180
	St Dev	312	115	187
	Count	54	61	75
Zinc (mg/l)	Minimum	<0.002	<0.002	<0.002
	Mean	0.029	0.0099	0.0208
	Maximum	0.257	0.08	0.27
	St Dev	0.037	0.0098	0.0408
	Count	98	117	164

[1] - Where concentrations are below the laboratory reporting limit, a value equal to 100% the reporting limit has been used

[2] - Statistical outliers for period removed

Table HRA6: Statistical Summary of Regional Groundwater Quality Data for Magnesian Limestone (County Durham and North Yorkshire) – Adapted from Bearcock and Smedley, 2009.

Parameter	Units	n	n (c)	Min	Mean	Max	0th Percentile Value	5th Percentile Value	25th Percentile Value	50th Percentile Value	75th Percentile Value	90th Percentile Value	95th Percentile Value
Arsenic	µg/l	36	17	<0.05	0.249	2.96	-	-	-	0.05	0.15	0.61	1.46
Cadmium	µg/l	104	87	<0.005	-	0.193	-	-	-	-	-	-	-
Chromium	µg/l	103	51	<0.2	0.044	222	-	-	-	0.2	1.39	2.77	4.9
Copper	µg/l	104	35	<0.5	-	12.5	-	-	-	0.786	1.34	3.6	5.69
Mercury	***No Records Available***												
Nickel	µg/l	104	93	<0.5	-	112	-	-	-	-	-	-	-
Lead	µg/l	104	63	<0.01	0.56	45	0.00165	0.005	0.02	0.059	0.152	0.324	0.48
Zinc	µg/l	104	36	<5	21.7	372	-	1.2	2.6	6.2	19.3	44.6	77.2
Chloride	mg/l	109	1	<2	138	9250	-	14.8	23.1	38.3	53.8	111	235
Fluoride	mg/l	36	0	0.033	0.444	2.09	-	0.271	0.409	0.824	1.39	1.57	1.69
Sulphate	mg/l	107	0	1.18	160	1610	-	21.8	49.5	89.1	153	400	461

Environmental Assessment Levels

2.3.23 The setting of Environmental Assessment Levels (EALs) is necessary in order to determine if the requirements of Schedule 22 to the Environmental Permitting Regulations 2016 will be met.

2.3.24 As previously indicated, the development proposal for the Skelbrooke Quarry Extension Area seeks to infill the existing flooded quarry void with selected non-hazardous materials.

2.3.25 To ensure that EALs representative to the Site are selected and that the subsequent Hydrogeological Risk Assessment provides a site assessment of groundwater pollution potential, the following selection criteria shall be employed.

- For Hazardous Substances, the EALs have been derived at the EAs published Minimum Reporting Values (MRV) of Limit of Quantification (LoQ) values as defined in UK Technical Advisory Group on the Water Framework Directive Report "Technical Report on Groundwater Hazardous Substances", 2016. Where higher, EALs have been set at the maximum recorded baseline concentration from site-specific datasets, or where such data is not available the baseline concentration is set at the 50th percentile concentration from (Beacock and Smedley, 2009).
- For Non-Hazardous Pollutants, the EALs have been derived at either:-
  - *Where the baseline concentration is 50% or less than the environmental standards, the EAL is set at ~25% above the maximum recorded baseline concentration*
  - *Where the baseline concentration more than 50% of the environmental standard the EAL is set at the standard value;*
  - *Where the baseline concentration is greater than the EQS or DWS, the EAL is set at the baseline concentration.*

2.3.26 For parameters that are routinely monitored at the site, the baseline concentration is set at the maximum recorded concentration recorded from 2019 onwards to account for the stabilised concentration ranges exhibited in many boreholes since the cessation of groundwater management activities at the adjacent landfill facility. For parameters that are not routinely monitored at the site, the baseline is set at the 50th percentile concentration listed in Beacock and Smedley (2009). The exceptions to these are ammoniacal nitrogen, chloride and zinc, for which EALs are set at the groundwater compliance limits set in the permit held for the adjacent Skelbrooke Landfill Site.

2.3.27 Details of the EALs to be taken forward for consideration are presented in **Table HRA7**.

Table HRA7: Proposed Environmental Assessment Levels (mg/l)

Substance	MRV/LoQ[1]	Laboratory Limits of Detection	EQS / DWS	Baseline Concentration[2]	Proposed EAL
Hazardous Substances					
Arsenic	0.005	(0.001)	-	0.05	0.05
Lead	0.0002	0.001	-	<0.001	0.0002
Mercury	0.00001	(0.00001)	0.00007 / 0.001	NS	0.00001
Non-Hazardous Pollutants					
Ammoniacal Nitrogen	-	0.04	0.3/0.39	0.04	1.2[5]
Cadmium	-	0.0001	0.00025 / 0.005	0.0003	0.0004[4]
Chloride	-	2	250 / 250	50	250[5]
Chromium	-	0.001	0.0047 / 0.005	<0.001	0.0047

Substance	MRV/LoQ[1]	Laboratory Limits of Detection	EQS / DWS	Baseline Concentration[2]	Proposed EAL
Copper	-	0.001	(0.001[3]) / 2	0.011	0.015[4]
Fluoride	-	(0.03)	5 / 1.5	0.824	1.5
Nickel	-	0.001	(0.004[3]) / 0.02	0.006	0.008[4]
Phenols	-	(0.0005)	0.0077 / -	NS	0.0077
Sulphate	-	3	400 / 250	1,560	1,560
Zinc	-	0.002	(0.0109[3])	0.024	0.075[5]

[1] - applies to hazardous substances only
[2] - either maximum recorded concentration recorded in upgradient boreholes from 2019 onwards or the 50th percentile concentration published in Beacock and Smedley (2009).
[3] - bioavailable
[4] - 25% above baseline concentration
[5] - based on compliance limit for Skelbrooke Landfill
NS – Not sampled

2.4 Conceptual Site Model Summary

2.4.1 The Conceptual Site Model (CSM) associated with restoration of Skelbrooke Quarry Extension Area is summarised in **Table HRA8.**

Table HRA8: Conceptual Site Model Summary

Source	Pathway	Receptor
Direct deposition of waste on the Edlington Formation (Middle Marl)	Limited downward movement through marl, retardation processes	Groundwater in underlying aquifers
Direct deposit of wastes into groundwater with flooded quarry void	Direct contact and subsequent transport in groundwater.	Primary: Groundwater in Brotherton Formation (Magnesian Limestone - Principal Aquifer) Secondary: Surface water features; including the River Skell, its tributaries and springs lines.
Waste deposits within the saturated zone of the Brotherton Formation aquifer	Direct contact and subsequent transport in groundwater	
Waste deposits above the water table	Downward and lateral movement through saturated wastes	

3.0 HYDROGEOLOGICAL RISK ASSESSMENT

3.1 Introduction

3.1.1 The proposed development will involve the restoration of the flooded Skelbrooke Quarry Extension Area by the importation of selected non-hazardous materials which will be of a quality that prevents the discernible discharge of hazardous substances into groundwater and limits the discharge of non-hazardous pollutants to avoid pollution.

3.1.2 In order to achieve this, it is proposed to accept non-hazardous waste which satisfies site specific waste acceptance criteria derived from baseline groundwater quality associated with the Magnesian Limestone and the dilution available within the aquifer. The acceptance and deposition of this these selected materials will ensure that the risk associated with the proposed development will be negligible and as such it is proposed the abstraction of groundwater within the existing quarry void and the installation of basal/sidewall lining systems and a leachate management system are not required.

3.1.3 This assessment will examine not only the theoretical risk posed by the proposed waste deposits to the surrounding hydrogeological environment.

3.2 Nature of the Hydrogeological Risk Assessment

3.2.1 The Hydrogeological Risk Assessment submitted in support of the 1999 Waste Management Licence application consisted of a Hydrogeological (Regulation 15) Risk Assessment which; due to the nature of the wastes proposed for disposal as part of the 1999 Waste Management Licence Application consisted of a quantitative assessment which calculated the potential diffusion flux from the proposed landfill site into the Upper Magnesian Limestone adjacent to the site. This review identified that the magnitude of the potential risk presented by the fully developed Skelbrooke Quarry Extension Area accepting the original waste list containing Hazardous Substances (formerly referred to a List I Substances) and Non-Hazardous Pollutants (formerly referred to as List II substances) was negligible.

3.2.2 Since the Skelbrooke Quarry Extension Area was never developed, with the list of wastes removed from the Environmental Permit in 2007 and the site closed in 2015, no subsequent Hydrogeological Risk Assessment Review has been required/undertaken.

3.2.3 In order to support the restoration of the Skelbrooke Quarry Extension Area using selected materials it is considered prudent to undertake a new Hydrogeological Risk Assessment to confirm the hydrogeological conceptual site model and identify the potential interactions between the proposed non-hazardous materials for deposition and the surrounding hydrogeological receptors, and impacts this might entail.

3.2.4 As set out within the Environment Agency's "Inert Waste Guidance" the *"appropriate complexity of assessment for a site should be determined from the potential risks presented by the site, which are linked to the nature of potential hazards, the sensitivity of the surrounding environment, degree of uncertainty and likelihood of a risk being realised."*

3.2.5 The site will accept non-hazardous waste, in which;

- It does not undergo any significant physical, chemical or biological transformations;

- It does not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health; and
- Total leachability, pollutant content and the ecotoxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water or groundwater.

3.2.6 Based on this definition, the wastes should not produce any leachate that could result in any significant discharge of Hazardous Substances or Non-Hazardous Pollutants throughout the lifecycle of the site.

3.2.7 Additionally, the proposed development is located outside of a designated Source Protection Zone.

3.2.8 Nonetheless, a significant portion of the wastes to be used to restore the quarry extension area will be tipped directly into quarry groundwater sourced flood waters, with no attenuation afforded by a naturally or artificially established geological barrier along the sidewalls comprising Magnesium Limestone aquifer. Waste deposited below the groundwater table will therefore be permanently in direct contact with groundwater with the aquifer. On this basis, the waste types to be deposit below the water table will be limited to wastes with a relatively low contamination risk, which will also be subject to stringent waste characterisation testing to minimise the risk of any rogue loads being deposited.

3.2.9 Upon waste levels rising above groundwater levels, the initial deposits will form a platform that will prevent direct contact between groundwater and the subsequent waste deposits to be located above the groundwater table. This will therefore provide attenuation to any pollutants that may leach downwards through the wastes.

3.2.10 This risk assessment therefore considers the risks from waste deposited below and above the water table.

3.3 Assessment Scenarios

Previous Assessment Scenarios

3.3.1 Environment Agency guidance requires that Hydrogeological Risk Assessments are carried out for the whole lifecycle of the landfill.

3.3.2 The original Hydrogeological Risk Assessment submitted in support of the 1999 WML application considered the pollution potential of the Skelbrooke Quarry Extension Area during both the operational and post operational period and utilised LandSim modelling software to identify the theoretical diffusion rates from the then proposed wastes (i.e. a combination of biodegradable List I and List II substances) and their predicated impact on adjacent Upper Magnesian Limestone aquifer unit. The 1999 Hydrogeological Risk Assessment also accounted for the impact of the proposed technical precautions for the Skelbrooke Quarry Extension Area.

3.3.3 As the original Skelbrooke Quarry Extension Area (as authorised under EAWML65052) was not developed from the issuing of this Waste Management Licence in 2001 no subsequent Hydrogeological Risk Assessment Reviews have been undertaken.

Revised Assessment Scenarios

3.3.4 Following the review and update of the hydrogeological conceptual site model presented in **Section 2.0** and the proposed alterations to the nature of the wastes to be deposited within the Skelbrooke Quarry Extension Area it is considered appropriate to assess the potential risk to groundwater within the adjacent Upper Magnesian Limestone (Brotherton Formation) lithology.

3.3.5 Based on this pathway it is considered that the greatest risk to groundwater is associated with the direct placement of waste below the water table that are in direct contact with the Brotherton Formation aquifer. Demonstration of a low risk associated with this S-P-R linkage will adequately demonstrate that the there will be no significant risks associated with all other S-P-R linkages on the basis that the :-

- source term used to represent this risk pathway will ignore the initial rinsing of the waste during initial deposit into the flooded quarry waters;
- Direct deposit of waste into the flood waters offers greater dilution factors than all other S-P-R linkages
- Middle Permian Marl will provide a significant degree of attenuation to the movement of pollutants;
- movement of pollutants from wastes deposits above the water table into and through the underlying wastes deposits will provide a significant degree of attenuation to the movement of pollutants

3.3.6 The risk assessment considers the pollution potential associated with the proposed waste deposits during the initial phase of deposition and ongoing interaction with the adjacent groundwater following cessation of deposition activities and full restoration of the Skelbrooke Quarry Extension Area. It also extends to the potential deposition of a roque load at the site.

3.3.7 It is considered that a risk assessment of lifecycle phases is not required given that there are no technical precautions included within the construction and management of the site that will be subject to long degradation. Additionally, due to the nature of the proposed waste and the absence of any proposed active management processes (i.e. leachate or groundwater management) during the infilling process it is considered that the interaction of the proposed deposition material during the operational and post-operational lifecycle phases will remain the same and as such can be incorporated into a single assessment.

3.4 Numerical Modelling

Justification for Hydrogeological Risk Assessment Approach

3.4.1 A quantitative assessments of the potential impact from the deposit of inert wastes and of rogue loads have been carried out using Consim 2.5. This software was used for the following reasons:

- it uses Monte Carlo (stochastic) techniques and so allows a probabilistic appreciation of the site's performance;
- it provides a consistent approach to the estimation of hydrogeological risks;
- it provides an audited and verified code that is widely accessible;
- it allows the estimation of the potential attenuation of contaminants through the AEGB (modelled as an unsaturated zone);
- it allows dilution of contaminants in the saturated zone;

- leakage rates from the waste deposits can be controlled by using specified infiltration values based on a calculated water balance;
- it aids comprehensive reporting of input values, assumptions, and results; and
- it can allow for declining leachate source terms for individual pollutants to be considered

3.4.2 The following assumptions have been incorporated into the ConSim models:

- Any reduction in the source term when waste are initially deposited directly into water has been conservatively ignored;
- the bulk hydraulic conductivity of the waste deposits is conservatively assumed at $1x10^{-6}$ m/s to account for the limited consolidation of the deposits;
- a declining source term has been considered;
- The compliance point for hazardous substances has been set on the downgradient edge of the modelled sidewall;
- The compliance point for non-hazardous pollutants has been set at the boundary of the site;
- Any limited attenuation offered by the fractured limestone aquifer is ignored;
- Vertical sidewalls have been modelled;
- The hydraulic gradient applied in the modelling has been derived from site specific groundwater level data;
- the hydraulic gradient within the waste mass assumes doming of the in-waste water levels at the approximate site centre, with typical peak level of 27mAOD and high groundwater water level at the northeastern edge of the quarry void of 24.5mAOD
- The calculations do not account for any subsequent dilution within the fluvial channel of the River Skell or it tributaries.

3.4.3 The quantitative modelling has been carried out in a stochastic fashion. The acceptable probability of an undesirable outcome occurring is set at the 95th percentile for stochastic estimations carried out for a complex hydrogeological risk assessment. In addition, the 95th percentile value is commonly selected as a reasonable worst case, against which it is acceptable to make decisions considering the assumptions and limitations of the modelling process.

3.5 Model Parameterisation

3.5.1 Details relating to the parameters used for the Consim model are presented in in **Appendix HRA3.**

Leakage Rates

3.5.2 The leakage rates were calculated following an assessment of the water balance for the waste deposits after final levels are achieved. The water balance is based on the assumption that the flux infiltrating the wastes must balance the flux discharging from the waste. The discharge through the sidewalls can be calculated landfill as the flow through the waste mass, assuming a hydraulic gradient controlled by a maximum head equal to the maximum elevation of the landfill surface and the average groundwater head at the boundary of the landfill; a hydraulic conductivity representative of the expected waste composition; the depth of the waste and the landfill perimeter in contact with groundwater.

3.5.3 If this maximum value is greater than effective rainfall, then the flux out of the quarry sidewall is limited to effective rainfall and runoff from the waste surface is considered to be 0. If the maximum value is less than effective rainfall, then the flux out of the waste deposits is set to the maximum value, the infiltration flux is also set to this maximum value and the difference between the effective rainfall and the infiltration flux is assumed to be runoff. For Skelbrooke Quarry the maximum sidewall discharge rate is significantly less than equivalent volume generated by the regional effective rainfall value of ~200 mm/yr. This value was derived from climate data presented in the accompany ESSD (Doc Ref.: WR7640/05) which indicated a total average annual rainfall of ~600mm. The annual effective rainfall for the region is calculated at between 112 to >400mm/yr. The higher values range is attributable to limestone areas with limited soil cover. However, in lieu of the low-permeability of the waste deposits the annual effective rainfall for the restored quarry is assumed to be in the region of ~200mm/yr .

3.5.4 The specific infiltration rate utilised in the semi-quantitative model were calculated based on Darcy's Law:

$$Inf = k \times i \times A$$

Where:
k = Hydraulic conductivity of the compacted qualifying materials (ms-1)
i = hydraulic gradient across the compacted qualifying materials
A = Area of Saturated receiving aquifer (m2)

3.5.5 As discussed in **Section 3.3**, it is considered that due to the anticipated nature of inert wastes that will be deposited in the quarry void, they will achieve a bulk permeability of $\leq 1x10^{-6}$m/s. Consequently, this permeability was taken forward in calculating the potential worst case . Due to the nature of materials anticipated to be deposited in the quarry void, it is considered that lower permeability materials (e.g. clays and concrete) will also be deposited. Accordingly, it is considered likely that the deposited inert waste will achieve permeabilities lower than the $\leq 1x10^{-6}$m/s modelled. Based on Sirius' experiences, permeability data derived from sites currently accepting similar materials as proposed to support restoration of the quarry have frequently returned permeability values of a few of orders of magnitude lower than the value assume for under this assessment. Consequently, it is considered that the selected permeability utilised in calculating the leakage rates incorporates sufficient conservativism into the assessment.

3.5.6 The hydraulic gradient used in the modelling spreadsheets was derived from the average in-waste hydraulic gradient calculated between the top of the assumed leachate mound and ground water levels at the edge of the quarry. As indicated above, maximum water level in the fill materials would correlate to the restoration contours along the approximate centreline of the final restoration profile. The in waste hydraulic gradient were calculated by dividing the head difference between the restoration elevation contour along the centreline of the quarry and the average groundwater level in the modelled sidewall by the distance between the centreline of the inert landfill and the edge of the quarry.

3.5.7 The sidewall dimensions presented in the models were derived from the length and wetted height of the sidewall.

<u>Rogue Load 'Leachate' Source Term</u>

3.5.8 The 'leachate' source term parameters adopted for the assessment of the deposit of a rogue load at the site are based on a conservative range of concentrations derived by the EA from a review of inert waste datasets. These parameters are adopted from the possible range of leachate quality values identified by the EA for high sensitivity sites. To support the proposed WAC limit the maximum concentrations for lead has been increased to percolation test threshold for inert wastes specified in Council Decision of 19th December 2022, which are recommended when highly leachable wastes are suspected. The source term parameters utilised in the Rogue Load Modelling is present in **Table HRA9.**

Table HRA9: Rogue Load Leachate Source Term Parameters

Substance	Modelled Source Term Range (mg/l)		
	Minimum	Most Likely	Maximum
Ammoniacal Nitrogen	0.3	8	25
Chloride	100	300	800
Sulphate	200	1200	1800
Lead	0.002	0.007	0.15
Nickel	0.002	0.02	0.12

3.6 Emissions to Groundwater

3.6.1 The results of the semi-quantitative modelling are summarised and discussed below. The models used in this Hydrogeological Risk Assessment are presented in **Appendix HRA3.**

3.6.2 The results will be separated according to their classification as hazardous substances or non-hazardous pollutants.

3.6.3 The EALs selected for assessment purposes have taken into consideration baseline groundwater concentrations.

<u>Hazardous Substances</u>

3.6.4 A summary of the results of the quantitative modelling of predicted groundwater concentrations of hazardous substances are presented in **Table HRA10.**

Table HRA10: WAC Limits - Predicted 95th percentile groundwater concentrations of hazardous substances at the site boundary

Substances	EAL (mg/l)	Predicted Groundwater Concentration (mg/l)
Arsenic	0.05	0.0002
Lead	0.0002	0.0002
Mercury	0.00001	0.000004

3.6.5 The model indicates the diluted concentrations for hazardous substance will be not exceed the selected EALs when the WAC thresholds presented in **Table HRA1** are adopted for the wastes to be deposited at the site.

<u>Rogue Load Assessment</u>

3.6.6 The potentials risk to groundwater from the deposit of a rogue load containing excessive leachable concentration of hazardous substances has been modelled. The result of the model is presented in **Table HRA11.**

Table HRA11: Rogue Load Assessment - Predicted 95th percentile groundwater concentrations of hazardous substances at the site boundary

Substances	EAL (mg/l)	Predicted Groundwater Concentration (mg/l)
Lead	0.0002	0.00017

3.6.7 The results demonstrate that the deposit of a rogue load with excess soluble concentrations of hazardous substances at the site will not result in a discernible input of hazardous substances to groundwater.

Non-Hazardous Pollutants

3.6.8 A summary of the results of the modelling for non-hazardous pollutants are presented in **Table HRA9.**

Table HRA12: Predicted 95th percentile groundwater concentrations of non-hazardous pollutants at the site boundary

Substances	EAL (mg/l)	Predicted Groundwater Concentration (mg/l)
Cadmium	0.0005	0.00002
Chloride	250	0.5
Chromium	0.0047	0.00016
Copper	0.015	0.0007
Fluoride	1.5	0.005
Nickel	0.008	0.00014
Sulphate	1,560	0.5
Zinc	0.075	0.0013

3.6.9 The model indicates that the diluted concentrations for hazardous substance will be not exceed the selected EALs when the WAC thresholds presented in **Table HRA1** are adopted for the wastes to be deposited at the site.

Rogue Load Assessment

3.6.10 The potentials risk to groundwater from the deposit of a rogue load containing excessive leachable concentration of non-hazardous pollutants has been modelled using Consim. The results of the models are presented in **Table HRA13.**

Table HRA13: Rogue Load Assessment - Predicted 95th percentile groundwater concentrations of non-hazardous pollutants at the site boundary

Substances	EAL (mg/l)	Predicted Groundwater Concentration (mg/l)
Ammoniacal Nitrogen	1.25	0.041
Chloride	250	1.2
Nickel	0.008	0.00018
Sulphate	1,560	3.5

3.6.11 The calculations indicate that the deposition of a rogue load with excessive leachable concentrations of non-hazardous pollutants will not result in a significant deterioration (or pollution of) groundwater.

3.7 Review of Technical Precautions

Leachate Management

3.7.1 Due to the proposed infilling strategy and the non-hazardous, non-biodegradable nature of the proposed materials for deposition, it is considered that the potential for leachate generation is absent. Accordingly, it is proposed that active leachate abstraction or monitoring activities are not required.

3.7.2 Due to the absence of any geological barrier to prevent the direct discharge of hazardous pollutants to groundwater within the limestone aquifer, waste acceptance procedures have been developed to provide further verification of the wastes streams prior to deposit into flooded sections of the quarry void.

Groundwater Management

3.7.3 As discussed earlier within this section, the adjacent engineered Skelbrooke Landfill Site (Cells 1-6); which operates under the principle of hydraulic containment, and the restored Doncaster Metropolitan Borough “dilute and attenuate” landfill are located immediately west and east of the Skelbrooke Quarry Extension Area respectively.

3.7.4 In order to ensure that the hydraulic containment conditions under which the main Skelbrooke Landfill Site (Cells 1-6) operates and to prevent the ingress of contaminated groundwaters from the neighbouring Doncaster MBC landfill it is proposed that groundwater management operations do not seek to draw down water levels significantly below the invert level of the existing inlet associated with the surface water management network for the adjacent landfill.

Surface Water Management

3.7.5 Due to the nature of proposed site operations which involve the tipping of material which satisfies the site-specific Waste Acceptance Criteria and Procedures into the flooded landfill void it is proposed that surface water management will not be required.

3.7.6 During the infilling of the Skelbrooke Quarry Extension Area, surface water from the adjacent Skelbrooke Landfill Site will continue to be discharged into Skelbrooke Extension Area Void, further enhancing the dilution available during active tipping phase of the activity.

3.7.7 Upon restoration of the Skelbrooke Quarry Extension Area, a wetland area will be established within the footprint of the Skelbrooke Quarry Extension Area void to act as an flood attenuation lagoon for the wider Skelbrooke Quarry and Landfill complex (**Drawing No. WR7640/10/ESSD5**). Surface water contained within this quarry area will subsequently discharge by gravity via the existing discharge point (SKSW04) to the River Skell, as shown in **Drawing No. WR7640/10/HRA2**.

3.8 Accidents and their Consequences

3.8.1 Details of accidental occurrences at the site that could present a potential risk to groundwater adjacent to the site are provided in **Table HRA14**.

Table HRA14: Qualitative Accident Risk Assessment

Hazard	Risk to Groundwater	Likelihood	Mitigation and Corrective Measures
Deposition of biodegradable and non-degradable, non-hazardous and hazardous wastes	Generation of landfill gas and leachate containing Hazardous Substances and Non-Hazardous Pollutants	**High** – due to the absence of any attenuation systems and the direct placement of waste into the groundwater flooded quarry	Appropriate characterisation of wastes prior to delivery to the site will be provided by the customer, with the appropriate verification checks/tests performed wastes by the operator. Any incorrectly accepted wastes will be

Hazard	Risk to Groundwater	Likelihood	Mitigation and Corrective Measures
			immediately returned to the customer or moved to a suitable storage area prior to removal to a suitable site.
Spillage of fuels from storage tanks or vehicles	Release of hydrocarbons (Hazardous Substances) into the ground and migration into groundwater	**Low** – fuel stores will be bunded in accordance with regulation requirements. A traffic management system and speed limit will be imposed at the site to reduce both the risk of accidents and the likelihood of spillage occurring.	Any spillage will be cleaned up immediately and any resulting contaminated soils removed to a suitable installation.

3.8.2 With respect to the deposition of potentially contaminated wastes, it is considered that the risks and potential consequences of such accidents are extremely low for the following reasons:

- All waste deliveries will be pre-arranged and come from known sources to ensure no contaminated material is delivered;
- If deemed necessary, characterisation testing will be undertaken to demonstrate that the waste will not give rise to polluting leachate, prior to the acceptance of waste at the site;
- Verification/compliance testing will be undertaken on all sources of wastes to be deposited below the water table to minimise the risk from the deposit of a significant contaminated rogue load;
- Visual inspection will be undertaken of every waste load deposited at the site; and
- In the event of suspicion regarding the acceptability of the waste, quarantine procedures will be enforced.

3.8.3 In the unlikely event of contaminants from a rogue load being deposited at the site, attenuation processes will occur within the waste body, and most organic Hazardous Substances are very likely to be degraded and/or retarded during migration through the surrounding wastes within the quarry.

3.8.4 Other processes such as volatilisation can also be expected for volatile and semi-volatile organic substances resulting in a loss of contaminant from the waste.

4.0 REQUISITE SURVEILLANCE

4.1 Leachate Monitoring

4.1.1 Leachate testing will be limited to that required as part of the waste acceptance requirements as detailed in **Section 2.2** of the accompanying Supporting Statement (**Doc. Ref.: WR7640/04**).

4.1.2 Due to the non-hazardous, non-biodegradable nature of the proposed wastes for deposition; the quality of which will be such that the materials will not degrade the natural groundwater geochemistry, and the absence of engineered basal and sidewall lining systems, it is considered that no in-waste water quality or level monitoring is undertaken following the cessation of infilling operations.

4.2 Groundwater Monitoring

4.2.1 The groundwater monitoring schedule during the operational phase of the infilling activities of the Skelbrooke Quarry Extension Area it presented in **Table HRA15**. The location of the proposed groundwater monitoring points for the Skelbrooke Quarry Extension Area are presented in **Drawing No. WR7640/10/HRA2**.

4.2.2 It is noted that the proposed Skelbrooke Quarry Extension Area and the adjacent Skelbrooke Landfill Site (Cells 1-6) will share three groundwater monitoring boreholes (SK01, SK02 and SK03). In order to streamline the monitoring process and reduce the costs associated with monitoring the same borehole twice, it is proposed to synchronise the monitoring schedules of the existing Skelbrooke Landfill Site and the proposed Skelbrooke Quarry Extension Area so that all common monitoring requirements can be undertaken in a single site visit.

4.2.3 Additionally, it is important to highlight that although the proposed groundwater monitoring points of SK15, SK16, SK17, SK18 and SK19 are currently identified as unmonitored landfill gas monitoring boreholes, the basal elevations of these boreholes place the within the Upper Magnesian Limestone and DQL has confirmed that they screen the Magnesian Limestone and can be converted to combined gas/groundwater monitoring boreholes.

Table HRA15: Groundwater Monitoring Schedule

Monitoring Point Reference	Parameter	Monitoring Frequency
Upgradient (SK01, SK02, SK03 & any replacement monitoring boreholes)	Water Level, ammoniacal nitrogen, chloride, electrical conductivity, chloride, Electrical Conductivity, pH, zinc	Quarterly
	Arsenic, calcium, cadmium, chromium, copper, iron, lead, nickel, magnesium, manganese, potassium, sodium, total alkalinity, sulphates, PAHs	Annually
Cross-Gradient (SK17, SK18, SK19 & any replacement monitoring boreholes) Or Downgradient (SK15, SK16 & any replacement	Water Level, ammoniacal nitrogen, chloride, electrical conductivity, chloride, Electrical Conductivity, pH, zinc	Quarterly
	Arsenic, calcium, cadmium, chromium, copper, iron, lead, nickel, magnesium, manganese, potassium, sodium, total alkalinity, sulphates, PAHs	Annually

Monitoring Point Reference	Parameter	Monitoring Frequency
monitoring boreholes)		
All Monitoring Points	Base of Monitoring Point (mAOD)	Annually

4.2.4 Groundwater compliance levels will be derived for downgradient monitoring boreholes SK15 and SK16 following the collection of at least 6 months of background data.

4.2.5 Details of the post-closure groundwater monitoring requirements are presented in **Section 7.0** of the accompanying Support Statement (**Doc. Ref.: WR7640/04**).

4.3 Surface Water Monitoring

4.3.1 During the operational phase of the infilling activities, surface water monitoring will be undertaken on both the water contained within the Skelbrooke Quarry Extension Area void. This monitoring will entail monthly chemical analysis of selected parameters and visual inspections for hydrocarbon contamination.

4.3.2 In addition to monitoring the water contained within the Skelbrooke Quarry Extension Area void, the monitoring point SKSW04; which is also included within the monitoring schedule for the adjacent Skelbrooke Landfill Site (EPR/BV1470IE) will be incorporated into the surface water monitoring schedule for the extension area. As the waters being discharged will come into contact with the waste deposits being used to restore the extension area the range of parameters will be adapt for the extension area permit to include those linked to the waste characteristics.

4.3.3 The proposed surface water monitoring schedule for the extension area is present in **Table HRA16.**

Table HRA16: Surface Water Monitoring Schedule

Monitoring Point Reference	Parameter	Reference Period	Monitoring Frequency
SKSW04 & SKSW07 SKLAGOON	Ammoniacal Nitrogen, Chloride, Electrical conductivity, pH, suspended solids, visual oil and grease, COD, BOD	Spot Sample	Monthly
	Total alkalinity, magnesium, potassium, lead, zinc, copper, cadmium, nickel, iron, chromium, total sulphates, calcium, manganese, sodium, TOC, TON		Quarterly

Note – all metal and metalloids parameters to be tested for dissolved fractions only

4.3.4 Compliance limits are also proposed at 'SKLAGOON' (see **Table HRA17**) to ensure that the quality of any waters that need to be discharge from the site during the active tipping phase do not present a significant risk to surface water quality in The Skell river. Compliance limits are based on those currently specified on Environmental Permit EPR/BV1470IE for the main landfill.

Table HRA17: Proposed surface water compliance limits

Monitoring Point Reference	Parameter	Source	Limit (incl. unit)	Reference Period	Monitoring Frequency
SKLAGOON and SKSW04	Ammoniacal Nitrogen	Surface water and groundwater	1.2 mg/l	Spot Sample	Monthly
	Chloride		250 mg/l		Quarterly
	Zinc		0.075 mg/l		
	Visible Oil and Grease		None visible		

5.0 CONCLUSIONS

5.1 Compliance with the Schedule 22 of the EPR2016

5.1.1 The results of this risk assessment have established the revisions to the landfill development will continue to comply with the relevant requirements of the Groundwater Regulations 2009 as follows:

- The restoration of the quarry with wastes pose a potential hazard to ground and surface water quality. Consequently, it continues to fall within the scope of the Schedule 22 of the EPR2016;
- This assessment forms a review of the “prior investigation” that must be carried out for this type of development;
- The proposed technical precautions are considered appropriate and reasonable to prevent the discernible entry of hazardous substances into groundwater throughout the lifecycle of the facility
- The proposed technical precautions will limit the introduction of non-hazardous pollutants into groundwater to avoid pollution throughout the lifecycle of the facility; and
- Groundwater and surface water monitored schedules will be used in accordance with the requisite surveillance requirements of Schedule 22 to the EPR2016.

6.0 REFERENCES

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