Greetham Quarry Environmental Permit Application

Hydrogeological Risk Assessment

Mick George Limited

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Prepared on Behalf of Tetra Tech Environment Planning Transport Limited.
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TETRA TECH

TABLE OF CONTENTS

DRAWINGS

APPENDICES

1.0 INTRODUCTION

1.1 REPORT CONTEXT

1.1.1 This report has been prepared by Tetra Tech on behalf of Mick George Limited (Mick George) to support an environmental permit application to gain a bespoke waste disposal permit at Greetham Quarry (the site) in Rutland.

1.1.2 This report presents the Hydrogeological Risk Assessment (HRA) for the proposed waste operation. The objectives of this document are to assess whether the proposed operations and end-use as an inert landfill, its engineered containment design and construction, monitoring network and management controls fulfil the requirements of the Groundwater Regulations 2009 and Landfill Directive 1999 and ensure that the site is in compliance with the requirements of the Environmental Permitting Regulations, 2016.

1.1.3 Details regarding other aspects of the proposed waste operation are provided in other supporting documents that have been prepared to support the Environmental Permit Application. This includes the Environmental Setting & Site Design (ESSD) report, Operating Techniques and Environmental Risk Assessment (ERA).

1.2 SITE LOCATION

1.2.1 The application site is located on a parcel of land adjacent to the existing Greetham Quarry and is located on the northern boundary of the village of Greetham and 1.75 kilometres (km) southwest of the village of Stretton. The site is centred at National grid Reference (NGR) SK 92941 15078 and the environmental permit boundary is shown on MGL/B027573/PER/01.

1.2.2 Access to the existing quarry is via an access road off Stretton Road (B668) on the south east side of the existing quarry. The proposed development includes plans for a new access point into the proposed extension are which would allow for the site to be accessed directly of Thistleton Lane which runs along the northern boundary of the site. The site is bounded by Great Lane to the west, Thistleton Lane to the north, the existing Greetham Quarry to the East and the village of Greetham to the south.

1.2.3 Beyond the wider quarry site, the immediate surroundings are agricultural to the west, north and east with the village of Greetham located to the south. The nearest residential property is considered to be White House which is located approximately 40m east of the application site.

1.2.4 There is a limited height change across the site ranging from approximately 120m above Ordnance Datum (AOD) on the southern boundary up to approximately 122m AOD along the northern boundary.

1.3 BRIEF SITE HISTORY

1.3.1 The existing Greetham Quarry site has been in operation since the 1950's by virtue of a number of planning permissions. In September 2000, the majority of these old mining permissions were reviewed, updated and consolidated through the Review of Old Mining Permissions (ROMP) process, resulting in consent M/1999/0326/09 and a schedule of modern conditions was issued.

1.3.2 In 2006, a 6.4ha extension was approved under permission MIN/2004/1051. Both of these current consents are time limited and expire on 30th September 2020.

1.4 PROPOSED DEVELOPMENT

1.4.1 In 2020, a planning application was submitted to Rutland County Council for the North-Western Extension to Greetham Quarry including the Extraction of Limestone and Building Stone and Importation of Suitable Inert Materials.

1.4.2 As part of the restoration works, Mick George seeks to utilise imported inert waste materials in addition to on site discarded quarry waste products and soils. As such, the proposal entails the importation of inert waste to supplement the on-site quarry waste and soils to infill and progressively form a stable base and side slopes that will be created following mineral extraction activities.

1.5 LANDFILL DESIGN PHILOSOPHY

Basal Layer

1.5.1 A geological barrier is a fundamental requirement for all landfills according to the Landfill Directive and must provide sufficient attenuation to prevent a risk to soil and groundwater. The geological barrier shall have a minimum thickness of 1m and a permeability of no greater than 1×10^{-7} m/s or equivalent.

1.5.2 Prior to the commencement of landfilling, a geological barrier will be engineered using imported materials. The geological barrier will be constructed in compliance with the Environmental Permitting Regulations and will have a hydraulic conductivity of less than 1m at 1×10^{-7} m/s or its direct equivalent of 0.5m at 5×10^{-8} m/s.

Side Sloping Lining

1.5.3 A clay side slope liner will be constructed from suitable waste materials against a suitable 1 in 2.5 subgrade slope. The liner will have a horizontal crest width of 2m from the edge of the formation and be constructed at a slope of 1 in 3. The engineered clay liner will have a thickness of 0.5m perpendicular to the side slope with a hydraulic conductivity of 5.0 x 10^{-8} m/s or the equivalent.

1.5.4 The proposed construction of the clay liner would be to the specification detailed in the Construction Quality Assurance (CQA) Plan that will be submitted to the Agency for approval prior to engineering taking place. See the Hydrogeological Risk Assessment for further details (Appendix E of the Environmental Permit Application).An engineered side wall liner is to be constructed along the sidewall of the quarry and is to have a thickness of 1m and a permeability of no greater than 1x10^{-7} m/s.

Capping

1.5.5 In accordance with the current requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required. On completion of filling to final levels, the site will be capped with 1m of restoration soils.

Restoration

1.5.6 The application site is presently in agricultural use and it is the intention of Mick George to restore the site back to agricultural land with calcareous grassland around the perimeter which will provide the opportunity for contributions to green infrastructure improvements.

Aftercare

1.5.7 Aftercare for the proposed calcareous grassland and agricultural land will be undertaken for a minimum of 5 years. The calcareous grassland will also include exposed rock faces (or crags) and scree areas comprising loose tipped limestone quarry waste with randomly spaced limestone boulders to provide a variation in habitat. The calcareous grasslands require a management regime of cutting, the frequency and timing of which will, in part, dictate the type of vegetation community that forms'

1.5.8 Details regarding the site's aftercare are provided in the Closure and Aftercare Plan (Appendix K of the Environmental Permit Application).

1.6 REGULATORY CONTEXT, GROUNDWATER AND SURFACE WATER PROTECTION

Aquifer designation

1.6.1 With reference to the Multi Agency Geographic Information for the Countryside's (MAGIC) website under the Groundwater Vulnerability Map, the site is situated within an area of High vulnerability and lies in a Source Protection Zone 2. Zone 2 (Outer Protection Zone) is defined by the 400-day travel time from a point below the water table.

1.6.2 In terms of aquifers, the MAGIC website shows that the site overlies a Principal Aquifer. The existing quarry also overlies the same Principal Aquifer.

Licensed and Unlicensed Abstractions

1.6.3 According to Aggregate Industries (2021) there are six licensed groundwater abstractions within a 5km of the site and primarily relate to spray irrigation and mineral processing. In addition, there's a water abstraction licence (6/33/22/*G/0064/R02) registered at the site which relates to a fixed pump that's used for the wheel wash and mineral washing plant.

Water Table

1.6.4 It has been approved that the site shall be worked dry therefore the void will be worked to 1m above the water table or 1m above the underlying limestone whichever is greater. Hence, the installation is not described as being sub-water table.

1.6.5 Table 1 below is a comparison between the top of the Chalk formation and range of groundwater levels in order to maintain the proposed 1m unsaturated zone throughout the site. Information gathered from Geotechnical & Environmental Consulting, Stability Risk Assessment, Report No. GEC2002430006, 2020.

Table 1: Summary of geological and groundwater information (2019-2022)

Borehole ID	Top of Chalk (mbgl)	Min. GW depth (mbgl)	Max. GW depth (mbgl)	Ave. GW depth (mbgl)	Residual unsaturated zone using min. GW depth (m)
BH1	8.80	11.54	13.04	12.29	2.74
BH2	6.50	11.20	13.53	12.45	4.7
BH3	4.80	6.36	8.95	7.66	1.56
BH4	8.50	7.46	9.20	8.33	1.04
BH5	9.00	7.46	8.69	8.08	1.54
BH6	7.50	10.14	10.55	10.35	2.64

* The residual unsaturated zone thickness is marginally less than the arbitrarily specified 1m. However, the Operator will ensure that around these locations a slightly thicker cover of superficial deposits will be left in situ to offset the decreased unsaturated zone.

Hydrology

1.6.6 According to the Flood Map for Planning Service (FMPS) and the Amber Planning Flood Risk Assessment produced, this is located in Flood Zone 1 which has a low probability of flooding.

1.6.7 The site is located within the catchment of North Brook a tributary of the River Gwash. North Brook flows west to east approximately 75m south of the existing quarry boundary and approximately 220m south of the proposed extension area. There are no other open surface water features in the vicinity of the proposed development area.

Ecology

1.6.8 A 'Nature and Heritage Conservation Screen' (reference EPR/KB3305HH/A001) was requested from the EA. The screen determines the presence of any site of nature and heritage conservation, or protected species or habitats that may be impacted by the proposal. A copy of the results is appended in the Environmental Risk Assessment (Appendix D of the Environmental Risk Assessment).

1.6.9 The results of the screen identified the following:-

- Greetham Meadows SSSI (515m to NE) Great Lane Hedgerow, Greetham Verge and Greetham Roadside Verge Nature Reserve (with 2om of site).

2.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

2.0.1 The conceptual hydrogeological model for the site is based on the source-pathway-receptor linkages and relies on the geological and hydrogeological information gathered during site investigations.

2.0.2 A preliminary schematic conceptual hydrogeological model for the site (See cross sections in Drawing number MGL-B027573-HYD-01). This model will be updated as the site develops and more information becomes available.

2.0.3 It is proposed to excavate to 103mAOD into the Lower Lincolnshire Limestone Member.

Source: potentially-contaminating leachate that could be generated by rainfall infiltration through the emplaced inert material and any moisture inherent to the inert material itself.

Pathways: to include the landfill liner system (base and sides), an unsaturated zone within the *in situ* geology, and a saturated zone below the groundwater table in which dilution and degradation processes may occur.

Receptors: the groundwater system beneath the site is considered to be the primary receptor. To our knowledge there are no secondary receptors in the form of licensed surface water abstractions.

2.0.4 A detailed discussion of the three components of the conceptual model is given in the sections below.

3.0 CONCEPTUAL MODEL: SOURCE TERM

3.0.1 The requirements of the Landfill Directive for the disposal of inert waste material do not necessitate the installation of a leachate management or monitoring system. However, a leachate source term component will be incorporated into this risk assessment process.

3.0.2 Permitted wastes accepted at the site will be strictly inert as classified under the Landfill Directive (1999/31/EC) and Council Decision (2003/33/EC) of 19 December 2002 'Establishing criteria and procedures for the acceptance of waste landfills'.

3.0.3 Details regarding the proposed waste types including restrictions are provided in the Operating Techniques (Appendix B of the Environmental Permit Application).

3.0.4 A volume of 400,000m^3 of imported material (or 640,000 tonnes using a conversion factor of 1.6m^3/tonne) is required in order to restore the site following mineral extraction.

3.0.5 The proposed types of waste to be deposited into the landfill void are detailed in the Operating Techniques report (Appendix B of the environmental permit application).

3.0.6 However, a consideration is made for the potential of accepting waste that is not inert (e.g. potentially contaminated soil) or non-inert waste concealed within a load of waste that appears to be inert. Due to the inert nature of the material to be used to restore the quarry, it is considered highly unlikely that water coming into contact with the material at the site will generate high concentrations of pollutants. It is proposed to screen incoming waste under Council Decision (2003/33/EC) Inert waste acceptance criteria.

3.0.7 It is recognised that hazardous substances and non-hazardous pollutants are present in these criteria and could occur from rogue loads of non-inert waste. However, to mitigate this, the operator would restrict the source of waste materials allowed on to the site and all waste would be subject to stringent Waste Acceptance Procedures (as detailed in the Operating Techniques, Appendix B of the Environmental Permit Application). It is therefore considered that hazardous substances are not expected to be present and non-hazardous substances are expected to be low with respect to the background groundwater quality.

3.0.8 The likelihood of any (or both) of these types of actions is predicted to be very low as strict source characterisation procedures will be applied to the loads being imported and visual inspection of each load will be undertaken prior to and during disposal.

3.0.9 Any fuel tanks and oil drums used on the site and by sub-contractors will be stored in a containment bund capable of containing 110% of the total quantity of fuel present at any one time.

3.0.10 All fuel spillages from moving plant or machinery will be remediated immediately in a safe and controlled manner by ensuring spills kits are kept on site and checked daily.

4.0 CONCEPTUAL MODEL: PATHWAYS

4.1 GEOLOGY

4.1.1 A total of 6 no. boreholes were installed around the site's perimeter. In addition to providing basic geological and hydrogeological information these boreholes indicated the depths of exploitable minerals.

4.1.2 According to the British Geological Survey's (BGS) 'Geology of Britain Viewer' and drilling information gathered, there is no recorded superficial geology for the majority of the site, however the north and north east boundary of the site is underlain by Till, Mid Pleistocene (Diamicton). These superficial deposits were formed up to 2 million years ago in the Quaternary Period. Local environment previously dominated by ice age conditions.

4.1.3 The bedrock geology for the southern side of the site is Lower Lincolnshire Limestone Member. The northern side of the site is underlain on Upper Lincolnshire Limestone Member. This sedimentary bedrock formed approximately 168 to 170 million years ago in the Jurassic Period. Local environment previously dominated by shallow carbonate seas.

4.2 HYDROGEOLOGY: AQUIFER DESIGNATION AND GROUNDWATER VULNERABILITY

4.2.1 The MAGIC website under the Groundwater Vulnerability Map, the site is situated within an area of High vulnerability and lies in a Source Protection Zone 2. Zone 2 (Outer Protection Zone) is defined by the 400-day travel time from a point below the water table.

4.2.2 In terms of aquifers, the MAGIC website shows that the site overlies a Principal Aquifer. The existing quarry also overlies the same Principal Aquifer.

4.3 GROUNDWATER MONITORING BOREHOLES

Groundwater levels

4.3.1 The available groundwater data submitted by Mick George were plotted on the hydrograph of Appendix B (raw level data also in this appendix). The following comments apply to the plotted data:-

- The highest average water table levels are recorded in BH4 at the north of the site, whereas the lowest average levels were measured in boreholes BH1 and BH6, located to the south of the site. From these data the groundwater flow direction can broadly be inferred to be north to south.

- A groundwater contour map have been prepared and is presented as Drawing Number MGL-B027573-HYD-02, HYD-03 and HYD04.

4.3.2 The inferred groundwater flow direction has allowed for the identification of the up- and down-gradient boreholes, namely:-

Baseline Groundwater Quality

4.3.3 Groundwater quality data were obtained from the boreholes forming the current monitoring network (Drawing MBF_BH001) between February 2019 and June 2022.

4.3.4 The groundwater quality results for the indicator substances ammoniacal nitrogen (Amm. N) and chloride are chosen to identify are potential contamination arising from the landfill due to their high mobility. Sulphate is included as an additional substance as being a primary potential leachable component of inert waste along with chloride. The remaining substances analysed as part of the standard chemical suite collected during each monitoring visit.

4.3.5 Various metals have also been included in the interpretation of the chemical characteristic of the groundwater and these have been discussed in detail in the TerraConsult (2019) report, and therefore not repeated here.

4.3.6 The potential for an impact from the adjacent Mayton Wood closed landfill on the groundwater quality can be risked out as this closed landfill is situated down the hydraulic gradient of the proposed development.

4.3.7 The raw and plotted data to derive the time series chemographs are shown in Appendix C. Plotting of “less than” reported values has been possible by the application of the substitution rule of 0.5 x L, where L is the “less than” value, as per guidance “Final Technical Report P1-471_Techniques for the interpretation of monitoring data”.

4.3.8 It should be noted that potential outliers have not been removed at this stage, but statistical analysis has been performed on the data set for the calculation of the Compliance Limits (CLs) in Section 6.2.

Up-gradient boreholes

- The Amm. N chemograph displays a peak in values on three occasions within all the sampled boreholes i.e. Jan., March and May 2019. The remaining data points are in an harmonised linear pattern, with no discernible trends. Average concentrations are recorded between a maximum of 0.38mg/l and a minimum of 0.10mg/l, however the maximum value could be skewed as a result of the noted peaks.

- Chloride average concentrations are all below 100mg/l for these up-gradient boreholes although a distinctive value of 180mg/l was returned for the Nov. 2018 sampling round. The remaining trends are generally stable and linear which reflect the narrow range in average concentrations of between 66mg/l and 73mg/l.

- Average sulphate values are within a relatively narrow range of between 85mg/l and 103mg/l. The plot of these concentrations displays a relatively stable and linear trend for all the monitoring locations with the exception of the reading taken in March 2020 from BHC. This monitoring point shows a clear decrease in concentration thereafter and in the context of the pattern shown by the remaining readings is considered to be anomalous.

- Common metal values up-gradient display similar patterns within the four monitoring boreholes, with cadmium and lead not detected in all the visits and iron being consistently found in the dissolved state. The remaining metals have varying concentrations between being below the limits of detection or a narrow range of values.

Down gradient boreholes

- The Amm. N plot is also affected by the noted spurious (anomalous) behaviour of values found up-gradient during the January, March and May 2019 visits in BH4, BH10 and BHD. For the remainder of the monitoring period trends are mostly linear and stable and fall within a very narrow range of values. Average concentrations vary between a minimum of 0.19mg/l and a maximum of 0.67mg/l, although these values could be affected by the noted peaks in concentration.

- Average chloride concentrations are also all below 100mg/l and fall within a range of 62mg/l and 80mg/l. The linear trends displayed in the chemograph by all the monitoring points reflect the narrow plotting series of these boreholes.

- Average sulphate values are also within a narrow range of between a maximum of 94mg/l and a minimum of 48mg/l. Hence, the plot of these concentrations displays a relatively stable and linear trend for all the monitoring locations with the exception of BH4, which shows a less regular pattern with peak and lower average values in Jan. and May 2019 respectively.

- Metal values down-gradient display similar patterns to those up-gradient and within the five monitoring boreholes. Again, cadmium and lead have not been detected in all the visits and iron is being consistently found in the dissolved state. The remaining metals have varying concentrations between being below the limits of detection or a narrow range of values.

4.3.9 As an overall comment, the groundwater quality between the up-gradient and down-gradient monitoring points is identical, as expected to be found within a hydrogeological environment that is anthropogenically undeveloped.

Long Term Hydrogeological Changes

4.3.10 Hydrogeological changes are expected within the Superficial Deposits as a result of the proposed extraction activities. These impacts are predicted as localised changes to recharge characteristics and flow directions; but would not affect resources within the underlaying Chalk Formation. The impact of the proposed activity on recharge and flow direction are assessed as being minor, but long term, due to the localised nature of the development.

4.3.11 Any impacts in terms of both magnitude and duration that future climatic changes could bring about on the groundwater regime are too difficult to predict given the localised nature of the development.

5.0 CONCEPTUAL MODEL: RECEPTORS

5.1 CURRENT LICENSED/EXEMPT GROUNDWATER OR SURFACE WATER ABSTRACTIONS

5.1.1 As noted in Section 1.6.5, there's a water abstraction licence (6/33/22/*G/0064/R02) registered at the site which relates to a fixed pump that's used for the wheel wash and mineral washing plant. This is the only abstraction licence that's registered within 1km of the site.

5.1.2 As noted in Section 1.6.4, the site does not lie within the source protection zone (SPZ) but does coincide with a drinking water safeguard zone.

5.1.3 Therefore, the underlying remaining geological unit(s) i.e. Lincolnshire Limestone, is considered to be the principal receptor for this assessment, following extraction of the superficial deposits.

5.2 EXISTING NATURAL/INDUCED DISCHARGES (E.G. SPRINGS/WETLANDS)

5.2.1 Groundwater flow direction appears to be north to southt, down the topographic dip of the strata towards the River Bure. There is a suspected spring emanating down-gradient of the area (TerraConsult, 2019), however, this can be risked out given the reported distance (approx. 875m) from the boundary of the site.

Surface Water

5.2.2 The site lies within the Nene Middle catchment and the river flows approximately 330m south of the site and therefore is considered to be a potential receptor. In addition, there are a number of lakes around the site which may be considered as potential receptors.

5.2.3 Any surface water generated by the restored landform will be conveyed into a formalised surface water management and drainage system as presented in the TerraConsult (2019) report and likely to comprise two suitably-sized infiltration basins.

6.0 QUANTITATIVE HYDROGEOLOGICAL RISK ASSESSMENT

6.1 THE NATURE OF THE ASSESSMENT

6.1.1 The proposed environmental permit application will be submitted for the site in order to receive inert materials. Given the definition of the inert wastes to be imported, the total leachability, pollutant content and ecotoxicity of any leachate generated are considered to be insignificant and unlikely to endanger the quality of any receiving environment.

6.1.2 In line with current legislation, inert landfills could be subject to a quantitative risk assessment process if a reduction in the specification of the Landfill Directive, Annex 1 “geological barrier”, would be considered and the receiving environment has been identified as being particularly sensitive.

6.1.3 In the case of the proposed geological barrier its specification, as set out in the Operating Techniques, will not be reduced therefore the receiving environment i.e. the limited areal extent of the underlying Lincolnshire Limestone is not affected. However, due to the sensitive nature of the receiving environment a quantitative risk assessment will be undertaken in order to consider the risk due to an accidental acceptance of a rouge load of materials.

6.1.4 The inert nature of the materials imported into the site will ensure that any leachate generated (both in terms of quality and quantity) is expected to pose a negligible risk to the receiving environment therefore has considerably lowered the sensitivity of the first component of the Source-Pathway-Receptor linkage.

6.1.5 The likelihood of accidents that could result in a potential impact would be during the operational phase of the excavation and infilling activities, when plant and machinery are used in those tasks. Any fuel tanks and oil drums used on the site and by sub-contractors will be stored in a containment bund capable of containing 110% of the total quantity of fuel present at any one time.

6.1.6 All fuel spillages from moving plant or machinery will be remediated immediately in a safe and controlled manner by ensuring spills kits are kept on site and checked daily. However, the risk is considered low and closely related to efficient site management and conscientious equipment and plant operators who will ensure lowering/minimising risk through a robust implementation of site procedures which are detailed in the Operating Techniques document accompanying this application.

6.1.7 A risk screening exercise has also been carried out in order to identify key contaminants potentially generated within the leachate and associated with the Waste Acceptance Criteria (WAC) to be adopted, in accordance with EU Council Decision 2003/33/EC.

6.1.8 The WAC parameters for inert waste used as key indicators substances are listed in Table 2 below. Equivalent leachability values for the inert WAC concentrations have been calculated using the methodology of C=A/10, where C is the contaminant concentration within the eluate (mg/l) and A is the leachate contaminant concentration within the soil sample (mg/kg).

Table 2: Inert WAC and Equivalent Leachate Quality

Substance	Leaching Limit (mg/kg) L/S=10l/kg	Leachate Concentration (mg/l)
Hazardous Substances		
Arsenic	0.5	0.05
Chromium VI*	0.5	0.05
Lead	0.5	0.05
Mercury	0.01	0.001
Non-hazardous Pollutants		
Antimony	0.06	0.006
Barium	20	2
Cadmium	0.04	0.004
Chloride	800	80
Copper	2	0.2
Fluoride	10	1
Molybdenum	0.5	0.05
Nickel	0.4	0.04
Selenium	0.1	0.01
Sulphate	1000	100
Zinc	0.4	0.04
Phenol Index**	1	0.1

* *Note: Chromium VI is a hazardous substance. However, the source term concentration taken from European Union Council Decision 2003/33/EC is for total chromium. It is conservatively assumed that all chromium is present as chromium VI and is therefore considered as hazardous.*

** *Note: Phenol Index is not a substance, so instead the chemical Phenol has been chosen.*

6.1.9 The equivalent leachate concentrations will be screened against the Compliance Limits as discussed and developed in the next section.

6.2 COMPLIANCE LIMITS

6.2.1 Although the site will accept inert materials, a set of Compliance Limits (CL) will still be required to form part of the Environmental Permit, since this is defined as a value set at the down gradient compliance points BH1 and BH 6, calculated to be a maximum concentration allowable at that point in order to protect the identified potential principal receptor i.e. groundwater.

6.2.2 It is proposed to set the CLs at the UKDWS (or EQS for freshwater in the absence of a UKDWS value, except where background quality exceeds the specified standard) for non-hazardous pollutants for the inert WAC indicator substances listed in Table 3.

6.2.3 For hazardous substances, the CLs will be set at the corresponding minimum reporting value (MRV) as defined in EA guidance – "Hazardous substances to groundwater: minimum reporting values" and UK Technical Advisory Group (UKTAG) – "Technical report on groundwater hazardous substances" or where background water quality exceeds the specified standard.

6.2.4 In the event that background quality exceeds the specified standards, the CL will be set at the maximum recorded concentration, following removal of outliers where necessary. Where background concentration is less than the corresponding environmental standard, the CL will be derived as the midpoint between the maximum concentration and the environmental standard. See Appendix C for their statistical derivations.

6.2.5 The compliance limits derived by the mean plus 3 times standard deviations (after stripping out any outliers) for the non-hazardous substances Cadmium, Chloride, Copper, Nickel and Selenium were compared with the original calculations and the lowest used.

6.2.6 The additional excel spreadsheet tabs have been added to Appendix C. This contains the raw data for the five substances requested by the EA. The "Outliers" tab shows the derivation of the new Compliance Limits based on the removal of outliers, according to the Grubb's graphical method, and the calculation according to the suggested statistical protocol of mean plus 3x standard deviation. The "Histograms" tab shows the normal distribution of the complete raw data (i.e. with outliers) plotted as histograms, which clearly show the suspicious nature of the maximum values that constitute outliers. Cadmium has been set at the laboratory's limit of detection (or equivalent if this value changes). These changes have been added to Table 3 below.

Table 3: Inert WAC and CLs

Substance	EQS (µg/l)	UKDWS (µg/l)	MRV (µg/l)	Max. conc. (µg/l)	Selected CL (µg/l)	Derivation of CL
Arsenic	20	10	5	NM	5	Minimum Reporting Value
Chromium VI	5	1	5	8	8	Maximum recorded concentration (as highlighted in Appendix C of Hydrogeological Risk Assessment)
Lead	20	10	0.2	<1	0.2	Minimum Reporting Value
Mercury	1	1	0.02	<0.01	0.01	Maximum recorded concentration (as highlighted in

						Appendix C of Hydrogeological Risk Assessment)
Antimony		5		NM	5	UK Drinking Water Standard
Barium		1,300		NM	1,300	UK Drinking Water Standard
Cadmium	5	5		0.008	0.008	Minimum Reporting Value
Chloride	250,000	250,000		49,000	104,000	Calculated at mean plus 3 x Standard deviation
Copper	1	2,000		1	3.75	Calculated at mean plus 3 x Standard deviation
Fluoride		1,500		NM	1,500	EQS
Molybdenum		70		MN	70	EQS
Nickel	4	20		1	4.9	Calculated at mean plus 3 x Standard deviation
Selenium		10		1	5.3	Calculated at mean plus 3 x Standard deviation
Sulphate		250,000		110,000	180,000	Midpoint between maximum recorded concentration and the EQS.
Zinc	12.3			15	15	Maximum recorded concentration (as highlighted in Appendix C of Hydrogeological Risk Assessment)
Amm N		500		1,200	1,200	Maximum recorded concentration (as highlighted in Appendix C of Hydrogeological Risk Assessment)
Phenol	7.7			NM	7.7	EQS

**NM denotes parameter not included in the monitoring of groundwater quality.*
***Cells coloured grey indicate no water quality screening or MRV available.*

6.2.7 It is noted that the limit of detection (LOD) for lead and mercury is greater than the UKTAG limit of quantification. The concentrations thus obtained are not above the LOD therefore the baseline LODs have been used as the CLs.

6.2.8 It is recommended these CLs be reviewed during the annual monitoring reporting procedure but also informally following each monitoring visit due to the specific environmental circumstances associated with the site once operational.

6.3 THE HYDROGEOLOGICAL RISK ASSESSMENT

6.3.1 Quantitative assessments are not typically requested for inert restoration sites as they fall outside the scope of the Groundwater Directive unless the proposed site is located within a setting which presents a risk to a sensitive receptor (i.e. Principal Aquifer or Secondary A Aquifer), in which case further consideration of risk due to the accidental acceptance of contaminated material is required.

6.4 PROPOSED ASSESSMENT SCENARIOS AND PRIORITY CONTAMINANTS MODELLED

6.4.1 The restoration of the site will be achieved by using inert waste materials which will be subject to a robust Waste Acceptance procedure during the entire operation.

6.4.2 An engineered geological barrier will be formed at the base of the void with sidewall liners. Both the geological barrier and sidewall liners will be will 1m in thickness with a minimum hydraulic conductivity of $1x10^{-7}$ m/s.

6.4.3 There will be no difference in the water balance or contaminant transport mechanisms and processed between the operational and post close phases. Therefore, a single lifecycle has been considered in the quantitative assessments. The models conservatively assume that the site is instantaneously filled and therefore the operational phase is not simulated. The model considers the post-completion phase.

6.4.4 As there is no cap or artificial sealing liner considered, there is no consideration of deterioration of these components by the risk model.

6.4.5 In addition to the above, a 'Rogue Load' Assessment has also been carried out, which simulates higher leachate concentrations resulting from a 'rouge' non-inert waste types being present in the waste mass.

6.4.6 WAC parameters for inert waste have been used as the key indicator substances to be modelled. Equivalent leachability concentrations for the Inert WAC values have been calculated in Table 2 (Section 6.1). The equivalent 'leachate' concentrations have been screened against the CLs which are outlined in Section 6.2. The concentrations which exceed the CLs (highlighted in orange) are detailed in Table 4 below.

Table 4: Inert WAC, Leachate Quality and CLs

Substance	Leaching Limit (mg/kg) L/S=10l/kg	Leachate Concentration (mg/l)	CLs (mg/l)
Hazardous Substances			
Arsenic	0.5	0.05	0.005
Chromium VI*	0.5	0.05	0.008
Lead	0.5	0.05	0.0002
Mercury	0.01	0.001	0.00001
Non-hazardous Pollutants			
Antimony	0.06	0.006	0.005
Barium	20	2	1.3
Cadmium	0.04	0.004	0.008
Chloride	800	80	104
Copper	2	0.2	0.0037
Fluoride	10	1	0.0015
Molybdenum	0.5	0.05	0.007

Nickel	0.4	0.04	0.0049
Selenium	0.1	0.01	0.0053
Sulphate	1000	100	180
Zinc	0.4	0.04	0.015
Phenol Index**	1	0.1	0.0077

6.4.7 In addition to Inert WAC limits, the Landfill Directive recommends using parameters for early indication of a change in quality. Ammoniacal Nitrogen (Amm N) will also be used within the model to determine the potential nature of the 'leachate' generated. The source term for Amm N has been assumed in the absence of a WAC limit. A value of 0.5mg/l has been applied in the model as the 'leachate' source which is the UKDWS for ammonium and therefore is considered to be a highly conservative assessment of 'leachate' quality for inert waste.

6.5 QUANTITATIVE RISK ASSESSMENT MODEL

6.5.1 The EA approved computer software LandSim (Version 2.5.16) is used to model the risks arising from the entire site on the groundwater system. This simulation package is considered valid for the quantification of the risks associated with the development as it uses a probabilistic approach to quantitatively assess potential hazards to receptors.

6.5.2 Analysis was undertaken on the basis of the following assumptions/criteria which are also applicable to this review process:-

1. The underlying groundwater table was assumed to be the primary receptor;
2. A declining source term was used to reflect flushing of contaminants from the waste by infiltrating precipitation;
3. Retardation or degradation of contaminants in the clay liner was modelled;
4. An aftercare period of 100 years is chosen to represent a reasonable timespan for the site to stabilise and ensure that it poses no environmental threat. During this period of long-term management, it is assumed that active control and management of the monitoring network will be carried as part of the permit;
5. The receptors for the purposes of the model are:-
    - Base of the unsaturated zone; and
    - A monitoring borehole located hydraulically down gradient at the site boundary.

6.5.3 Model defaults have only been used where site-specific data are unavailable and applied with a range of values wherever possible, rather than a single input. It is considered the approach to model the entire site as one single cell to be more conservative than using smaller individual cells as this would have a far larger impact on the environment.

6.5.4 Table D in Appendix D presents the model's input parameters, values and justifications for their applicability to the simulation.

6.6 LANDSIM MODEL RESULTS

6.6.1 The LandSim results in graphical format are presented in Appendix E.

6.6.2 The concentrations of the modelled Hazardous substances at the base of the unsaturated zone, as predicted by LandSim, are presented in Table 5, along with concentrations of the modelled Non-hazardous pollutants at the off-site down hydraulic gradient receptor (Table 6).

6.6.3 All results are reproduced at the worst case or 95th percentile since this level of confidence provides a robust factor of safety in the reporting of the simulated results.

Hazardous Substances

6.6.4 Table 5 and the LandSim plot confirm that the chosen indicator substances were not detected within the stipulated management period of 100 years.

Table 5: Predicted concentrations of hazardous substances at base of unsaturated zone within 100 years (95th percentile)

Parameter	Concentration at 100 years	Time to reach maximum concentration (years)	MRVs (mg/l)
Chromium VI	0.0003mg/l	192	0.008
Arsenic	0.0mg/l	248	0.005
Lead	0.0mg/l	790	0.0002
Mercury	0.0mg/l	1374	1e-5

Non-hazardous pollutants

6.6.5 The model predicts that the concentrations of the modelled Non-hazardous pollutants (Table 6) would not exceed their relevant CLs at the receptor point, with 95% probability and within the chosen management period of 100 years.

6.6.6 It is interesting to note that Amm N, antimony, barium, cadmium, nickel, and phenol concentrations at the 100 years management threshold occur after the reported peak of maximum concentrations. However, the maximum concentrations obtained were still within the chosen CLs.

Table 6: Predicted concentrations of non-hazardous pollutants at off-site receptor within 100 years (95th percentile)

Parameter	Concentration at 100 years (mg/l)	Time to reach maximum concentration (years)	CLs (mg/l)
Ammoniacal N	0.00018	13	1.2
Antimony	8.3e-5	100	0.005
Barium	0.08	70	1.3
Cadmium	0.0003	70	0.008
Nickel	0.002	74	0.0049
Selenium	0.0003	113	0.0053
Zinc	1.1e-5	480	0.015
Phenol	0.0006	88	0.0077

6.6.7 From the above results of the LandSim simulations it is concluded that the predicted discharges will remain in compliance with the requirements of the Groundwater Regulations, 2016, throughout the lifecycle of the installation.

6.7 SENSITIVE ANALYSIS

6.7.1 The nature of the material proposed for the restoration at the site is inert. The material is therefore unlikely to exceed the inert test criteria (Inert WAC Assessment) limits. It is expected that 'leachate' concentrations generated will be lower that the upper limits of the WAC threshold.

6.7.2 However, to assess the risk of 'rogue loads' being accepted at the site and as part of the sensitivity analysis model, simulations based on the maximum concentration of WAC source term inputs multiplied by a factor of 1.5 have been run. These upper limits have been used to define the source term inputs into the model 'leachate' inventory and are intended to provide a worst-case scenario as the model assumes that all waste deposited at the site is greater than the inert WAC.

6.7.3 The maximum simulated contaminant concentration of hazardous substances and non-hazardous pollutants are reported in Table 7 and Table 8 respectively, at the 'Phase Monitor Well' when the initial concentration of contaminants is increased to account for the acceptance of a rogue load at the site.

Table 7: Simulation of predicted concentrations of hazardous substances at base of unsaturated zone within 100 years after rouge load (95th percentile)

Parameter	Concentration at 100 years	Time to reach maximum concentration (years)	MRVs (mg/l)
Chromium VI	0.008mg/l	186	0.008
Arsenic	1.7e-5mg/l	517	0.005
Lead	4.8e06mg/l	580	0.0002
Mercury	4.9e-8mg/l	1152	1e-5

Table 8: Predicted concentrations of non-hazardous pollutants at off-site receptor within 100 years after rouge load (95th percentile)

Parameter	Concentration at 100 years (mg/l)	Time to reach maximum concentration (years)	CLs (mg/l)
Ammoniacal N	0.0008	25	1.2
Antimony	1.6e-4	135	0.005
Barium	0.08	66	1.3
Cadmium	0.00032	54	0.008
Nickel	0.0036	106	0.0049
Selenium	0.0004	125	0.0053
Zinc	1.4e-5	565	0.015
Phenol	0.001	88	0.0077

6.7.4 All of the simulated maximum concentrations, using rogue load 'leachate' concentration estimates as the source term, fall below their respective CL.

6.7.5 Maximum (95th%ile) concentrations increase when rogue load leachate concentration estimates were used as the source term, as expected, however it appears that the model is only moderately sensitive to contaminant concentrations changes at the source, when compared to the original values.

6.7.6 However, these elevated concentrations (which are above the inert WAC limits) have been applied across the entire source term. This indicates that the whole waste stream is no longer inert and therefore is highly conservative. Stringent precautions to ensure WAC are maintained will be in place at the site to limit any risk of exceedances.

7.0 REVIEW OF TECHNICAL PRECAUTIONS

7.1 REVIEW OF TECHNICAL PRECAUTIONS

7.1.1 A series of necessary technical precautions have been identified as part of this risk assessment, which will be reviewed during the life of the permit.

Capping

7.1.2 On completion of infilling to final waste levels, the installation will not require a capping system but the final landform will be restored with soil materials recovered during the preparation phase of the site.

Lining Design

7.1.3 The base and side slopes will have an engineered containment system, which has been risk assessed on the basis of the proposed design and according to the waste stream to be imported. Additional confidence in the robustness of these designs will be provided by the CQA supervision programme that will be implemented during the construction phases of each individual cell.

Leachate Head Control, Drainage and Extraction Systems

7.1.4 These operational controls will not be required as the installation is an inert landfill.

Groundwater Management

7.1.5 Given the difference in proposed basal level of the development and current average groundwater elevations it is not expected to counteract any groundwater inflow, especially when the stand-off of 1m unsaturated zone is to be maintained between the void's base and the top of the groundwater levels within the underlying Lincolnshire Limestone aquifer.

7.1.6 The operator will also ensure that any rainfall collected within the open void is managed as necessary. Site CQA supervision will also ensure that any potential heave encountered during construction works will be managed and that safe working conditions will be maintained.

Surface Water Management

7.1.7 A surface water management system has been proposed and will be installed around the perimeter of the site in the form of collection drains and any water generated will be conveyed into infiltration ponds located

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down-gradient of these ditches.

8.0 REQUISITE SURVEILLANCE

8.1 THE RISK BASED MONITORING SCHEME

Groundwater Monitoring

8.1.1 Groundwater level and chemical data are to be collected from the groundwater monitoring points shown in Drawing MGL-B027573-HYD-02.

8.1.2 The parameters to be sampled and monitoring frequency to be included in the Environmental Permit are presented in Table 9 below. These requirements are considered adequate in providing an ongoing characterisation of the groundwater conditions.

Table 9: Groundwater Determinants and Sampling Frequency

Monthly	Quarterly	Annually
Levels	pH, Chloride, Alkalinity, Amm N, Sulphate, Sodium, Potassium, Iron, Manganese, Cadmium, Chromium, Copper, Calcium, Nickel, Lead, Zinc, Electrical conductivity, Magnesium, Selenium, Cyanide, Arsenic, Mercury, Antimony, Barium, Fluoride, Molybdenum and Phenol	*To include quarterly suites plus:* Water soluble boron, Chromium IV, PAH and TPH.

Surface Water

8.1.3 Surface water run-off will be controlled and conveyed in accordance with the agreed Surface Water Management Plan.

8.1.4 The frequency and sampling suite to be implemented for the characterisation of surface water quality is presented in Table 10.

Table 10: Surface Water Determinants and Sampling Frequency

Quarterly
pH, Chloride, Amm N, Phosphorus, Suspended Solids, Sulphate, COD, Electrical conductivity, suspended solids, visual oils and grease

8.2 COMPLIANCE

8.2.1 Compliance limits are set for the chosen down-gradient boreholes, namely BH1 and BH6 and presented in Table 11.

8.2.2 The compliance limits for non-hazardous pollutants have been calculated following the statistical protocol outlined in Section 6.2.3 (see data sheet in Appendix C).

8.2.3 These limits can be applied to the proposed down gradient boreholes, as prescribed in the regulatory requirement in Agency's H1 guidance, Annex J3 since these down-gradient boreholes intersect the same geology.

Table 11: Proposed Environmental Assessment Limits

Substance	CLs (mg/l)
Hazardous substances	
Arsenic	0.005
Chromium VI*	0.008
Lead	0.0002
Mercury	0.00001
Non-hazardous pollutants	
Antimony	0.005
Barium	1.3
Cadmium	<0.008
Chloride	104
Copper	0.0037
Fluoride	0.0015
Molybdenum	0.007
Nickel	0.0049
Selenium	0.0053
Sulphate	180
Zinc	0.015
Phenol	0.0077

8.3 CONTINGENCY ACTION PLAN

8.3.1 An annual review of the proposed compliance limits should be carried out and any alterations in the compliance levels discussed and agreed with the EA.

8.3.2 Where the site monitoring programme identifies an increase in groundwater determinants that could lead to a breach, then a series of contingency actions will be required. Suggested contingency actions, which will need to be agreed with the EA, are presented in Table 12.

Table 12: Suggested Contingency Actions

Appropriate Contingency Action	Timescale
Advise Site Management	Immediately
Advise Operator's Environmental Manager	1 Week
Advise EA	1 Week
Confirm by repeat sampling and analysis	1 Month
Review existing monitoring information	1 Month
Review site management/operations, implement actions to prevent future failure of a compliance level	3 Months
Review assumptions in conceptual site model	3 Months
Review existing HRA Compliance Levels	6 Months
Consult EA about need for corrective action	6 Months

9.0 CONCLUSIONS

9.0.1 The proposed engineered containment for the inert landfill at the site (Little Paxton Quarry) complies with the requirements of the Landfill Directive.

9.0.2 Surface water runoff is to be controlled within a proposed set of perimeter ditches around the landform and gravity released to infiltration ponds down-gradient of the development.

9.0.3 The proposed installation will comply with current engineering design, materials, specifications and CQA protocols applicable to current landfill containment best practices.

9.0.4 An independent CQA procedure will be carried out for all aspects of the basal and sidewall lining construction. This ensures that the liner meets the required engineering standards and thus complies with the Landfill Directive and will not have an impact on the groundwater system.

9.0.5 The LandSim quantitative modelling has demonstrated that the proposed geological barrier will provide adequate containment of landfill 'leachate' to meet the requirements of Landfill Directive (1999/31/EC) and will provide sufficient attenuation to prevent a risk to the underlying strata and groundwater environment.

9.0.6 Compliance limits for groundwater have been derived and a robust monitoring network has been installed to ensure that the future performance of the site will be correctly managed.

9.0.7 The requirements of the Groundwater Regulations, 2016, have been satisfied by the inclusion of requisite surveillance of the groundwater quality to be carried out regularly as discussed in Section 6.

DRAWINGS

MGL-B027573-HYD-01 – Geological Cross Sections

MGL-B027573-PER-01 - Site Location and Permit Boundary

MGL-B027573-HYD-02 – Average Groundwater contours

MGL-B027573-HYD-03 – Maximum Groundwater contours

MGL-B027573-HYD-04 – Minimum Groundwater contours

G17-1-19-04 Revision C – Restoration Plan

APPENDICES

APPENDIX A – BOREHOLE LOGS

APPENDIX B – GROUNDWATER LEVEL DATA AND PLOT

APPENDIX C – GROUNDWATER QUALITY DATA AND PLOTS

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APPENDIX D – LANDSIM PARAMETERS

APPENDIX E – LANDSIM GRAPHICAL OUTPUTS