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environmental water management

HYDROGEOLOGICAL RISK ASSESSMENT

COLSTERWORTH TRIANGLE QUARRY

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GENERAL NOTES

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1 INTRODUCTION

1.1 Report context

The site referred to as Colsterworth Triangle is located on Crabtree Lane at Stainby, Lincolnshire, NG33 5BH. It comprises a currently operational limestone quarry, which is nearing completion, and an Environmental Permit is required for its restoration using inert fill.

The site is owned and operated by Construction and Environmental Services Limited (CESL). An Environmental Permit Application, EPR/KB3207FH/A001, for restoration using inert fill was submitted by GPP on behalf of CESL in 2021 and this was Duly Made on 19th November 2021. Following a Schedule 5 Notice issued by the Environment Agency in July 2022, a revision to the Hydrogeological Risk Assessment (HRA) was produced by RSK. In October 2022 the Environment Agency issued its initial comments on the revised reports and confirmed that the Conceptual Site Model (CSM) was not yet sufficiently robust; a review of the CSM and monitoring data, amongst others, was requested. It was decided at this time to withdraw the application and revisit the CSM and monitoring at the site.

It is now intended to re-apply for a permit for importation of inert fill as a landfill under the Environmental Permitting (England and Wales) Regulations (EPR) (2016). No waste has been placed at the site historically. The Permit Application is being prepared by GPP Ltd on behalf of CESL.

Hafren Water has been requested to prepare a new HRA report, which sets out the background and revised baseline understanding in support of a new Permit Application for restoration of the site. This is version 2 of the new HRA incorporating Environment Agency comments made during the 'Duly Making' process.

The report has been divided into two parts; Part 1 presents the revised CSM and sets out the environmental baseline of the site. The conceptual model forms the basis of the assessment of the impact of the proposed infilling on the environmental baseline. The baseline is defined as the current situation and does not necessarily reflect natural conditions.

Part 2 provides an analysis of the potential hazards associated with the proposed infilling in a Hydrogeological Risk Assessment (HRA).

The format of Part 1 is based upon the Environment Agency on-line guidance entitled 'What to include in your environmental setting and site design report" and "Plan the environmental setting of your site" dated 30th January 2020, as updated 17th January 2024. Part 2, the HRA, has been prepared with due regard to the 'What to include in your hydrogeological risk assessment' guidance as updated 17th January 2024.

1.2 Previous reports

The following reports and documents have been reviewed as part of this risk assessment:

- Greenfield Environmental Ltd, January 2024. Stainby Quarry Stability risk assessment report (CES/STQ/01 v3)
- Greenfield Environmental Ltd, January 2020. A Geotechnical Assessment Review of Stainby Quarry Nr Colsterworth, Lincolnshire
- RSK, July 2022. Hydrogeological Risk Assessment, Colsterworth Triangle Quarry, Stainby, Lincolnshire. Report ref: 302280-R01(0)
- GP Planning Ltd, November 2021. Environmental Setting and Site Design, Inert Landfill Permit. Colsterworth Triangle Quarry
- Environment Agency, 26/05/2022. (Schedule 5) Notice of request for more information, The Environmental Permitting (England & Wales) Regulations 2016. Application number: EA/EPR/KB3207FH/A001
- Environment Agency, 14/10/22. EA/EPR/KB3207FH/A001 Colsterworth Triangle Quarry (Stainby) email response to Schedule 5 submissions dated 20th and 30th June 2022, provided by Lucy Snape, Groundwater Specialist (Onshore Oil and Gas)

1.3 Other sources of information

- McDonnel Cole, September 2019. Hydrogeological Risk Assessment Review, Colsterworth Landfill, Granthan, Lincolnshire. Ref 1739-01
- Sirius Environmental. December 2021. Environmental Permit Variation Application Hydrogeological Risk Assessment. Ref: WR7600/07.R1
- Sirius Environmental. December 2020. Environmental Setting and Installation (ESID) Revision Hydrogeological Risk Assessment. Ref: WR7600/06

PART 1: CONCEPTUAL HYDROGEOLOGICAL SITE MODEL

2 SITE DETAILS AND CONTEXT

2.1 Site location

The site is located two kilometres (km) west of Colsterworth village, 1 km south of Skillington village and 2 km north of Stainby village as shown on *Drawing 3601/HRA/01*. The site occupies a triangle of land between Crabtree Road to the north and Woolsthorpe Road to the south. Colsterworth Landfill site, operated by FCC, abuts the eastern boundary of the site with an intervening promontory of exposed limestone, which has a face height of approximately 21 metres (m). A disused railway embankment, with a mature planted hedge interspersed with mature trees, lies between the southern site boundary and Woolsthorpe Road.

2.2 Site classification

It is proposed to restore the site back to pre-existing ground levels using inert waste under a landfill permit.

2.3 Application boundary

The site layout and proposed direction of working is shown on *Drawing 3601/HRA/02*. The proposed permit boundary covers the worked-out area west of the FCC Landfill and totals approximately 4.3 hectares (ha). The site is accessed off Crabtree Road to its northeast.

2.4 Landform

The site lies in an area of general low rolling relief. The highest elevation in the area, 158 metres Above Ordnance Datum (mAOD), is at Buckminster, west of the site. Ground elevations decline in all directions but most steeply towards the valley of Cringle Brook, north of Buckminster. Nearer to the site, a local high of 130 mAOD occurs on Skillington Road, to the southeast of the FCC landfill with ground elevations declining to approximately 100 mAOD in the Cringle Brook valley to the northwest.

Within the site, the elevation of the base of the void declines eastward from approximately 128 mAOD to approximately 120 mAOD, based on the 2019 topographical survey and LiDAR data. It is noted that further limestone extraction and extraction of some Grantham Formation mudstone for use in the site's geological barrier has occurred since the survey in 2019.

2.5 Surrounding land use

The environmental site setting is provided in the ESSD report prepared by GPP Planning and is summarised in the table below, which forms an extract from the ESSD report.

3601/HRA/T1: Summary of land uses	
Receptor	**Distance/direction from site**
Local Wildlife Site- Crabtree Road Verges	65 m north
Local Wildlife Site - Woolsthorpe Road Verge, West	165 m south
Local Wildlife Site- Skillington to Gunby Road Verges	645 m east
Local Wildlife Site- Woolsthorpe Line	750 m southeast
Protected Habitat	255 m southeast
Aerodrome Farm	700 m southeast
Cotswold Farm	1.6 km northeast
Cringle Brook	650 m northwest
Sroxton Quarry SSSI	3.3 km northwest
FCC Non-Hazardous Inert & Waste Management	Immediately east
King Luds Entrenchment & The Drift SSSI	3.5 km northwest

3 SOURCE

3.1 Historical activities

3.1.1 On-site

Colsterworth Triangle Quarry was granted Planning Permission (S22/0289/05) on 8th June 2006 for the extraction of limestone and subsequent restoration using imported inert wastes. Prior to mineral extraction, the land was in agricultural use.

3.1.2 Adjacent landfill sites

Vast portions of land in the vicinity of the site have been subject to ironstone working. Overburden was removed to expose the ironstone creating a long gulley/valley feature. Following extraction of the ironstone, the overburden from the next strip was placed behind the working area, infilling the void as the ironstone extraction and gulley advanced. As ironstone workings moved to different areas, thin gulley shaped voids remained and these were often later restored via landfilling.

Historical landfill

Based on Environment Agency data, a number of such 'strips' of historical landfill exist to the southwest, south and east of the site. These were landfilled and the licences surrendered by 1994. They received inert waste, with the exception of two sites, 'Corner of The Drift and Crabtree Road', which was also licensed to receive household waste, and 'Disused Railway Cutting', which was licensed to receive inert, industrial, commercial and household wastes.

Three larger historical landfills are noted in the vicinity of the site, their details are summarised below:

3601/HRA/T2: Summary details of historical landfills				
Name	**Licence ref**	**Type of waste**	**Key dates**	**Distance/direction from site**
Crabtree Road Landfill	EAHLD00338	Inert Household	First input - 1995 Last input - ND	Adjacent to east
Crossway Farm	EAHLD00307	Inert Household Commercial Special	First input - 1986 Surrendered - 1994	1.6 km southeast
Crabtree Road	EAHLD35244	Inert Household	First input - ND Last input - ND	1.3 km southwest

The areas affected by ironstone workings are shown together with currently authorised and historical landfills on *Drawing 3601/HRA/03*.

Current authorised landfill

Two authorised landfills, ie ones for which a current Permit exists, are located in the vicinity of the site.

The Colsterworth Landfill is located adjacent and to the east of the site. It is operated by FCC Environment Ltd under Permit reference EPR/BV14371B. The site was formerly known as Crabtree Road Landfill (details above) and the permit was originally issued to Lincwaste Limited and has since been transferred to FCC.

Colsterworth Landfill was initially worked as an ironstone quarry and subsequent extraction of the underlying clay was undertaken to elevations of 91 mAOD. Landfilling began in 1995. It is reported by consultants McDonnel Cole (HRA review of Colsterworth Landfill for FCC in 2019) that in 2003 the site was permitted to receive household, commercial, industrial and special wastes and contaminated soils. At that time, landfilling was taking place in Phase 4, other phases were temporarily capped at approximately 120 mAOD and there was still active quarrying on-site to the west. By 2013 the filling of Phase 4 was almost complete and over-tipping of other phases was being undertaken to levels around 130 mAOD. The site ceased accepting waste in January 2019.

According to McDonnel Cole, Spencer's Field to the east of the FCC Landfill and Clark's Field to the northwest are both restored quarry waste sites and the former railway cutting to the west had also been landfilled.

The Stainby Landfill located to the southwest of the Colsterworth Triangle site was operated by Lincwaste Limited under Permit reference EA/EPR/GP3098NB/A001. The original licence was issued in September 1993 for co-disposal of waste, most likely including household waste. The site status is recorded as 'Closure', indicating that it is no longer receiving waste and has been fully restored. Monitoring of impacts from potential leachate and landfill gas migration will remain on-going until the Permit is surrendered.

3.2 Proposed development

A Planning Application exists for the restoration of Colsterworth Triangle site using imported inert fill. The permission allows for mineral extraction to a final depth of approximately 121 to 122 mAOD, which coincides with the base of the limestone deposit. The agreed restoration profile is a domed shape with an elongate ridge elevation of 140 mAOD, tying into the restoration of the adjacent Colsterworth Landfill. Within the site itself, final contours will decline to the north and south and less steeply to the west. The lowest boundary elevation will be approximately 136 mAOD in the northeastern and southeastern corners, coincident with existing ground levels.

It is estimated that approximately 850,000-900,000 tonnes of inert waste will need to be imported to achieve the agreed restoration profile. This will be at a rate of 150,000 tonnes per year over a 6 year period.

a) Waste types

The materials to be imported into the site have been detailed elsewhere in the application and are summarised in *Table 3601/HRA/T3* below. The site will only accept materials classified as non-hazardous, excluding wastes that are solely or mainly of dusts, powders or loose fibres, and not in a form that is either sludge or liquid.

3601/HRA/T3: Permitted waste types				
Source	**Sub-source**	**Waste code**	**Description**	**Additional restrictions**
10: Wastes from thermal processes	10 11: Wastes from manufacture of glass and glass products	10 11 03	Waste glass-based fibrous materials	
15: Waste packaging, absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	15 01: packaging (including separately collected municipal packaging waste)	15 01 07	Glass packaging	
17: Construction and demolition wastes	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	Metal from reinforced concrete must have been removed
	17 02: wood, glass and plastic	17 02 02	Glass	

3601/HRA/T3: Permitted waste types				
Source	**Sub-source**	**Waste code**	**Description**	**Additional restrictions**
	17 05: Soil, stones and dredging spoil	17 05 04	Soil and stones other than those mentioned in 17 05 03	Restricted to topsoil, peat, subsoil and stones only Topsoil and peat will be limited to placement in the upper 0.5 m only
19: Wastes from waste management facilities	19 12: Wastes from the mechanical treatment of waste (eg sorting, crushing, compacting, pelletising) not otherwise specified	19 12 05	Glass	
		19 12 09	Minerals (eg sand, stones) only	Restricted to wastes from treatment of waste aggregates that are otherwise naturally occurring minerals. Does not include fines from treatment of any mixed non-hazardous waste or gypsum from recovered plasterboard
20 Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions	20 01: separately collected fractions (except 15 01)	20 02 02	Glass	
	20 02: Garden and park wastes (including cemetery waste)	20 02 02	Soils and stones	Restricted to topsoil, peat, subsoil and stones only Topsoil and peat will be limited to placement in the upper 0.5 m only

All incoming material will be subject to the rigorous Waste Acceptance Procedures as provided elsewhere in the Application. It is noted that the proposed waste stream is limited to only those wastes which pose the least potential impact. The waste codes are all ones that, under the EU Landfill Directive (2002/33/EC), are "*… assumed to fulfil the criteria as set out in the definition of inert waste in Article 2(e) of the Landfill Directive and the criteria listed in* *section 2.1.2. The wastes can be admitted without testing at a landfill for inert waste".* These can therefore be considered completely inert in terms of chemical and physical properties.

b) Phasing

It is proposed that restoration of the site will be completed over a period of 6 years. Waste placement will commence in the northeast and continue in an anti-clockwise direction around the site. Waste will be placed in 300 mm thick layers, compacted in place.

c) Waste volumes

In order to achieve the approved restoration profile, up to 750,000 m^3 (up to 900,000 tonnes) is required, based on a conversion of 1.2 tonnes to 1 m^3 (as provided for Waste Code 19 12 09) developed by the Environment Agency for the 1998/99 commercial and industrial waste survey in England.

d) Restoration and afteruse

The final restoration contours are provided in the ESSD report as Drawing ESSD/D5.

3.3 Proposed management measures

Management measures will be implemented in order to ensure the safe operation of the proposed inert landfill facility and ensure no environmental impact. These measures are discussed below.

3.3.1 Control of incoming waste

In order to ensure the incoming waste is appropriate for acceptance at the site there will be:

- Strict enforcement to Waste Acceptance Criteria and procedures
- Waste codes of all incoming waste will be reviewed and only waste with codes itemised on the Permit will be allowed on site
- Detailed knowledge of where imported waste has been generated

Requisite testing before receipt on-site is not needed due to the nature of the proposed waste to be received at the site and the proposed selection of limited waste codes.

3.3.2 Monitoring of groundwater quality

Monitoring of groundwater in boreholes surrounding the site will continue throughout the life of the proposed development including the active and post-closure phases, as described in Section 6 below. Monitoring infrastructure that becomes inoperable will be replaced as necessary.

3.3.3 Settlement

Differential settlement is not anticipated due to the proposed waste types to be accepted at the site.

3.3.4 Hydrogeological Risk Assessment (HRA)

A Hydrogeological Risk Assessment has been undertaken and the results are provided in Part II of this report.

4 PATHWAY AND RECEPTOR

4.1 Geology

4.1.1 Bedrock

The site is excavated into limestone bedrock from the Jurassic Lincolnshire Limestone Formation.

The Lincolnshire Limestone is underlain by a sandy clay of the Grantham Formation (formerly the Lower Estuarine Series), which, based on BGS mapping, is shown locally in a small outcrop 200 m west of the site. The Northampton Sand Formation, which includes ironstone, lies beneath the Grantham Formation and is the strata widely extracted at the various iron workings. The Northampton Sand is in turn underlain by the Upper Lias Clay, which was partially extracted at the adjacent FCC Landfill. Locally the Upper Lias Clay outcrops in the base of the valley north of the site and to the west.

The regional bedrock geology is illustrated on *Drawing 3601/HRA/04* and the geological succession in the area is summarised in *Table 3601/HRA/T4.*

Strata dip at approximately 2 degrees to the east towards a syncline whose axis crosses the adjacent FCC Landfill in an approximate northwest to southeast direction. A series of faults are also noted in the area, trending roughly northwest to southeast. Two such small faults are indicated on the BGS 1:10,000 scale map crossing the southern boundary of the site, down-throwing the eastern side by approximately 3 m in combination. An extract of the 1:10,000 map is provided on *Drawing 3601/HRA/04*.

3601/HRA/T4: Regional bedrock stratigraphy

	Formation	Thickness	Lithology
Bedrock	Lincolnshire Limestone Formation	4 -15 m	Highly fractured oolitic and micritic limestones
	Grantham Formation	1 – 11 m	Mudstones, sandy mudstones and argillaceous siltstone-sandstone. FCC borehole information describes brown clay and green/blue shale.
	Northampton Sand Formation	0 – 6 m	Very strong ferruginous sandstone/ sandy limestone
	Upper Lias Clay (Whitby Formation)	60 m	Dark blue grey mudstone
	Marlstone Rock Formation	>9 m	Ferruginous oolitic limestone and calcareous sandstone

4.1.2 Superficial deposits

Superficial deposits are relatively sparse in the area and none are present in the immediate vicinity of the site.

To the north, alluvial deposits are confined to the floor of the Cringle Brook valley.

Glacial Diamicton (formerly Till) described by the BGS as unsorted sediment with gravel in a fine mud matrix, lies to the east, beyond Colsterworth and to the west beyond Buckminster.

4.1.3 Geology of the site

Numerous boreholes have been drilled around the site and the FCC site to the east although geological logs are not always available. In order to understand the detailed geology within the site and adjacent area a geological model has been created using approximately 32 BGS logs from boreholes drilled in the area prior to ironstone working and more recent limestone quarrying. Multiple geological section lines drawn using the BGS Groundhog software have been used to visualise the pre-development geology.

The combination of the dip and the faulting results in the base level of the Lower Lincolnshire Limestone being at around 130-132 mAOD in the western corner of the site, dropping to around 127-130 mAOD in the central part of the site, and then dropping further to between 123-126 mAOD in the eastern part. The final proposed limestone extraction level is therefore anticipated to vary across the site from around 130 mAOD in the west to around 123 mAOD in the east.

The thickness of Grantham Formation clay is indicated to vary between approximately 0.3 and 4.5 m with an average of 2 m based on BGS and FCC borehole logs.

Boreholes WP1 to WP6 were drilled around the periphery of Colsterworth Triangle Quarry in 2019. These boreholes were not logged in detail when installed and poor records remain. The section lines have been used to identify the geology encountered within these boreholes and also to confirm the target formation, sampled by the boreholes. To do this the site boreholes, using the current ground and base of borehole elevations, have been superimposed on the inferred geology to allow determination of the response zone (1 metre below ground level (mbgl) to base of borehole, pers comms Lee Craighead (CESL)) for each borehole.

It is noted that the top of the headworks was surveyed relative to Ordnance Datum in March 2023 and before this it is known that boreholes WP3 and WP5, within the curtilage of the quarry working area, were periodically shortened as quarrying around them progressively lowered ground level.

Borehole WP1A was machine dug into the northern batter of the quarry to the base of the limestone.

WP4 is now (since monitoring re-commenced in March 2023) referred to as WP4B and WP4 refers to the FCC Environment Limited (FCC) borehole 07/09, associated with their adjacent landfill to the east. Borehole WP4A refers to FCC borehole BH2D, which is 91 m deep and monitors the Marlstone Rock at depth beneath the site.

A fault zone, shown on BGS maps as two faults, has been mapped crossing the southern site boundary, orientated southeast to northwest. Strata is downthrown to the east.

Cross-sections along the northern (southwest to northeast) and southern (northwest to southeast) boundaries have been produced and are presented as *Drawings 3601/HRA/05 and 3601/HRA/06*. An extract of the southern boundary cross-section has been enlarged to allow more detail to be shown and this is provided as *Drawing 3601/HRA/07*. The location of the lines of cross-section are shown on *Drawing 3601/HRA/04.*

The following response zone interpretation is derived from the cross-sections (*Table 3601/HRA/T5*).

3601/HRA/T5: Response zone interpretation						
Borehole ID	**Alternative ID**	**Cap mAOD**	**GL mAOD**	**Depth mbd**	**Base BH mAOD**	**Response zone**
WP1		124.93		6.26	118.67	**Lwr Lincs Lst**, Granthan & top of NHS
WP1A		130.38		3.90	126.48	**Lwr Lincs Lst** & Grantham
WP2		138.88	138.82	13.40	125.48	**Lwr Lincs Lst** & Grantham
WP2A		138.93		13.22	125.71	**Lwr Lincs Lst**, Grantham & **NHS**
WP3		128.453	128.12	9.74	118.71	Bottom of Grantham & **NHS**
WP4	BH 07/09	137.60	136.57	22.23	115.37	**NHS** (120.17 to 115.37 mAOD)
WP4A	BH2D	137.94		91.10	46.84	**Marlstone Rock**
WP4B	WP4	137.84		20.44	117.40	**Lwr Lincs Lst** & Grantham & **NHS**
WP5		137.15	136.99	13.96	123.19	**Lwr Lincs Lst**, Grantham & top of NHS

3601/HRA/T5: Response zone interpretation						
Borehole ID	**Alternative ID**	**Cap mAOD**	**GL mAOD**	**Depth mbd**	**Base BH mAOD**	**Response zone**
WP6		124.34		8.76	115.58	Grantham & **NHS**

Lwr Lincs Lst = Lower Lincolnshire Limestone
NHS = Northampton Sand Formation
Bold text denotes aquifer sampled
GL = Ground level
BH = Borehole
mbd = metres below datum

4.2 Hydrogeology

4.2.1 Aquifer characteristics

The Lincolnshire Limestone Formation is classified by the Environment Agency as a Primary aquifer. The fabric of the oolitic limestone results in a relatively low primary, intergranular porosity and permeability (geometric mean of 1.3×10^{-4} m/d (Allen et al 1997)). However, the presence of macro and micro fractures results in a higher secondary permeability with a resultant interconnected porosity of 10 to 25% (Smith-Carrington et al, 1983), storage coefficient of 4.9×10^{-5} to 5.2×10^{-4} (interquartile range, Allen et al 1997) and transmissivity 665 m^2/d (geometric mean) and range of 259 to 2265 m^2/d (interquartile range, Allen et al 1997). Groundwater flow is almost entirely through fractures and bedding planes joints. Sirius reported (HRA, December 2021) that pumping tests undertaken by Anglian Water at Kirkby la Thorpe, which is located approximately 18 miles from Colsterworth Landfill Site, indicated a transmissivity of 700 to 1280 m^2/d (Griffiths et al, 2006).

The Northampton Sand Formation is classified as a Secondary A aquifer. Groundwater flow is likely to be a combination of matrix, or granular flow and fracture flow. Due to the extensive ironstone mining in the area, blasting may have increased the number and size of fractures in the remaining Northampton Sand rendering fracture flow the more dominant flow mechanism locally. Published data indicates that where a fully saturated, 6 m thickness of the Northampton Sand Formation is present, transmissivity is around 60 m^2/d (Allen et al 1997).

The Northampton Sand is often in hydraulic continuity with the overlying Lincolnshire Limestone Formation. However, due to the confirmed presence of the Grantham Formation locally both the Lincolnshire Limestone and the Northampton Sand Formations could be considered hydraulically separate. This will be affected by the presence of historical mine workings that extended through the lower permeability Grantham Formation into the Northampton Sand. Allen et al (1997) report that "…ironstone workings have had a profound and irreversible effect on the hydrogeological regime within the aquifer."

Post-mining, increased recharge of the Northampton Sand can be expected from infiltration via spoil infill material. This is likely to mean that present day water levels are higher than those existing in the ironstone prior to mining and by 1982, the water level was reported to be "at least partly in the overlying beds, with unconfined conditions beneath permeable spoil in the worked out areas…" (Stanyer, 1982) and porosity within the spoil material may act as a storage reservoir for the aquifer, accumulating infiltration and feeding the unworked aquifer at a fairly constant rate.

4.2.2 Groundwater abstractions

<u>Licensed abstractions</u>

One licensed abstraction has been identified by the Environment Agency within a 2 km radius of the site, as shown on the 1:10,000 geology extract on *Drawing 3601/HRA/04*.

Licence AN/030/0001/002, issued to LincWaste in March 2022, is located east of Colsterworth Triangle. It permits the transfer of water from dewatering activities at Colsterworth Landfill from a single point, NGR SK 60365 24294. There is no volumetric limit on the licence.

4.2.3 Groundwater levels and flow

Groundwater levels are recorded in ten monitoring boreholes installed around the periphery of the site. A summary of the borehole details and response zone is provided in *Table 3601/HRA/T5* above and their locations are shown on *Drawing 3601/HRA/02*.

Groundwater level data from these monitoring boreholes are available from November 2019 to September 2020 and then monthly since March 2023. The reliability of the data from 2019-2020 is uncertain due to confusion at the time regarding borehole references and datum elevations. As a result, this data has not been used in the current assessment. Hydrographs showing the temporal variation are provided on *Drawing 3601/HRA/08* and data is provided in *Appendix 3601/HRA/A1*.

Boreholes in the north of the site, which penetrate the full thickness of the Lincolnshire Limestone (and into the Grantham Formation below), have been dry since monitoring recommenced in March 2023.

Groundwater levels have been recorded in the south and east of the site in boreholes with response zones that extend into the Northampton Sand, underlying the Lincolnshire Limestone and Grantham Formation. Little variation is seen in the hydrographs for boreholes WP3, WP4B and WP5. However a greater response to seasonal variation in rainfall is seen at boreholes WP4 and WP6, which are both drilled deeper within the Northampton Sand. A summer decline in water elevation was observed in these boreholes, followed by general increase up to March 2024 resulting in a seasonal fluctuation of between 2.5 and 2.8 m.

Borehole WP4A is drilled significantly deeper than the other site boreholes and has a response zone within the Marlstone Rock, an aquifer unit at depth below and separated from the Lincolnshire Limestone and Northampton Sand Formation by the Lias Clay. The groundwater level within the Marlstone Rock is between 95.5 and 97.7 mAOD, over 20 m below the groundwater within the shallower aquifers, and completely isolated from near surface activities of former ironstone mining.

Spatial distribution

The highest groundwater elevations of between 125.6 and 125.3 mAOD, are recorded in borehole WP5 in the southwest of the site. Elevations decline to the southeast and are at their lowest at borehole WP6 in the southeastern corner of the site, where elevations of between 115.9 and 118.8 mAOD have been recorded.

Groundwater contours have been inferred using data from March 2024 and are reproduced as *Drawing 3601/HRA/09*. The contours indicate an east-southeastwards flow direction and the watertable tapering out in the north and northwest.

Interpretation

The Colsterworth Triangle site has always been above the watertable and its base free draining. Based on this and the results of groundwater level monitoring it is concluded that the Lincolnshire Limestone at the site is entirely dry and any groundwater resides below the base of the limestone.

It is suggested (Stanyer, 1982) that the influence of spoil being used to infill former Ironstone workings has been to create 'sumps' with higher porosity acting as a storage reservoir, accumulating rainfall recharge and feeding the adjacent unworked aquifer at a fairly constant rate. This has the effect of dampening usual seasonal fluctuations and supporting summer groundwater levels. Spoil filled mine workings are located within 250 m of each of the site's boundaries effectively creates an 'island' of natural strata. Within the former mine workings groundwater will be mixed and where the former workings are adjacent to the Lincolnshire Limestone and Northampton Sand Formation, will allow mixing between the two aquifer units. It is therefore unlikely that distinct separate groundwater bodies remain in the aquifers local to the site and the Lincolnshire Limestone, Grantham Formation and Northampton Sand Formation can be considered to act as a continuum, ie a single aquifer unit.

The winter 2023 to 2024 has been particularly wet hence inferred groundwater contours on *Drawing 3601/HRA/09* are likely to reflect extreme winter highs. However, it is noted that dewatering is being undertaken at the adjacent FCC Colsterworth Landfill. The base of Colsterworth Landfill is below the base of the Northampton Sand and a groundwater cut-off drain is situated around Colsterworth Landfill at the interface between the Northampton Sand and the underlying Lias Clay. The drain discharges to the licensed dewatering point on the southern boundary. This will depress local groundwater levels within the Northampton Sand and overlying Lincolnshire Limestone as indicated on Drawing WR7600/11/11, provided in *Appendix 3601/HRA/A2*.

Whilst few monitoring boreholes around the site and the Colsterworth Landfill monitor exclusively either the Lincolnshire Limestone or the Northampton Sand Formation, it is considered that groundwater levels recorded are likely to be representative of groundwater at the base of the Northampton Sand with the overlying Lincolnshire Limestone being dry. This is consistent with the findings at the FCC Colsterworth Landfill, where consistent groundwater levels were attributed to the Northampton Sand Formation.

<u>Unsaturated thickness</u>

The base of the site/floor of the quarry currently slopes from approximately 130 mAOD in the west to 123 mAOD in the east, due largely to the faults in the west of the site. The highest recorded groundwater level in the vicinity of the site is 125.3 mAOD recorded in December 2023 in borehole WP5 in the southwest of the site.

On the basis of the current quarry floor elevations in the area of borehole WP5 (128 mAOD) and the highest water level at this borehole (125.3 m AOD) an unsaturated thickness of approximately 2.7 m exists.

At Borehole WP6 in the southeast of the site, the highest groundwater level of 118.78 mAOD was recorded in January 2024. The base of the limestone at this location is approximately 125 m AOD (based on BGS borehole SK92SW15) indicating a minimum unsaturated zone of 6.2 m. The thickness of unsaturated zone to the top of the Northampton Sand Formation (at 121.93 m AOD) is 3.15 m

The watertable resides in the Northampton Sand Formation which will not be disturbed as part of this development, hence the site will therefore remain above the watertable. Groundwater level data indicates that the unsaturated zone thickness to the base of the limestone varies from a minimum of 6.2 m in the east and thins to a minimum 2.7 m in the west.

4.2.4 Groundwater quality

Groundwater quality has been determined based on monthly samples from on-site boreholes since March 2023. Boreholes WP1, WP1A, WP2, WP2A and WP5 are up-gradient of the site. Due to the general eastward groundwater flow direction borehole WP4 is also representative of background water quality from agricultural land to the north of the site. However, as no infilling has taken place within Colsterworth Triangle, all data recorded represents background groundwater quality.

Boreholes WP1, WP1A, WP2 and WP2A have remained dry throughout the monitoring period. Samples have been collected from boreholes WP3, WP4, WP4A, WP4B, WP5 and WP6. The results of the analyses are provided in *Appendix 3601/HRA/A3* and are summarised below.

3601/HRA/T6: Groundwater quality (2023-24)

	Count	Maximum	Minimum	Mean	Count >LDL	Count >DWS
pH	48	8	6.8	7.2	-	0
EC (µS/cm)	48	1660	585	1213	-	0
Chloride (mg/l)	48	78	21	45.2	-	0
Ammoniacal Nitrogen (mg/l)	48	6.2	0.01	0.61	41	9
Nitrate as NO3 (mg/l)	48	308	4.7	43.2	46	16
Total Sulphur as SO4 (mg/l)	48	429	76	241	-	28
Total Organic Carbon (TOC) (mg/l)	48	44.5	1.06	7.26	45	-
COD (Settled) (mg/l)	48	35	5	7.23	15	-
BOD (5 day) (mg/l)	48	10.1	1.2	1.89	8	-
Arsenic as As (mg/l)	48	0.005	0.001	0.001	6	0
Cadmium as Cd (mg/l)	48	0.00039	0.00002	0.00004	16	0
Copper as Cu (mg/l)	48	0.007	0.001	0.001	5	0
Lead as Pb (mg/l)	48	0.023	0.002	0.002	3	1
Mercury as Hg (mg/l)	48	0.00004	0.00004	0.0003	1	0
Nickel as Ni (mg/l)	48	0.02	0.002	0.005	32	1
Selenium as Se (mg/l)	48	0.003	0.001	0.001	5	0
Total Chromium as Cr (mg/l)	48	0.007	0.001	0.001	13	0
Zinc as Zn (mg/l)	48	0.042	0.003	0.01	44	0
Boron as B (mg/l)	48	0.018	0.01	0.08	41	0
Iron as Fe (mg/l)	48	6.62	0.001	0.24	47	5

LDL = Lower Detection Limit DWS = Drinking Water Standard

Water quality at borehole WP5 tends to exhibit lower conductivity, chloride and sulphate concentrations than boreholes WP3, WP4 and WP6. However, pH is higher than elsewhere on-site.

Total Organic Carbon concentrations tended to be stable in boreholes WP6 and WP4, however were 'spiky' at boreholes WP3 and WP5 at the southern site boundary.

Ammoniacal nitrogen was low in all boreholes except borehole WP6 in the southeastern site corner. At this borehole concentrations spiked in October 2023 and then increased from below the detection limit, steadily to a peak of 6.2 mg/l in March 2024. This is the only parameter showing a rising trend at the site.

It has previously been hypothesised that water quality at the site may be being impacted by leachate migration from the Stainby Landfill located west of the site. Groundwater contours indicate that impact on the southeastern boundary would be possible from waste deposited in the north of Stainby Landfill. An element of northward flow from Stainby Landfill will be induced as a result of dewatering at the FCC Colsterworth Landfill, east of Colsterworth Triangle.

4.3 Surface water

4.3.1 Watercourses

The site is located within the catchment of the River Witham, which is located approximately 2.7 km east of the site. Cringle Brook, the nearest watercourse and tributary of the Witham, flows northeastward approximately 620 m north of the site as shown on *Drawing 3601/HRA/10.* Drainage adjacent to the site flows to the west and north towards Cringle Brook. South of the site drainage is to the south-southeast.

Two springs are identified on the OS map on the southern banks of Cringle Brook at elevations of approximately 115 mAOD, 640 m north of the site. Further springs are noted on the western banks of the River Witham to the east of the site. The locations of the nearest springs are shown on *Drawing 3601/HRA/10*.

4.3.2 Waterbodies

There are a number of waterbodies associated with the Colsterworth Landfill to the east of the site. These occur in low-lying areas with the largest being approximately 115 m east of the eastern site boundary at an elevation of approximately 112.5 mAOD (based on LiDAR data).

A man-made waterbody lies north of Crabtree Road and 120 m northeast of the site. This appears to be an agricultural reservoir; it is likely to be lined and isolated from groundwater.

Two lines of small waterbodies are shown on the OS maps; one, immediately south of Colsterworth Landfill, paralleling the southern boundary and the second perpendicular to, and 450 m from, the southern site boundary (*Drawing 3601/HRA/10)*. Due to their locations in areas of former ironstone workings it is likely that they are also man-made.

4.3.3 Surface water abstractions

Licensed abstractions

No licensed surface water abstractions have been identified within 2 km of the site boundary, by the Environment Agency.

4.3.4 Flood risk

Colsterworth Triangle Quarry is located within Flood Zone 1 on the Environment Agency's Flood Map for Planning. Flood Zone 1 is land designated as having an annual probability of fluvial flooding less than 0.1 % (<1 in 1000).

4.4 Man-made sub-surface pathways

There are no known buried services located across or within 500 m of the site. However, much of the area has been subject to mine workings and these areas impart a strong influence on the natural hydrology and hydrogeology of the area.

5 RECEPTORS AND COMPLIANCE POINTS

The baseline environmental and hydrogeological data have been used to develop a site conceptual model to identify the key aspects of the site, its' setting and potential pathways and receptors. The schematic cross-section of the conceptual model is provided as *Drawing 3601/HRA/11* and cross-sections of the proposed restoration profile are appended to the permit application prepared by GPP.

5.1 Groundwater flow pathways

The site is extracted into the Lower Lincolnshire Limestone, which is dry. Due to extensive ironstone workings to within 250 m of the site in all directions, it effectively sits within an 'island' of limestone with limited unworked residual limestone to its west, northwest and south only.

The quarry floor is separated from the underlying Northampton Sand Formation aquifer by clays of the Grantham Formation. Groundwater resides within the Northampton Sand Formation and levels decline to the east-southeast towards the FCC site where dewatering occurs.

A minimum unsaturated zone of between 6.2 m (in the east) and 2.7 m (in the west) exists below the base of the limestone and the watertable in the Northampton Sand. Any pollutants from the waste imported to site will travel vertically through an artificially enhanced geological barrier (see Section 6.1), residual Grantham Formation and the unsaturated Northampton Sand to the watertable. Pollutants would then travel in the direction of groundwater flow, ie to the east, before exiting the eastern site boundary.

Superficial strata is absent from the site hence no pathways exist in superficial strata.

5.2 Groundwater receptors

No superficial aquifers exist at the site and hence these cannot be a receptor. Groundwater exists below the base of the site within the Northampton Sand aquifer, and this forms the primary groundwater receptor.

Whilst the site is located within the Lower Lincolnshire Limestone Principal Aquifer, as described above, it is isolated from any expanse of aquifer due to former ironstone workings on all sides of the site with only strips of residual limestone remaining. As a result the limestone is dry and is not considered to be the primary receptor.

One licensed groundwater abstraction exists within 2 km of the site. This licence allows dewatering from the FCC Colsterworth Landfill, approximately 180 m from the eastern site boundary. This forms a secondary groundwater receptor.

5.3 Surface water pathway

There will be no water discharges from the site. Dewatering is not required and surface water will be managed within the curtilage of the site. Surface water does not therefore act as a direct pathway from the site.

5.4 Surface water receptor

Groundwater flow is to the east and may provide some baseflow to River Witham, which flows northwards, 2.7 km east of the site. Cringle Brook and the River Witham form secondary surface water receptors.

Alternatively, once dewatering ceases at the FCC Colsterworth Landfill, a component of groundwater flow may occur northeastwards towards Cringle Brook, approximately 620 m from the northern site boundary. In the long-term Cringle Brook may form a secondary surface water receptor.

5.5 Habitat receptors

No water-supported ecological sites have been identified down-gradient of the site and therefore there are no plausible ecological receptors.

5.6 Compliance points

Groundwater compliance points will comprise groundwater beneath the site for hazardous substances and at the site boundary for non-hazardous pollutants. This will be measured at borehole s WP6 and WP4. Whilst the latter is not directly downgradient of the majority of the site it may be indicative of site conditions once dewatering at the FCC Colsterworth Landfill ceases.

As off-site discharge of surface water will not be required, surface water is not a direct receptor and surface water compliance points are not required.

6 POLLUTION CONTROL MEASURES

6.1 Site engineering

6.1.1 Basal and side slope engineering

As the site is to be permitted as an inert landfill and, due to the proposed nature of the restoration materials, leachate collection is not required, an artificial sealing liner is not necessary.

However, an artificial geological barrier (AGB) will be necessary to comply with the Landfill Directive. The AGB will be constructed across the base and sides of the landfill. Clays from the Grantham Formation in the west of the site have been extracted and replaced with limestone waste from the quarry. This clay has been stockpiled for use in the construction of the AGB.

If insufficient Grantham Formation clay is available this will be supplemented with carefully selected inert materials, largely comprising clays derived from the locality of the site. The AGB will be placed to achieve a minimum layer 1 m thick with a maximum permeability of 1×10^{-7} m/s or equivalent, in accordance with Landfill Directive requirements. Construction details for the basal and side slope engineering are provided in the Stability Risk Assessment undertaken by Greenfield Associates. It should be noted that the Northampton Sand will not be disturbed as part of the engineering works.

6.1.2 Capping requirements

The site will be operating under an inert landfill permit and there is no requirement for an engineered low permeability cap. The infill will generally be of lower permeability than the surrounding sandstone and therefore no cap is proposed.

6.2 Groundwater management

The watertable beneath the site resides within the Northampton Sand Formation and an unsaturated zone exists. Groundwater management will therefore not be required during the construction or operational phase of the development.

6.3 Surface water management

6.3.1 Operational phase

Currently surface water run-off occurs as a result of direct rainfall only. Historically it has collected in low points on the quarry floor before gradually soaking away with no active surface water management.

Where the quarry floor now comprises clay, surface water collects and is periodically pumped off-site. Currently, this is only required after heavy rainfall events.

During waste placement, run-off will be directed away from active areas using an informal ditch and berm structures as necessary. Formal surface water management will not be required and if necessary collected surface water will be pumped off site as is current practise.

6.4 Post-closure controls

6.4.1 Restoration

The proposed final restored landform is a gentle domed profile, to be tied in to the restoration of the adjacent FCC Colsterworth Landfill and in keeping with the surrounding topography. The site will be returned to an agricultural afteruse. The proposed restoration will ensure soils removed from the site are returned and supplemented with imported soils where necessary.

6.4.2 Surface water management

The agreed restoration scheme includes a slightly domed profile encouraging surface water drainage to the site perimeters where ditches will be reinstated. Surface water accumulating in these ditches will be allowed to soak away into the free-draining in-situ limestone remaining around the perimeter of the site.

6.4.3 Subsistence and settlement

It is considered that settlement of the restored landform will be negligible due to the types of material to be accepted by the site and the method of placement. Post-settlement contours are provided as Drawing ESSD/D5 within the ESSD report.

PART 2: HYDROGEOLOGICAL RISK ASSESSMENT

7 NATURE OF THE HYDROGEOLOGICAL RISK ASSESSMENT

Environment Agency guidance proposes a tiered approach to risk assessment such that the degree of effort and complexity reflects the potential risk posed by a particular site or situation, the sensitivity of the site setting, and the degree of uncertainty and likelihood of the risk being realised. To meet the requirements, a robust conceptual model for the site has been set out in Part 1 of this report. A risk screening has been undertaken below. This exercise is used to determine whether the proposed inert landfill represents, or potentially represents, a risk to groundwater or surface water resources and whether more detailed quantitative risk assessment modelling is required.

The hydrogeological conceptual site model has been completely revisited and revised since the previous Permit Application. The previous application included LandSim modelling of the site due to the "proximity of neighbouring landfills". As a result of the better hydrogeological understanding of the site and its setting the approach to the risk assessment has changed. A tiered approach has been used with risk screening used to identify <u>if</u> quantitative modelling is required.

7.1 Policy and guidance

<u>Compliance with Environmental Permitting (England and Wales) Regulations (2016)</u>

It is proposed to accept <u>only</u> those wastes detailed within the Landfill Directive as not requiring testing before acceptance at a landfill. These are the lowest risk inert wastes and based upon this it can be accepted that the site would not produce leachate (defined here as water coming into contact with the waste) that could result in the discharge of Hazardous substances or Non-hazardous pollutants. Hence the site falls outside the scope of the Environmental Permitting (England and Wales) Regulations (2016), Schedule 22 Groundwater Activities and the Groundwater Directive.

<u>Environment Agency Landfill location Policy</u>

The proposed landfill is located within the Lower Lincolnshire Limestone, a bedrock classified as a Principal Aquifer. The aquifer has been the subject of extensive disruption in the area due to historical ironstone mining, exploiting the Northampton Sand Formation, which underlies the limestone. Possibly as a result of this historical mining, the limestone is now largely dry at the site and the closest watertable resides within the residual Northampton Sand Formation, separated from the site by clays of the Grantham Formation. The groundwater in the Northampton Sand is unconfined and a minimum 2.7 m unsaturated zone exists beneath the quarry floor (based on highest groundwater levels recorded at the site).

Groundwater within the Northampton Sand may be impacted by the Stainton Landfill to the west, and up-gradient of the site and the FCC Colsterworth Landfill lies immediately to the east and down gradient of the site.

The site is not located within a Source Protection Zone of a public water supply and the only nearby licensed abstraction is the one for dewatering the adjacent Colsterworth Landfill. Similarly, no groundwater dependent ecosystems have been identified within close proximity to the site.

As previously stated, the landfill will only receive the lowest risk inert waste, which is described in the Landfill Directive as not requiring testing to confirm it is compliant with the definition of "inert".

The site location therefore complies with the Environment Agency landfill location policy.

Environment Agency Tier 1 risk screening guidance

Environment Agency guidance indicates that "*Your qualitative risk screening should assess whether the potential discharge from your activity is acceptable and so will not require further assessment.*

This could be because:

- *the discharge has acceptably low concentrations of hazardous substances, or in concentrations that are the same as the natural background levels in the groundwater (whichever is the higher concentration)*
- *the discharge has concentrations of non-hazardous pollutants that are within the relevant environmental standards, or in concentrations that are the same as the natural background levels in the groundwater*
- *there's a very low risk to groundwater-fed receptors due to the presence of unproductive drift or unproductive bedrock strata (and there are no aquifers present or near your activity) and remoteness from surface waters*
- *the volume or hydraulic loading rate of the discharge is so small such that only minimal dilution in underlying groundwater will be needed to avoid pollution by non-hazardous pollutants*"[1]

[1] Environment Agency Guidance. Groundwater risk assessment for your environmental permit. 3rd April 2018

A risk screen of this proposed development has been undertaken below with due regard to this guidance.

8 QUALITATIVE RISK SCREEN

8.1 Site design

The proposed landfill construction includes an artificial geological barrier (AGB) constructed using reworked Grantham Formation clays. A clay layer equivalent to a 1 m thickness of soils compacted to achieve a maximum permeability of 1 x 10^{-7} m/s or equivalent, will be constructed on the side walls and across the base of the site. The design is detailed in the Stability Risk Assessment.

If insufficient site derived clay is available this will be supplemented with suitable inert clayey soils imported to the site. This material will confirm to the waste codes proposed for the site which are ones that are identified as being of such low risk that chemical testing is not required. Any clayey material used to supplement the AGB will be derived from a local source and hence will be of similar nature to that found within the site.

Groundwater management is not required as a minimum unsaturated zone of 2.7 m unsaturated zone will exist below the AGB.

8.2 Source

Despite the proposed EU Waste Codes to be accepted at the site being restricted to only those that do not require testing, a comprehensive Waste Acceptance Procedure (WAP) will be employed at the site. This will allow all waste accepted onto site to be appropriately assessed prior to acceptance.

Any imported wastes, including topsoil containing organic matter that may degrade to release gasses and lower groundwater quality, will be utilised only in the upper 0.6 m of the landfill, to enhance soils stripped from the site and stockpiled for use in its restoration.

As a result of the above control measures, the risk posed by the restoration of the site via importation of carefully selected inert wastes is considered to be very low. The proposed engineering and control measures are considered to be of more than sufficient robustness to safeguard groundwater and surface water quality as the specification was designed with a much wider selection of inert waste in mind (as per the Landfill Directive).

8.3 Site sensitivity

There are no sites of ecological interest in the vicinity.

The closest watercourse, Cringle Brook, is currently up-gradient of the site and is separated from it by backfilled, deep, ironstone workings. The River Witham is 2.7 km down-gradient of the site, however, it is also separated from the site by extensive former iron workings, and the FCC Colsterworth Landfill.

The site is not within a Source Protection Zone and the nearest abstraction is for dewatering at the FCC Colsterworth Landfill, hence water is only 'transferred' and not subject to consumptive use.

The presence of historic landfills to the west and east of the site together with extensive backfilled iron workings to the north, west and east is such that only a limited lateral extent of limestone Principal aquifer remains and the site sits effectively within an 'island' of limestone. Due to this and the upgradient landform with incised dry valleys, very limited upgradient outcrop exits from which recharge to the limestone can occur. As a result, the limestone aquifer is dry at the site.

The Northampton Sand Formation is a Secondary A aquifer. A watertable exists within the base of this strata, however, this formation has been subject to significant mining in the region and is therefore absent to the east, northwest, northeast and southwest of the site. Only strips of unworked Northampton Sand Formation remain between the worked out areas and the site is effectively located in an 'island' or remaining aquifer.

Therefore, despite the site being situated within strata designated by the Environment Agency as a Principal aquifer, it is considered that the site setting is not a sensitive one.

8.4 Risk screening summary

Based on the assessment of the nature of the source and the sensitivity of the site location, it is considered that the proposed development poses negligible risk to the identified receptors. As a result of the restricted list of proposed waste codes to be accepted at the landfill together with the planned Waste Acceptance Procedures (WAP) and the site design, the following conditions from the Environment Agency Tier 1 risk screening guidance are considered to apply to the site:

- *the discharge has acceptably low concentrations of hazardous substances, or in concentrations that are the same as the natural background levels in the groundwater (whichever is the higher concentration)*
- *the discharge has concentrations of non-hazardous pollutants that are within the relevant environmental standards, or in concentrations that are the same as the natural background levels in the groundwater*

- *the volume or hydraulic loading rate of the discharge is so small such that only minimal dilution in underlying groundwater will be needed to avoid pollution by non-hazardous pollutants"*

As such it is considered that further detailed quantitative risk assessment is not required as per the Environment Agency's qualification for a Tier 1 risk screen.

8.5 Rogue load assessment

Environment Agency guidance suggests that a Rogue Load assessment is required where an inert landfill is sited within a Principal aquifer. However, for the reasons stated above, the site setting is not considered a sensitive one and the waste codes to be permitted at the site are very restricted to only the lowest risk waste streams. Therefore it is considered that a quantitative rogue load assessment is not required.

9 REVIEW OF TECHNICAL PRECAUTIONS

Due to the low risk posed by the site it is considered that the proposed precautions detailed below are appropriate and sufficient to prevent any unacceptable discharge:

1. Provision of basal and side slope artificial geological barrier with a thickness and permeability of 1 m at 1 x 10^{-7} m/s or equivalent
2. Strict controls on waste types, sourced and accepted
3. Strict adherence to Waste Acceptance Procedures
4. Progressive restoration to a slightly domed profile that will encourage surface water run-off
5. Proposed on-going groundwater monitoring (see Section 10)

Details of the Waste Acceptance Procedures are provided elsewhere within the Permit application.

10 REQUISITE SURVEILLANCE

10.1 Risk-based monitoring scheme

The site is not considered to be in a sensitive location and the nature of the waste is such that it does not pose a risk to the water environment. Despite this groundwater monitoring has been undertaken at the site and this will continue in order to build up a body of evidence to support future Permit surrender.

10.2 Groundwater

10.2.1 Groundwater infrastructure

Groundwater monitoring boreholes already exist around the periphery and down-gradient of the site. It is proposed to continue the use of these boreholes for future monitoring. The locations of the boreholes are shown on *Drawing 3601/HRA/02.* In the previous Permit Application there was some discrepancies with the interpretation of the on-site monitoring borehole response zones. These have been re-evaluated using a detailed assessment of the geology at and surrounding the site. The interpreted response zones are provided in *Table 3601/HRA/T5* above.

All of the monitoring boreholes extend to the base of the limestone and those in the east and south also extend into Northampton Sand Formation. The eastern boreholes represent the down gradient side of the site and will be used for compliance monitoring once landfilling commences.

10.2.2 Groundwater monitoring

It is proposed that groundwater level is recorded on a quarterly basis and the base of each borehole is recorded annually.

Groundwater samples should be collected on a quarterly basis from boreholes on-site and analysed for the following:

- pH
- Electrical conductivity
- Chloride
- Ammoniacal nitrogen
- Nitrate
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Total Organic Carbon
- Sulphate

On an annual basis the following dissolved metals analyses should be undertaken on samples from the boreholes :

- Arsenic
- Cadmium
- Total Chromium
- Copper
- Lead
- Nickel
- Selenium
- Zinc
- Boron
- Iron

10.3 Surface water monitoring

The conceptual site model has indicated that surface water monitoring is not required.

10.4 Groundwater compliance limits

An assessment of the baseline groundwater quality has been undertaken. This data has been used to establish appropriate Compliance values for key parameters.

Compliance limits are proposed for boreholes WP6 and WP4 as below, using the same determinants as in the previous Permit Application;

- Chlorie 76 mg/l
- Ammoniacal Nitrogen 3.6 mg/l
- Nickel 0.013 mg/l

The above limits are based on the monitoring data collected in support of this HRA and represent the mean plus 2 x Standard Deviation.

11 CONCLUSIONS

11.1 Summary

Colsterworth Triangle Landfill is not considered to be in a sensitive location due to a number of facts, including the absence of groundwater within the surrounding limestone aquifer and the extensive historical mining backfill in the area together with up and down-gradient landfills. Additionally, the source is considered to pose a very low risk due to the very limited waste codes being accepted and the defined low risk they pose, as defined in the Landfill Directive.

Any potential risk posed by the site would be mitigated by provision of an artificial geological barrier and the adherence to the Waste Acceptance Procedures.

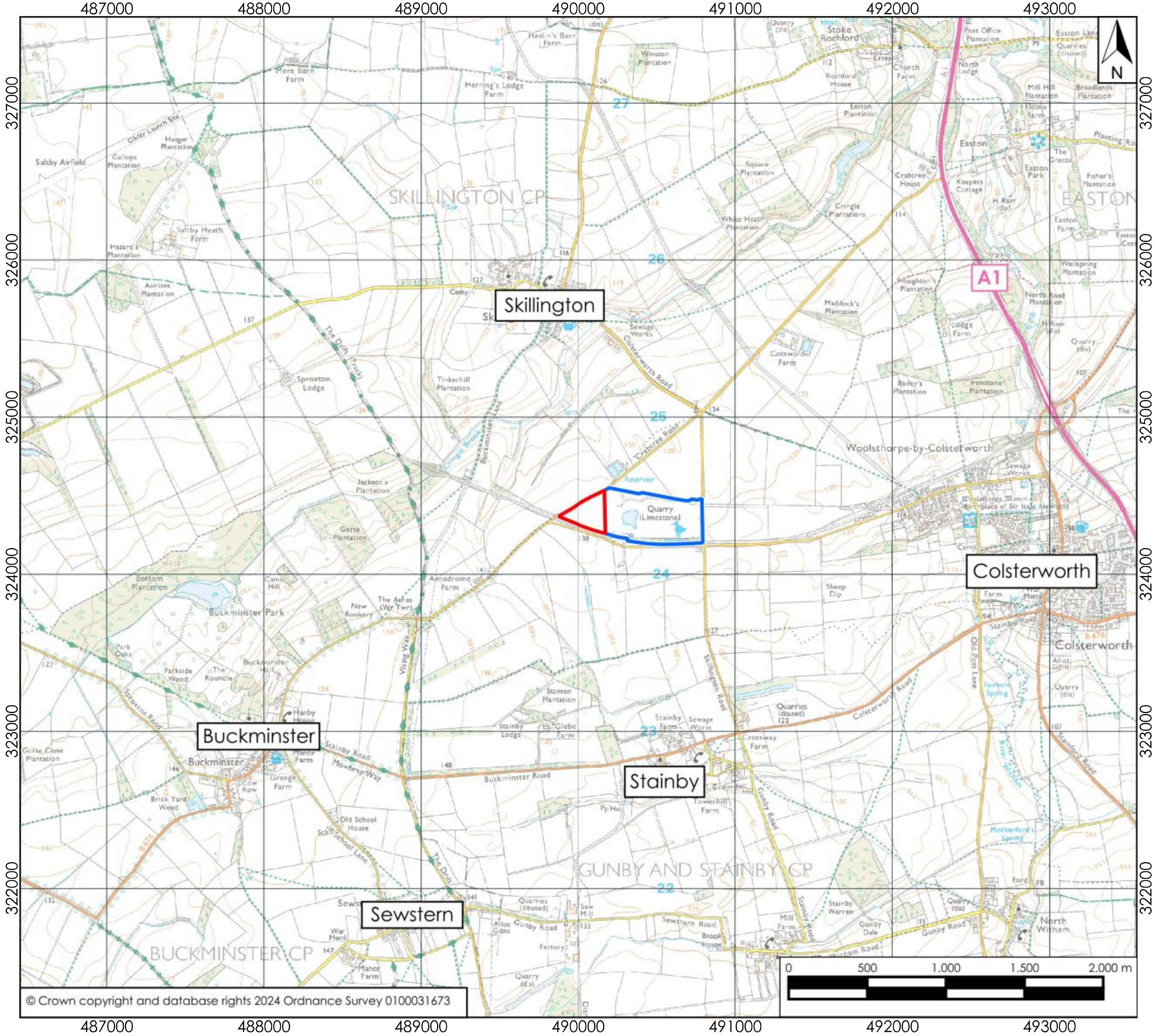
Due to the above it is considered that the site does not pose a risk to the groundwater or surface water environment. Groundwater monitoring will continue at the site to support future Permit surrender.

11.2 Compliance with the Environmental Permitting (England and Wales) Regulations (2016)

This risk assessment has demonstrated that under normal operational working and post-restoration, hazardous substances would not be present on-site and non-hazardous pollutants will not be present in concentrations such that pollution of nearby groundwater and surface water is caused.

It is therefore considered that the site will be compliant with respect to the Environmental Permitting (England and Wales) Regulations (2016).

DRAWINGS



Key

Application boundary

FCC Colsterworth Landfill

Scale correct at A4

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Site Location
Project	Colesterworth Triangle
Drawing	3601/HRA/01
Version	1
Date	Jul 2024
Scale	1:35,000

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Key

- Application boundary
- FCC Colsterworth Landfill
- 1m contour (mAOD)
- Monitoring borehole (id)
- Proposed direction of infilling

Scale correct at A4

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Site Layout and Borehole Locations
Project	Colesterworth Triangle
Drawing	3601/HRA/02 — Version 1
Date	Jul 2024 — Scale 1:2,500

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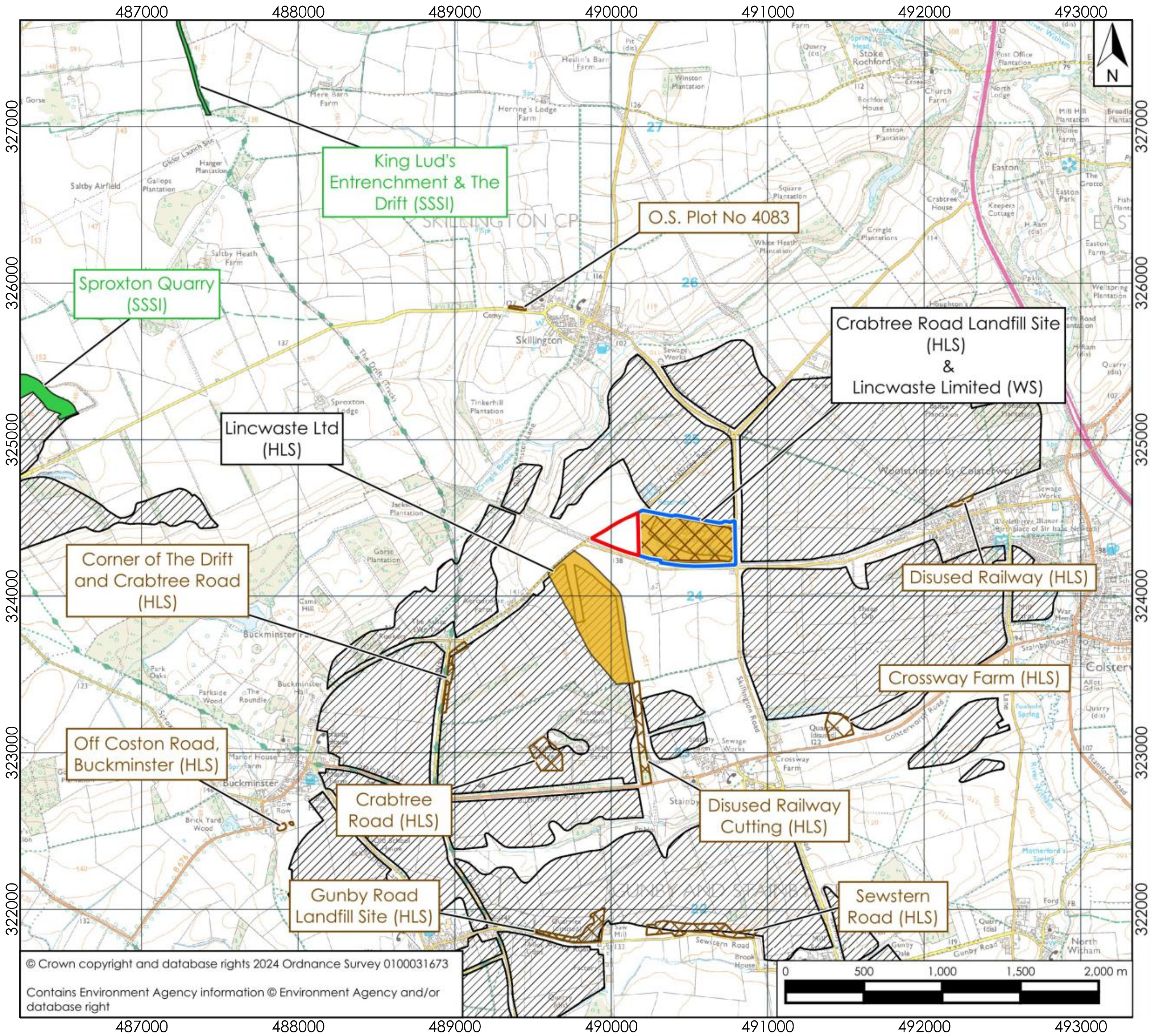

Key

- Application boundary
- FCC Colsterworth Landfill
- Permitted Waste Site (WS)
- Historic Landfill Site (HLS)
- Site of Special Scientific Interest (SSSI)
- Former Ironstone working

Scale correct at A4

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH		
Title	Landfill and Ecological Sites		
Project	Colesterworth Triangle		
Drawing	3601/HRA/03	Version	1
Date	Jul 2024	Scale	1:35,000

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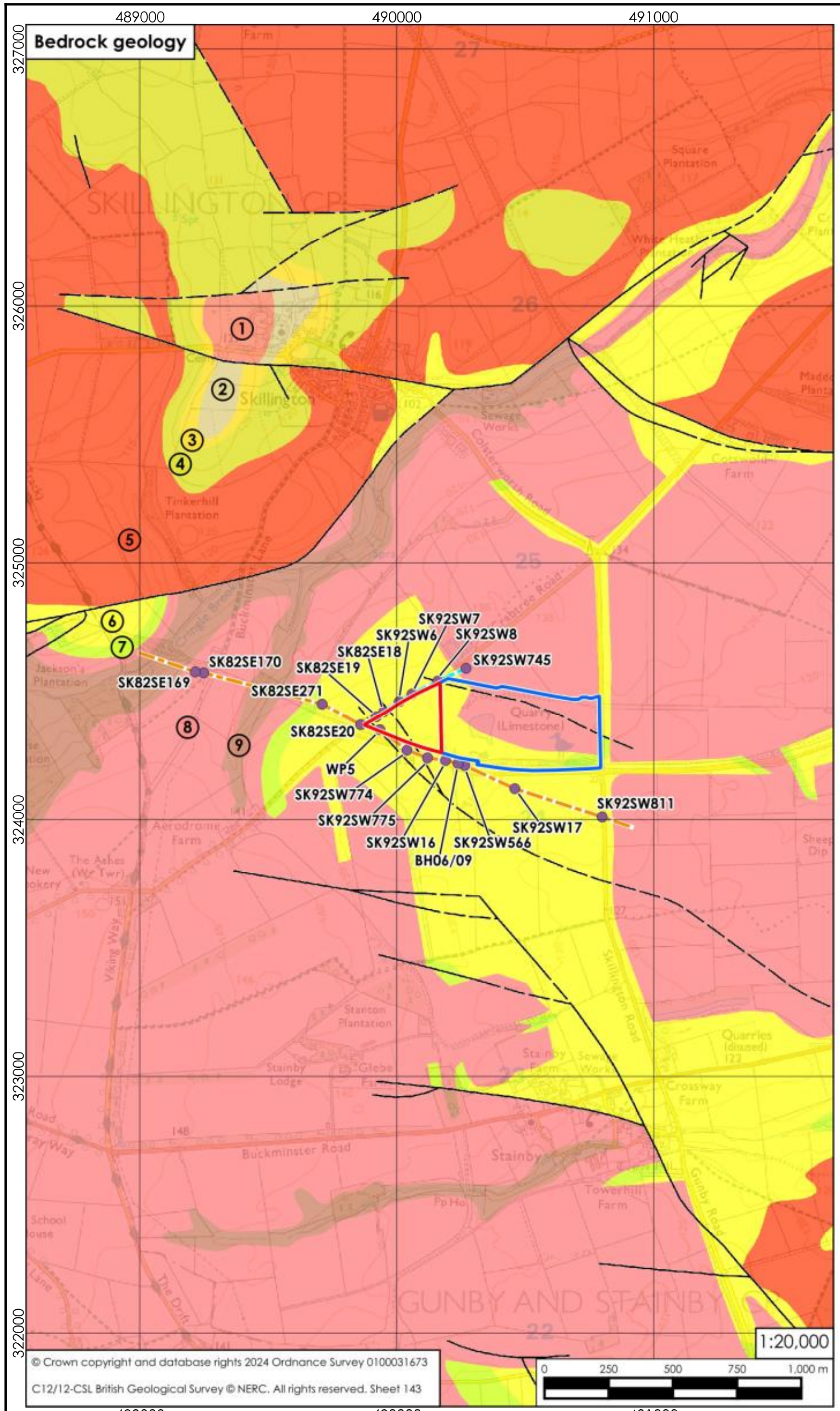

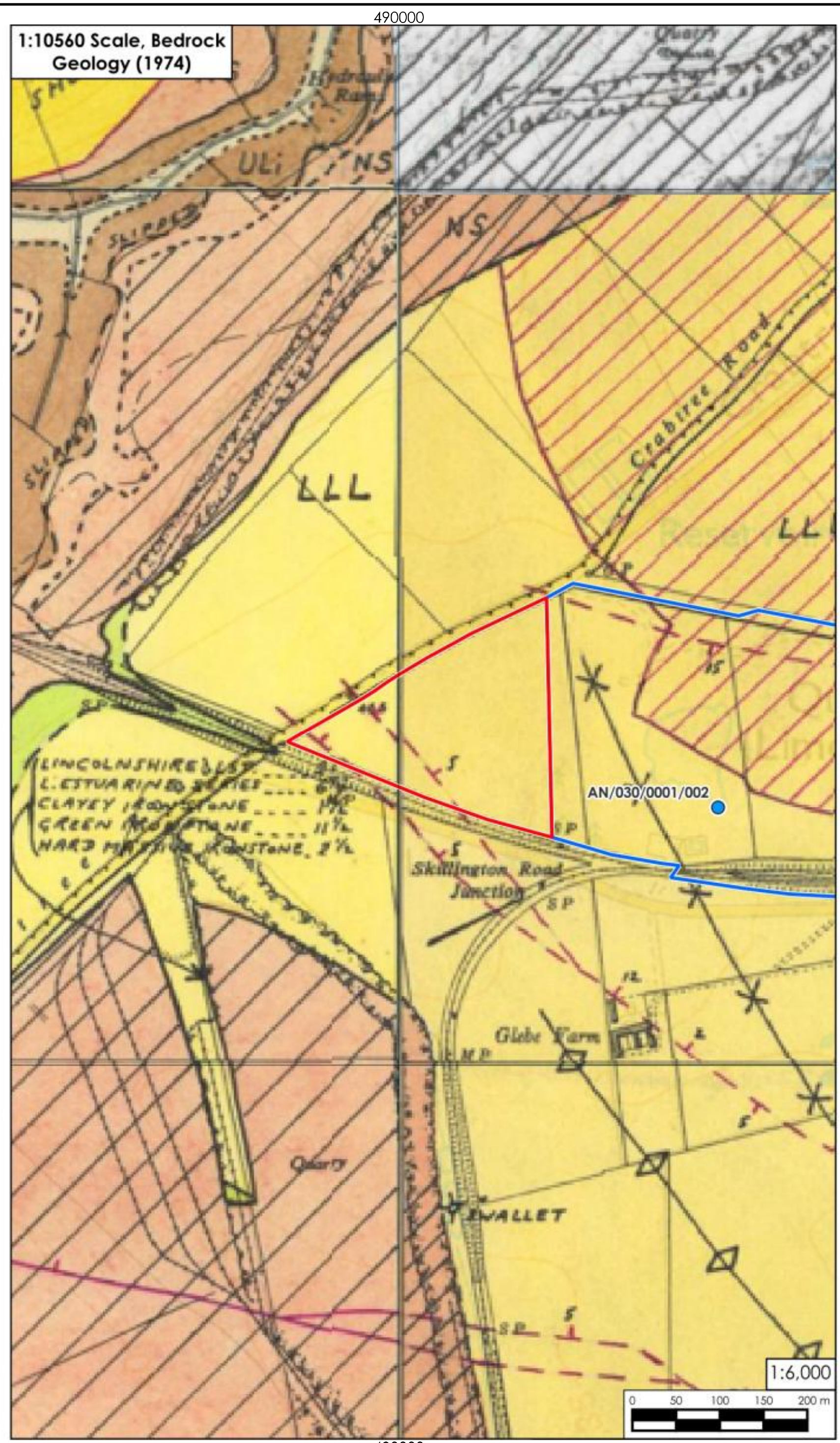

Key

- Application boundary

Bedrock Geology Key:

- ① Cornbrash formation - limestone
- ② Blisworth clay formation – mudstone
- ③ Blisworth limestone formation – limestone
- ④ Rutland formation - argillaceous rocks with subordinate sandstone and limestone
- ⑤ Upper Lincolnshire limestone member – limestone
- ⑥ Lower Lincolnshire limestone member – limestone
- ⑦ Grantham formation - sandstone, siltstone and mudstone
- ⑧ Northampton sand formation - ironstone, ooidal
- ⑨ Whitby mudstone formation – mudstone
- Fault
- BGS boreholes used in cross-sections
- SW - NE Section Line
- NW - SE Section Line

1:10560 Bedrock Geology (1974) key:

- Lower Lincolnshire limestone member – limestone
- Grantham formation - sandstone, siltstone and mudstone
- Northampton sand formation - ironstone, ooidal
- Whitby mudstone formation – mudstone
- Fault
- Groundwater abstraction (licence number)

Scale correct at A3

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Regional Geology
Project	Colsterworth Triangle
Drawing	3601/HRA/04
Version	1
Date	Jul 2024
Scale	See maps

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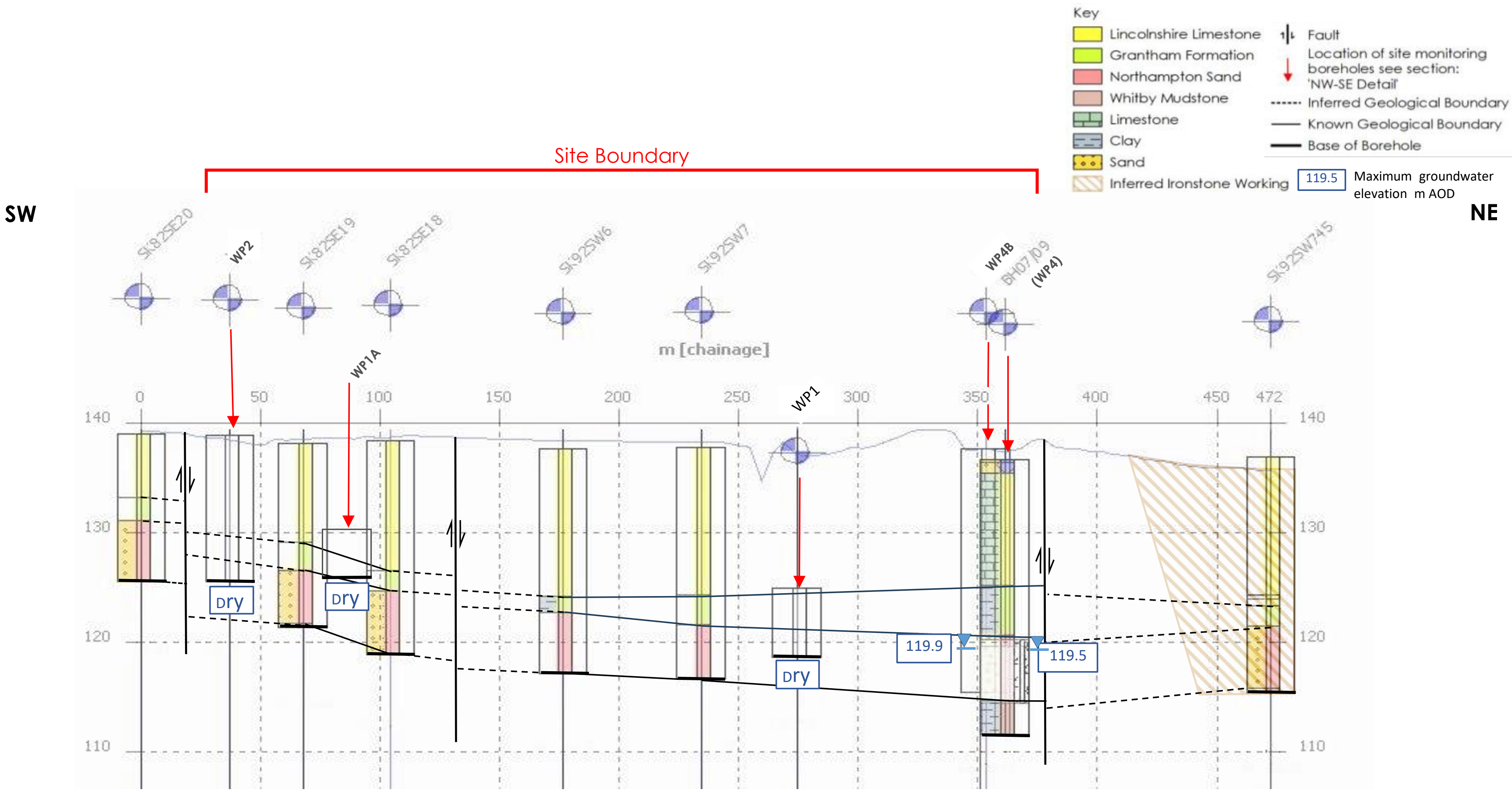
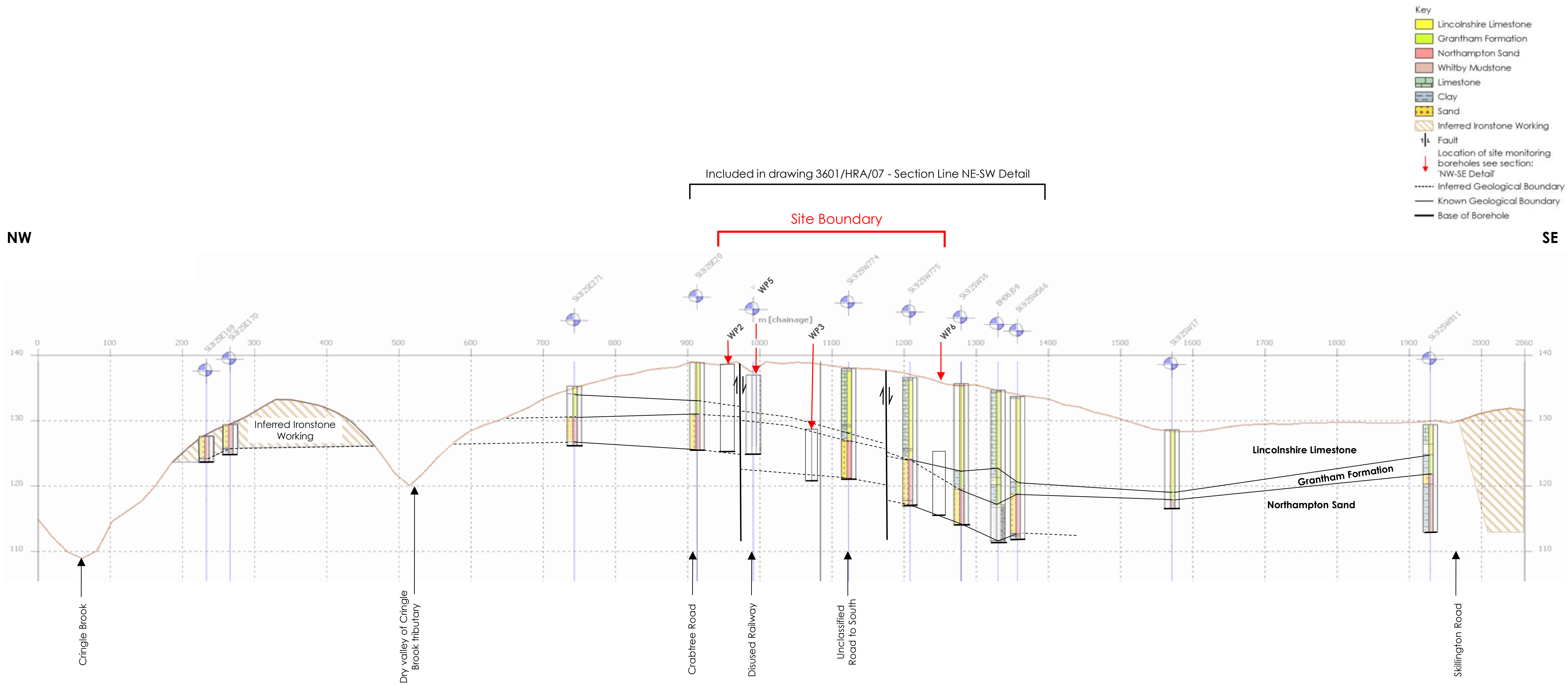


hafrenwater environmental water management Barkers Chambers • Barker Street • Shrewsbury • United Kingdom • SY1 1SB E: info@hafrenwater.com • T: 01743 355 770	Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH	

Title	Northern Boundary Section Line SW - NE		
Project	Colsterworth Triangle		
Drawing	3601/HRA/05	Version	2
Date	01/011/2024	Scale	n/a



Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Southern Boundary Section Line NW - SE Main
Project	Colsterworth Traingle
Drawing	3601/HRA/06
Version	1
Date	Jul 2024
Scale	n/a

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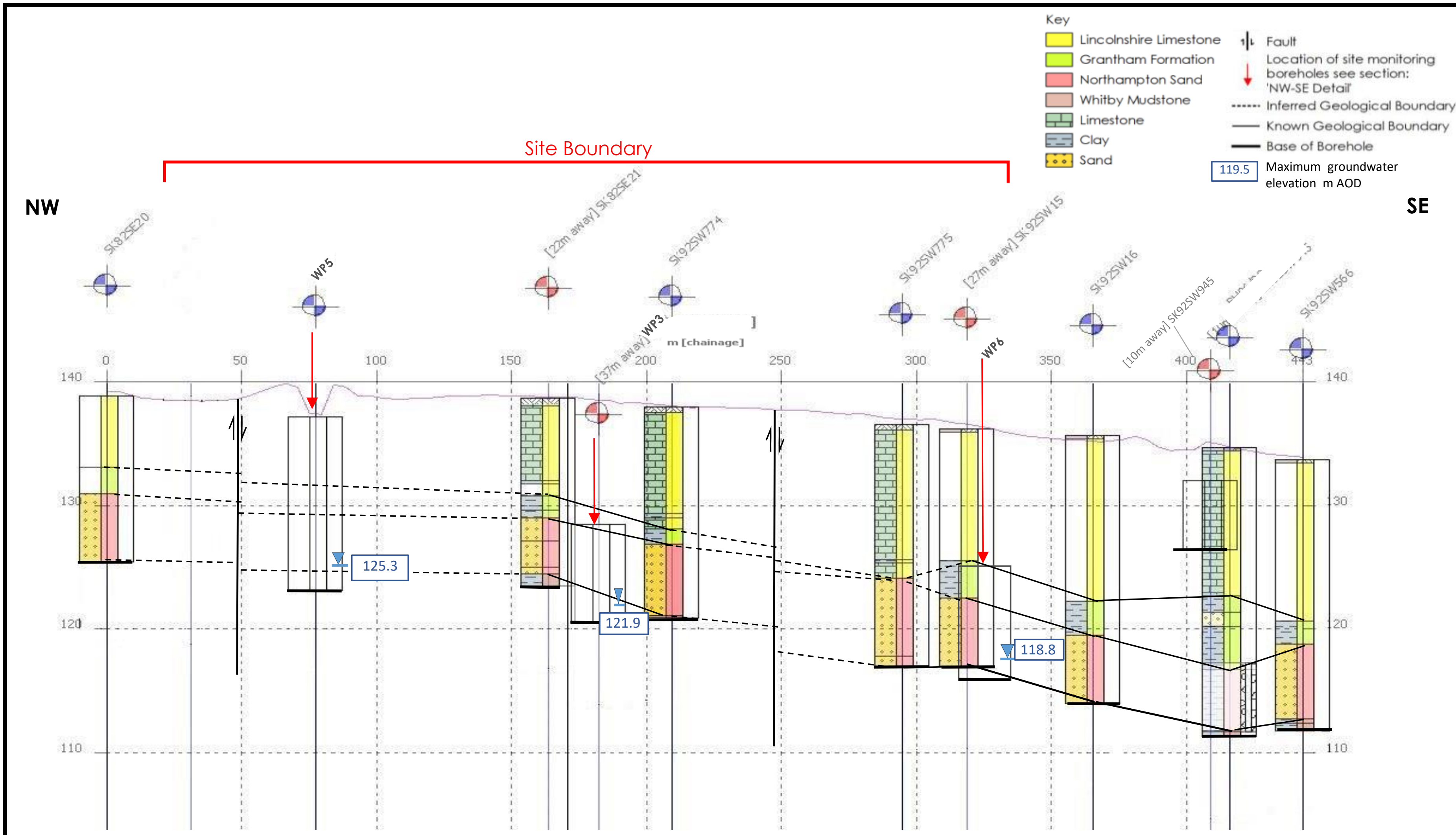

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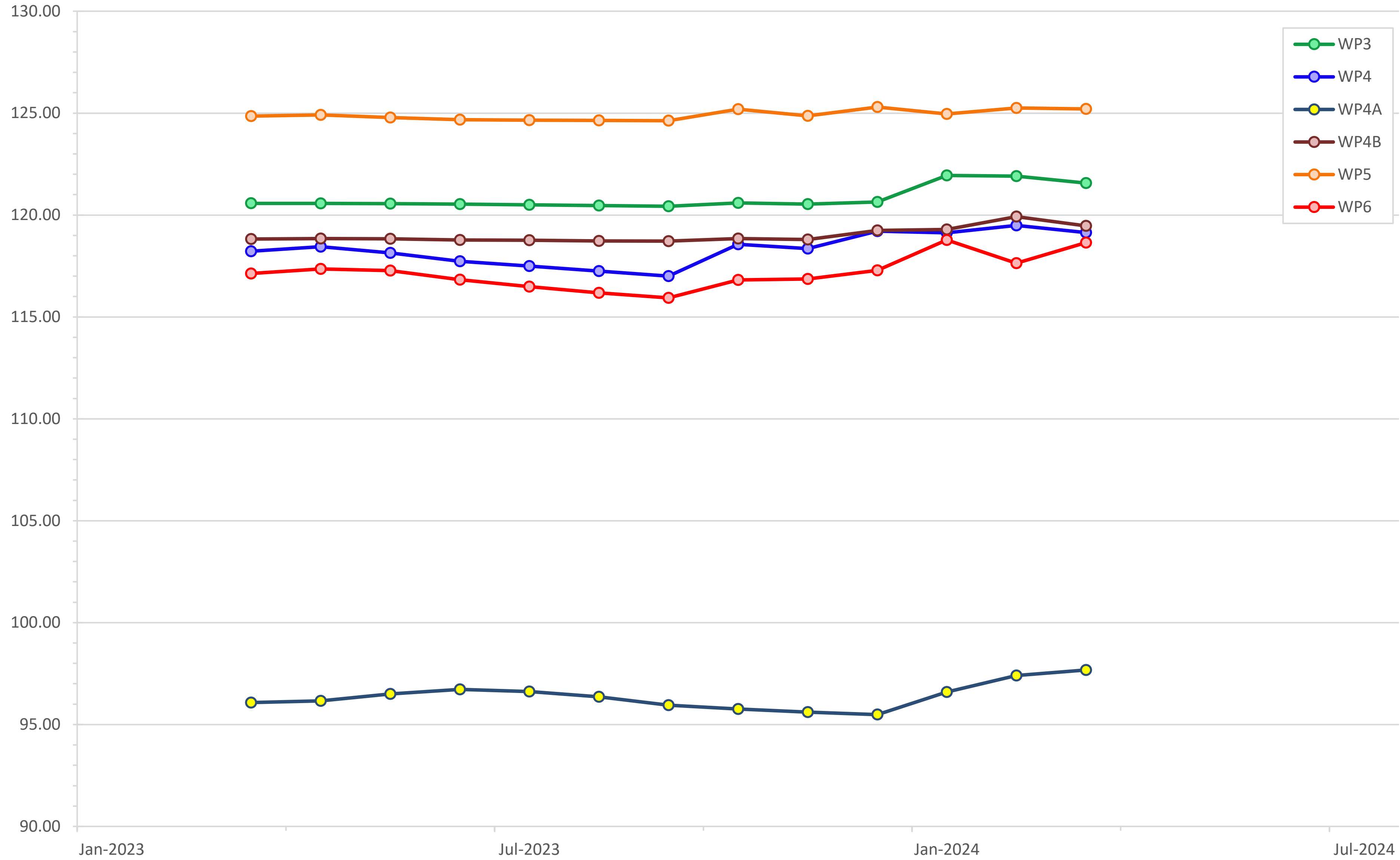
Title	Southern Boundary Section Line NW - SE Detail		
Project	Colsterworth Triangle		
Drawing	3601/HRA/07	Version	2
Date	01/011/2024	Scale	n/a



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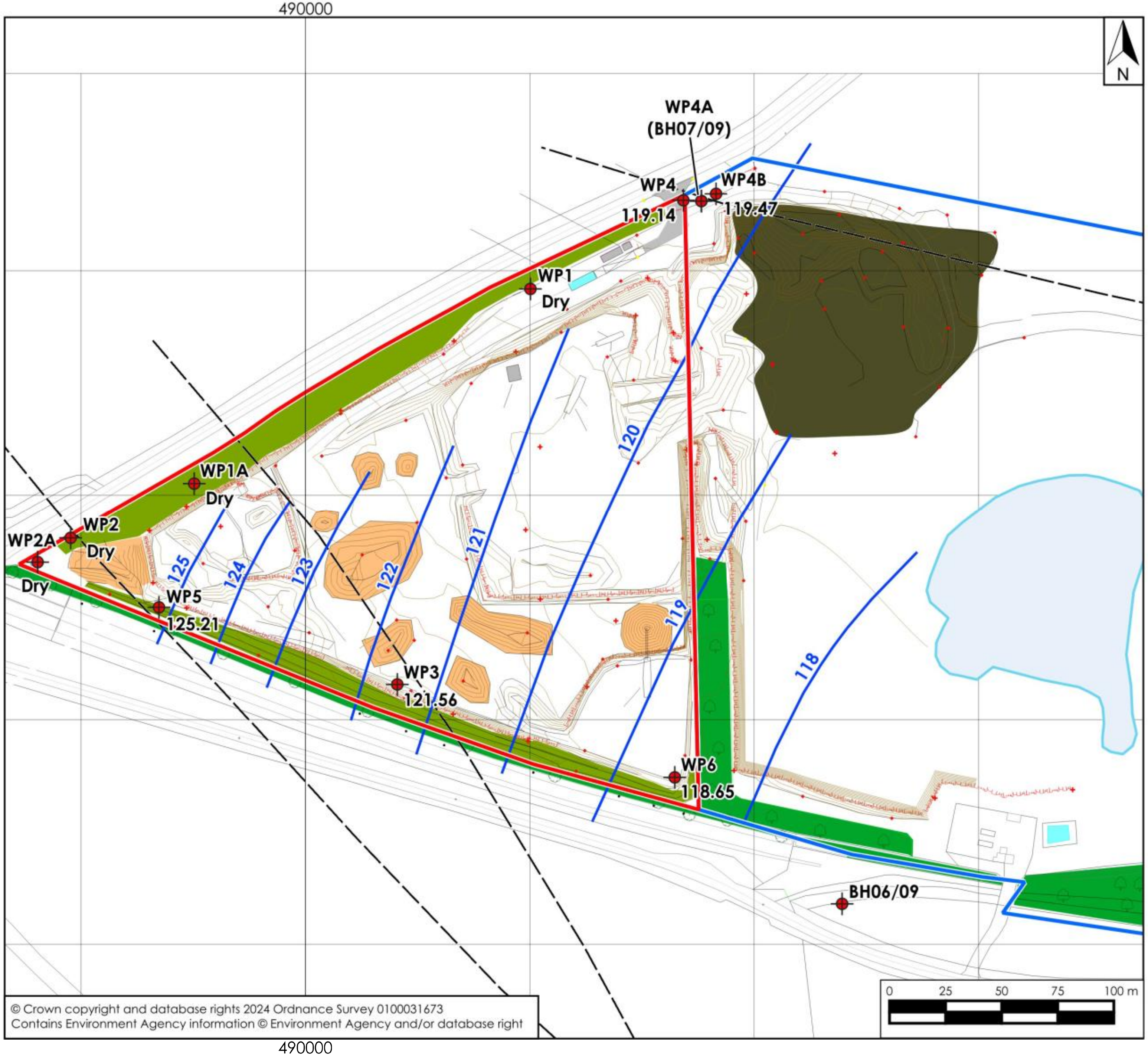
	Title	Groundwater Hydrographs	
	Project	Colsterworth Triangle	
	Drawing	3601/HRA/08	Version 1
	Date	Jun 2024	Scale n/a



Key
- Application boundary
- FCC Colsterworth Landfill
- Monitoring borehole (id) (125.21) groundwater elevation in mAOD (19/03/24)
- Licensed groundwater abstraction (Lic. no.)
- Groundwater contour (mAOD)
- Fault

Scale correct at A4

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Inferred Groundwater Contours
Project	Colesterworth Triangle
Drawing	3601/HRA/09 — Version 2
Date	Nov 2024 — Scale 1:2,500

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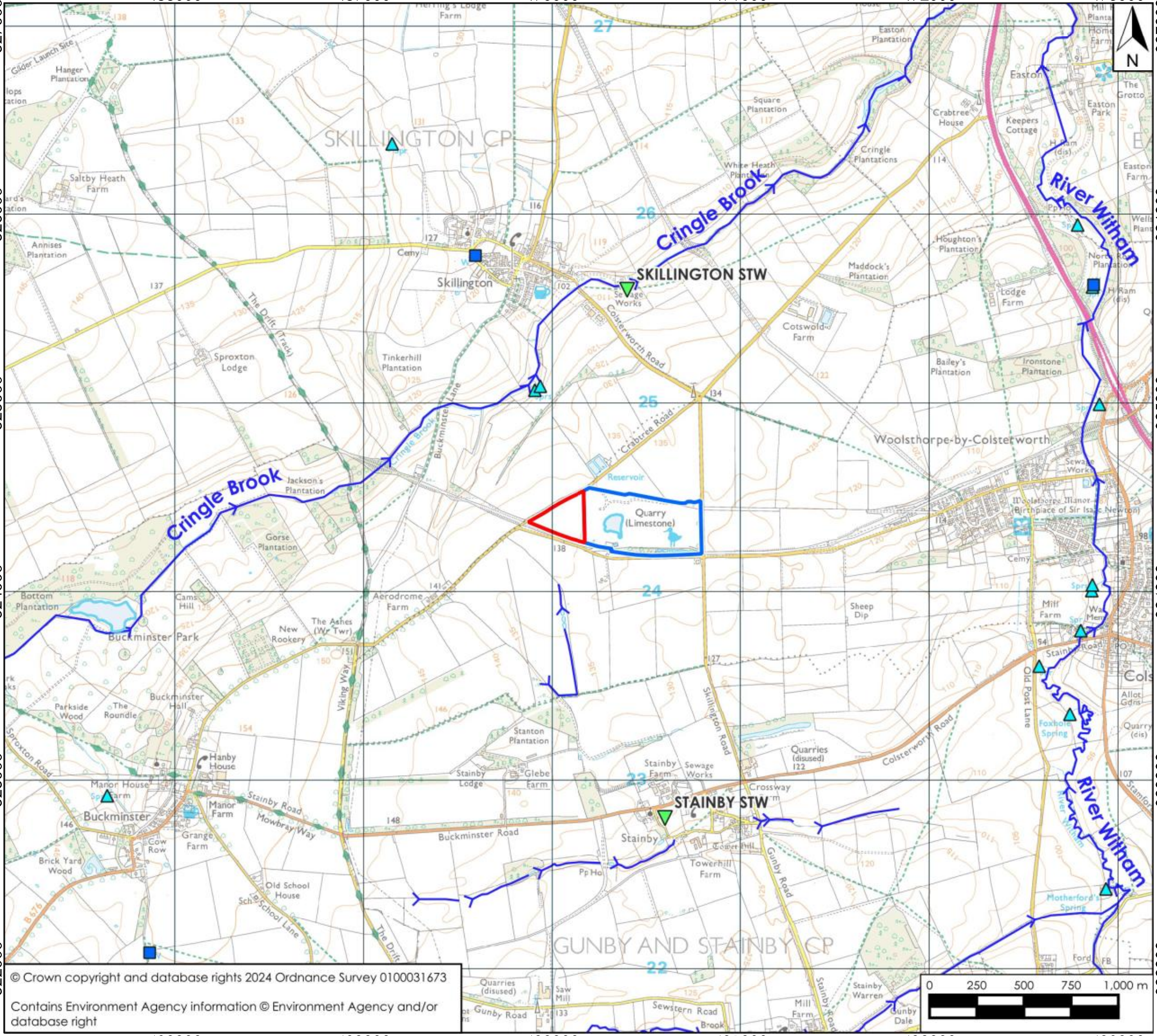

Key

- Application boundary
- FCC Colsterworth Landfill
- Watercourse
- Waterbody
- Spring
- Well
- Discharge consent (name)

Scale correct at A4

Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Surface Water Features
Project	Colesterworth Triangle
Drawing	3601/HRA/10
Version	1
Date	Jul 2024
Scale	1:30,000

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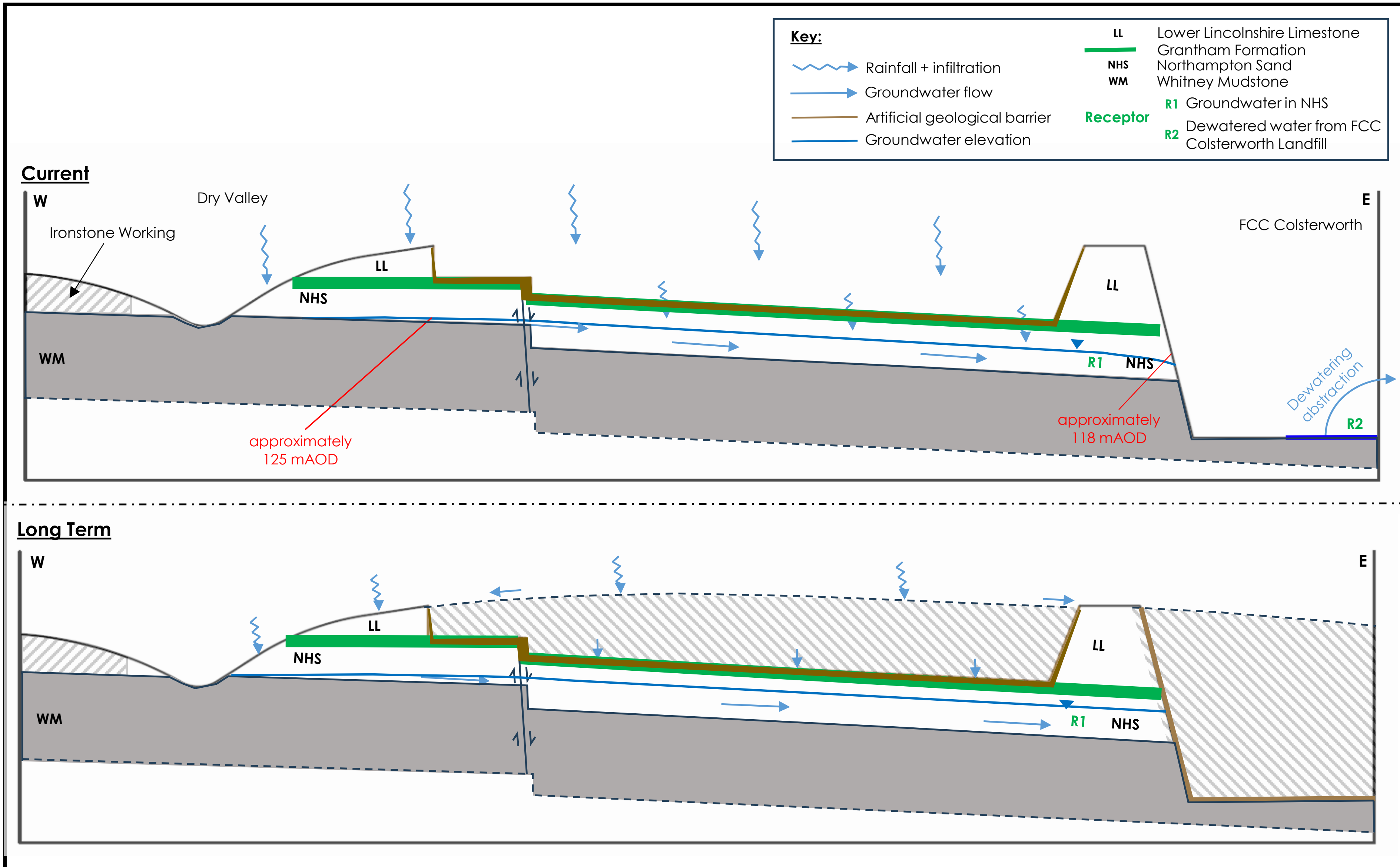

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Client	CESL Colsterworth Triangle Quarry Stainby, Lincolnshire NG33 5BH
Title	Source and Receptor Schematic Cross-section
Project	Colsterworth Triangle
Drawing	3601/HRA/11
Version	2
Date	Nov 2024
Scale	n/a

APPENDIX 3601/HRA/A1

Groundwater level data

GROUNDWATER LEVEL MONITORING RESULTS

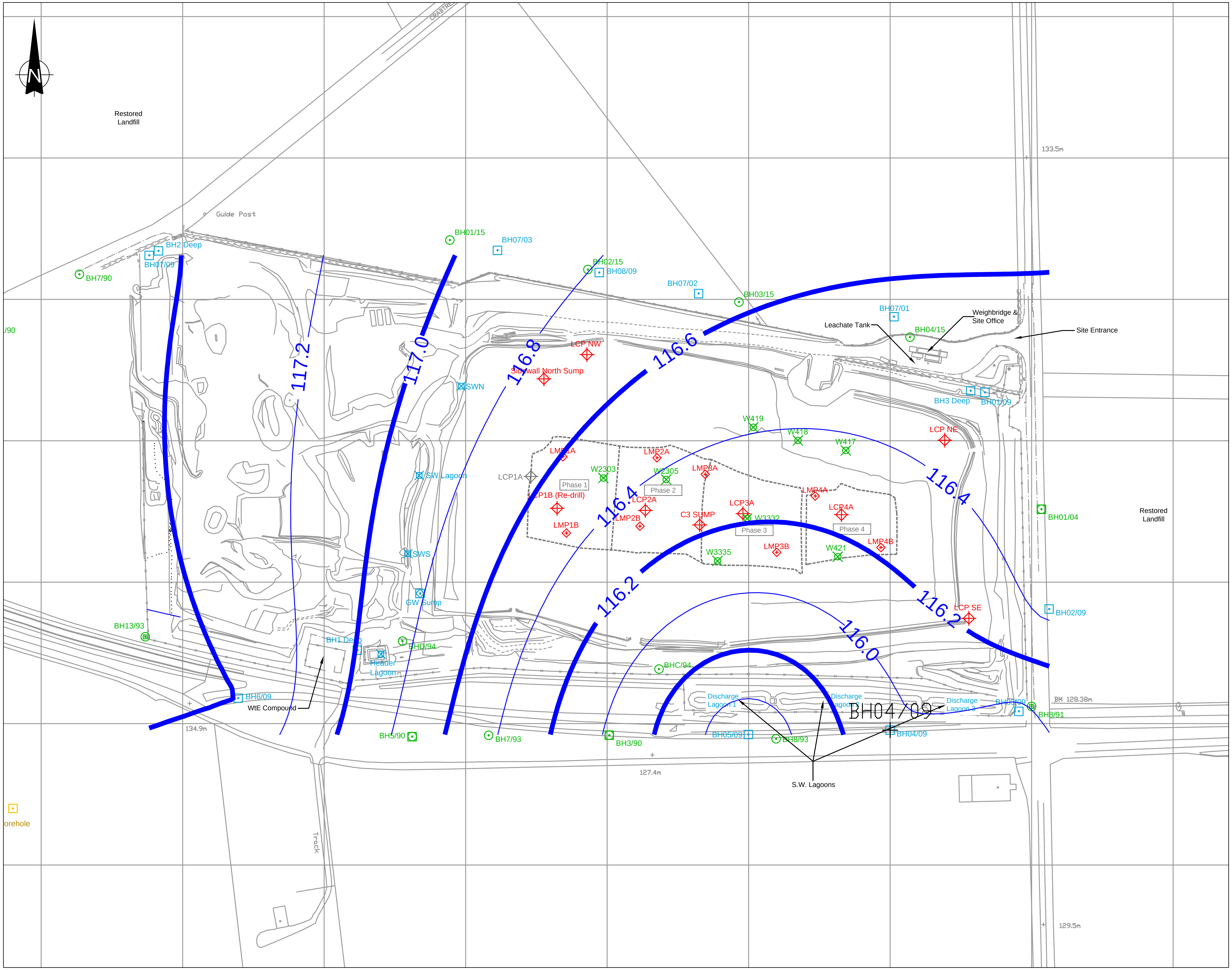
Site: Colsterworth Traingle

Client: CESL Site Grid Reference:-

Borehole ID	WP1		WP1A		WP2		WP2A		WP3		WP4		WP4A		WP4B		WP5		WP6		Comments
Alternative ID											BH 07/09		BH2D								
2023 Cap mAOD	**124.93**		**130.38**		**138.88**		**138.93**		**128.45**		**137.60**		**137.94**		**137.84**		**137.15**		**124.34**		**RELIABLE from DPR Survey 2023**
2019 Cap mAOD	137.15				138.82				128.42						137.91		136.99		127.52		
Cap above gl (m)	0.20		0.28		0.27		0.54		0.32		0.22		0.49		0.23		0.37		0.43		D Jones measurement (25/09/23)
GL calculated	124.73		130.10		138.61		138.39		128.13		137.38		137.45		137.61		136.78		123.91		based on 2023 data
GL m AOD					138.82				128.12		136.57						136.99				From RSK report & confirmed with LiDAR
Pipe Size	50 mm		50 mm		50 mm		50 mm		50 mm		50 mm		50 mm		50 mm		50 mm		50 mm		
Depth	6.26		3.90		13.400		13.220		9.740		22.230		91.100		20.440		13.960		8.760		m BD
Base BH mAOD	118.67		126.48		125.48		125.71		118.71		115.37		46.84		117.40		123.19		115.58		based on 2023 data
Response zone	Lwr Linc Lst, Granthan & top of NHS		Lwr Linc Lst		Lwr Lincs Lst & Grantham		Lwr Lincs Lst, Grantham & NHS		Bottom of Grantham & NHS		NHS (120.17 to 115.37 m AOD)		Marlestone Rock		Lwr Lincs Lst, Grantham & NHS		Lwr Linc Lst, Granthan & top of NHS		Grantham & NHS		
Groundwater level	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	m below cap	m AOD	
Date																					
29/11/2019	18.13	119.02							10.78	117.64	18.20	119.40					12.00	124.99	16.85	110.67	Not considered reliable
19/02/2020	17.80	119.35							9.90	118.52	17.35	120.25					11.95	125.04	15.48	112.04	Not considered reliable
10/06/2020	19.50	117.65							10.90	117.52	19.20	118.40									Not considered reliable
09/09/2020	18.29	118.86							10.80	117.62	18.00	119.60							15.96	111.56	Not considered reliable
29/03/2023	6.28		3.90		13.41		13.22		7.88	120.57	19.38	118.22	41.86	96.08	19.02	118.82	12.29	124.86	7.21	117.13	
25/04/2023	6.28		3.90		13.40		13.22		7.88	120.57	19.16	118.44	41.78	96.16	19.00	118.84	12.23	124.92	6.98	117.36	
23/05/2023	6.26		3.90		13.40		13.22		7.89	120.56	19.46	118.14	41.43	96.51	19.01	118.83	12.37	124.78	7.07	117.27	
21/06/2023	6.26		3.90		13.40		13.22		7.92	120.53	19.87	117.73	41.21	96.73	19.07	118.77	12.47	124.68	7.51	116.83	
18/07/2023	6.26		3.90		13.4		13.22		7.95	120.50	20.11	117.49	41.32	96.62	19.08	118.76	12.49	124.66	7.85	116.49	
18/08/2023	6.26		3.90		13.4		13.22	10.00	7.99	120.46	20.35	117.25	41.58	96.36	19.11	118.73	12.51	124.64	8.16	116.18	
25/09/2023	6.25		3.90		13.43		13.22		8.02	120.43	20.60	117.00	41.99	95.95	19.12	118.72	12.52	124.63	8.40	115.94	
24/10/2023	6,26		3.90		13.4		13.22		7.86	120.59	19.04	118.56	42.17	95.77	19.00	118.84	11.95	125.20	7.52	116.82	
16/11/2023	6.27		3.90		13.4		13.20		7.92	120.53	19.25	118.35	42.33	95.61	19.04	118.80	12.28	124.87	7.48	116.86	
11/12/2023	6.27		3.90		13.4		13.20		7.81	120.64	18.39	119.21	42.45	95.49	18.60	119.24	11.85	125.30	7.05	117.29	
22/01/2024	6.25		3.90		13.4		13.22		6.51	121.94	18.48	119.12	41.34	96.60	18.55	119.29	12.19	124.96	5.56	118.78	
21/02/2024	6,25		3.90		13.4		13.22		6.54	121.91	18.11	119.49	40.53	97.41	17.92	119.92	11.89	125.26	6.70	117.64	
19/03/2024	6.22		3.90		13.35		13.22		6.89	121.56	18.46	119.14	40.26	97.68	18.37	119.47	11.94	125.21	5.69	118.65	

APPENDIX 3601/HRA/A2

Drawing WR7600/11/11



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3. ANY ANOMALIES IDENTIFIED WITH THE DETAILS SHOWN ON THIS DRAWING ARE TO BE BROUGHT TO THE ATTENTION OF FCC ENVIRONMENT (UK) LIMITED PRIOR TO CONSTRUCTION WORKS COMMENCING.

LEGEND:

- Landfill Gas Monitoring Borehole
- Landfill Gas Surface Monitoring Point
- Combined Gas/ Groundwater Monitoring Point
- Gas Flare Stack
- Landfill Gas Extraction Point
- Landfill Gas Extraction/ Leachate Monitoring Point
- Condensate Unit (Knock-out Pot)
- Gas Manifold
- Groundwater Monitoring Borehole
- Groundwater Pumping Point
- Surface Water Monitoring Point
- Leachate Collection Point
- Leachate Monitoring Point
- Leachate Recirculation Point
- Leachate Collection Sump
- Leachate Discharge Sampling Point
- Leachate Detection Point
- Underdrainage Monitoring Point
- Settlement Monitoring Point
- Drain/ Dewatering Tank
- Valve
- Proposed Well
- Redundant Well
- As-built Cell Footprint
- Inferred Groundwater Contours Within Northampton Sand Formation

REV	DESCRIPTION	DATE	BY

CLIENT

FCC Environment

FCC Environment (UK) Limited
Ground Floor West, 900 Pavilion Drive, Northampton Business Park, Northampton, NN4 7RG

Sirius Environmental

4245 Park Approach, Thorpe Park, Leeds, LS15 8GB. 0113 264 9960

JOB TITLE

COLSTERWORTH LANDFILL SITE
ENVIRONMENTAL PERMIT VARIATION APPLICATION

DRAWING TITLE

Northampton Sand Formation
Groundwater Contours

DRAWN	DATE	APPROVED	DATE
M.K	20/2/2020	D.T	20/2/2020

SCALE	SHEET	DRAWING NUMBER	REVISION
1:2,500	A3L	WR7600/11/11	0

APPENDIX 3601/HRA/A3

Groundwater quality data

GROUNDWATER QUALITY DATA

Site: Colsterworth Triangle
Client: CESL

Analysis	MDL	Units											
		Sample ID	001	001	001	001	001	001	001	001	001	001	001	001
		Customer ID	WP3	WP3	WP3	WP3	WP3	WP3	WP3	WP3	WP3	WP3	WP3	WP3
		Sample Type	WATER	WATER	WATER	WATER	WATER	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Water
		Sampling Date	25/04/2023	19/05/2023	21/06/2023	18/07/2023	18/08/2023	25/09/2023	24/10/2023	16/11/2023	11/12/2023	22/01/2024	21/02/2024	19/03/2024
Ammoniacal Nitrogen as N	0.01	mg/l	0.1	0.02	0.07	1.4	0.9	0.2	0.06	0.13	<0.01	0.02	0.07	0.04
Conductivity at 25°C	100	µS/cm	1440	1330	1580	1590	1550	1540	1290	1430	952	1330	1280	1220
pH	1	pH units	6.9	7	7.1	7	7	7.1	7	7.1	7.4	6.9	7.6	7
Chloride as Cl	1	mg/l	47	43	54	55	56	57	47	51	26	44	42	41
Nitrate as NO3	0.9	mg/l	22.2	38.5	48.9	42.1	33.5	32.1	33.9	18.1	50.9	55.9	25.6	34.1
COD (Settled)	5	mg/l	<5	<5	<5	21	8	<5	<5	<5	10	<5	<5	<5
BOD (5 day)	1	mg O2/l	<1.0	<1.0* B	3.2	7.1* B,G	7.9* G	10.1	1.3	<1.0	1.2	<1.0	<1.0	<1.0
Total Organic Carbon	0.4	mg/l	35.8	1.55	1.67	23	4.32	4.15	<4.00	11.4	1.86	2.16	7.38	11.2
Arsenic as As	0.001	mg/l	0.003	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001
Cadmium as Cd	0.00002	mg/l	0.00009	<0.00002 C	0.00004	<0.00002	0.00003	<0.00002	<0.00002	<0.00002	0.00039	0.00003	0.00004	<0.00002
Total Chromium as Cr	0.001	mg/l	0.002	<0.001 C	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.007	<0.001	<0.001	<0.001
Copper as Cu	0.001	mg/l	0.002	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	0.002
Lead as Pb	0.001	mg/l	0.002	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.023	<0.001	0.008	<0.001
Mercury as Hg	0.00003	mg/l	<0.00003	<0.00003 C	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Nickel as Ni	0.001	mg/l	0.005	0.003 C	0.003	0.003	0.003	0.003	0.003	0.003	0.018	0.002	0.003	0.002
Selenium as Se	0.001	mg/l	<0.001	<0.001 C	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc as Zn	0.002	mg/l	0.019	0.005 C	0.005	0.009	0.012	0.011	0.01	0.011	0.029	0.011	0.028	0.017
Boron as B	0.01	mg/l	0.18	0.16	0.11	0.12	0.13	0.1	0.14	0.06	0.12	0.08	0.13	0.09
Iron as Fe	0.01	mg/l	<0.01	0.01	0.08	0.06	0.05	0.14	0.05	0.04	6.62	0.19	0.1	0.04
Total Sulphur as SO4	3	mg/l	341	279	318	331	323	304	275	228	254	262	279	265

GROUNDWATER QUALITY DATA

Site: Colsterworth Triangle
Client: CESL

		Sample ID	2	002	002	002	002	002	002	002	002	002	002	002
		Customer ID	WP4	WP4	WP4	WP4	WP4	WP4	WP4	WP4	WP4	WP4	WP4	WP4
		Sample Type	WATER	WATER	WATER	WATER	WATER	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Water
		Sampling Date	25/04/2023	19/05/2023	21/06/2023	18/07/2023	18/08/2023	25/09/2023	24/10/2023	16/11/2023	11/12/2023	22/01/2024	21/02/2024	19/03/2024
Analysis	MDL	Units												
Ammoniacal Nitrogen as N	0.01	mg/l	0.02	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	0.01
Conductivity at 25°C	100	µS/cm	588	593	620	613	616	608	616	625	605	585	591	620
pH	1	pH units	7.5	7.5	7.4	7.4	7.7	7.6	7.5	7.5	7.6	7.5	8	7.6
Chloride as Cl	1	mg/l	23	21	28	27	28	29	24	21	22	22	22	29
Nitrate as NO3	0.9	mg/l	52.1	308	65	63.3	63.2	65.9	57.4	56.7	59	56.1	54.5	49.9
COD (Settled)	5	mg/l	<5	<5	<5	27	6	<5	5	<5	9	<5	<5	<5
BOD (5 day)	1	mg O2/l	<1.0	<1.0* B	<1.0	<1.0* B	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Organic Carbon	0.4	mg/l	1.66	1.46	1.51	1.06	1.12	4.19	4.03	3.59	2.5	1.68	2.38	2.59
Arsenic as As	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium as Cd	0.00002	mg/l	<0.00002	<0.00002 C	0.00003	<0.00002	0.00003	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Total Chromium as Cr	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead as Pb	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury as Hg	0.00003	mg/l	<0.00003	<0.00003 C	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	0.00004	<0.00003
Nickel as Ni	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium as Se	0.001	mg/l	<0.001	<0.001 C	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc as Zn	0.002	mg/l	0.003	0.011 C	0.003	0.008	0.007	0.01	0.008	0.024	0.009	0.011	0.011	0.026
Boron as B	0.01	mg/l	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Iron as Fe	0.01	mg/l	0.02	0.17	0.03	0.03	0.14	0.31	0.05	0.06	0.01	0.01	0.05	0.02
Total Sulphur as SO4	3	mg/l	89	85	91	88	84	76	80	86	88	86	88	93

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GROUNDWATER QUALITY DATA

Site: Colsterworth Triangle
Client: CESL

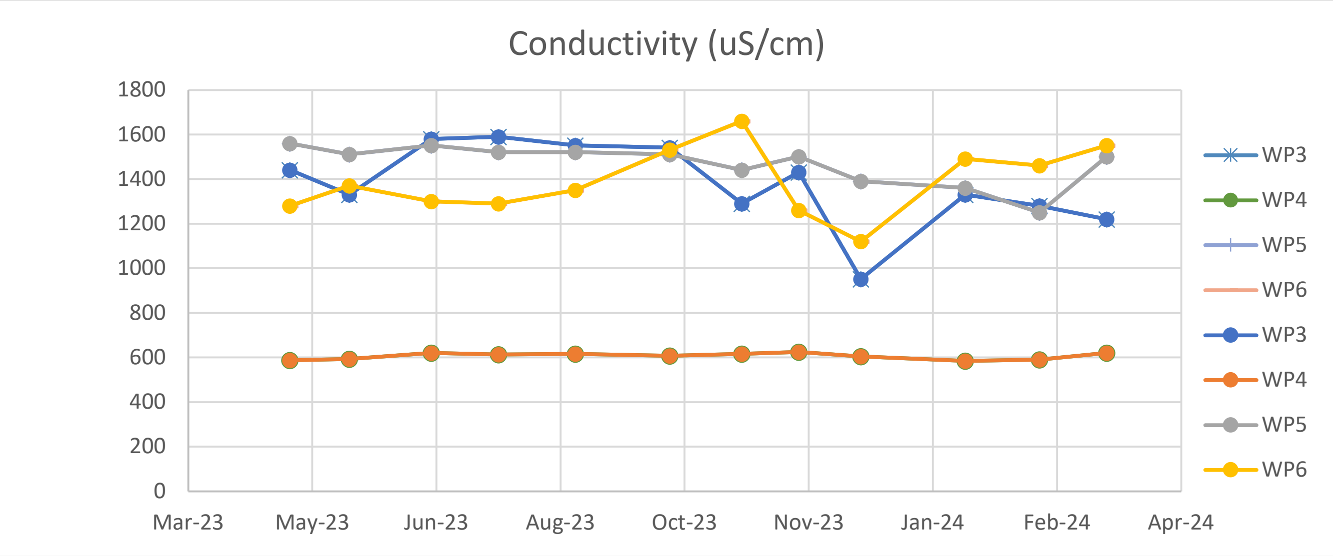
		Sample ID	003	003	003	003	003	003	003	003	003	003	003	003
		Customer ID	WP5	WP5	WP5	WP5	WP5	WP5	WP5	WP5	WP5	WP5	WP5	WP5
		Sample Type	WATER	WATER	WATER	WATER	WATER	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Water
		Sampling Date	25/04/2023	19/05/2023	21/06/2023	18/07/2023	18/08/2023	25/09/2023	24/10/2023	16/11/2023	11/12/2023	22/01/2024	21/02/2024	19/03/2024
Analysis	MDL	Units												
Ammoniacal Nitrogen as N	0.01	mg/l	0.02	0.03	0.1	0.04	0.7	0.2	0.06	0.14	0.03	0.02	0.02	0.03
Conductivity at 25°C	100	µS/cm	1560	1510	1550	1520	1520	1510	1440	1500	1390	1360	1250	1500
pH	1	pH units	7	7	7.2	7	7.1	7.1	7.1	7.1	7.2	7.1	7.6	7
Chloride as Cl	1	mg/l	64	48	69	62	60	63	63	55	52	38	24	51
Nitrate as NO3	0.9	mg/l	17.1	6.9	28.1	24.9	4.7	24.9	37.9	8.7	22.7	36.9	29.1	9.1
COD (Settled)	5	mg/l	6	<5	<5	<5	11	<5	<5	<5	16	35	<5	<5
BOD (5 day)	1	mg O2/l	<1.0	2.8* B	<1.0	<1.0* B	7.4* G	4.8	<1.0	<1.3	<1.0	<1.0	<1.0	<1.0
Total Organic Carbon	0.4	mg/l	44.5	1.58	1.82	11.2	<4.00 D	4.06	<4.00	30.3	1.51	4.24	37	17.7
Arsenic as As	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	0.004	0.004	<0.001	0.002	0.001	<0.001	<0.001	<0.001
Cadmium as Cd	0.00002	mg/l	<0.00002	<0.00002 C	0.00016	0.00006	0.00003	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00003	<0.00002
Total Chromium as Cr	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	0.001	0.004	0.002	0.002	<0.001	<0.001	<0.001	<0.001
Copper as Cu	0.001	mg/l	0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead as Pb	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury as Hg	0.00003	mg/l	<0.00003	<0.00003 C	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Nickel as Ni	0.001	mg/l	0.009	0.009 C	0.005	0.007	0.008	0.012	0.004	0.007	0.007	<0.001	0.002	0.006
Selenium as Se	0.001	mg/l	<0.001	<0.001 C	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc as Zn	0.002	mg/l	0.011	0.011 C	0.007	0.012	0.008	0.021	0.007	0.022	0.008	0.042	0.006	0.013
Boron as B	0.01	mg/l	0.14	0.14	0.1	0.12	0.13	0.13	0.08	0.13	0.13	0.07	0.05	0.1
Iron as Fe	0.01	mg/l	0.04	0.02	0.01	0.02	1.07	0.97	0.06	0.01	0.5	0.02	0.03	0.14
Total Sulphur as SO4	3	mg/l	404	359	391	340	336	332	321	429	353	373	375	399

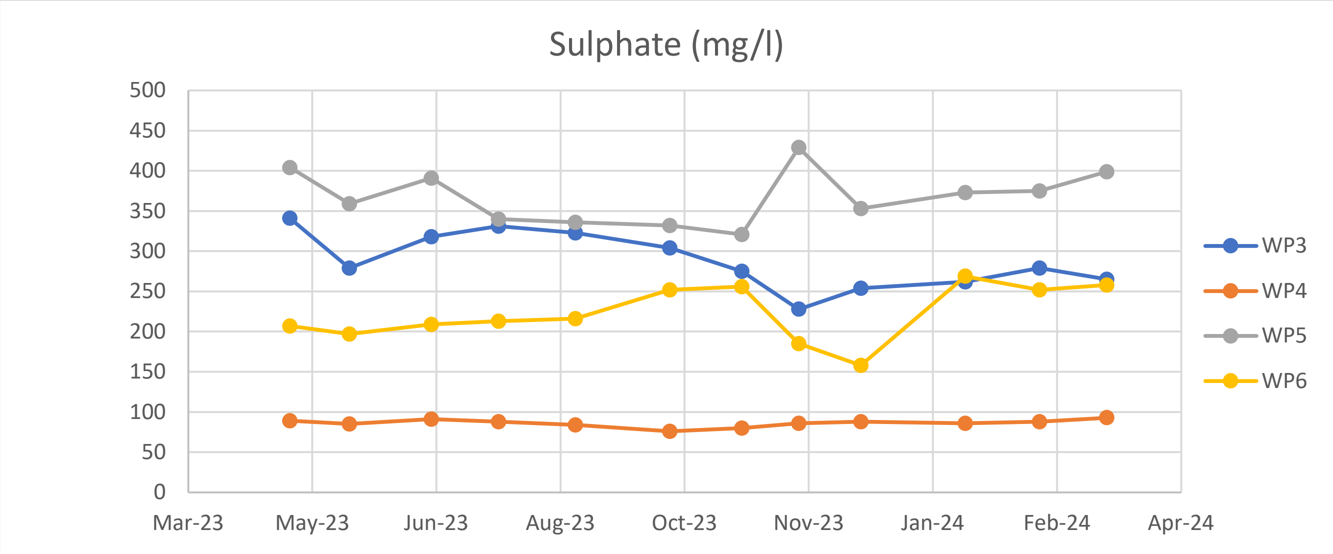
hafrenwater
environmental water management

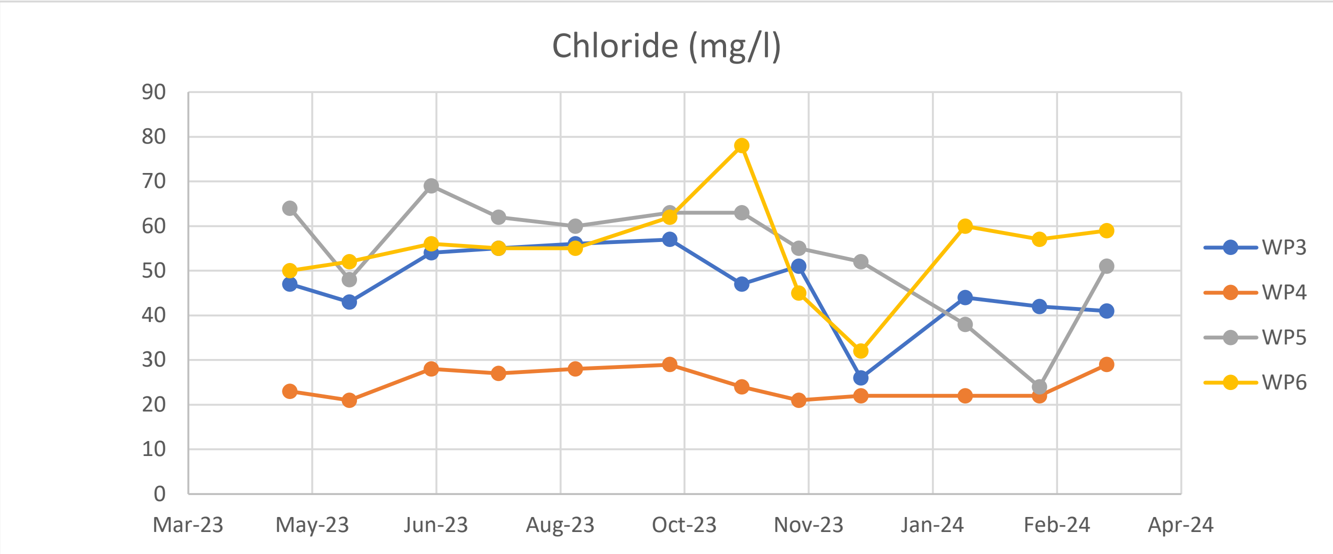
GROUNDWATER QUALITY DATA

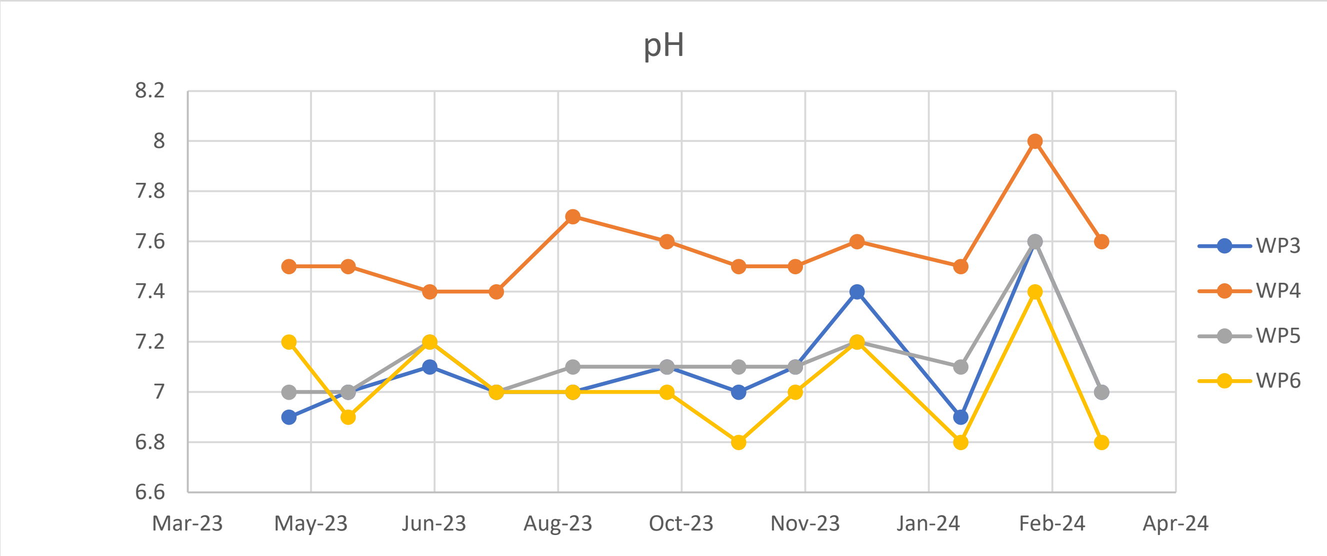
Site: Colsterworth Triangle
Client: CESL

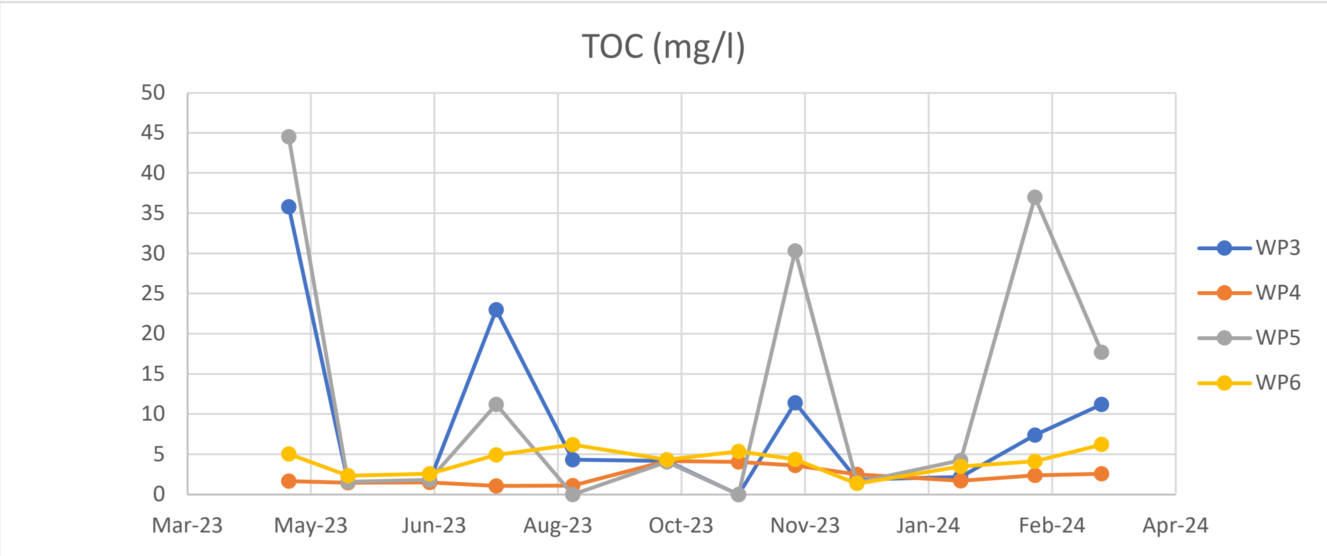
		Sample ID	004	004	004	004	004	004	004	004	004	004	004	004
		Customer ID	**WP6**	WP6	WP6	WP6	WP6	WP6	WP6	WP6	WP6	WP6	WP6	WP6
		Sample Type	WATER	WATER	WATER	WATER	WATER	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Wate	Ground Water
		Sampling Date	25/04/2023	19/05/2023	21/06/2023	18/07/2023	18/08/2023	25/09/2023	24/10/2023	16/11/2023	11/12/2023	22/01/2024	21/02/2024	19/03/2024
Analysis	**MDL**	**Units**												
Ammoniacal Nitrogen as N	0.01	mg/l	0.2	0.03	0.01	0.05	0.6	2.4	5.4	0.2	<0.01	3.9	5.6	6.2
Conductivity at 25°C	100	µS/cm	1280	1370	1300	1290	1350	1530	1660	1260	1120	1490	1460	1550
pH	1	pH units	7.2	6.9	7.2	7	7	7	6.8	7	7.2	6.8	7.4	6.8
Chloride as Cl	1	mg/l	50	52	56	55	55	62	78	45	32	60	57	59
Nitrate as NO3	0.9	mg/l	62.2	55.7	41.9	31.6	14.2	<0.9	<0.9	47.5	86	24.4	15.4	11.9
COD (Settled)	5	mg/l	<5	<5	6	<5	<5	8	<5	<5	<5	8	<5	6
BOD (5 day)	1	mg O2/l	<1.0	<1.0* B	3.2	2.2* B	<1.0	2.7	1.5	<1.0	<1.0	<1.0	<1.0	<1.0
Total Organic Carbon	0.4	mg/l	5.04	2.34	2.57	4.91	6.18	4.32	5.37	4.38	1.37	3.47	4.14	6.22
Arsenic as As	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium as Cd	0.00002	mg/l	<0.00002	<0.00002 C	0.00002	0.00003	<0.00002	<0.00002	0.00003	<0.00002	<0.00002	0.00003	<0.00002	<0.00002
Total Chromium as Cr	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	0.002	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
Lead as Pb	0.001	mg/l	<0.001	<0.001 C	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury as Hg	0.00003	mg/l	<0.00003	<0.00003 C	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Nickel as Ni	0.001	mg/l	0.004	0.004 C	0.004	0.006	0.005	0.011	0.02	0.005	0.002	0.009	0.005	0.005
Selenium as Se	0.001	mg/l	<0.001	<0.001 C	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Zinc as Zn	0.002	mg/l	0.007	0.011 C	0.004	0.013	0.008	0.027	0.016	0.016	0.015	0.035	0.008	0.016
Boron as B	0.01	mg/l	0.08	0.09	0.08	0.08	0.08	0.1	0.12	0.06	0.08	0.1	0.1	0.11
Iron as Fe	0.01	mg/l	0.02	0.04	0.01	0.04	0.09	0.06	0.1	0.03	0.08	0.04	0.02	0.03
Total Sulphur as SO4	3	mg/l	207	197	209	213	216	252	256	185	158	269	252	258

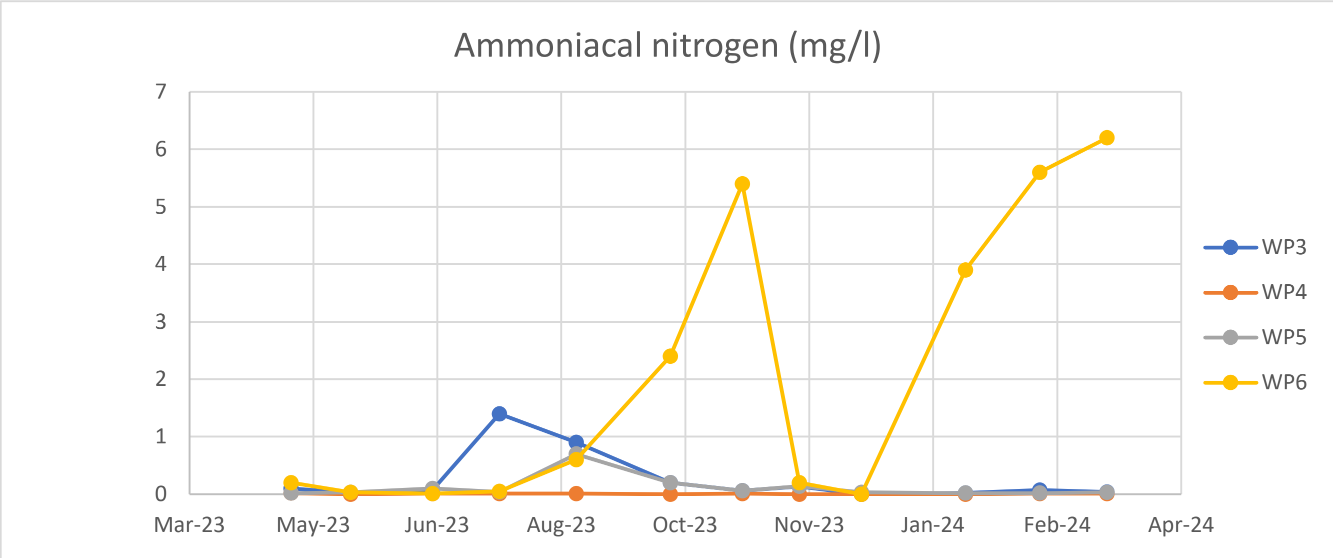

Conductivity (uS/cm)
1800
1600
1400
1200
1000
800
600
400
200
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6
WP3
WP4
WP5
WP6

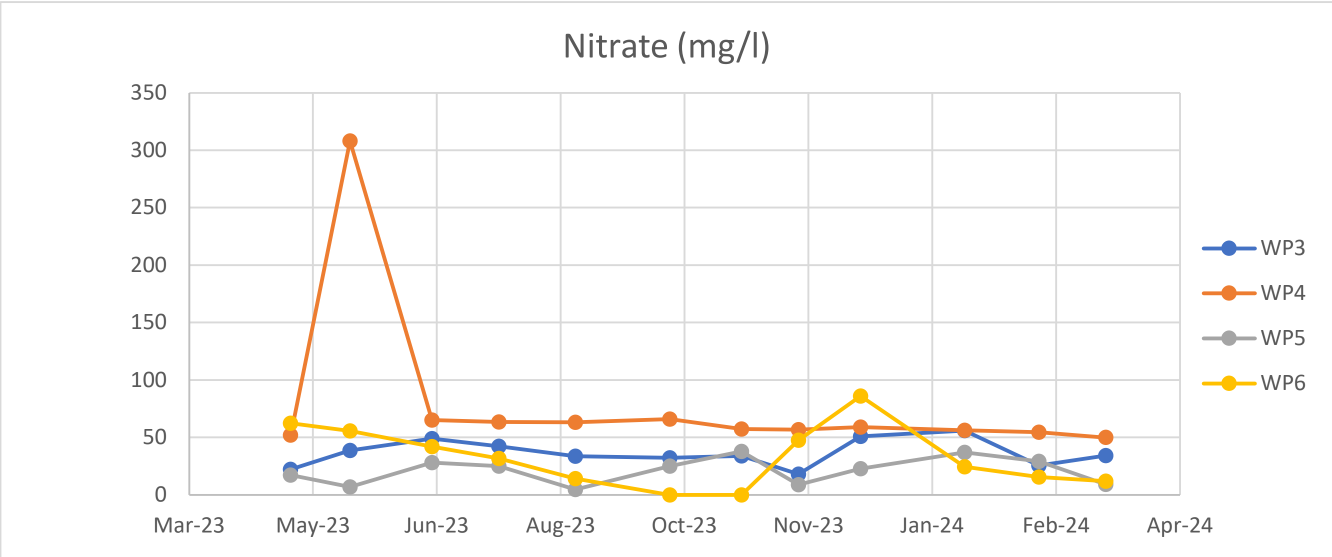

Sulphate (mg/l)
500
450
400
350
300
250
200
150
100
50
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6


Chloride (mg/l)
90
80
70
60
50
40
30
20
10
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6


pH
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6


TOC (mg/l)
50
45
40
35
30
25
20
15
10
5
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6


Ammoniacal nitrogen (mg/l)
7
6
5
4
3
2
1
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6


Nitrate (mg/l)
350
300
250
200
150
100
50
0
Mar-23
May-23
Jun-23
Aug-23
Oct-23
Nov-23
Jan-24
Feb-24
Apr-24
WP3
WP4
WP5
WP6