Harlestone Quarry Extension

Proposed Mineral Extraction and Restoration by Inert Landfilling

Hydrogeological Risk Assessment (HRA)

784-B043007

Issued to Mick George Limited

Document prepared by Tetra Tech Limited.

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1.0 INTRODUCTION

1.1 REPORT CONTEXT

This report has been prepared by Tetra Tech on behalf of Mick George Limited (Mick George) to support an environmental permit application for Harlestone Quarry (the site), Harlestone Rd, Northampton, NN7 4EW.

A quantitative Hydrogeological Risk Assessment (HRA) with groundwater modelling is required for a permit and planning approval due to the potential impacts of sub-water table working on the surrounding area. The permit is to be for the permanent extraction of Northampton Sandstone and backfilling with inert fill material to restore the excavated void.

This quantitative HRA has been prepared to evaluate the potential risks of the proposed development on local surface water and groundwater resources, as well as the wider surrounding environment. Through the development of hydrogeological modeling, opportunities for effective mitigation measures can be established and implemented.

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).

Due acknowledgement is made for specific background information used in this document which was obtained from S M Foster Associates SMF report: Hydrogeological Impact Assessment, April 2023 parts of which are repeated here for completeness.

This report is subject to the Terms and Conditions presented within Appendix A.

2.0 ENVIRONMENTAL SITE SETTING

2.1 SITE LOCATION

Harlestone Quarry is located approximately 5.4km northeast from the Northampton city centre of Northampton. The site is centred at approximate National Grid Reference (NGR) SP 70652 63914, accessed via an existing quarry entrance off the A428.

This application relates to an extension to the west of the original quarry site. The site location plan can be viewed in Figure 1, appended to this report. A surface area of approximately 7.90ha incorporates both the application area and access road.

The immediate surroundings of the site comprise predominantly of woodland to the southeast and open agricultural land to the west with a residential property and road infrastructure just north of the proposed site. The original quarry which has been restored on the site is adjacent to the north-eastern and south-eastern boundaries of the proposed site.

2.2 SITE HISTORY

The south of the application site is located adjacent to an authorised inert landfill, Harlestone Quarry (Reference EPR /WP3235SN/A001).

Furthermore, the site is adjacent to the historic quarry, located to the north-west, which was in operation from 1880-1990 and was deemed disused in the 1930s.

The former Harlestone Quarry, located to the east of the proposed extension area, was worked to the base of the Northampton Sand Formation and subsequently restored by infilling with inert waste materials to establish a landform close to pre-extraction ground level being completed in 2016.

The proposed extension would be established to the west of the restored area with mineral extracted to the base of the Northampton Sand Formation. The extension area would be accessed via the existing quarry access road from the A428 Harlestone Road.

2.3 PROPOSED DEVELOPMENT

The proposed development involves the importation of inert waste to infill and restore the quarry void that will be created following mineral extraction activities. Works will be completed in accordance with the restoration scheme (Appendix B). It is expected that the site will be completed withing four years.

2.4 STATUTORY DESIGNATIONS

There are no scheduled monuments or listed buildings in the immediate vicinity of the site, but a farmhouse with accompanying buildings and stables is located directly to the north.

There are three environmental designations within 8km of the site, but Defra Magic mapping indicates that there are no statutory or non-statutory groundwater dependent ecological or landscape designations or features within a 1 km radius of the Site. A summary of environmental designations within the surrounding area to the application site shown on 'MAGIC map' is replicated at Table 2-1 below.

Table 2-1: Summary of Environmental Designated Sites

Name	Designation	Reason for designation	Distance
Bugbrooke Meadows	SSSI	Never been ploughed or had chemical fertilizers applied creating low fertility soil which supports over 60 varieties of wildflowers and insects.	6.4km SW

Storton's Pits	LNR	Important wetland for birds and insects.	4.4km SE
Kingsthorpe	LNR	Green corridor home to many species of dragonfly and damselfly.	3.8km E

2.5 TOPOGRAPHY

Ordnance Survey mapping of the area indicates that existing ground level at the Site ranges from a maximum of 105 mAOD at the western boundary to a minimum of approximately 100 mAOD at the eastern corner. In general, ground level on surrounding land reduces in north easterly and easterly directions towards shallow stream valleys.

2.6 GEOLOGY

2.6.1 Published Geology

The published geology of the area has been sourced from British Geological Survey (BGS) paper mapping and online digital mapping.

Areas of 'Artificial Ground' (made up, infilled or worked ground) are shown to be absent within the site boundary and local area. However, it is known that the site has old landfill sites to the northwest, south and east. These previously worked sites may possibly have had an effect on both the groundwater flow patterns and quality within/ beneath and adjacent to the site.

Superficial deposits are shown not to be present within the site boundary, although deposits of Glacial Till are shown to be present to the south-west of the site, and deposits of Alluvium are present to the north-west.

The bedrock geology of the site is shown to be the Northampton Sandstone Formation, which consists of sandy ironstone, greenish grey when fresh and weathering to an oxidised brown colouration where exposed. The unit includes lenses of mudstone and limestone in places.

The Northampton Sand is underlain by the Whitby Mudstone, which comprises medium and dark grey fossiliferous mudstone and siltstone, with occasional thin siltstone or silty mudstone beds and rare fine-grained calcareous sandstone beds.

Geological mapping of the area indicates the presence of Rutland Formation mudstone and the overlying Blisworth Limestone Formation on higher ground to the southwest of the application Site. The two watercourses to the east and northeast of the application Site both flow on the Whitby Mudstone Formation, which forms the base of each valley, below outcrop of the Northampton Sand Formation.

2.6.2 Historic Borehole Records

The BGS borehole records that are present within 1km of the site are presented in Table 2-2.

Table 2-2: Summary of Borehole Records within ~1km radius of the Site (BGS, 2023)

Licence No.	Name	Depth (m)	Grid Reference	Direction from Site
SP76SW113	HARLESTONE 30	11	470410 264010	0.3km E
SP76SW121	HARLESTONE 46	5	470530 263800	0.3km SW
SP76SW115	HARLESTONE 35	7	470820 263770	0.2km S
SP76SW116	HARLESTONE 37	8	470888 263777	0.2km SE
SP76SW108	HARLESTONE 25	12	471020 263860	0.2km SE

SP76SW114	HARLESTONE 31	10	470740 263520	0.4km S
SP76SW111	HARLESTONE 28	18.89	470450 263270	0.8km SW
SP76SW109	HARLESTONE 26	14	471330 263370	0.8km SE

The records detailed above are brief, do not provide any information on water strikes, and appear to relate to historic shallow mineral proving investigations to prove the depth and thickness of ironstone within the Northampton Sand Formation.

2.6.3 Site Investigation Data

A total of 6 no. monitoring boreholes (BH1 to BH6) were installed around the perimeter of the site in February 2022 and their logs are shown in Appendix C. These boreholes were rotary drilled with intention of finding the groundwater within the Northampton Sand and find the base of the Northampton Sand and the top of the Whitby Mudstones. These boreholes provided basic geological and hydrogeological information as well as indicating the depths of exploitable minerals. The boreholes demonstrate a predominate presence of ironstone and sandstone, although grey mudstones indicative of the Whitby Mudstone was proved in several boreholes.

It is also noted that the groundwater within the Northampton Sands at times seems to coincide with the top of the Whitby Mudstones (particularly in BH3). Following discussions with the EA it has been decided to only use four of these boreholes for the conceptual model for the site (BH1 and BH6 upstream and BH3 and BH4 downstream of the site). Tetra Tech can confirm that the groundwater levels and geochemistry under the site is extremely consistent between the boreholes and they are monitoring the same aquifer.

Table 2-3: Interpretation of borehole logs

Location	Location GL (mAOD)	Topsoil and Weathered bedrock		Northampton Sand		Whitby Mudstone	
		Depth to base (mbgl)	Base Level (mAOD)	Depth to base (mbgl)	Base Level (mAOD)	Depth to base (mbgl)	Base Level (mAOD)
BH01	105.22	0.80	104.42	16.50	88.72	ne	ne
BH03	104.39	0.60	103.79	15.40	88.99	16.50*	87.89
BH04	102.01	0.50	101.51	13.00	89.01	13.50*	88.51
BH06	102.78	0.40	102.38	12.00	90.78	ne	ne

* denotes base not proven ne denotes not encountered

Sandstones and ironstones of the Northampton Sand were encountered at depths of 0.40 to 0.80mbgl, beneath weathered bedrock. The Whitby Mudstone was encountered at depths of 13.20 to 15.40mbgl, or 88.99 to 92.02mAOD.

2.7 HYDROLOGY

The Site is situated within the surface water catchment area of the River Nene which flows west to east approximately 6 km to the south-east. Surface water drainage in the vicinity of the Site occurs via a series of small tributary watercourses. Site hydrological survey and local topographic data indicates that the proposed extension area is currently drained by a field drainage system running along the south-eastern Site boundary and flowing eastwards through the restored quarry area, to flow beneath the A428 and along the north western boundary of Harlestone Heath. The watercourse passes beneath a railway line approximately 1 km downstream before joining a tributary of the River Nene at the northern side of Northampton.

A second watercourse (unnamed but referred to here as Harlestone Brook) flows south-west to north-east through the village of Lower Harlestone approximately 600 m to the north of the Site. The watercourse flows in a shallow valley from a small reservoir at the western side of Lower Harlestone, past Mill Farm, and joins the Harlestone Heath watercourse at the railway culvert. FEH catchment models indicate that, at the railway culvert, the two watercourses drain a catchment area of 7.21 km^2.

Land to the south of the Site drains in a south easterly direction towards Dallington Brook, another tributary of the River Nene. At the A428 crossing, the brook drains a catchment area of 4.2 km^2. The only other surface water features in the vicinity of the Site are the small reservoir at Harlestone and a small mill pond near to Mill Farm. There are several mapped springs within a 1.5 km radius of the Site.

Geological mapping indicates that surface watercourses in the area are underlain by the low permeability Whitby Mudstone Formation which is present below the Northampton Sand Formation in the area; literature sources indicate that springs commonly develop at the junction between the Northampton Sand and the underlying Whitby Mudstone. However, as there are three different landfills surrounding the site it seems unlikely that springs will be present in the immediate vicinity. The nearest spring is shown on OS mapping to be located approximately 1km to the north-west at 'Mill Farm'.

2.8 HYDRGEOLOGY

2.8.1 Aquifer designation

The Northampton Sand Formation is designated a Secondary A Aquifer by the Environment Agency. The Whitby Mudstone is designated as Unproductive Strata by the Environment Agency.

2.8.2 Aquifer Properties

Groundwater flow in the Northampton Sand Formation is a combination of matrix and fracture flow. Where weathered, the formation is very porous, as the cement has been leached out. As a result, groundwater movement occurs by both intergranular and fracture flow, whereas in the lower unoxidised sandstones groundwater movement is predominantly via fracture flow. Therefore, the sands form the more reliable aquifer at shallow depths (generally less than 10 m) beneath the ground surface or superficial deposits. Generally intergranular flow predominates except where fractures are well developed.

The vast majority of argillaceous Whitby Mudstone typically acts as an aquitard, with limited amounts of groundwater flow and storage occurring within the formation, although where fractured or fissured some groundwater may be present. This is likely to be the case at the very top of the Whitby Mudstone at this site and why some of the aquifer actually occurs on or near the top of the Whitby Mudstones.

2.8.3 Protected Areas

The proposed development is not located within a Groundwater Source Protection Zone and does not fall within any surface water drinking protected areas (MAGIC).

2.8.4 Licensed Abstractions

There are two licenced groundwater abstractions within 1 km of the Harlestone Quarry application site area.

The closest groundwater abstraction to the site is operated by DF Cooch Manor Farm for farming and domestic usage (5/32/03/G/0005). The other licensed groundwater abstraction nearby the site is recorded for Landry usage by E&RS Page Ltd (5/32/04/G/0012).

Table 2-4 - Licensed Abstractions

License No.	Owner	Source	Distance	Use
5/32/03/G/0005	DF Cooch, Manor Farm	Groundwater	420m NE	Farming & domestic
5/32/03/S/0103	Northampton Golf Club	Surface, Harlestone Lake	600m S	Spray irrigation
5/32/04/G/0012	E&RS Page Ltd	Groundwater	920m NE	Laundry Use

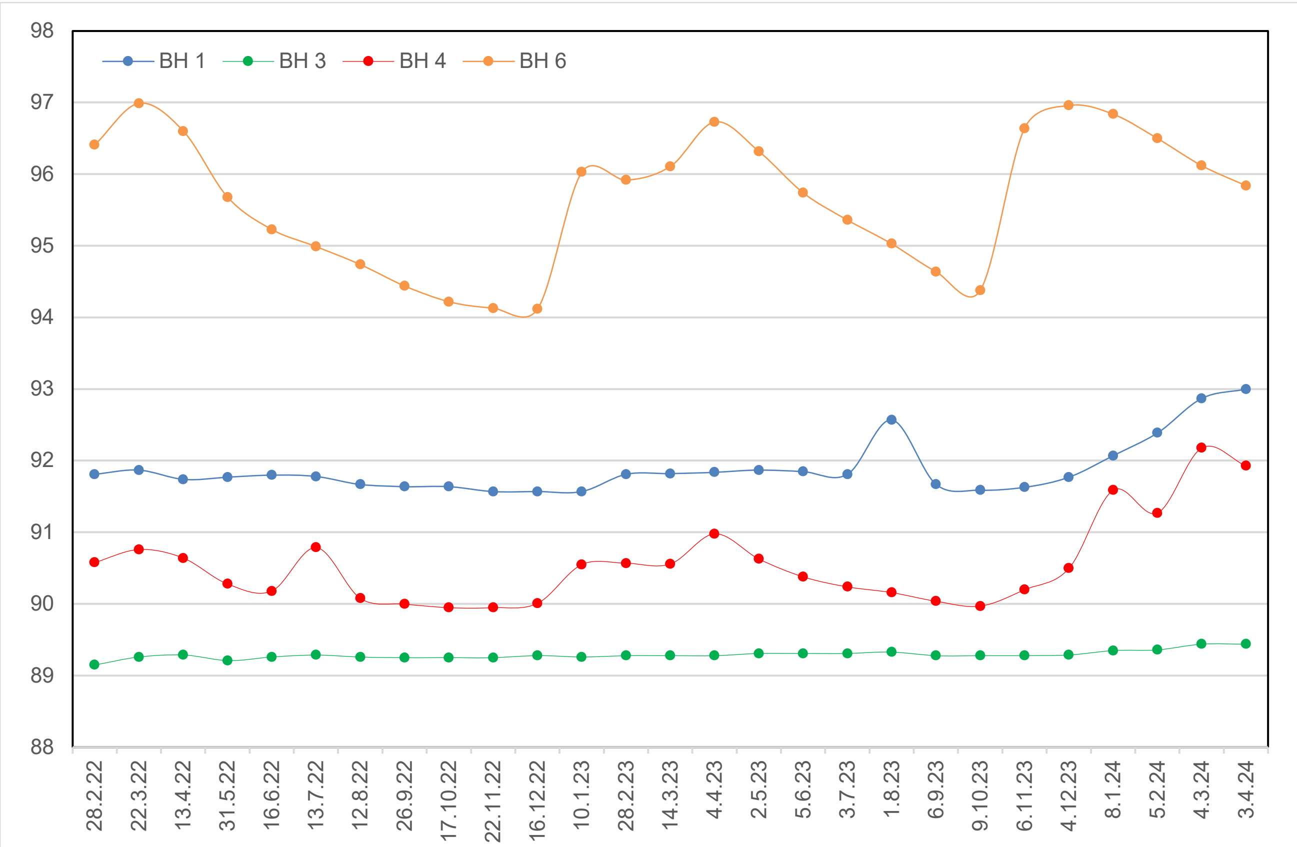
Of the two licenced groundwater abstractions, one (5/32/03/G/0005) is down-gradient of the application Site and the other (5/32/04/G/0012) is up-gradient of the application Site. Both abstractions are from boreholes in the Northampton Sand Formation.

There are no groundwater source protection zones (SPZ) around either groundwater abstraction borehole, but a water quality protection zone with nominal 50 m radius is often assumed.

2.8.5 Groundwater Levels

Monitoring boreholes at the Site demonstrate the presence of groundwater towards the base of the Northampton Sand Formation, above the Whitby Mudstone. Groundwater levels at the Site have been monitored since February 2022. The results between February 2022 and April 2024 are shown graphically in Insert 2-1.

Insert 2-1 - Groundwater Hydrograph



Groundwater monitoring data demonstrates that, with the exception of Borehole BH6, groundwater levels across the Site have shown small amounts of seasonal variation during the monitoring period. BH6 which is located at the south eastern Site boundary, show more significant seasonal variability with a range of up to 3m. This may be related to lower aquifer transmissivity within the aquifer surrounding this borehole, which can lead to greater seasonal water level variations.

S M Foster Associates Limited utilised groundwater level data from October 2022 to construct groundwater contours for the Site, which can be viewed in Appendix D. Available evidence indicates that groundwater flowing through the lower sections of the Northampton Sand Formation beneath the application Site discharges as baseflow to Harlestone Brook, located towards the north-west and north-east of the Site.

More localised groundwater contours, produced by Mick George based off the February 2022 to April 2024 data can be viewed in Appendix D Drawing 204A, along with the base of mineral contour plans. These contours demonstrate a groundwater flow direction to the north-east with a hydraulic gradient that reduces in a down-gradient direction.

2.8.6 Groundwater Quality

Groundwater quality sampling has been conducted since February 2022 from the four boreholes located around the perimeter of the site, with data up until April 2024 available for review, presented in Table 2-5. The full dataset can be viewed in Appendix E.

Concentrations have been screened against Threshold Screening Values (TSV), which comprise the minimum of the UK Drinking Water Standard (DWS) or Environmental Quality Standard (EQS) for the substance. For the hazardous substances cadmium, lead and mercury, the Minimum Reporting Value (MRV) is the TSV.

Monthly groundwater quality analysis demonstrates the intermittent presence of trace quantities of some hazardous substances in groundwater flowing beneath the Site; lead and cadmium were above the MRV on three occasions, and mercury on 11 occasions. Trace quantities of hazardous metals are predominantly found in groundwater at BH01 which is located at the north western Site boundary, approximately 200 m from the restored former quarry working to the south east of the Site.

Exceedance were noted against the TSV for heavy metals including copper, nickel and zinc on numerous occasions. Manganese concentrations were persistently elevated from February 2022 until December 2022, but have declined since this time; this may be due to post drilling disturbance and oxidation of the ironstones.

Overall, metal detections in excess of the TSV within groundwater is likely to be related to groundwater flow through the ironstone formations.

Although former mineral workings to the east and south east of the Site have been infilled and restored, there is no hydrogeochemical evidence to indicate the presence of any significant anthropogenic contamination of groundwater beneath the Site. This is highlighted by the instance that when the parameters are screened against only the Drinking Water Standards, only 40 exceedances are detected in total, 31 of which are for manganese prior to December 2022.

Table 2-5 - Groundwater Quality Screening

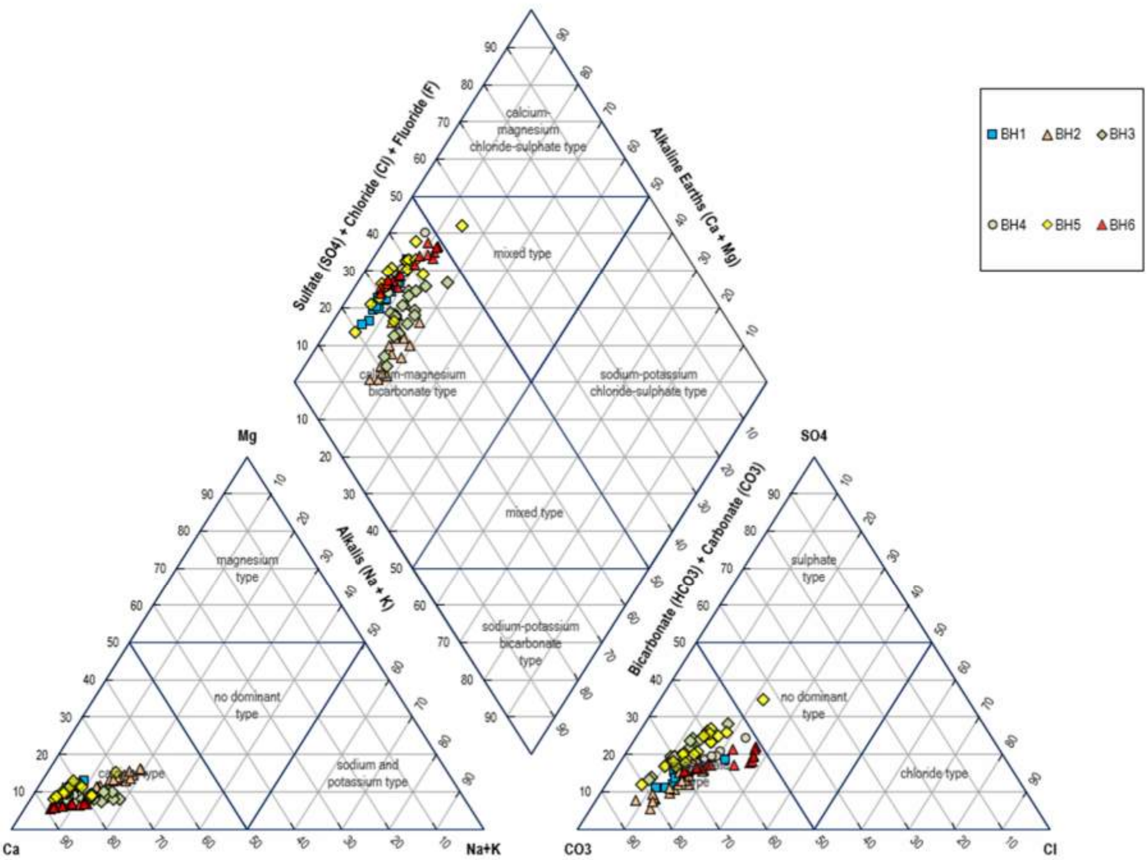
Parameter	Units	MRV	EQS	UKDWS	TSV	No. >LOD	Exceedances	Min	Mean	Max
Electrical Conductivity	µS/cm					106	N/A	170	617.59	1400
Alkalinity (Total)	mg/l					106	N/A	24	222.18	550
Chloride	mg/l			250	**250.00**	106	None	0.00	29.34	39.00
Ammonia (Free)	mg/l					4	N/A	0.05	0.09	0.14
Ammoniacal Nitrogen	mg/l			0.5	**0.50**	70	7	0.05	0.32	1.90
Sulphate	mg/l			250	**250.00**	106	None	7.40	46.31	81
Calcium	mg/l			250	**250.00**	106	None	2.30	85.13	240
Potassium	mg/l			12	**12.00**	106	None	0.60	4.96	25
Magnesium	mg/l			50	**50.00**	106	None	3.00	33.61	270
Sodium	mg/l			200	**200.00**	106	None	0.00	11.22	30
Cadmium (Dissolved)	µg/l	0.1		5	**0.10**	3	3	0.00	1.58	2.80
Chromium (Dissolved)	µg/l			50.00	**50.00**	91	1	0.51	4.28	59.00
Copper (Dissolved)	µg/l		1.00	200.00	**1.00**	64	33	0.51	1.46	6.50
Iron (Dissolved)	µg/l			200.00	**200.00**	27	None	0.60	23.15	170
Manganese (Dissolved)	µg/l			50.00	**50.00**	100	31	0.54	31.21	330
Nickel (Dissolved)	µg/l		4.00	20.00	**4.00**	103	18	0.00	2.37	27
Lead (Dissolved)	µg/l	0.20	1.20	10.00	**0.20**	3	3	0.00	3.84	7.10
Selenium (Dissolved)	µg/l			10.00	**10.00**	37	None	0.50	0.78	3.30
Zinc (Dissolved)	µg/l		10.90	5000.00	**10.90**	75	17	0.04	8.99	43.00
Mercury Low Level	µg/l	0.01	0.07	1.00	**0.01**	11	11	0.01	0.05	0.33

*Note – the calculation of minimums and averages in the table above is for laboratory detections only, and does not include results where the reported concentration was less than the limit of detection

There have been discussions with the EA regarding the fact that the groundwater around the site seems to lie both in the Northampton Sands and the Whitby Mudstones and whether there are in fact two different water bodies under the site. Geochemical analyses have been carried out by Tetra Tech that shows that the groundwater chemistry within the boreholes at site is uniform, regardless of the screened Formation.

For example, electrical conductivity is consistent in the boreholes, averaging 639µs/cm. Major ions, when plotted on a piper graph, shown no separate groupings; groundwater samples are generally of the Ca/Mg bicarbonate type and plot closely. If two groundwater bodies were present within two differing Formations, with markedly different lithologies, it would be expected that the boreholes would display different groundwater chemistries.

Insert 2-2 – Piper Graph



Groundwater levels between the boreholes are also consistent, with groundwater contours replotted for March 2022 and April 2024 and there is no evidence of two separate potentiometric surfaces which would indicate separate groundwater bodies. See Drawing Number 204A.

3.0 CONCEPTUAL SITE MODEL

3.1 CSM OVERVIEW

This section sets out our Conceptual Site Model (CSM), which describes the potential contaminant sources / ground conditions associated with the proposed inert landfill, the receptors upon which contaminants could potentially have an impact and also pathways that may exist to allow contaminants to impact upon the identified receptors.

The CSM development has focussed on characterising the hydrogeological model for groundwater beneath the site, both in its current condition and post restoration of the site following further sand extraction and then infilling with inert materials. A conceptual understanding of the hydrogeological regime in the vicinity of Harlestone Quarry and the proposed restoration has been derived from an assessment of published and site-specific information.

To assess the potential impact of any contamination identified at the site on groundwater receptors, a risk assessment has been progressed. For a risk to be present at the site, three components must exist:-

- Contaminant(s) must be present at concentrations capable of causing adverse effects on groundwater (Source);
- There must be exposure migration pathway by which the receptor encounters the contaminant (Pathway); and
- A groundwater dependent receptor must be present, (Receptor).

The source-pathway-receptor scenario is used to generate a conceptual site model (CSM), which can be used to identify potentially significant pollutant linkages, to inform the decision whether a more detailed quantitative analysis of risk is required. The first stage of the process is to determine the presence or absence of any contaminant(s) of concern (source) at the site, followed by the most likely pathways that these contaminants would take in the environment and finally the potential receptors of concern.

A graphical CSM of the hydrogeological situation at the site, originally produced by S M Foster Associates Limited for the HIA, can be viewed in Figure 2.

3.2 SOURCE TERM CHARACTERISTICS

3.2.1 Waste Types

It is proposed to complete the restoration with inert material as defined in Article 2 of the Landfill Directive 1999/31/EC as follows:-

'Inert waste' means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will 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. The total leachability and pollutant content and the ecotoxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water and/or groundwater. Table 4-1 lists those wastes that may be accepted at the site which do not require Waste Acceptance Criteria (WAC) testing under Council Decision (2003/33/EC), provided that they are inert and from a single source only (mixed loads from more than one site cannot be accepted without testing).'

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 19th December 2002 'establishing criteria and procedures for the acceptance of waste landfills…' and are set out in Table 3-1.

Table 3-1 - Accepted Waste Types

EWC Code	Description
17	**CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOILS FROM CONTAMINATED SITES)**
17 01	**Concrete, Bricks, Tiles And Ceramics**
17 01 01	Concrete
17 01 02	Bricks
17 01 03	Tiles And Ceramics
17 01 07	Mixtures Of Concrete, Bricks, Tiles And Ceramics Other Than Those Mentioned In 17 01 06
17 05	**Soil (Including Excavated Soil From Contaminated Sites) Soil And Dredging Spoil**
17 05 04*	Soil And Stones Other Than Those Mentioned In 17 05 03
20	**MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES INLCUDING SEPARATELY COLLECTED FRACTIONS**
20 02	**Garden And Park Wastes**
20 02 02	Soil And Stones

Table 3.1.1: Proposed Waste Types that will Require WAC Testing

EWC Code	Description
01	**WASTES RESULTING FROM EXPLORATION, MINING, QUARRYING AND PHYSICAL AND CHEMICAL TREATMENT OF MINERALS**
01 04	**Wastes From Physical And Chemical Processing Of Non-Metalliferous Minerals**
01 04 08	Waste Gravel And Crushed Rocks Other Than Those Mentioned In 01 04 07
01 04 09	Waste Sand And Clays
19	**WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS AND PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION / INDUSTRIAL WASTE**
19 12	**Wastes From The Mechanical Treatment Of Wastes**
19 12 09	Minerals (For Example Sand, Stones)

Any suspected non-compliant material will not be accepted onto site and will be dealt with in accordance with the Sites Waste Acceptance Procedures.

3.2.2 Leachate Generation

Due to the inert nature of the material to be used to restore the quarry, it is considered highly unlikely that water encountering the material will generate high concentrations of pollutants. The operator will make sure that this is the case by restricting the source waste materials allowed on to the site and by adopting stringent Waste Acceptance Procedures. Hazardous substances are not expected to be present and non-hazardous substances are expected to be very low with respect to the background groundwater quality.

The decline in leachate concentrations is controlled by water inputs to the fill material at the site. The site is to be restored progressively in a phased approach and therefore will be open to rainfall infiltration. Rainfall falling on the inert materials will either run-off over the waste and be subject to evapotranspiration and / or infiltrate through waste mass as effective rainfall. The annual average rainfall (1981-2010 annual average) for the site is 650mm/year. Effective rainfall to the site is estimated to be approximately 325mm/year.

Effective rainwater which does infiltrate through the capping topsoil and subsoil will migrate vertically through the inert waste materials. Leachate generated will be subject to attenuation and retardation processes.

Given the inert nature of the emplaced materials and reference to EA guidance 'Standards and Measures for the Deposit of Inert Waste on Land', it is not necessary to manage and monitor leachate at sites which comprise the recovery or disposal of inert waste. The site will fall outside the scope of the EPR 2016 (as amended) and therefore, no leachate management and monitoring are proposed for the site.

3.2.3 Leachate Contaminants of Concern

Waste types listed above are assumed to meet the definition of inert waste. The standard WAC threshold values for inert landfills and the equivalent leachate quality are summarised in Table 3-2 for ease of reference.

Table 3-2 – Waste Stream & Inert WAC Limit Leachate Quality

Pollutant	WAC Inert Limit (mg/kg to 10 l/kg)*	Equivalent Leachability (µg/l)	EQS (µg/l)	UKDWS (µg/l)
Arsenic	0.5	**50**	50	10
Barium	20	**2,000**	-	700
Cadmium	0.04	**4**	0.15	50
Chromium	0.5	**50**	4.7	-
Copper	2	**200**	1	2,000
Mercury	0.01	**1**	0.07	1
Molybdenum	0.5	50	-	70
Nickel	0.4	**40**	4	20
Lead	0.5	**50**	1.2	10
Antimony	0.06	**6**	-	5
Selenium	0.1	10	-	10
Zinc	4	**400**	14**	-
Chloride	800	80,000	-	250,000
Fluoride	10	1,000	-	1,500
Sulphate	1000	100,000	-	250,000
Phenol	1	**100**	7.7	-

*Limit values (mg/kg) for compliance leachate testing using BS EN 12457-3 at L/S 10 l/kg
**Zinc 10.9µg/l + 3.1µg/l in accordance with 2015 Environmental Quality Standards (EQS) Guidance.
Text in bold **green** text highlights an exceedance of the UKDWS
Text in bold **orange** text highlights an exceedance of the EQS

This view that 10: L:S ratio tests are useful for establishing waste mass behaviour is supported by the Environment Agency (2013) report1 on waste sampling and testing for disposal to landfill (page 27), which states:-

'…*for most wastes destined for disposal in landfill sites government consider that a single step leaching test at a Liquid to Solids (L:S) ratio of 10:1 l/kg is adequate for establishing and monitoring the cumulative mass leached and general leaching behaviour*'.

Equivalent leachability concentrations for the Inert WAC values have been calculated and screened against EQS/UKDWS. The derived leachability values for the below pollutants exceed the screening values:-

- Arsenic;
- Barium;
- Cadmium;
- Chromium;
- Copper;

[1] Environment Agency, Waste Sampling and Testing for Disposal to Landfill EBPRI 11507B,I March 2013.

- Mercury;
- Nickel;
- Lead
- Antimony;
- Zinc; and,
- Phenol

Please note that the inert WAC limit values represent the maximum values (worst case scenario) and the majority of imported waste is expected to be significantly below these levels. It is considered that a risk assessment based upon a source term set at the inert WAC limits will be highly conservative.

3.3 PROPOSED LANDFILL ENGINEERING

Stripped and stored soils will then be spread over the infill to allow the intended agricultural after use.

3.3.1 Artificial Geological Barrier

Prior to the commencement of landfilling following extraction of the Northampton Sands, the condition of the basal mudstone will be inspected by the CQA Engineer to ensure that there are no continuous cracks, fractures or fissures and if proven then a liner will be deemed unnecessary. However, if it is not found to be suitable, a artificial barrier will be created using reworked Whitby Mudstones or imported waste materials to allow for the removal / repair of localised fissures and cracks.

This geological barrier will be constructed in compliance with the Environmental Permitting Regulations and will have a hydraulic conductivity of less than 1m at 1 x 10^{-7} m/s or its direct equivalent of 0.5m at 5 x 10^{-8} m/s. Full detail of the proposed repair schedule to be included in the CQA Plan.

A clay side slope liner will be constructed from on-site materials or suitable waste against a suitable 1 in 2.5 subgrade slope. The liner will have a horizontal crest width of 1m from the edge of the formation and be constructed at a slope of 1 in 2.5. 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. The clay barriers will be engineered as soon as possible after extraction commences. However, they cannot be constructed until the base of the gravel is reached with the result that there could be short-term drawdown effects on adjoining areas.

3.3.2 Capping

In accordance with the requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required. Therefore, on completion of infilling, the site will be restored with c. 1m of previously stripped low permeability restoration soils and no less than 0.30m of topsoil.

3.3.3 Restoration and Aftercare

Upon completion of the restoration works, it is envisaged that the final topographical contours will compliment that of the surrounding landscape. The site is be restored in line with the restoration sections, contours and plans presented in Appendix B.

As detailed in the restoration scheme the site is to be restored to conservation grassland, native scrub, broadleaved woodland and a small seasonal wetland.

The operator will undertake a topographical survey of the site, referenced to ordnance datum, both prior to commencement of the recovery activity and on completion of the recovery activity.

Aftercare will be undertaken for a period of 5 years in accordance with an aftercare scheme that will be submitted to Northamptonshire County Council (NCC) for approval.

An annual site meeting between Mick George and NCC will be undertaken to review the performance of the aftercare scheme for that year to ensure that the programme of aftercare arrangements is employed. The meeting shall also provide an opportunity for the Northampton County Council to agree alterations to the aftercare works for the following 12 months and these shall thereafter be implemented. Furthermore, annual review meeting will be held with the Mineral Planning Authority, during which the previous year's operations will be discussed and the proposals for the following year presented for approval.

Any amendments to the aftercare steps will be agreed in writing between Mick George and NCC.

3.4 PATHWAYS

A conceptual understanding of the hydrogeological regime in the vicinity of the Site has been derived from an assessment of both published and site specific information.

The Site is mapped as being underlain by the Northampton Sands, a Secondary A Aquifer. This is underlain in turn by the Whitby Mudstone Formation. The Northampton Sandstone has been proven to be partially saturated in its lower part, just above the Whitby Mudstone, which is generally unproductive.

Upon completion of excavation works, the Northampton Sands hard rock mineral resource will have been removed, leaving underlying residual Whitby Mudstone.

3.4.1 Groundwater Levels

The regional watercourse network is assumed to receive baseflow from the Northampton Sand. Groundwater flow is thought to be broadly to the north-east.

Groundwater flow within the Northampton Sand is primarily via intergranular flow (primary flow), with some secondary flow occurring within fractures and fissures.

Measured groundwater levels within perimeter boreholes indicate that the saturated thickness of the Northampton Sands at the site ranges from around 4m in the south-west, to around 0.50m in the north-east (see Appendix D). Drawing Number ENG-01 shows the configuration of site post extraction and filling confirming this.

As detailed within the S M Foster Associates Hydrogeological Impact Assessment, dewatering will be required towards the base of the workings. Assessment of dewatering impacts upon local groundwater dependant receptors has been assessed within the HIA. However, once dewatering ceases it is expected that the lower part of the inert waste mass will lie beneath the water table.

As such, the main pathway for contamination out of the inert waste mass will be laterally through the sides of the filled void, and into the residual saturated Northampton Sands.

3.4.2 Baseline Groundwater Quality

Baseline hydrogeological analysis has demonstrated that the quality of groundwater in the Northampton Sand Formation aquifer in the vicinity of the Site is generally good and generally consistent with UKDWS, with the exception of intermittently elevated concentrations of some hazardous and non-hazardous substances.

When compared with EQS, there are exceedances for serval heavy metals; however, the presence of such substances in natural groundwater is likely to be related to groundwater flow through ironstone formations.

3.5 RECEPTORS

The following are considered to represent potential receptors for any leachate generated from the proposed infilling at Harlestone Quarry:-

(i) Groundwater present in the Northampton Sand Formation;

(ii) Licenced groundwater abstractions down-gradient of the Site; and

(iii) Local surface watercourses via groundwater baseflow.

The predominantly argillaceous Whitby Mudstone Formation is classed as unproductive and it is assumed that its presence will limit the downward transmission of contaminants to any deeper aquifer units. Therefore, the Whitby Mudstone and any deeper aquifers are not considered further as a receptor in the assessment.

3.6 CONCEPTUAL HYDROGEOLOGICAL SITE MODEL SUMMARY

The conceptual site model for the site is summarised below:-

- The primary potential source of concern is considered to be the import of inert material which will be used to restore the quarry void;
- Given the inert nature of the fill material, it is considered that there is a very low potential for generating significant volumes of leachate and pollutant concentrations. This can be ensured by the adoption of strict compliance with Waste Acceptance procedures at the site;
- The quarry will be dewatered whilst worked, but following the cessation of mineral extraction it is expected that groundwater levels will rebound and the inert was mass will be partially saturated at its base;
- Contaminants from the site will be able to migrate laterally through the sides of the site into the remaining Northampton Sands, which is classified as a Secondary A Aquifer. The site is not located within a groundwater source protection zone (SPZ);
- It is not thought that contaminants will be able to migrate through the basal Whitby Mudstone Formation;
- Groundwater flow is anticipated to be towards the north-east, primarily via intergranular flow through the Northampton Sands, providing baseflow to water courses and a groundwater abstraction to the north of the site;
- The proposed restoration material is expected to consist of inert material and consist predominantly of lower permeability imported material. The void is to be restored to conservation grassland, native scrub, broadleaved woodland and a small seasonal wetland;
- No engineered capping layer is proposed;
- The site will use the Whitby Mudstones as the basal lining; as stated in section 3.3.1, the condition of the basal Whitby Mudstone will be inspected by a CQA Engineer prior to infilling, and any discontinuities repaired with low permeability material;
- An engineered Artificial Geological Barrier (AGB) will be utilised for the side wall liner, constructed using low permeability material. 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;
- The site will be subject to effective rainfall infiltration and groundwater throughflow via the residual Northampton Sand aquifer at the edge of the site; however, due to the saturated thickness of the aquifer being quite low, contaminant flux into the aquifer is expected to be minimal;
- Following restoration, groundwater levels within the remaining Northampton Sand present around the sides of the quarry are anticipated to rebound to pre-quarrying levels;
- Infiltration incident on the site is expected to percolate through the capping soils and inert soil waste mass, generating dilute leachate. As the inert fill is likely to mainly consist of lower permeability clay rich soils, there will be some ‘doming’ of groundwater within the inert fill, leading to radial flow outwards from the restored site. This is discussed in more detail within the water balance section of this report (Section 4.7);
- The two main mechanisms for chemical interaction between the (contaminant mass concentration) inert material below the water table is through the initial mixing (dilution) of the waste pore water and groundwater throughflow. Later diffusion of contaminants leaching from the waste material into the adjacent aquifer may occur; and

- The most sensitive receptor with respect to the proposed development is considered to be groundwater immediately downgradient of the site, within any remaining Northampton Sand aquifer.

3.7 DETERMINATION OF COMPLIANCE LIMITS (CLS)

The setting of Compliance Limits (CLs) is necessary to ensure the protection of controlled water receptors that exist beyond the site boundary. Since this is defined as a value set at the down gradient compliance points BH3 and BH4, calculated to be a maximum concentration allowable at that point in order to protect the identified potential principal receptor i.e. groundwater. Five indicative substances had been chosen for this purpose: Amm N, Chloride, Nickel, Sulphate and Lead. The CLs have been set as follows:-

- For the hazardous substance (Lead), the CL will set at the figure the EA has given us previously (0.0006 mg/l as with similar permit applications approved recently); and
- For Non-Hazardous Pollutants the EALs have been derived using the protocol of the mean plus 3 plus 4 or plus 5 times standard deviations using the average data from the boreholes for Amm N, Chloride, Sulphate and Nickel as follows:

Action limits have also been added into this table at the request of the Environment Agency. The selected CLs for the modelled hazardous and non-hazardous contaminants are summarised below.

Table 3-3 - Selected CLs

Substance	Action Limits (mg/l)	Selected CL (mg/l)
Chloride	37	43
Amm N	0.54	0.89
Sulphate	68	77
Nickel	0.006	0.008
Lead	0.0006	0.0006

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.

4.0 QUALITATIVE HYDROGEOLOGICAL RISK ASSESSMENT

4.1 INTRODUCTION

The hydrogeological risk assessment has been carried out using conservative assumptions regarding the source, pathways and receptors. Site specific data have been used wherever possible to parameterise the risk assessment.

As discussed in Section 2, the quarry void at the site is proposed to be restored using inert material. Based on the definition of inert waste, the site 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.

However, notwithstanding this, a risk assessment is required for an inert landfill where the receiving environment is particularly sensitive, for example where waste is located below the water table or a direct pathway exists to a sensitive surface water receptor.

4.2 PROPOSED ASSESSMENT SCENARIO

One assessment scenario is necessary for the site, namely the closure of the site following the completion of the infilling activities. The modelling for the site considered the impact for all phases of the site in conjunction.

4.3 RISK ASSESSMENT MODEL

The site conceptual model has been developed based on quantifying contaminant migration from a source along each possible pathway identified. This follows the Agency's recommended approach to landfill risk assessment (Environment Agency, 2010b). This approach has been implemented in a site specific spreadsheet model based on Stantec's (formerly ESI's) commercial software package RAM3 (Risk Assessment Model v3).

This software uses a spreadsheet model to solve a water balance for the site, considering as many distinct regions as required. The source of contaminant is then defined in terms of a contaminant inventory and the release of contaminants from the inventory has been quantified in a contaminant mass balance, leading to a declining source term. An advantage of the RAM software is that this contaminant mass balance can address several distinct pathways to receptors.

ESI benchmarked a number of groundwater risk assessment tools for the Agency and used a similar approach to benchmark RAM (ESI, 2001). Additionally, the equations used in RAM have been verified by comparison between direct evaluation of an analytical solution and the semi-analytic transform approach applied for more complex pathways, and by comparison with published solutions used for verification as part of the nuclear waste industry code comparison exercise INTRACOIN (Robinson and Hodgkinson, 1996).

In the case of Harlestone Quarry, RAM is used to address pathways of potential contaminant migration laterally out of the sides of the site to the Northampton Sand, into the adjacent groundwater body. The MRVs, UK DWS and freshwater EQS were used as EAL's for the groundwater and surface water compliance points respectively, as described in Section 3.7. The simple risk assessment model constructed is based on a Level 3 risk assessment (Environment Agency, 2006), which accounts for dilution in groundwater and for attenuation, dispersion, decay and retardation.

4.4 SOURCE DEFINITION

The volume of restoration soils within the site at the time of completion is estimated to equal approximately 530,000m^3. Assuming a conversion factor of 1.6 tonnes/m^3, this is equivalent to 848,000 tonnes. It is expected that the site will be completed withing four years.

Landfill Directive compliant inert material is currently accepted at the site, and a large portion of the site has already been infilled. With inert material, by definition, the pollutant content of the material and any resultant leachate must be insignificant and not endanger the quality of groundwater.

4.5 THE PRIORITY CONTAMINANTS TO BE MODELLED

The representative contaminants that are modelled in the assessment are as follows:-

- Chloride;
- Ammoniacal Nitrogen;
- Cadmium;
- Chromium;
- Nickel;
- Lead;
- Copper; and
- Mercury.

4.6 MODEL ASSUMPTIONS

There are a number of general assumptions made which simplify the model:-

- For the sake of simplicity and clarity the thickness of the inert restoration material is averaged across the Site, at 15m; and
- It is assumed that the entire material mass is present at the start of the simulation. Since filling of the site will be progressed over several years, the actual source term will begin to decline during this time and will subsequently be smaller than that represented in the model by the time filling is complete, which thus represents a conservative approximation of the system.

4.7 WATER BALANCE

The various fluxes into and out of the Site are estimated in the model using a water balance approach. The model calculates the fluxes as described below:-

- Rainfall will fall onto the ground surface, where a proportion will infiltrate the restoration soils and the balance will run off;
- Infiltration to the restoration soils will be subject to evaporation and use by plants (transpiration). These two processes are often jointly referred to as evapotranspiration. During the summer the evapotranspiration demand may be higher than rainfall, whereas during the winter the rainfall may be greater than evapotranspiration. For this reason, in summer all of the rainfall is usually accounted for by evapotranspiration, whilst during the winter months there is excess water which percolates downwards deeper into the soil zone. Within this deeper zone, there may be lateral movement of this water due to local heterogeneity. This lateral flow will ultimately infiltrate into the Northampton Sand aquifer at the site perimeter. The remaining water will percolate further down into the inert restoration material;
- The inert restoration material is likely to be less permeable than the surrounding aquifer. As the low permeability Whitby Mudstone lies beneath the site, it is likely there will be a ‘doming’ of water within the inert restoration material due to recharge to the site and discharge at the sides. Water may cross the boundary of the site through the up and down gradient sides, and potentially through the lateral sides of the site if the leachate head remains high enough. Depending on the leachate level, this flux

may be either into or out of the site. The direction and quantity of flow will be determined based on the relative head difference between the leachate in the site and groundwater in the surrounding aquifer;

- If the leachate head in the site does not rise to ground level, then all the effective rainfall will be able to infiltrate the inert restoration material and the outflow from the Site must balance the inflow. In this case, there is no runoff from the Site surface;
- Any water running off the Site surface is considered to infiltrate the aquifer at the Site perimeter and will act to dilute any contamination that migrates out the sides of the Site. As a conservative measure, this dilution is not taken into account in the HRA; and
- If the leachate head in the site rises above ground level run-off will occur. This is not leachate breakout overflowing from the site; rather it is excess recharge ('rejected recharge') that is not able to infiltrate the inert restoration material. As such this water will be clean. The outflow from the site thus reaches a maximum value controlled by the hydraulic gradient between the site and the surrounding groundwater and the hydraulic conductivity of the inert restoration material and base and sides.

4.8 REPRESENTATION OF THE WATER BALANCE

4.8.1 Inflitration

The infiltration flux for each phase is calculated from the recharge rate (effective rainfall (ER)) multiplied by the surface area of the phase. Recharge is assumed to be 100% of the effective precipitation:-

Qinf = ER x Area

4.8.2 Flux Through Sides

For the up and down hydraulic gradient edges of each of the phases, the combined flux out of the two faces is calculated as follows:-

Qup/down = [(hl – hgw / (W/2)) x Kwaste x L x SatThick] x 2

And, for the remaining sides of each of the phases, the combined flux out of the two faces is calculated as follows:-

Qside = [(hl – hgw / (L/2)) x Kwaste x W x SatThick] x 2

Where:-

- hl = leachate head in phase;
- hgw = groundwater head outside phase;
- Kwaste = hydraulic conductivity of waste;
- L = Length of site (perpendicular to groundwater flow);
- W = width of site (parallel to groundwater flow); and
- SatThick = saturated thickness of Northampton Sands aquifer.

Flux through the base of the site is assumed to be zero, due to the presence of the Whitby Mudstone Formation.

The total flux out of the site (Qpath total) is equal to the sum of the fluxes out of the sides of the site. Or, if this value exceeds the infiltration flux, then Qpath is limited to the infiltration. This is included in the model using the following logic:-

Qpath = min(Qinf, (Qup/down + Qside + Qbase))

4.8.3 Dilution

If the conditions are such that the permeability of the strata around the restored site leads to more water entering the source by infiltration, than is able to leave via the sides or base, this will result in surface runoff. This is calculated as follows:-

Qrunoff = Qinf - Qpath

This runoff will contribute to dilution between the source and receptors, re-entering the aquifer through the permeable soils. Conservatively, this dilution has not been incorporated in the model, although the ratio and amount of rejected recharge is presented within the water balance worksheet of each model.

4.8.4 Potential Receptors

The potential receptors for any leachate generated from the proposed infilling at Harlestone Quarry identified from the site conceptual model are as follows:-

- Groundwater present in the adjacent Northampton Sand following extraction of the mineral (Secondary A Aquifer);
- The groundwater abstraction located approximately 420m north of the site; and
- Surface watercourses present to the north of the site, which are likely to be fed by groundwater within the Northampton Sand.

To provide a conservative assessment for the Site on potential impact on groundwater and surface water receptors, the compliance point for non hazardous substances within the assessment has been set at 50m downgradient of the landfill, and for hazardous substances has been set at a nominal 5m downgradient distance.

4.9 MODEL PARAMETERISATION

4.9.1 Site Geometry

Table 4-1 - Site Geometry

Description	Value	Data Source / Justification
Surface Area	62,100 m^2	From surveyed plans, measured in GIS
Typical thickness of fill in Northampton Sand	15 m	Average estimated from site plans and sections
Length parallel perpendicular to groundwater flow	275 m	From surveyed plans, measured in GIS
Width perpendicular to groundwater flow	225 m	From surveyed plans, measured in GIS
Proportion of leachate that would freely drain from the soil source	30%	From Beavan, 1996; Robinson 1996.
Hydraulic conductivity of restoration soils	$5x10^{-6}$ m/s	Assumed value for inert material
Average elevation of worked base of site	89 mAOD	Estimated from site sections and survey plans
Maximum leachate head before overtopping occurs	104 mAOD	Average of Restoration Contours

4.9.2 Source Term Values

Source term values have been set to pore water concentration equivalent to the inert WAC leachability limits, converted to mg/l. This is highly conservative assumption, as it assumes that all material within the site will be at the Inert WAC limit, with the exception of Ammoniacal Nitrogen.

Ammoniacal nitrogen is not detailed in Section 2.1.2.1 of Council Decision 2033/33/EC but has been included in case small quantities of wood or other biodegradable material are accidentally placed into the Site. Although biodegradable material will not be deliberately disposed of at the Site, it is possible that some residual biodegradable material may be placed. Therefore, it is possible that some degradation products, such as ammoniacal nitrogen, may be produced. The value of 1mg/L is considered to be a high value for the generation and leachability of ammoniacal nitrogen from inert wastes and is therefore conservative.

Table 4-2 – Source Term Values

Pollutant	WAC Inert Limit (mg/kg to 10 l/kg)*	Source Term Value – Pore Water Concentration / Equivalent Leachability (mg/l)
Cadmium	0.04	0.004
Chromium	0.5	0.05
Mercury	0.01	0.001
Nickel	0.4	0.04
Copper	2	0.2
Chloride	800	80
Ammoniacal Nitrogen	-	1

4.9.3 Pathway Definition

For the saturated pathway, the parameters given in Table 4-3 are used for modelling.

Table 4-3 - Aquifer Parameters

Description	Northampton Sand	Units	Data Source
Unit Thickness	12.1	m	Average proved in BH's.
Mean Groundwater Head	2.42	m	Average of site data
Hydraulic gradient	0.012	-	Average of GW contours.
Porosity	0.30	-	Minor Aquifer Properties handbook suggests is high for a sandstone. Max of ConSim suggested range for a sandstone.
Hydraulic Conductivity	1.16×10^{-4}	m/s	Based on transmissivity data from Minor Aquifer Properties handbook.
Tortuosity	5	-	Mid of range for sands and clays (Marsily, 1986)
Dry bulk density	2.10	kg/m^3	Midpoint of ConSim suggested value for sandstone.
Mixing Depth	2.42	m	Assumed to be full thickness due to thin saturated zone (<10m, as per RTM)
Mixing Width	225	m	Width perpendicular to groundwater flow

4.9.4 Contaminant Specific Parameters

Contaminant specific parameters have typically been selected from ConSim suggested values, with values suggested for low FOC selected when available.

Table 4-4 - Selected retardation parameters

Parameter	Kd (L/kg)	Justification
Cadmium	74	ConSim Suggested Value
Chromium	67	ConSim Suggested Value
Mercury	450	ConSim Suggested Value
Nickel	400	ConSim Suggested Value
Copper	295	ConSim Suggested Value
Chloride	0	ConSim Suggested Value
Ammoniacal Nitrogen	1.25	ConSim Suggested Value

For the organic contaminant ammoniacal nitrogen, ConSim suggested values were utilised for the KoC and FoC (in the aquifer). Aerobic half-life in groundwater was sourced from a 2003 EA publication[2].

Table 4-5 - Contaminant parameters for Ammoniacal Nitrogen

Parameter	Value	Unit	Justification
Half life	1278	days	Mid value given in Buss et al., 2003
KoC	1	L/kg	ConSim Suggested value, sand
FoC in Aquifer	0.007	fraction	Midpoint of ConSim Suggested value, sandstone

4.9.5 Receptor Definition

The parameters below were used to model the receptors. The receptor was set as a groundwater monitoring borehole set 50m downgradient of the site for non hazardous contaminants, and a nominal 10m downgradient of the site for hazardous contaminants.

Table 4-6 - Parameters for receptors applied in the model

Description	Value	Justification
Distance to receptor (Non Hazardous Contaminants)	50m	Protective of GW downgradient of site.
Distance to receptor (Hazardous Contaminants)	10m	Non discernible at site boundary
Dispersion	10% of pathway length	-

[2] Buss, S.R., Herbert, A.W., Morgan, P. and Thornton, S.F., 2003. Review of ammonium attenuation in soil and groundwater. NGWCLC report NC/02/49. Environment Agency.

4.10 MODEL RESULTS

The model was run deterministically using the input parameters defined in previous sections. An electronic copy of the model is included in Appendix H.

The model is run for a maximum time period of 1,000 years. This is significantly longer than the time period that is likely to be required to achieve permit surrender and is considered to be a conservative upper time limit for an inert simulation.

The results of the risk assessment model for the groundwater receptors for non-hazardous and hazardous contaminants are shown in Table 4-7 and Table 4-8, respectively.

These tables present the predicted combined concentration at the receptors at 1, 5, 10, 50, 100 and 500 and 1,000 years, compared with the applicable EAL.

Table 4-7 - Predicted concentrations, non hazardous contaminants, 50m receptor

Pollutant Linkage: Restoration Soi, Northampton Sand, Groundwater Receptor

Concentrations in mg/L in Groundwater Receptor

Compared with EAL target concentration in mg/L

Time(years)	Species1 **Chloride**	Species2 **Amm N.**	Species3 **Chromium**	Species4 **Nickel**	Species5 **Copper**
EAL	1.445E+02	7.000E+00	5.900E-02	2.700E-02	6.500E-03
5	8.852E-01	1.035E-02	5.602E-04	4.768E-04	4.676E-03
10	5.990E-01	7.002E-03	3.790E-04	3.227E-04	3.164E-03
50	2.633E-02	3.078E-04	1.666E-05	1.419E-05	1.391E-04
100	5.299E-04	6.194E-06	3.353E-07	2.855E-07	2.799E-06
500	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1000	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Table 4-8 - Predicted concentrations, hazardous contaminants, 10m receptor

Pollutant Linkage: Restoration Soi, Northampton Sand, Groundwater Receptor

Concentrations in mg/L in Groundwater Receptor

Compared with EAL target concentration in mg/L

Time(years)	Species1 **Cadmium**	Species2 **Mercury**
EAL	1.000E-04	2.000E-04
5	4.345E-05	1.104E-05
10	2.940E-05	7.467E-06
50	1.292E-06	3.282E-07
100	2.601E-08	6.606E-09
500	0.000E+00	0.000E+00
1000	0.000E+00	0.000E+00

Predicted concentrations within are predicted to remain below the contaminants respective EALs. The majority of contaminants break though relatively quickly to groundwater at the site, but the presence of the side wall liner limits the contaminant flux which can enter the Northampton Sands aquifer.

5.0 REQUISTE SURVEILLANCE

The requisite surveillance for groundwater and surface water that is considered necessary and appropriate for the site is presented in the following sections. A comprehensive monitoring infrastructure is currently in place such that no additional monitoring boreholes are required.

5.1 GROUNDWATER MONITORING

A comprehensive monitoring infrastructure is currently in place such that no additional monitoring boreholes are required. The monitoring boreholes BH03 and BH04 are present on the downgradient side of the Harlestone Quarry site and borehole BH1 and BH06 are present on the upgradient side.

The proposed routine groundwater monitoring proposed is presented in Table 5-1.

Table 5-1 - Proposed groundwater monitoring schedule

Monitoring Location	Parameter	Frequency
Downgradient Boreholes BH03 and BH04 Upgradient Borehole BH01 and BH06	Groundwater level (mAOD), pH, Electrical Conductivity, Alkalinity, Chloride, Ammoniacal Nitrogen, Sulphate, Calcium, Potassium, Magnesium, Sodium, Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Lead, Selenium, Zinc, Mercury Low Level	Quarterly

5.2 SURFACE WATER MONITORING

There are no surface water features in the immediate vicinity of the quarry which are thought to be in hydraulic continuity with groundwater, and therefore surface water monitoring is not proposed.

5.3 CONTROL AND COMPLIANCE LIMITS

Compliance Limits for groundwater are proposed within Table 5-2. Quantitative modelling of the site predicts minimal breakthrough of contaminants to groundwater. However, since baseline groundwater monitoring was commenced at the site in February 2022 there have been detections of contaminants within groundwater, including some trace detections of hazardous substances. The compliance limits for the site are therefore based upon the baseline groundwater monitoring dataset for the site.

Table 5-2 - Groundwater Compliance Limits

Substance	Action Limits (mg/l)	Selected CL (mg/l)
Chloride	37	43
Amm N	0.54	0.89
Sulphate	68	77
Nickel	0.006	0.008
Lead	0.0006	0.0006

6.0 CONCLUSIONS

This report presents an assessment of the hydrogeological regime at Harlestone Quarry as the basis of a risk assessment. The assessment uses an accurate model of the relevant flow mechanisms and contaminant transport theory and is based on detailed knowledge of the hydrogeology and hydrology of the area surrounding the proposed restoration site.

A conceptual model of Harlestone Quarry was developed through the interpretation of data in the vicinity of the site to provide detailed information on the local geology, hydrogeology and hydrology. A conceptual model has been formulated for the site, and a number of possible source, pathway, receptor linkages have been identified.

The quantitative risk assessment approach is presented, along with data input parameters. A simple risk assessment model was constructed. The model considers the fate of the leachate determinands derived in the source along the transport pathway and the effects of attenuation, decay, retardation, dispersion and dilution.

6.1 COMPLIANCE WITH THE ENVIRONMENTAL PERMITTING REGULATIONS (ENGLAND AND WALES) 2016

Compliance of the Harlestone Quarry site with the relevant parts of the Environmental Permitting Regulations 2016 (as amended) is discussed in the following sections.

6.1.1 Accidents and their consequences

In the event of the site contributing unacceptable contamination to the groundwater the source should be capped to reduce rainwater infiltration. However, given the quantities of listed substances expected to be placed at the site, this is considered an unlikely requirement.

6.1.2 Acceptance of Simulated Contaminants

It is conceivable that the recovery materials may unintentionally contain substances not acceptable by sites classed as inert, in spite of strict waste acceptance criteria being adhered to. The HRA shows that, even if small quantities of non-hazardous substances were tipped at the site, all simulated contaminants are predicted to be present at low concentrations at environmental receptors.

Therefore, the risk assessment model predicts that non-hazardous substances from the Site will not impact on the wider groundwater or surface water environment.

6.1.3 Compliance Limits

Technical precautions including requisite surveillance and proposed compliance limits have been proposed for the site. Groundwater control and compliance limits are presented and are based on observed background groundwater quality data for the site.

6.1.4 Groundwater quality

The risk assessment model shows that the Harlestone Quarry is unlikely to impact upon the groundwater quality or the quality of the surface water.

The maximum concentrations that may result from Harlestone Quarry are based on a theoretical source term. Given that the actual source term concentrations in the site are likely to be much smaller than simulated here, as strict adherence to the Waste Acceptance Criteria and Procedures will be applied, the actual resultant concentrations are likely to be much lower. It is considered extremely unlikely that a breach of the EP Regulations will occur.

The HRA has demonstrated that the input of hazardous and non hazardous substances into groundwater would be prevented. Therefore, the Site complies with the requirements of Schedule 10 of the Environmental Permitting Regulations (2010).

Figures

Figure 1 - Location Plan

Figure 2 Original Site Conceptual Model

Appendices

Appendix A: Standard Terms & Conditions

This report is produced solely for the benefit of Mick George and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site. This report is based on a visual site inspection, reference to accessible referenced historical records, information supplied by those parties referenced in the text and preliminary discussions with local and Statutory Authorities.

Some of the opinions are based on unconfirmed data and information and are presented as the best that can be obtained without further extensive research. Where ground contamination is suspected but no physical site test results are available to confirm this, the report must be regarded as initial advice only, and further assessment should be undertaken prior to activities related to the site. Where test results undertaken by others have been made available these can only be regarded as a limited sample. The possibility of the presence of contaminants, perhaps in higher concentrations, elsewhere on the site cannot be discounted.

Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, being subject to risk analysis, we are unable to give categoric assurances that they will be accepted by Authorities or Funds etc. without question as such bodies often have unpublished, more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to WYG. In time, improved practices or amended legislation may necessitate a re-assessment.

The assessment of ground conditions within this report is based upon the findings of the study undertaken. We have interpreted the ground conditions in between locations on the assumption that conditions do not vary significantly. However, no investigation can inspect each and every part of the site and therefore changes or variances in the physical and chemical site conditions as described in this report cannot be discounted.

The report is limited to those aspects of land contamination specifically reported on and is necessarily restricted and no liability is accepted for any other aspect especially concerning gradual or sudden pollution incidents. The opinions expressed cannot be absolute due to the limitations of time and resources imposed by the agreed brief and the possibility of unrecorded previous use and abuse of the site and adjacent sites. The report concentrates on the site as defined in the report and provides an opinion on surrounding sites. If migrating pollution or contamination (past or present) exists further extensive research will be required before the effects can be better determined.

Appendix B – Restoration Plan

Appendix C – Borehole Logs

Appendix D – Groundwater Contours From SM Foster & Up to date Tetra Tech Data Engineering Drawing

Appendix E – Groundwater Quality Dataset

(DIGITAL APPENDIX ONLY)

Appendix F – RAM3 Model Files

(DIGITAL APPENDIX ONLY)