Wressle Wellsite Extension: Hydrogeological and Flood Risk Assessment

Prepared for Egdon Resources U.K Ltd

March 2024

CONFIDENTIAL

North Office
Aske Stables
Aske
Richmond
North Yorkshire
DL10 5HG

Tel: 01748 889 268
E mail: info@envireauwater.co.uk
Web: www.envireauwater.co.uk

Quality Control Sheet

Title	Wressle Wellsite Extension: Hydrogeological And Flood Risk Assessment
Client	Egdon Resources U.K. Ltd
Issue Date	12/03/2024
Reference	3490616 Egdon Wressle Ext \ RPT Wressle-2&3 HRA-FRA

Authors

	Name	Signed
Prepared by	Mairi Teasdale – Hydrologist	
Checked by	Michael Underwood – Senior Hydrologist	
Approved by	Dr Phil Ham – Managing Director and Principal Hydrogeologist	

Revision History

Revision	Details	Prepared by	Checked by	Approved by	Issue Date
REV01	First draft for client comment	MT	MU	PH	17/01/2024
REV02	Second draft for client approval	DB	PH	PH	28/02/2024
REV03	Client Issue	DB	PH	PH	12/03/2024

Contents

Figures

Tables

Appendices

1 INTRODUCTION

1.1 Background

Envireau Water has been commissioned by Egdon Resources U.K. Limited (Egdon Resources) to prepare a Hydrogeological Risk Assessment (HRA) and Flood Risk Assessment (FRA) to support a planning application for the construction and operation of an extension to the Wressle-1 wellsite at Broughton, North Lincolnshire, DN20 0BN. The Site is located within the Petroleum Exploration and Development Licences (PEDLs) 182 and 180.

Egdon Resources proposes to extend the existing Wressle-1 wellsite ('the wellsite') which will include the drilling of two new wells (Wressle-2 and Wressle-3) targeting hydrocarbons (potentially both oil and gas) in the Ashover Grit and Penistone Flags reservoirs. If gas volumes from the wells are sufficiently viable, it is proposed to install a gas pipeline (the Proposed Pipeline) to export gas produced at the Site to the local Cadent gas network in the B1208 road located 600 m to southwest of the Site.

The Site occupies an area of approximately 3.9 ha within the red line boundary and is located 7.5 km east of the centre of Scunthorpe and 2 km northeast of the centre of Broughton, as shown on Figure 1. The centre of the Site is at National Grid Reference SE 96770 1106.

1.2 Previous Assessments

Envireau Water prepared an HRA for Egdon Resources in July 2018 (Envireau Water, 2018) to support a planning application for development of the wellsite for commercial oil production. Planning permission was subsequently granted at appeal, in January 2020. Envireau Water's technical specialist, James Dodds, provided a Proof of Evidence to address specific hydrogeological matters to support the appeal (Dodds, 2019).

To fulfil the requirements of an Environment Agency environment permit (ref. EPR/AB3609XX/V004), groundwater and surface water monitoring has been carried out at the wellsite since 2020. The monitoring has been conducted and reported on by Envireau Water, and the results have been provided to the Environment Agency and made publicly available via the Egdon Resources website (Egdon Resources, 2023).

This report draws on the previous assessments that have been prepared to support the 2018 planning application (and appeal) and ongoing monitoring work to comply with the requirements of the environmental permit.

1.3 Pre- Application Advice

Pre-application advice was provided by North Lincolnshire Council (NLC) with regard to the Proposed Development through an Advice Note (reference PRE/2023/57, dated 19th July 2023). It should be noted that this advice was sought in relation to a scheme that included options for an underground gas pipeline to Scunthorpe Steel Works, which has subsequently been removed from the project.

NLC advised the following with regard to hydrology/hydrogeology, flood risk and drainage:

Development Plan Policies

The relevant extant development plan policies against which to assess the proposed development's effect upon the water environment are 'saved' NLLP policy DS14 which states that developments will not be permitted if they "adversely affect the quality and quantity of water resources…unless the impact is mitigated to an acceptable level". 'Saved' policy M23 of the NLLP also requires all proposals for oil and gas production to incorporate protection measures adequate to mitigate their impacts.

Constraints

The application site is located in flood zone 1 of the Environment Agency flood maps and the Environment Agency has confirmed that the site is not considered to be in an area of high flood risk. The eastern edge of the site abuts flood zone 2/3a (fluvial) of the Strategic Flood Risk Assessment, with the access to the site located in this flood zone and the rest of the site being within flood zone 1 (low risk).

Water abstraction wells are located within 100 metres of the site; there are also identified secondary aquifers lying beneath the site. Ella Beck runs to the north of the site.

Consultation Responses

Environment Agency: *An appropriate hydrogeological risk assessment will be needed to assess risks to groundwater from the proposed development and identify measures to protect these. A Flood Risk Assessment will also be required to be submitted as part of any forthcoming application to consider the potential impacts in respect of flooding.*

Drainage: *The Council's drainage officer raises no objections or comments in respect of the proposed development. A surface water drainage strategy should be submitted as part of the application for formal consideration.*

1.4 Scope of Work

This report has been prepared to support a planning application for the Proposed Development and consists of:

1. An HRA based on a robust hydrogeological conceptual model for the Site. The assessment has been conducted in accordance with the methodology and framework for groundwater risk assessment set out by DEFRA in Green Leaves III (GL III) (DEFRA, 2011), and the Environment Agency's (EA's) approach to groundwater protection (Environment Agency, 2018b) and technical guidance (Environment Agency, 2018a).

2. An FRA carried out in accordance with the National Planning Policy Framework (NPPF) (Department for Communities and Local Government, 2023) and the accompanying online resource, National Planning Practice Guidance (NPPG): Flood Risk and Coastal Change (Department for Local Communities and Local Government, 2023).

This report takes into account the contents of the NLC Pre-Application Advice Note (Ref. PRE/2023/57) and EIA Screening Opinion (ref. PA/SCR/2023/4) with respect to hydrology/hydrogeology, flood risk and drainage.

1.5 Data Sources

The main sources of data used to inform this HRA and FRA are:

- Hydrogeological and Flood Risk Assessment – Wressle-1 Well, Wressle Wellsite, Lodge Farm, Appleby, Scunthorpe, North Lincolnshire (Envireau Water, 2018);
- Proof of Evidence by James Dodds (Dodds, 2019);
- Groundwater and surface water monitoring reports since 2020 (Egdon Resources, 2023);
- EIA Screening Opinion (ref. PA/SCR/2023/4) (North Lincolnshire Council, 2023a);
- North Lincolnshire Council (NLC) Pre-Application Advice Note (North Lincolnshire Council, 2023b);
- The detailed description of development in the accompanying Planning Statement;
- Environmental Permit (ref. EPR/AB3609XX/V004);
- Development plan(s) provided by Zetland Group/Egdon Resources;
- British Geological Survey (BGS) published mapping;
- Hydrogeological data published by the Environment Agency/BGS;
- Ordnance Survey mapping;
- Private Water Supply records from North Lincolnshire Council;
- Data from designated sites from Natural England;
- Data from the Environment Agency including LiDAR data, flood risk mapping, and abstraction licenses; and
- North and North East Lincolnshire Strategic Flood Risk Assessment (North Lincolnshire Council, 2022).

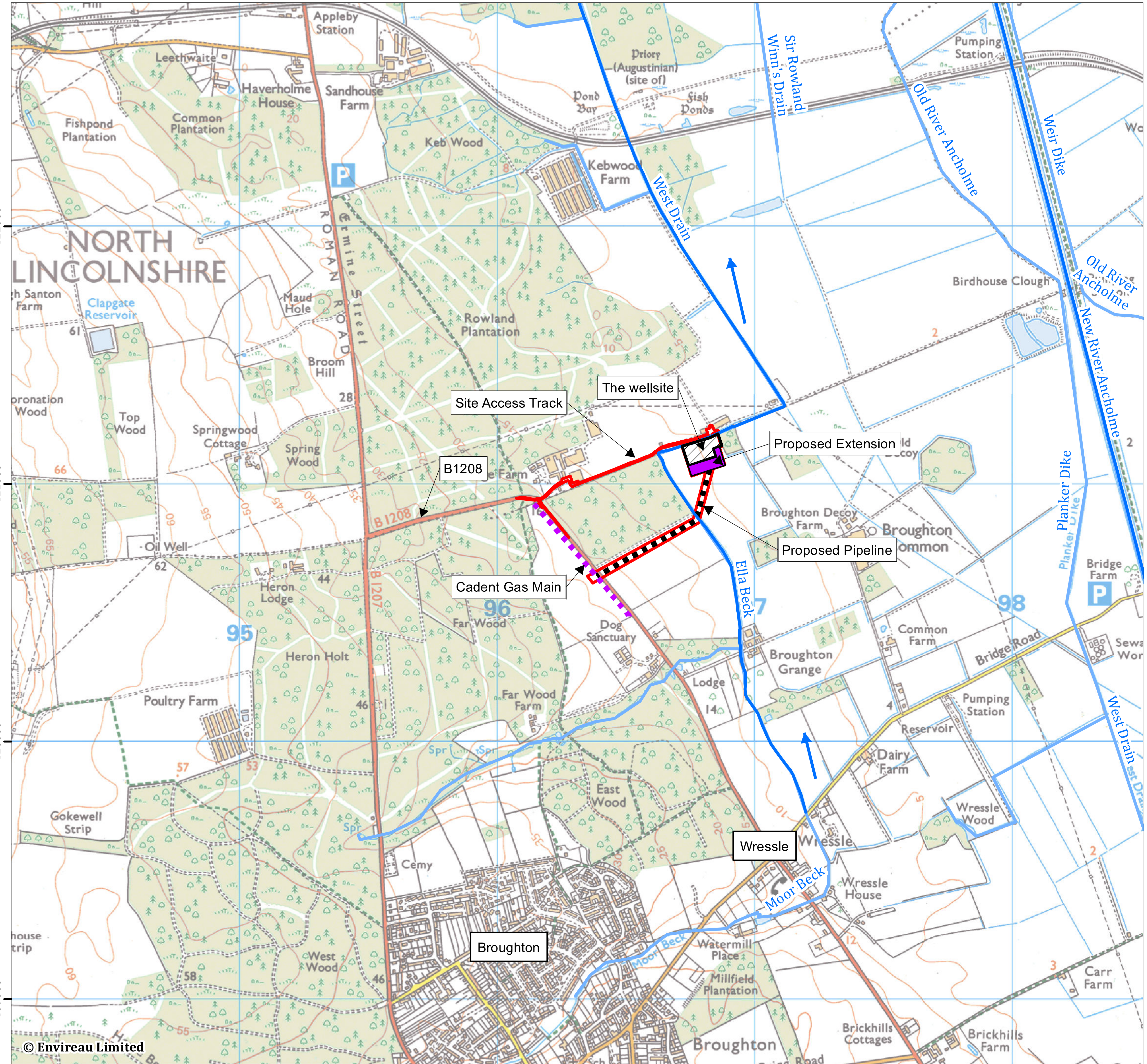
1.6 Relevant Development Plan Policies

The planning policies cited in Appendix E have been taken into account in preparing this Hydrogeological and Flood Risk Assessment.

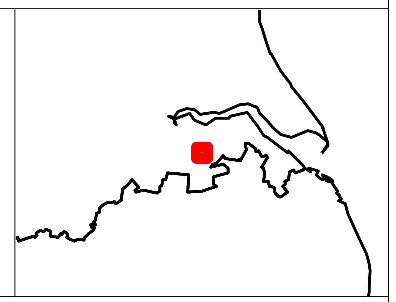
Figure 1: Site Location and Setting

Wressle, North Lincolnshire

Red outline	Planning Application Boundary
Hatched box	Existing Wellsite
Purple box	Proposed Extension
Purple dotted line	Cadent Gas Main
Black dotted line	Proposed Pipeline
Dark blue line	Main River
Light blue line	Ordinary Watercourse
Blue arrow	Flow Direction



Notes:



0 150 300 450 600 Meters

Scale: 1:15,000 at A3

24 November 2023

NGR: 496,311 E / 410,805 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Site Location and Setting

envireau WATER

2 PROPOSED DEVELOPMENT

2.1 Existing Development

The Site was developed for oil production in 2020, following the granting of planning permission and discharge of pre-commencement conditions, as per Appeal Decision (ref. APP/Y2003/W/19/3221694) dated 17th January 2020.

The Site was reconfigured to enable the installation of a tertiary containment system (TCS) in accordance with the Construction Quality Assurance report (CQA), approved by NLC when discharging Condition 17 of the 2020 Appeal Decision. Concrete bunds were constructed to house process equipment including storage tanks and a separator system. A concrete internal roadway system was also constructed to facilitate road tanker movements and to reduce traffic on the aggregate surface.

The Wressle-1 well was recompleted and placed on production in January 2021. In August 2021, a proppant squeeze was undertaken to overcome near wellbore formation damage that impaired the permeability of the producing formation. This operation was successful and hydrocarbon production exceeded the pre-operational forecasts.

2.2 Development Proposals

The Proposed Development is as follows:

Extension of existing Wressle wellsite to construct three well cellars; drill two additional lateral underground boreholes to appraise and develop the hydrocarbon resources from the Penistone Flags and Ashover Grit reservoirs; upgrade existing production facilities to include additional fluid storage tanks, separator system, surface pump and associated bunds; install gas processing equipment, construct a 600m underground gas pipeline and flow gas to the existing National Grid pipeline; long term production of oil and gas.

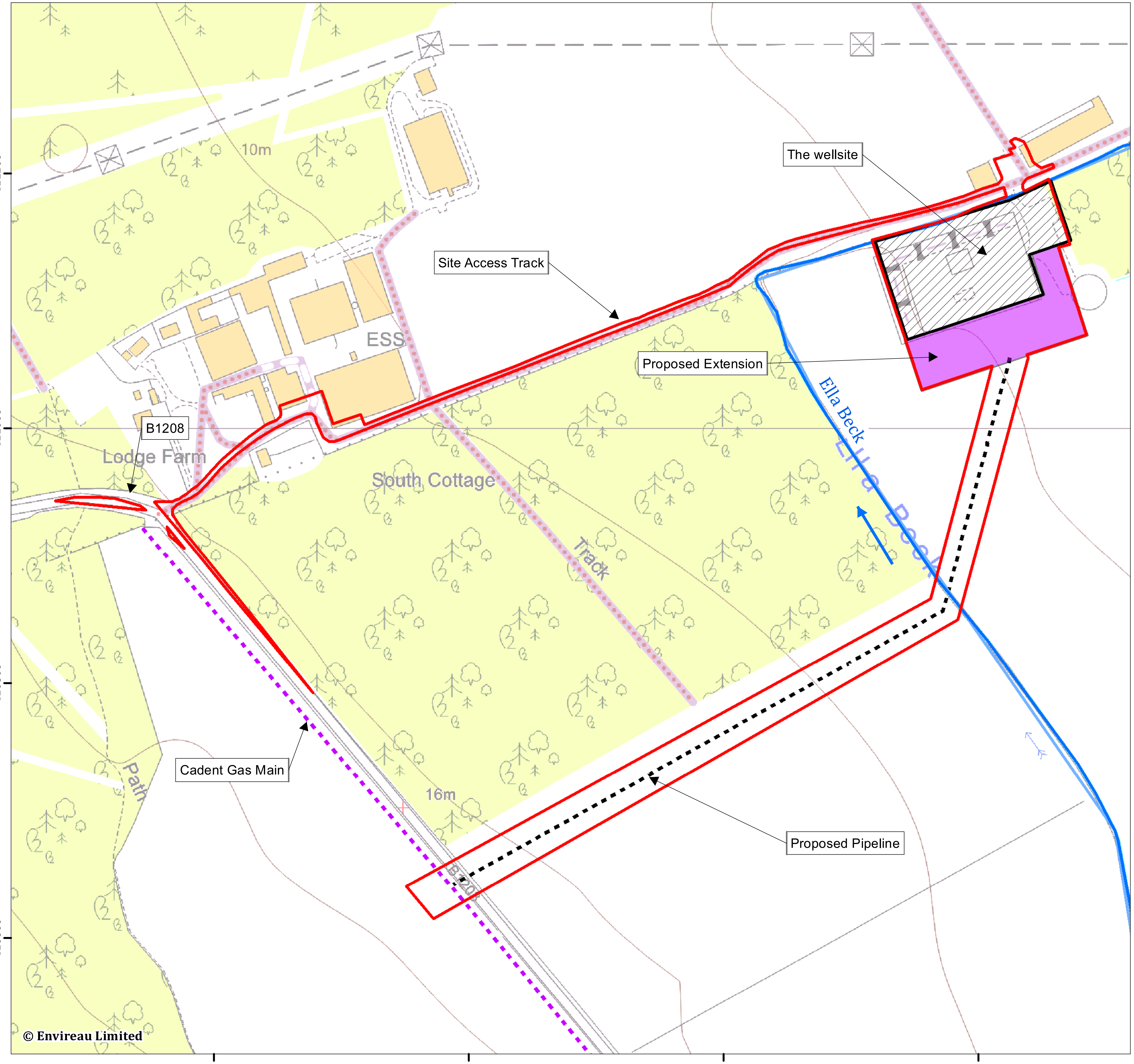
2.3 Development Area

The application boundary for the Proposed Development is shown on Figure 2 and covers approximately 3.9 ha of land and consists of:

- The existing Wressle-1 wellsite, which is approximately 1.85 ha in area (total) and includes a sealed well pad where the Wressle 1 and proposed Wressle-2 & Wressle-3 wells are/will be located, process areas, car parking/office area; and an access track; and
- The Proposed Extension, which is 0.67 ha in size and is required to accommodate all the equipment and facilities associated with the drilling of the new wells.
- The Proposed Pipeline and a working width of 25 m comprising an underground pipeline to export gas from the wellsite to the Cadent gas main just west of the B1208 road.

Figure 2: Proposed Development

Wressle, North Lincolnshire



- Planning Application Boundary
- Existing Wellsite
- Proposed Extension
- Cadent Gas Main
- Proposed Pipeline
- Main River
- Ordinary Watercourse
- Flow Direction

Notes:

0 25 50 75 100 Meters

Scale: 1:3,000 at A3

24 November 2023

NGR: 496,480 E / 410,922 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Proposed Development

envireau WATER

2.4 Development Phases

The Proposed Development is separated into 8 phases as summarised in Table 1.

Table 1 Proposed Development Phases

Development Phase	Description/Activities
Phase 1- Construction of proposed extension	In advance of the drilling operations, civils works will be undertaken as follows- • Removal of existing fencing on the southern aspect. • Excavation and removal of the existing southern aspect containment ditch and slotted drainage pipework. • Excavation and levelling of the area between the existing wellsite and proposed extension area. • Excavating topsoil from the proposed extension area and creating a bund on the new southern perimeter. • Creating a new containment ditch on the proposed extension area. • Installing a tertiary containment system comprising HDPE impermeable membrane, installed in accordance with an approved Construction Quality Assurance Plan (CQA). • Joining the new HDPE membrane to the existing wellsite membrane. • Installing slotted drainage pipe and inspection/rodding points. • Laying and compacting of suitable aggregate to a minimum of 300 mm on the proposed extension area. • Backfilling the containment ditch with non-compactible aggregate. • Securing the extended area with either palisade/meshmaster fencing.
Phase 2- Drilling of Wressle-2 and Wressle-3 wells	• The wells would be drilled "back-to-back" i.e. one after the other as part of a single operation. Wressle-2 will be drilled in a south-westerly direction, and Wressle-3 drilled towards the south. • A workover rig will be used to install the well completion equipment.
Phase 3- Production testing of Wressle-2 and Wressle-3 wells	• Production testing will begin from the new wells into the existing production facilities. • An additional three-phase separator will be installed within the existing separator system bunded area. • If necessary, a proppant squeeze will be carried out. • All fluids will be assessed for suitability and use by the Environment Agency. • The proppant squeeze programme would be applied first to the Wressle-2 well, and then immediately afterwards applied to the Wressle-3 well. • It may be necessary to apply a nitrogen lift, using coiled tubing equipment to enable each well to flow.
Phase 4 - Production	• Site civils work in respect of: - New storage tank bund

	- New surface pump bund - Extending the internal roadway - Installing plinths for gas process equipment • Production equipment to manage higher production rates may be required, over and above the existing process equipment on site, including:- - Up to 4 storage tanks - Additional separator system - Up to two surface pump systems • Oil and gas production will flow into the existing and enhanced facilities • If gas volumes from the new wells are sufficiently viable, gas will be utilised by installing process equipment on the existing site to enable the export of gas to the local gas transmission network, via an underground pipeline to the connection point c.600m southwest of the site.
Phase 5- Well decommissioning and site restoration	• Following the end of the productive life of the wellsite, the Site will either be restored back to agricultural use or to an approved new use appropriate for the area. • The wells will be plugged, hydrostatically tested, and sealed. • Each wellbore will be filled with specialist concrete plugs to surface. • The Site itself will then be restored; all equipment, infrastructure, membranes, aggregates and facilities will be removed. • Existing stored topsoil and subsoil bunds will be re-used and tested to ensure compatibility with surrounding land quality and the Site area returned to the landowner.

2.5 Granular Working Platform and Tertiary Containment

The existing Site currently comprises a secure fenced compound with a sealed wellsite platform, storage tank and separator system process bunds, gas micro turbines, site generator, electrical control room, site offices and a car parking area.

The proposed extension area will replicate and tie into the existing TCS that underlies the sealed wellsite platform, without compromising the integrity of the existing impermeable membrane. The proposed extension area will comprise a level platform formed from Type 3 granular material of a depth of at least 300 mm, underlain by a geotextile membrane (or similar), HDPE impermeable membrane and installed in accordance with an approved Construction Quality Assurance Plan (CQA). The existing perimeter containment ditch and containment bund will be extended to incorporate the proposed extension area. The TCS will run underneath the ditch and up the containment bund to ensure the proposed extension area is hydrologically sealed.

The existing wellsite platform surface is at an elevation of 4.10 mAOD with a nominal rise to the centre of the platform to 4.20 mAOD, to provide a shallow fall for direct surface runoff to the perimeter containment ditch. The perimeter bund around the wellsite platform has a minimum crest level of 4.40 mAOD (300 mm in height). The proposed extension area will be formed to the same levels.

The design of the extended wellsite platform enables it to drain water to the perimeter containment ditch. Whilst the platform is not impermeable, the mixed grain size of the platform material greatly reduces the permeability when compared to clean gravel. As such the platform surface will tend to shed rainfall rather than allow it to infiltrate. Surface water from the containment ditch system passes through an installed surface water interceptor prior to discharge of clean surface water to the adjacent Ella Beck. This will continue when the site is extended.

2.6 Bunded Containment Areas

All potentially polluting materials associated with the development of the new wells (e.g. produced hydrocarbons, produced fluids, chemicals, fuels) will be stored within bunded storage areas. Once the new wells are ready to be brought into production, they will connect into the existing production system, albeit with enhanced and additional facilities and equipment.

Bunded storage forms part of the secondary containment system for potential contaminants to the surface and shallow groundwater system at the Site in accordance with CIRIA guidance C736 – Containment Systems for the Prevention of Pollution (Walton, 2014).

Bunded containment areas for production operations are and will be constructed in accordance with the same CIRIA guidelines. Where two or more tanks are installed within the same bund, the capacity of the bund are sized as the greater of:

1. 110 per cent of the capacity of the largest tank within the bund, or,
2. 25 per cent of the total capacity of all of the tanks within the bund, except where tanks are hydraulically linked in which case they should be treated as if they were a single tank.

The bunded storage areas will contain storage of:

- Produced oil and water;
- Plant and equipment fuel; and
- Liquid chemicals including corrosion inhibitors, surfactants and other production chemicals for well treatment.

In addition, process equipment such as the separator system and surface pumps are and will be sited within constructed bunds.

When drilling of the additional wells is taking place, temporary bunding may be used to facilitate the mud systems and waste tanks associated with drilling activities.

2.7 Well Construction and Operation

Two new wells will be drilled during Phase 2 of the development: Wressle-2 and Wressle-3. Outline well construction diagrams are included in Appendix A.

The current development proposal does not include for a produced water re-injection well(s), which if required, would be subject to a separate planning application.

2.7.1 Well Cellars

All of the new wells will be drilled from 2.4 m diameter well cellars (specially constructed sealed concrete chambers) that will be installed on the proposed extension area.

Well head equipment will be contained within the well cellars at each well; each cellar will be approximately 2.75 m in depth and will be tied into the working platform and sealed to the very-low permeability liner system. These structures will contain any contaminants during drilling operations and safely contain the well head equipment during construction and operation of the wells. They also serve to capture any contaminants from wellhead maintenance, and any run-off of surface water (rain) that falls onto the surrounding concrete plinth.

2.7.2 Standards

It is a requirement for all new wells to be constructed and operated in accordance with the Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (SI No. 913, 1996) and the Borehole Sites and Operations Regulations (BSORS), 1995 (SI No. 2038, 1995). These regulations require a well to be designed, constructed, suspended and abandoned in such a way as to prevent unplanned escape of fluids at any time during operation and after abandonment.

Well records will be inspected by an independent well examiner to assess the well design, construction and maintenance and ensure that good industry practice is followed throughout their life-cycle and decommissioning.

Details of the proposed well construction and operation are provided in the Planning Statement and summarised in the subsections below.

2.7.3 Design concept

The two development wells will be constructed to target two different formations in the Carboniferous strata. Wressle-2 will primarily target the Penistone Flags Formation (oil and gas) whilst Wressle-3 will target the Ashover Grit Formation (oil).

Both wells will be constructed in the same manner, with:

- a cemented conductor casing set from the sealed concrete drilling cellar to a depth of approximately 70 m true vertical depth (TVD), into the top of the Lias Group (Whitby Mudstone Formation);
- cemented surface casings set at c. 450 m TVD depth near the base of the Mercia Mudstone, and a second casing set at c. 850 m TVD into the top of the Permian sequence; and
- production casing string set to c. 1850 m TVD (Total Depth) into the Dinantian Limestone. Perforation depths and intervals will be dependent on drilling well data and results.

The cemented steel casing strings provide a permanent hydraulic barrier between the wellbore and the surrounding formations. The casing design is shown on the indicative well construction diagrams in Appendix A.

2.7.4 Drilling fluids

Suitably weighted drilling fluids ('muds') will be used in well drilling to provide lubrication to the drill bit, remove cuttings from the drill bit, support the well integrity/stability, and prevent the ingress of fluids into the wellbore during drilling.

Water Based Muds (WBM) will be used from surface until the wells are cased into the top of the Permian strata (c. 850 m TVD). Oil Based Muds (OBM) will be used within the Permian and Carboniferous strata.

Proppant Squeeze

As with the drilling of the Wressle-1 well, if (during initial testing) the natural flow from the target formation is judged to have been impaired, a proppant squeeze may be undertaken on the two development wells.

The process involves pumping a mix of gelled fluids and proppant (sand or ceramic particles) down the wellbore and out through the perforations in the steel wellbore casing at a pressure exceeding the fracture propagation pressure of the formation. Injection pressure and pump rates high enough to propagate a fracture in the formation creates channels of communication through near wellbore formations. When the pressure is released, the proppant remains in situ, propping open the small fractures through which hydrocarbons can flow at enhanced rates. Unlike hydraulic fracturing of the main body of the formation, a proppant squeeze requires the use of only a small volume of proppant and carrier fluid as it seeks to overcome any restricted permeability in the near wellbore formations.

The proppant squeeze will comprise up to 150 m^3 of fluids and 20-30 tonnes of proppant per operation/well. The proppant squeeze is designed to extend some 40 m laterally in opposite directions from the wellbore, and approximately 20m in a vertical direction, both above and below the perforations. Typically, fresh water and proppant make up 97% or more of the treatment fluid, along with a number of minor non-hazardous chemical additives, all of which are widely used and will be transported and managed in accordance with the applicable regulations.

Each operation comprises:

1. A pre-treatment injectivity test using approximately 15 m^3 – 25 m^3 of gelled liquid. The purpose of the injectivity test is to determine the breakdown pressure, propagation pressure and carrier fluid leak-off rate, which in turn will inform the main proppant treatment. Should the pre-treatment injectivity test indicate that the main proppant treatment may extend further than the design, the fluid volumes and pressures are adjusted accordingly, to ensure the design parameters are maintained. This calibration process, comparing data obtained during the pre-treatment injectivity test with the original design parameters and adjusting the main proppant treatment accordingly, will be documented within the Hydraulic Fracture Plan, which must be

submitted to the North Sea Transition Authority (NSTA) and the Environment Agency for approval in advance of the proppant squeeze being carried out.

2. The main proppant treatment will consist of approximately 20 to 30 tonnes of ceramic proppant and approximately 80 m^3 to 120 m^3 of gelled liquid. This is pumped at a surface pressure of up to 9,000psi. The pumping operation takes approximately 2 hours, and the well is then shut in to allow the pressure in the formation to dissipate, prior to flowing back through the production facilities in a controlled manner.

The above process has been successfully and safely applied at Wressle-1 and was authorised by the Environment Agency through an environmental permit.

Nitrogen lift

If necessary, a nitrogen lift may be applied, using coiled tubing equipment to enable each well to flow. This involves circulating nitrogen in the well to lift any residual proppant that may reside within the wellbore, back to surface facilities. A nitrogen lift may be applied following the proppant squeeze.

2.7.5 Workovers

A workover is a mechanism to undertake work on an installed well, when intervention is required and involves ‘killing’ a well with weighted brine to enable maintenance activities. e.g. removal of downhole pumps, completions or production tubing.

2.8 Management of Produced Gas and Fluids

Currently at the Site, produced fluids and gas pass through a separator system, where oil and gas are separated out; oil is produced to a bank of oil storage tanks for export by road tanker to the oil refinery at Immingham. Produced water is separated and sent for reinjection at a separate Site. Gas is managed in two ways: -

1. Used within a bank of gas turbines to generate electricity for Site use; and/or
2. Combusted within an enclosed ground flare.

The two new development wells will target both gas and oil reserves. If gas volumes from the new wells are sufficient, gas will be processed on Site and exported by the Proposed Pipeline to the Cadent gas main, located approximately 600 m southwest of the Site.

It is expected that all gas will be exported to the main gas network, but the existing enclosed ground flare system will be retained and used as a relief system if needed.

2.9 Waste Management

Drilling and production operations will produce extractive waste including drilling muds, rock cuttings, excess cement, returned proppant, well cellar fluids and well completion/treatment fluids. These materials will be contained before transfer to an approved off-Site facility in accordance with an environmental permit.

2.10 Environmental Permit

Egdon Resources holds an Environmental Permit (ref. EPR/AB3609XX/V004) for the wellsite operations, emissions and discharges at the Site. A separate permit application will be submitted to the Environment Agency in respect of the activities associated with the Proposed Development. This will include the use of all chemicals during the drilling, testing and operation of the wells.

2.11 Proposed Pipeline

If gas volumes from the wells are sufficiently viable, it is proposed to install an underground gas pipeline (the Proposed Pipeline) to export gas produced at the Site to the local Cadent gas network.

The Proposed Pipeline will measure approximately 600 m and will run from the wellsite to the Cadent gas main connection point just west of the B1208 road. The pipeline from site will pass under the Ella Beck surface water course *enroute* to the connection point.

3 SURFACE WATER MANAGEMENT

3.1 Existing Drainage Scheme

The current drainage scheme manages rainfall runoff on-site to cater for a 1 in 100-year storm plus climate change allowance. Surface water drainage for the existing wellsite platform is currently provided by a piped and backfilled containment ditch which runs along the perimeter of the platform. The HDPE impermeable membrane and associated protective geotextile layers is laid beneath the containment ditch system. A 300 mm diameter perforated (twinwall plastic) pipe is installed within the ditch above the HDPE impermeable membrane, and the ditches have been backfilled with coarse, clean aggregate to the top of the granular platform. Inspection chambers are installed at each junction position on the containment ditch.

The method for disposal of rainfall runoff is dependent on operations at the Site. Discharge of clean rainfall runoff occurs when the Site is in normal production. During workover and other operational phases (well operations), rainfall runoff is stored and contained within the perimeter ditch system and wellsite platform (up to the height of the perimeter bund) and tankered off-site to an Environment Agency approved waste disposal/treatment facility. The operational procedure is to keep the containment ditch and platform empty (dry).

Under conditions when rainfall runoff is permitted to be discharged off-site, water collecting within the containment ditch passes via a drainage pipe through a Class 1 Full Retention oil-water separator before discharging at a restricted rate into Ella Beck. The flow of surface water to the separator is controlled by isolation valves which are installed on the inlet and outlet of the separator. These allow full isolation of the Site, as well as isolation of the separator for maintenance works.

The discharge of treated surface water to Ella Beck is carried out in accordance with the Environmental Permit (EPR/AB3609XX/V004). This permits a maximum rate of discharge of 5.0 l/s and a maximum daily discharge volume of 432 m^3/day. Monitoring of the discharge is undertaken in line with the requirements of the permit.

3.2 Proposed Drainage Scheme

The drainage scheme and method of draining the wellsite will remain the same as existing described above in Section 3.1. The existing TCS together with the existing perimeter containment ditch system and containment bunding will be extended to accommodate the proposed extension.

Stormwater storage calculations have been undertaken for the extended wellsite platform (6,900 m^2). Accounting for the bunded storage areas and making an allowance for plant and machinery that will be present at the Site during the development of the new wells, the platform area available for stormwater storage is 5,700 m^2. The platform storage area and calculations are presented in Appendix B.

The calculations demonstrate that the extended wellsite platform can contain in excess of a critical 7 day, 1 in 100-year event plus 40% climate change storm event. During well construction activities, stormwater will be wholly contained either within the containment ditch or above the finished surface level, with the top water level not exceeding the height of the perimeter bunding (minimum 300 mm). The water level during a 7 day, 1 in 100-year event plus 40% storm event is calculated to be a shallow depth of 0.188 m (188 mm).

The wellsite will be manned and controlled 24 hours a day, 7 days a week during all well operations and drilling. A contracted drainage management company will have tankers on standby and available to remove water from the well pad containment drain, during the consented operational hours.

The water level in the containment ditch will be monitored via the drain sumps on a daily basis and after a rainfall event by a designated member(s) of Egdon Resources site personnel. Periods of saturation will not occur as water levels will be monitored continually and water will be tankered from the wellsite platform as required. The operational procedure is to keep the platform dry.

Once the wells are constructed and normal production operations commence, surface water will be discharged to the Ella Beck via the existing Class 1 Full Retention oil-water separator, in accordance with the Environmental Permit for the Site. Although the extension will result in a greater surface area, runoff will be attenuated and there is no need to increase the discharge rate from the interceptor.

The existing Site access track from the B1208 road is constructed with a tarmacadam surface. The section of the track leading into the proposed extension area has not yet been constructed. It will be laid using permeable material as part of the development works to support the load of HGV vehicles visiting the Site. The track has a crossfall in one direction so that surface runoff generated over the track is allowed to infiltrate to ground over time with any excess shedding off over grass into the adjacent watercourse.

3.3 Maintenance

A maintenance plan for the surface water drainage scheme at the Site will be drawn up and carried out by the Site operators or nominated third party. The plan shall include daily and weekly inspections of all drainage elements. This shall include the removal of any obstructions and silt build-up where necessary and checks on the physical structure of the drainage elements.

3.4 Foul Water

There will be no changes to the management of foul water that is currently in place at the Site.

The Site office and welfare facilities will continue to discharge into a sealed foul water/sewage system, tanks will be sealed with no outfall to the environment and foul water/sewage will be emptied regularly by tanker and disposed of at an approved treatment facility.

4 HYDROGEOLOGICAL CONCEPTUAL MODEL

4.1 Background

A robust hydrogeological conceptual model was developed as part of the previous planning application (Envireau Water, 2018) and appeal (Dodds, 2019). The conceptual model was based upon a thorough review of relevant regional and local scale baseline geological and hydrogeological data.

The baseline setting is presented in Appendix C and has been updated to take account of the extensive programme of groundwater and surface water monitoring that has been carried out at the wellsite since 2020. The additional data validates and does not change the established conceptual model (Envireau Water, 2018) which is reproduced on Figure 3(a-d) and summarised below.

4.2 Terminology

The terms 'Groundwater', 'Aquifer' and 'Groundwater Body' are defined by the WFD and Groundwater Daughter Directive (GWDD) (European Parliament, 2020) (European Parliament, 2006) as follows:

- Groundwater – all water which is below the surface in the saturated zone and in direct contact with the ground or subsoil.
- Aquifer – a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.
- Groundwater Body – a distinct volume of groundwater within an aquifer or aquifers.

These definitions do not differentiate between (i) relatively shallow aquifers that contain relatively fresh, recently recharged groundwater with a 'resource value' for drinking water, support of the environment and other uses, and (ii) deeper systems containing poorer quality groundwater (typically more saline groundwater or 'formation water') with 'no freshwater resource value'.

It is recognised that some deep saline aquifers, which have no potable water resource value, and which do not interact to any meaningful extent with the natural surface environment, may have some other 'resource' value – for example, as a geothermal resource. In this context, we note that the deep Sherwood Sandstone is increasingly considered a useful geothermal resource and is even being drilled to provide heating to a hospital in Scunthorpe (Abesser, Gonzalez Quiros, & Boddy, 2023; Cuff, 2023). It is recognised that the current proposal must be demonstrated not to interfere with the future geothermal resource value of this aquifer.

The UK Technical Advisory Group (UKTAG) provides guidance to agencies responsible for implementing the WFD in the UK. The (UKTAG, 2011) defines a depth of 400 m as the default maximum depth at which a groundwater body loses its value as a (fresh groundwater) resource that can be either exploited for human activities and/or support surface flows and ecosystems and/or have a connection with surface water receptors. This UKTAG definition does not consider the geothermal resources value of deeper saline aquifers; nevertheless, this report adopts the convention of considering a 'groundwater body' to be a volume of groundwater in an aquifer or aquifers, less than

400 m deep, that may have some potable resource value and that may perform some role in supporting the surface hydrological environment.

4.3 Conceptualisation

The geology underlying the Site comprises formations that have been grouped into four hydrostratigraphic layers as summarised in Table 2, illustrated on Figure 3(a-d) and described in the subsections below.

Table 2 Geological Groups Forming Hydrogeological Layers

Layer Number	Groundwater Bearing Formations	Hydrostratagraphical Summary
Layer 1	Unconsolidated Sands Aquifer, Cornbrash Fm, Lincolnshire Limestone Fm, (& Northampton Sand / Grantham Fms), Marlstone Rock Fm.	Useful hydraulic conductivity and storage. Layer 1 comprises formations which have a potential potable or environmental groundwater resource value and extends down to the base of the Lias Group (Scunthorpe Mudstone Formation). Extending Layer 1 to this depth does not imply that all the formations contain useful potable groundwater resources at this depth, but it provides consistency with the geological stratigraphy and follows a conservative approach.
Layer 2	The Penarth and Mercia Mudstone Groups	Poorly permeable (very low hydraulic conductivity) and has limited useful storage. Layer 2 provides a barrier to upward movement of saline formation waters from Layer 3 and 4 into Layer 1, which is demonstrated by the good water quality within Layer 1.
Layer 3	The Sherwood Sandstone Group	Useful hydraulic conductivity and storage, but saline at this location. No potable or environmental resource value, but future potential as a future low-enthalpy geothermal resource.
Layer 4	The Permian and Carboniferous – the Zechstein Group, the Westphalian, Millstone Grit and Carboniferous Limestone Groups	Limited hydraulic conductivity and storage, and poorly permeable evaporite clay and mudstone horizons at the top of the Permian, effectively hydraulically separating Layers 3 and 4. Groundwater in these layers is highly saline, contains hydrocarbons, and has no potable or environmental resource value. The Carboniferous limestone may conceivably have some geothermal resource value, if permeable (Jones, Randles, Kearsey, Pharoah, & Newell, 2023), although this lies below the target hydrocarbon reservoirs.

4.3.1 Layer 1

The most significant Aquifers within this layer are the Unconsolidated Sands Aquifer and Lincolnshire Limestone Formation.

The Unconsolidated Sands Aquifer forms the top Aquifer of Layer 1, largely being a superficial unit widespread within the area. Horizontal hydraulic gradients in this layer are towards the east / north-east and the Aquifer has the potential to produce small volumes of groundwater for domestic/agricultural use at a useable rate. Groundwater from the formation will also support baseflow in the local stream/river network. Groundwater levels within this unit are likely to be in connection with the Ella Beck and are separated from other Aquifers in Layer 1 by underlying low permeability strata.

Below the superficial layer there is a predominantly clay and mudstone sequence. Hydraulic Conductivity testing of this mudstone material (carried out as part of site investigation works in 2018, (Envireau Water, 2018) has demonstrated low permeabilities. This mudstone-rich sequence forms a concealing layer to the Lincolnshire Limestone below, preventing significant downward flow (See Appendix C). Within the clay and mudstone sequence are sandstone/limestone units which can act as thin, discrete Aquifers.

The Lincolnshire Limestone Formation (Principal Aquifer) is the main Aquifer in Layer 1. This unit outcrops approximately 250 m west of the Site and dips to the east and thins from more than 30 m in thickness at outcrop to less than 20 m beneath the Site. It is concealed by the overlying mudstone and clays and, in a regional perspective, becomes increasingly confined (and artesian in nature) to the east, away from the effects of abstraction.

There is historic evidence to suggest that the groundwater head in the Lincolnshire Limestone below the Site was once (pre-1918) artesian. There was thus an upwards head gradient from the Lincolnshire Limestone to the surface. During the past century, this vertical head gradient has been reversed. Groundwater elevations within the Lincolnshire Limestone below the Site are now significantly lower than in the Unconsolidated Sands at around -16.5 mAOD (Appendix C), and are most likely depressed by the effects of groundwater abstraction in the vicinity. There is thus a downwards hydraulic gradient from the Unconsolidated Sands aquifer to the Lincolnshire Limestone. Although a downwards hydraulic gradient can promote the downwards movement of groundwater, the presence of very low hydraulic conductivity layers (mudstone strata) between the surface and the Lincolnshire Limestones means that the magnitude of any such downward movement into the Lincolnshire Limestone will be negligible. Similarly, the presence of clay layers above and between thin Aquifers within the Blisworth Clay / Limestone and Rutland Formations implies that vertical exchange of groundwater between these will also be limited. The data and calculations supporting this assessment are shown in Appendix C.

There exist around five abstraction boreholes in the Lincolnshire Limestone at Clapgate and Bridge Road, operated by British Steel for water supply to industrial works, at distances of around 0.3 to 1.8 m ENE and SSE of the Egdon site, respectively (Appendix C). It is likely, at least in part, to be these abstractions that result in the low groundwater head in the Lincolnshire Limestone.

Below the Lincolnshire Limestone, there is evidence for artesian groundwater head conditions from the Wressle-1 drilling log. This implies that, below the Lincolnshire Limestone, the vertical head gradient is predominantly upwards. This implies that there is no plausible pathway for dissolved contamination from the surface environment migrating into these deeper strata.

The proposed construction of the Wressle-2 and Wressle-3 wells involve the emplacement of multiple, cemented steel casings that protect and maintain the hydraulic isolation of all the aquifers in Layer 1.

4.3.2 Layer 2

The Penarth and Mercia Mudstone groups, form an approximately 240 m thick low hydraulic conductivity barrier between Layers 1 and 3, preventing groundwater flow between these layers.

4.3.3 Layer 3

Although considered as a Principal Aquifer by the Environment Agency (when it occurs at shallow depths and due to its hydraulic conductivity and storage), the Sherwood Sandstone Group underlying the Site has no potable or environmental resource value due to the depth at which is it encountered. At these depths the formation water is brackish (10,000 mg/L), e.g. as proven by geothermal investigations in the area (Gale et al., 1983).

The Sherwood Sandstone's permeability and storage, together with its elevated temperature at depth, mean that it is considered to be a potential future low enthalpy geothermal resource. The water within it could be used for space heating, in combination with heat pump technology. Indeed, Scunthorpe hospital is drilling four 500 m deep wells into the Sherwood Sandstone aquifer for geothermal usage (Abesser, Gonzalez Quiros, & Boddy, 2023). Any activity carried out by Egdon must not conflict with the future use of this aquifer as a geothermal resource. The main potential impacts which could detract from the geothermal resource value of the Sherwood Sandstone would be the escape of fugitive hydrocarbons from deeper strata into the formation. The proposed Egdon boreholes would be sealed with cement-grouted casing throughout the Sherwood Sandstone interval, into the underlying Permian succession, thus preventing any exchange of gas or fluids between the well and Sherwood Sandstone.

4.3.4 Layer 4

Where formation water is present within the more porous beds of Layer 4, the groundwater is saline. Hydrocarbons are also present in the Westphalian and Namurian sandstone reservoirs, resulting in it having no (potable or environmental) resource value. Clay and evaporite sequences at the top of Layer 4 prevent the migration of formation water upwards into Layer 3. In addition, there are a number of interbedded clay sequences throughout Layer 4 which limit vertical movement of formation water.

4.4 Groundwater Monitoring

Since 2017, groundwater head and quality data have been obtained from five on-site monitoring boreholes. Originally, in 2017, four such boreholes were drilled: GWMBH1 to 3 targeting the Unconsolidated Sands Aquifer and the 50 m deep GWMBH4 which specifically targets the Lincolnshire Limestone Aquifer. The monitoring zone of GWMBH4 is isolated from all the overlying strata.

In 2020, following grant of planning permission, monitoring boreholes GWMBH1 to 3 were re-drilled as GWMBH1R, GWMBH2R and GWMBH3R. GWMBH4 was retained unchanged, and a fifth new borehole (GWMBH5), targeting the Unconsolidated Sands Aquifer, was also drilled. Each of the shallow monitoring boreholes (GWMBH1R, GWMBH2R, GWMBH3R and GWMBH5) fully penetrate the Unconsolidated Sands aquifer and at least 0.5 m into the underlying Kellaways Clay. The old GWMBH1, 2 and 3 were decommissioned (Envireau Water, 2020a) (Envireau Water, 2020b).

The monitoring data collected between 2020 and 2023 shows that the groundwater level in the Unconsolidated Sands Aquifer is shallow at ~3 m below ground level (around +1 to +3 mAOD) whereas the water level in GWMBH4 (Lincolnshire Limestone) is much deeper at ~21 m below ground level (-16.5 mAOD).

The large difference in observed water level between the shallow sands and deeper Lincolnshire Limestone again demonstrates that the Lincolnshire Limestone is a hydraulically separate Aquifer system from the Unconsolidated Sands Aquifer and provides further strong evidence for the presence of a low hydraulic conductivity layer(s) between the two Aquifers. This hydraulic separation between the two aquifers remains unchanged since 2017.

Regular sampling and measurement of water quality has taken place before and during operations at the Wressle wellsite (Envireau Water, 2020b). To date, no evidence has been found of groundwater contamination in any of the monitoring boreholes which can be ascribed to operations at the wellsite (Envireau Water, 2023).

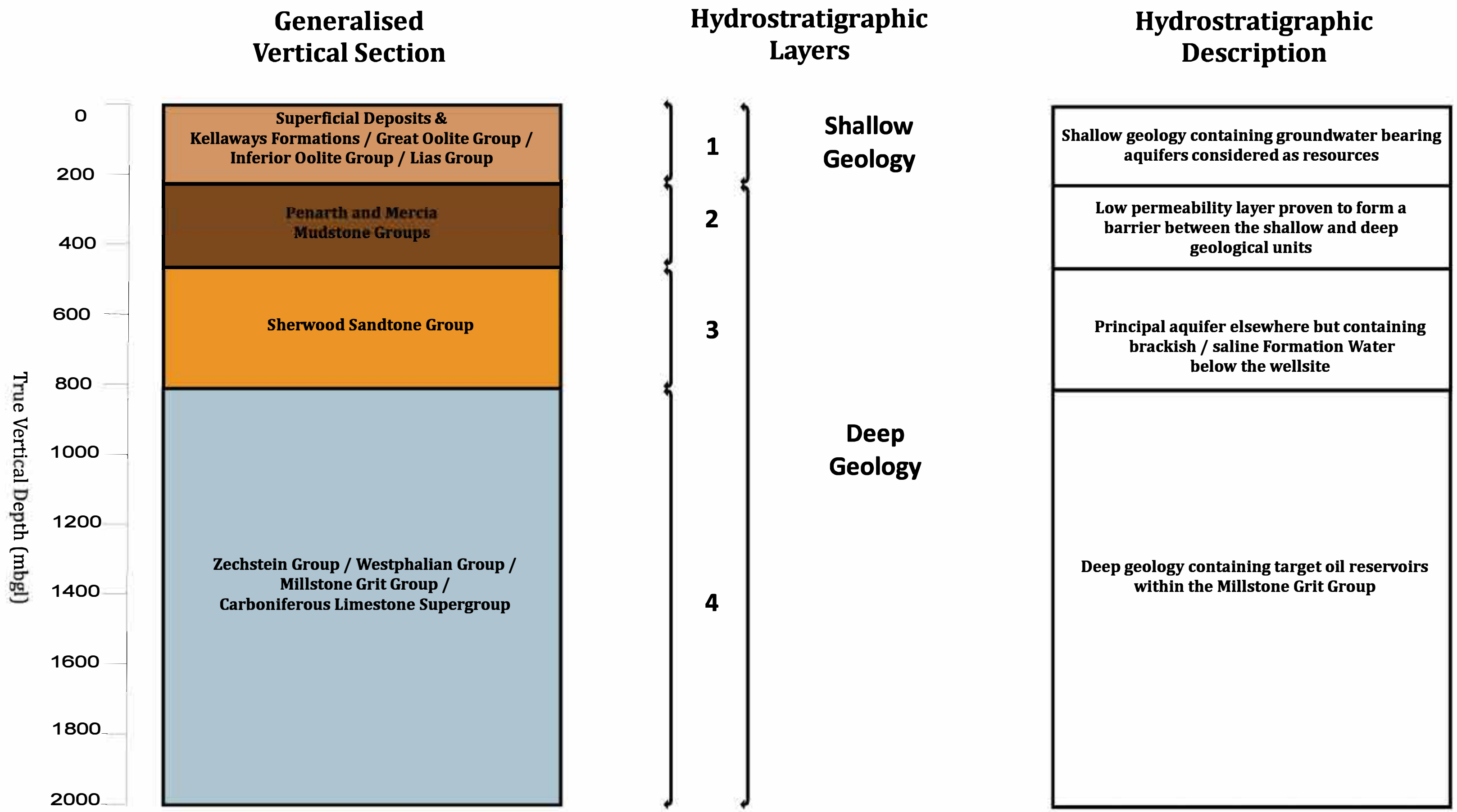
The baseline water quality data collected by Envireau Water from the four shallow groundwater monitoring boreholes in the Unconsolidated Sands reveals a considerable diversity of groundwater chemical conditions, which is especially apparent in parameters such as potassium, nitrate, calcium, arsenic and sulphate. It is likely that the source of potassium, nitrate and, possibly, sulphate relates to intensive agriculture in the vicinity of the Site. The source of sulphate could also be related to the oxidation of sulphide mineral within the Kellaways Formation. The groundwater was found to exceed drinking water standards for the following inorganic parameters:

- Nitrate - most likely due to surrounding agricultural activity;
- Manganese - most likely related to natural reductive dissolution processes;
- Nickel - presumably from a mineralogical source in the Kellaways Formation; and
- Arsenic - presumably from a mineralogical source in the Kellaways Formation.

Data collected by Envireau Water as part of the baseline data collection from GWMBH4 (Lincolnshire Limestone), showed the groundwater exceeded drinking water standards for the following parameters:

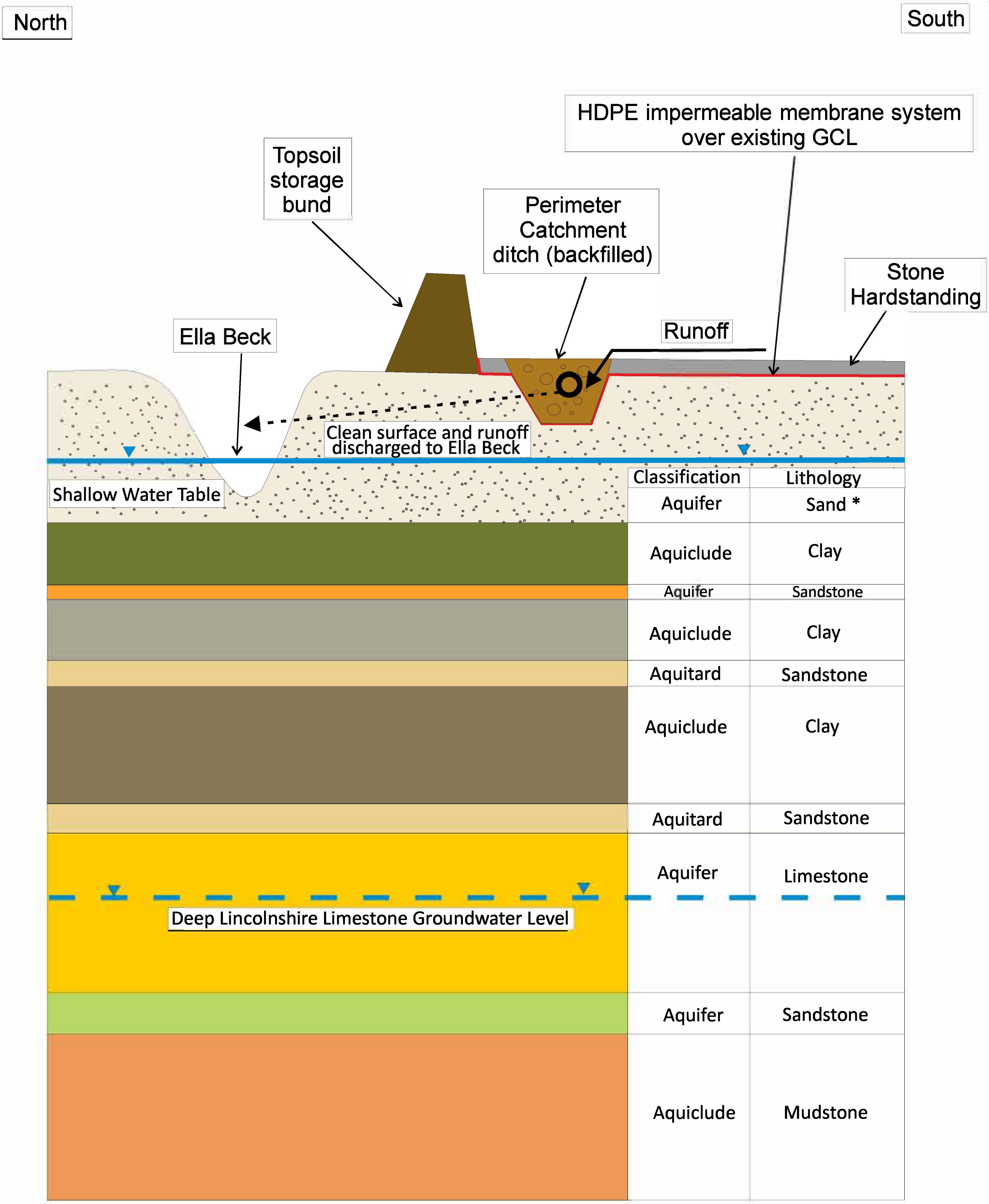
- Manganese - most likely related to natural reductive dissolution processes.

It is not believed that any of the monitored concentrations of these parameters is related to activities at the Wressle wellsite.



envireau WATER

Ref: P:\3490616 Egdon Wressle Ext Fig 3a Date: 06/03/2024	**Egdon Resources U.K. Limited**
Figure 3(a)	Hydrostratigraphy Model

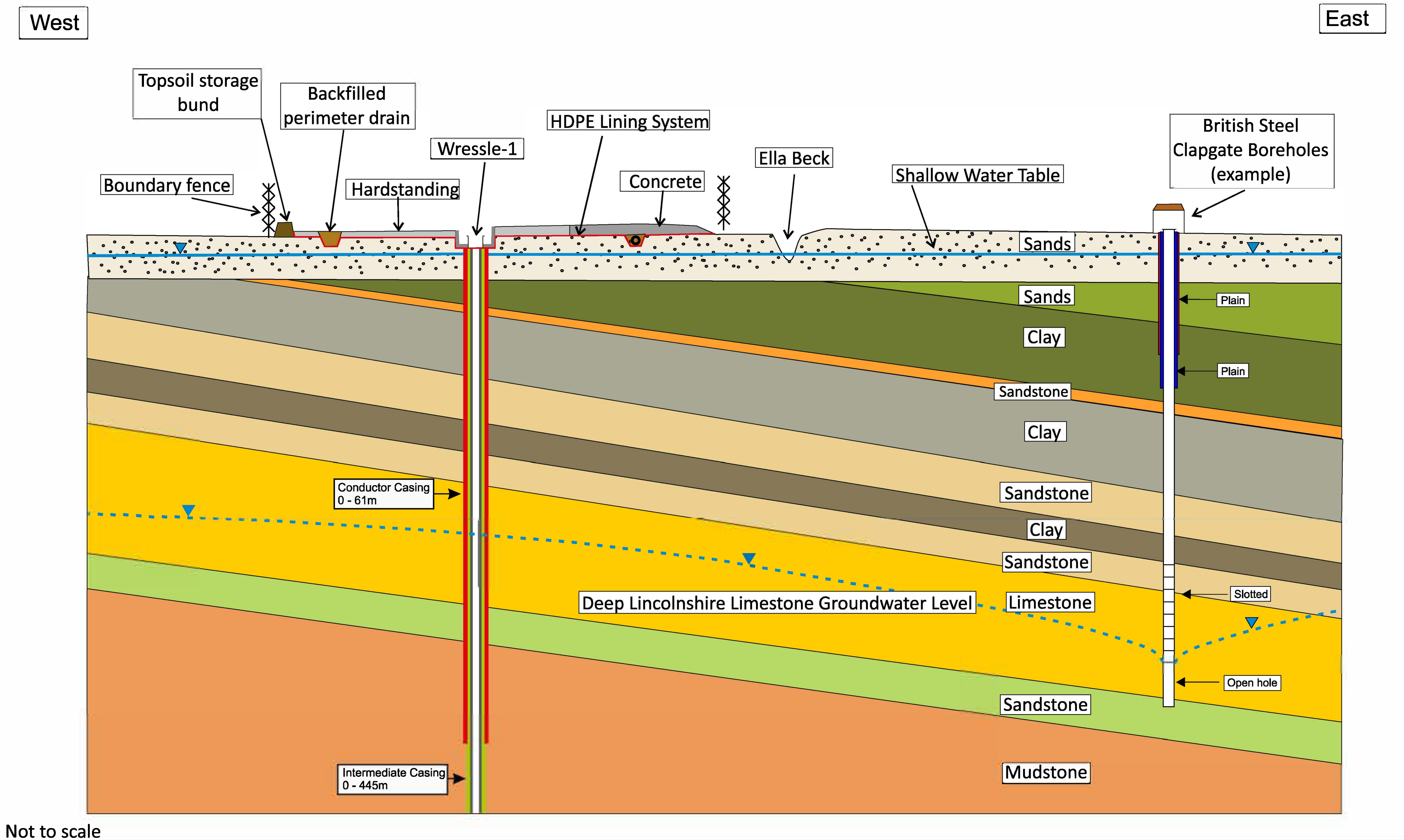


* Sutton Sand Formation & Kellaways Sand Formation (the Unconsolidated Sands Aquifer)

Not to scale

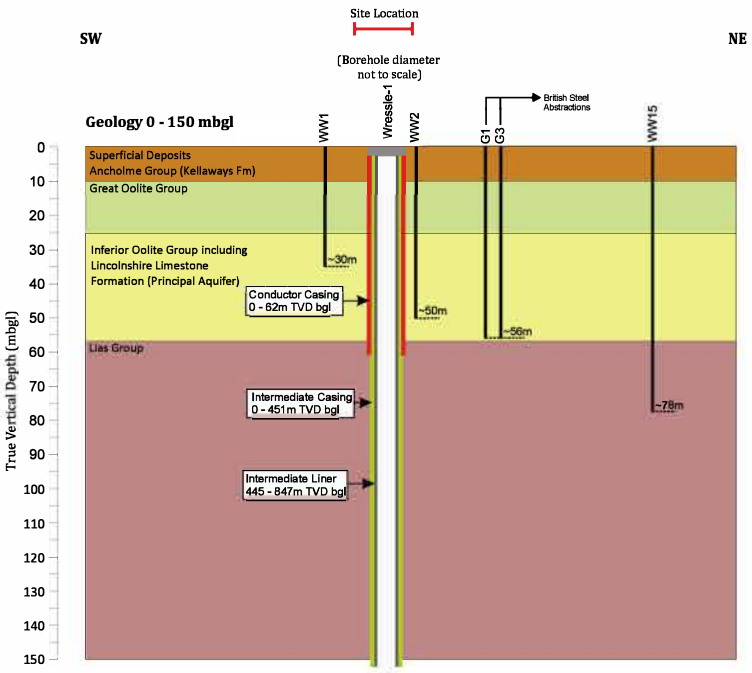
envireau WATER

Ref: P:\3490616 Egdon Wressle Ext Fig 3b Date: 06/03/2024	**Egdon Resources U.K. Limited**
Figure 3b	Wressle Wellsite Hydrogeological Conceptual Model (HCM) Sketch



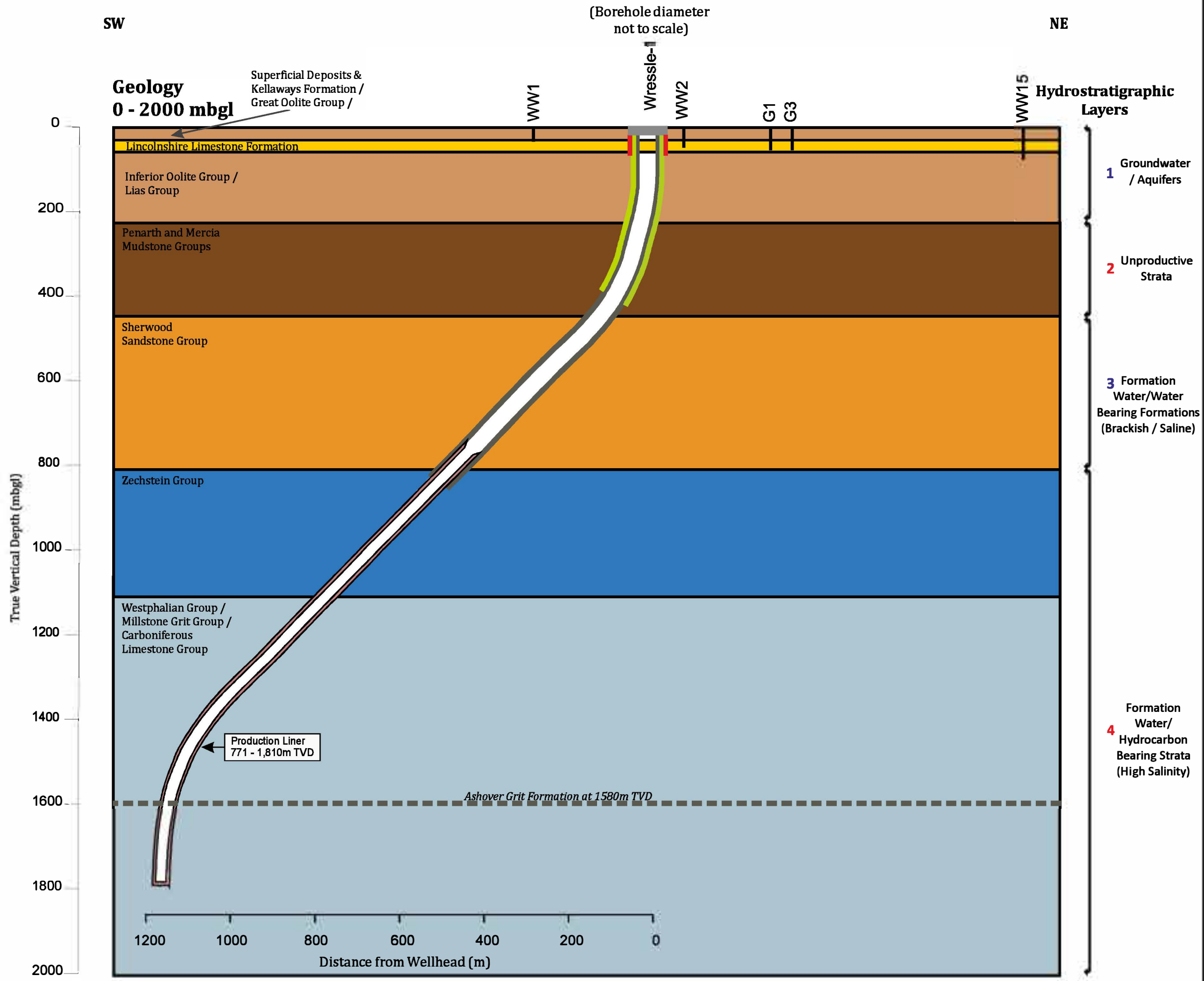
envireau WATER

Ref: P:\3490616 Egdon Wressle Ext Fig 3c Date: 06/03/2024	**Egdon Resources U.K. Ltd**
Figure 3c	Local Conceptual Model Sketch



Note: Wressle-1 tubular depths are as follows:

Size	Type	Depth (m TVD bgl)	
13 3/8 "	Conductor	0m	62m
9 3/8 "	Intermediate Casing	0m	451m
7 "	Intermediae liner	445m	847m
4 1/2 "	Production Liner	771m	1810m



Note: Depth of intersected stratigraphy by boreholes surrounding Wressle-1 not accurate due to 3-5 degree dip in geology

envireau WATER

Ref: P:\3490616 Egdon Wressle Ext Fig 3d Date: 06/03/2024	**Egdon Resources U.K. Limited**
Figure 3d	Deep Conceptual Model Sketch

5 HYDROGEOLOGICAL RISK ASSESSMENT

5.1 Assessment Methodology

A hydrogeological risk assessment (HRA) has been carried out in accordance with the Source-Pathway-Receptor (S-P-R) approach described in GL III (DEFRA, 2011) and the methodology in the EA's technical guidance (Environment Agency, 2018a).

The basis of the risk assessment method is the selection of an appropriate level of detail for the assessment. EA Guidance (Environment Agency, 2018a) proposes three levels of details or Tiers from Tier 1 to Tier 3, where Tier 1 is qualitative and Tier 3 is highly quantitative. The selection of the appropriate tier requires an iterative approach based on an initial assessment and consideration of the outcome using a Tier 1 system. If that approach shows that the system is too complex or outcomes cannot be fully mitigated then a more detailed or quantitative approach would be warranted.

The works at the Site are well understood and mitigation measures are clearly defined, tested and known to work. Therefore, a semi-quantitative (Tier 1/2) assessment is considered to be an appropriate level of assessment in this case.

The assessment method, scoring and risk calculation is presented in the following sections.

5.2 Hazard Identification

The following hazards have been identified for the Proposed Development:

- Mobilisation of contaminated soils during construction of the wellsite extension (earthworks/landforming);
- Spillage of fuels at surface from construction plant and machinery, or during normal operations;
- Spillage of hydrocarbons, produced water containing Naturally Occurring Radioactive Material (NORM) and chemicals at surface during well drilling and/or hydrocarbon production;
- Loss of drilling muds/additives from the wellbore during well drilling;
- Migration of hydrocarbons, formation water containing NORM and well treatment fluids along the wellbore; and
- Creation of vertical groundwater pathways for movement of poor quality groundwater or hydrocarbons between otherwise disconnected formations.

5.3 Sources

The sources associated with the identified hazards include:

- Soils present at the Site before and after construction;
- Plant and machinery, fuel storage containers, staff vehicles;

- Produced hydrocarbons/waters and chemicals present in wells, drilling cellars, pipework and storage tanks/areas, tankers;
- Drilling fluids, chemicals and additives used in well construction and operation; and
- Oil, gas and formation waters in wells and geological formations and well treatment fluids, including the proppant squeeze.

5.4 Receptors

The receptors associated with the identified hazards include:

- Ella Beck;
- Superficial deposits aquifer (Secondary Aquifer);
- Lincolnshire Limestone aquifer (Principal Aquifer);
- Kellaways Formation, Great Oolite Group, Northampton Sand Formation and the Lower Lias Group (Secondary bedrock aquifers);
- Potential Private Water Supplies targeting the above, including the British Steel boreholes at Clapgate, around 0.3 km east of the site (Appendix C, Figure C3); and
- Groundwater bearing strata beneath the Lias Group, including potential geothermal reservoirs such as the Sherwood Sandstone.

5.5 S-P-R Linkages

Source-Pathway-Receptor linkages have been assessed for all hazards and receptors stated above.

5.6 Risk Assessment

A risk assessment has been carried out for the proposed activities based on the identified hazards in accordance with the methodology described in the following sub-sections. The risk assessment is presented in Appendix D.

The risk assessment considers the significance of a hazard occurring, based on receptor sensitivity and magnitude. The likelihood of a hazard occurring has been assigned taking account of the embedded mitigation that is already present within the development and operation of the Site (see subsection 5.7). Where appropriate, additional mitigation is proposed to further reduce potential risk of a particular hazard occurring.

5.6.1 Receptor sensitivity

Receptor sensitivity has been assigned in accordance with the methodology presented in Table 3.

Table 3 Receptor Sensitivity

Receptor Sensitivity	Description	Examples
Very High	Water resource with an importance and rarity at an international level with limited potential for substitution.	A water resource making up a vital component of an SAC or SPA under the EC Habitats Directive. A waterbody achieving a status of 'High Ecological status or potential' under the WFD. Principal aquifer providing potable water to a large population. EC designated Salmonid fishery.
High	Water resource with a high quality and rarity at a national or regional level and limited potential for substitution.	A water resource designated or directly linked to a SSSI. Principal aquifer providing potable water to a small population. A river designated as being of Good Ecological status or with a target of Good status or potential under the WFD. EC designated Cyprinid fishery.
Medium	Water resource with a high quality and rarity at a local scale; or water resource with a medium quality and rarity at a regional or national scale.	Secondary aquifer providing potable water to a small population. An aquifer or surface water body providing abstraction water for agricultural or industrial use. A local nature reserve dependent on groundwater.
Low	Water resource with a low quality and rarity at a local scale.	A non 'main' river or stream or another waterbody without significant ecological habitat.

Based on the above:

- The Ella beck is classed as a Main River and the surface water features have all been assessed as having a high sensitivity. No Water Framework Directive (WFD) ecological status has been defined by the Environment Agency for the Ella Beck.
- The most significant groundwater receptor at the wellsite is the Lincolnshire Limestone Formation (Principal aquifer), which is assessed as having a very high sensitivity. The Lincolnshire Limestone aquifer is targeted by boreholes used for private water supply and licenced abstraction boreholes operated by British Steel.
- The superficial deposits and Secondary bedrock aquifers from the Kellaways Formation, the Great Oolite Group, the Northampton Sand Formation and the Lower Lias Group are assessed as having a medium sensitivity.
- The deeper water bearing formations beneath the Lias Group are assessed as having a low sensitivity, with the exception of the Sherwood Sandstone, which we regard as medium sensitivity, due to its potential as a geothermal reservoir.

5.6.2 Magnitude of impact

Magnitude of impact depends on the nature of the hazard and has been assigned following the methodology presented in Table 4.

Table 4 Magnitude of Impact

Magnitude of Impact	Description	Examples
High	Results in a loss of attribute and/or quality and integrity of the attribute. Following development, the baseline situation is fundamentally changed.	Loss of EU designated Salmonid fishery. Change in WFD classification of a waterbody. Compromise employment source. Pollution of potable source of abstraction.
Medium	Results in impact on integrity of attribute, or loss of part of attribute. Following development, the baseline situation is noticeably changed.	Loss/gain in productivity of a fishery. Contribution/Reduction of a significant proportion of the effluent in the receiving river but insufficient to change its WFD classification. Reduction/increase in the economic value of the feature.
Low	Results in some measurable change in attribute's quality or vulnerability. Following development, the baseline situation is largely unchanged with barely discernible differences.	Measurable changes in attribute, but of limited size and/or proportion.
Very Low	The impacts are unlikely to be detectable or outside the norms of natural variation.	Physical impact to a water resource, but no significant reduction/increase in quality, productivity, or biodiversity. No significant impact on the economic value of the feature.

Based on the above:

- If the Ella Beck, the Principal Lincolnshire Limestone aquifer or any of the Secondary aquifers became contaminated during the Proposed Development, the magnitude of the impact would be classed as high, because there could be a major change to the water quality.
- The magnitude of impact of contamination on the deeper water bearing formations (except the Sherwood Sandstone) is classed as very low because water from these formations is of poor quality, with limited or no resource value.

- The magnitude of impact of contamination on the Sherwood Sandstone is classed as low because, although the aquifer has potential for future geothermal usage, the presence of contamination would not necessarily detract from its potential.

5.6.3 Significance of effect

Significance of Effect is the significance of a hazard occurring before consideration of the likelihood that it will occur. The potential significance of effect is defined by combining the receptor sensitivity and the magnitude of impact according to the matrix in Table 5.

Table 5 Potential Significance of Effect

Receptor Sensitivity	Magnitude of Impact			
	High	Medium	Low	Very Low
Very High	Major	Major	Moderate	Moderate
High	Major	Moderate	Moderate	Minor
Medium	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible

It follows that, as a result of the Proposed Development, there is potential for

- Major effects to the surface water features and the Principal Lincolnshire Limestone aquifer;
- Moderate effects to the Secondary aquifers;
- Minor effects to the Sherwood Sandstone geothermal resource, and
- Negligible effects to the other deeper water bearing formations.

5.7 Embedded Risk Mitigation

The significance of effect recognises the potential effects which may arise but does not take account of embedded mitigation measures to avoid or prevent hazards occurring, either by breaking the pathway between the potential sources of pollution and the receptors and/or reducing the likelihood of the hazards occurring.

Each phase of the Proposed Development incorporates specific mitigation features designed to either break the pathway between potential sources of pollution and receptors and/or reduce the likelihood of occurrence of hazards occurring. The embedded mitigation within the construction design is displayed in Table 6 and is presented in the context that:

1. Each phase of the Proposed Development will be carefully planned. Detailed designs for construction works will be prepared by competent consultant engineers and construction works will be supervised by an experienced construction manager. The construction works will include integrity testing of the very-low permeability liner that forms the TCS and a quality assurance process.
2. All works will be undertaken in accordance with an Environmental Management Plan.

3. A variation to the existing environmental permit will be required from the Environment Agency prior to the commencement of operational activities at the Site. This will ensure that there are strict controls in place for the drilling of the new wells. It will also ensure that there is a process for the routine inspection and maintenance of the containment liner and a quality assurance process. Detailed descriptions of these aspects of the Proposed Development will be submitted to the Environment Agency as part of the environmental permitting process.

Table 6 Embedded Risk Mitigation

Development Phase	Embedded Mitigation
Phase 1 - Wellsite construction and ancillary works of the exploration pad	• Collection of foul water and sewage from welfare facilities in self-contained wastewater tanks which will be emptied and removed from Site by an appropriate contractor. • Spill response protocol. • QA/QC testing during installation of very-low permeability containment liner. • Protection of the very-low permeability liner with geotextiles and a compacted stone granular working platform. • Setting of a concrete slab around the drilling cellars to which the very-low permeability liner is tied in and sealed. • Testing of the seal in the drilling cellar by hydrotesting with water; disposed off-site via tanker to an authorised waste disposal facility.
Phases 2 – 7	• Well construction in accordance with oil and gas industry best practice and regulations (Offshore Installations and Wells (Design and Construction, etc) Regulations 1996; BSOR, 1995). Review of the well design, construction and maintenance by an independent well examiner. • Well designs incorporate cemented steel casings to the top of the Permian bedrock, which will prevent exchange of production fluids with groundwater bearing formations with a potable/environmental resource value and the Sherwood Sandstone geothermal reservoir. • Design, management and monitoring of drilling fluids (muds) to minimise losses from the wellbore to geological formations. Use of water-based muds above the Permian strata. • Blow out prevention equipment used to prevent uncontrolled movement of fluids within the wellbore. • Primary, Secondary and Tertiary Containment System for process areas, produced fluids, fuels and chemicals: enclosed tanks and pipework; concrete bunding (in line with CIRIA guidance) /tanking /kerbing; very-low permeability liner. • Management systems and processes in place to prevent environmental accidents e.g. high level fluid controls on storage tanks • Removal of dirty surface water via tanker. • Collection and disposal off-site of extractive waste including drilling muds, cement, drill cuttings and spent chemicals. • Collection of foul water and sewage from welfare facilities in self-contained wastewater tanks which will be emptied and removed from Site by an appropriate contractor. • Routine pipeline inspections and maintenance.
Phase 8 - Well abandonment, site decommissioning and restoration	• Well abandonment to UK oil and gas industry guidance in accordance with Well Decommissioning Guidelines, Issue 6 – June 2018. Oil and Gas UK (or equivalent at the time of decommissioning). • Review of the well abandonment programme by an independent well examiner.

Development Phase	Embedded Mitigation
	• Site reinstatement in accordance with Egdon's Site Restoration procedure, which details the measures to be taken to prevent any contamination issues during the deconstruction works • Collection of foul water and sewage from welfare facilities in self-contained wastewater tanks which will be emptied and removed from Site by an appropriate contractor.

5.7.1 Likelihood of occurrence

The likelihood of a hazard occurring has been assigned with reference to Table 7 and takes account of the hydrogeological conceptual model and embedded mitigation summarised in Table 6. The likelihood of occurrence for each hazard based on the below criteria is displayed in Appendix D. Where there is sufficient mitigation to break the S-P-R pathways, there is no likelihood of a risk arising and therefore no risk associated with the hazard.

Table 7 Qualitative Likelihood of Occurrence

Qualitative Likelihood of Occurrence	Description	Examples
Highly likely	High probability of occurrence	Spillage at a poorly maintained and operated facility. Uncontrolled activity in or on an aquifer, close to surface water. Uncontrolled known discharge.
Likely	On balance could occur	Controlled but un-mitigated activity. Complex process where failure of a part is likely to lead to release. Large area where 100% sealing cannot reasonably be expected
Moderate	Equally likely/unlikely	Unmitigated low risk Controllable activity Partially contained site
Unlikely	On balance would not occur	Mitigated higher risk Simple controllable activity Underlain by poorly permeable strata Existing contained site
Very unlikely	Very low probability of occurrence	Essentially no risk Extreme set of circumstances required to generate low probability Fully mitigated low or medium risk

Due to the very high level of embedded mitigation incorporated into the Proposed Development, the potential hazards are either 'Unlikely' or 'Very Unlikely' to occur.

5.7.2 Risk Assessment

A risk assessment has been carried out for the Proposed Development and is presented in Appendix D. The qualitative risk assessment has been evaluated using the relationships in Table 8.

Table 8 Qualitative assessment of risk

Qualitative Likelihood of Occurrence	Significance of Effect			
	Major	Moderate	Minor	Negligible
Highly likely	Very High	High	Medium	Low
Likely	High	Medium	Low	Very Low
Moderately Likely	Medium	Low	Very Low	None
Unlikely	Low	Very Low	None	None
Very unlikely	Very Low	None	None	None

It follows that the highest potential risk is to the Ella Beck and shallow groundwater. The risk assessment demonstrates that the risks to all receptors from all identified hazards are 'Low', 'Very Low' or 'None' provided that the embedded risk mitigation measures are implemented. Where the resultant risk associated with a given hazard is classified as 'None', this reflects that the risk is so small/negligible that there is essentially no risk to consider.

6 FLOOD RISK ASSESSMENT

6.1 Introduction and Data Sources

The risk of flooding to the Proposed Development has been assessed using information from the North and North East Lincolnshire Strategic Flood Risk Assessment (SFRA) (North Lincolnshire Council, 2022), Flood Map for Planning (Environment Agency, 2023b), Historic Flood Map (Environment Agency, 2023c) and Surface Water and Reservoirs flood risk mapping (Environment Agency, 2023e).

The objectives of this FRA are to demonstrate that the Proposed Development will:

- Result in no net loss of floodplain storage;
- Not impede water flows; and
- Not increase the risk of flooding at the Site or elsewhere.

This FRA has been prepared in accordance with the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities & Local Government, 2023a)and Planning Practice Guidance (PPG): Flood Risk and Coastal Change (Ministry of Housing, Communities & Local Government, 2023b).

6.2 Flood Risk Zones

An extract of the Flood Map for Planning (Rivers and Sea) covering the Site and surrounding local area is presented in Figure 4.

The Site is situated wholly within Flood Zone 1 and is therefore at a Very Low risk of flooding from rivers and sea.

6.3 Flood Risk Vulnerability Classification

The Proposed Development is classified as 'Less Vulnerable' with its activities focused on the production of oil and associated infrastructure and facilities. In accordance with the NPPF and PPG, this type of development is appropriate within Flood Zone 1.

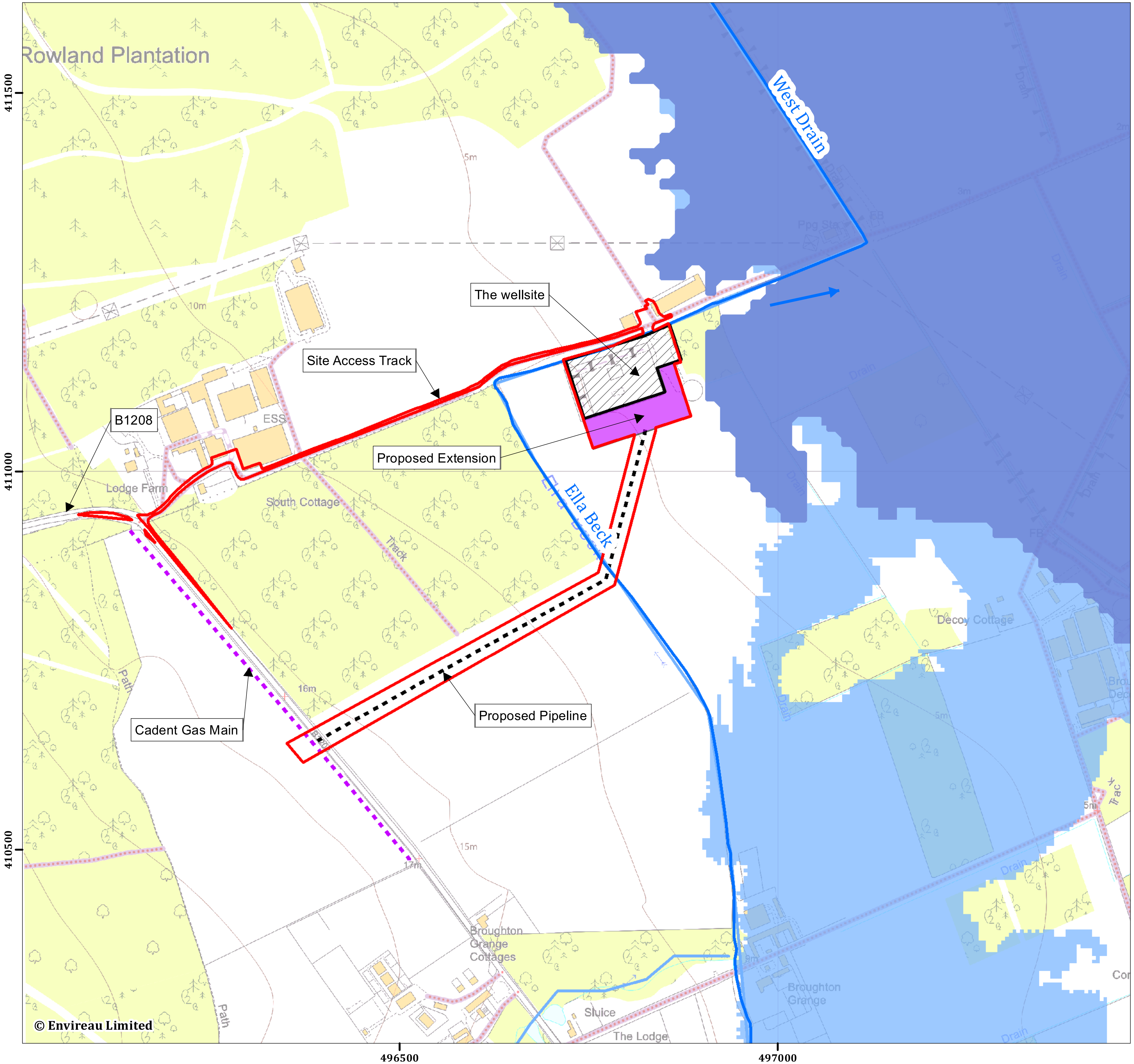


Figure 4: Flood Map for Planning

Wressle, North Lincolnshire

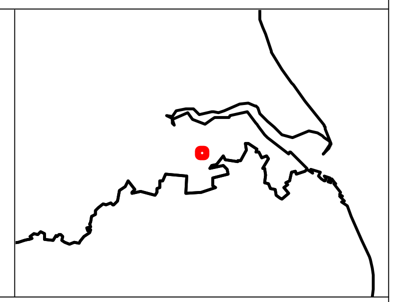
Planning Application Boundary
Existing Wellsite
Proposed Extension
Cadent Gas Main
Proposed Pipeline
Main River
Ordinary Watercourse
Flow Direction

Environment Agency Flood Zones

Flood Zone 1
Flood Zone 2
Flood Zone 3

Notes:

Contains Environment Agency information © Environment Agency and database right 2023.



0 50 100 150 200 Meters

Scale: 1:5,000 at A3

24 November 2023

NGR: 496,734 E / 410,932 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Fluvial Flood Risk

envireau WATER

6.4 Potential Sources of Flood Risk

6.4.1 Risk of flooding from the sea (tidal)

The Proposed Development is approximately 10 km inland from the River Humber on relatively flat land behind the New Ancholme River flood defences. The Humber Flood Risk Management Strategy identifies the level of protection for the Ancholme Valley varies between a 1 in 5 year to a 1 in 100 -year flood (Environment Agency, 2008). Overall, the risk to the Site from tidal flooding is considered 'Very Low'.

6.4.2 Risk of flooding from rivers (fluvial)

The Proposed Development is located wholly within Flood Zone 1 (Very Low risk of flooding from rivers).

There is no historic flooding recorded at the Site or local vicinity within the North and North East Lincolnshire SFRA or on the Historic Flood Map (Environment Agency, 2023c).

It is recognised that a section of the Ella Beck close to the wellsite entrance runs in culvert and that if this became blocked, there is a potential for localised flooding although due to land topography it is unlikely to affect the wellsite.

The Proposed Pipeline from the Site to the existing Cadent gas main just west of the B1208 road will be constructed to route it below the bed of the Ella Beck and therefore there will be no obstruction to flow. Construction of the pipeline will be undertaken in accordance with the requirements of a Flood Risk Activity Permit (FRAP).

6.4.3 Risk of flooding from surface water (pluvial)

The Flood Map for Surface Water (Environment Agency, 2023a) classifies the risk from surface water flooding using the following four categories:

- **High** – Greater than a 3.3% probability of occurrence in any given year;
- **Medium** – Between a 1%-3.3% probability of occurrence in any given year;
- **Low** – Between a 0.1%-1% probability of occurrence in any given year; and
- **Very Low** – Less than a 0.1% probability of occurrence in any given year.

An extract from the Flood Map for Surface Water is presented on Figure 5. The proposed extension to the existing wellsite is shown to be at No Risk from surface water flooding. Runoff from the proposed extension will be managed as part of the existing surface water drainage scheme which will be extended to accommodate the Proposed Development (see Section 3 for full details).

The Proposed Pipeline from the Site will be underground and will therefore not impede surface water runoff.

Based on the above, the risk of surface water flooding to the Site and is Very Low and will not increase the risk of flooding elsewhere.

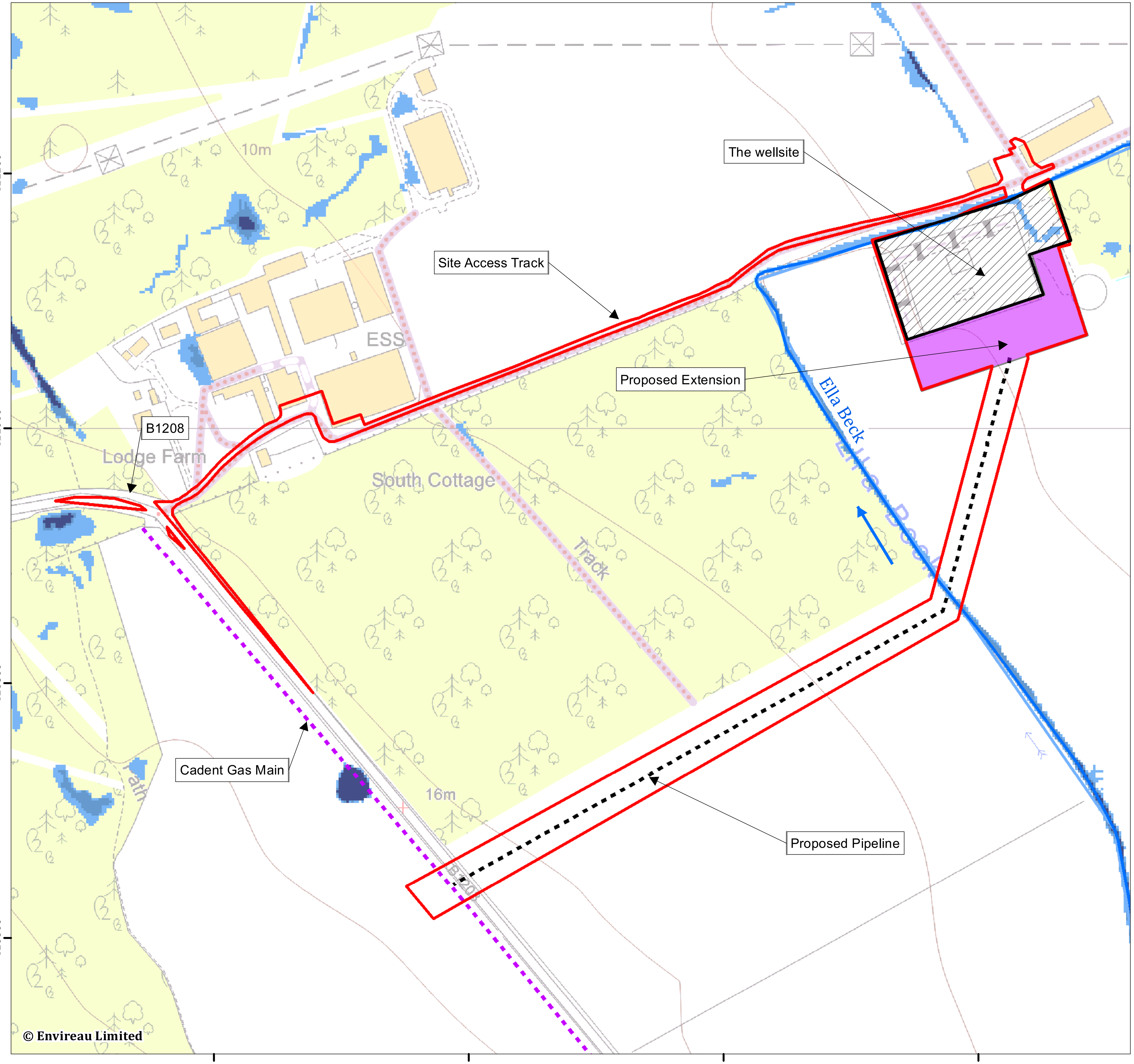


Figure 5: Surface Water Flood Risk

Wressle, North Lincolnshire

- Planning Application Boundary
- Existing Wellsite
- Proposed Extension
- Cadent Gas Main
- Proposed Pipeline
- Main River
- Ordinary Watercourse
- Flow Direction

Environment Agency Surface Water Flood Risk

- Very Low
- Low
- Medium
- High

Notes:

Contains Environment Agency information © Environment Agency and database right 2023.

0 25 50 75 100 Meters

Scale: 1:3,000 at A3

24 November 2023

NGR: 496,480 E / 410,922 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Surface Water Flood Risk

envireau WATER

6.4.4 Risk of flooding from groundwater

Groundwater flooding is the emergence of groundwater at the ground surface. Groundwater flooding occurs in response to a combination of already high groundwater levels (usually during mid or late winter) and intense or unusually lengthy storm events.

Shallow groundwater levels in the superficial deposits are between 2.3 and 3.4 metres below ground level and are controlled by the elevation of the Ella Beck. Water levels in the local drainage network are controlled by pumping to the New River Ancholme.

The HDPE liner which extends under the current wellsite platform will be extended to cover the proposed extension to the existing wellsite. The HDPE liner is an impermeable membrane which forms the tertiary containment system that will be installed below the granular material making up the wellsite platform.

Given the hydrogeological setting, there is no prospect of groundwater levels rising to the point that they would come into contact with the liner. Even if they did, the HDPE liner would prevent groundwater from entering the Site. This means there is 'No' risk of groundwater flooding at the Site.

6.4.5 Risk of flooding to/from reservoirs

The Flood Risk from Reservoirs Map indicates that the far eastern part of the Site lies within an area where water may go in the very unlikely event of failure of a large, raised reservoir coinciding with an extreme fluvial flood event (Environment Agency, 2023a). The reservoir in question is at Low Santon Farm (NGR SE 93907 13043), approximately 3 km northwest of the wellsite.

The likelihood of this scenario occurring is very low. Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers in accordance with the Reservoirs Act 1975.

Based on the above, the overall risk to Site of flooding from reservoirs is Very Low.

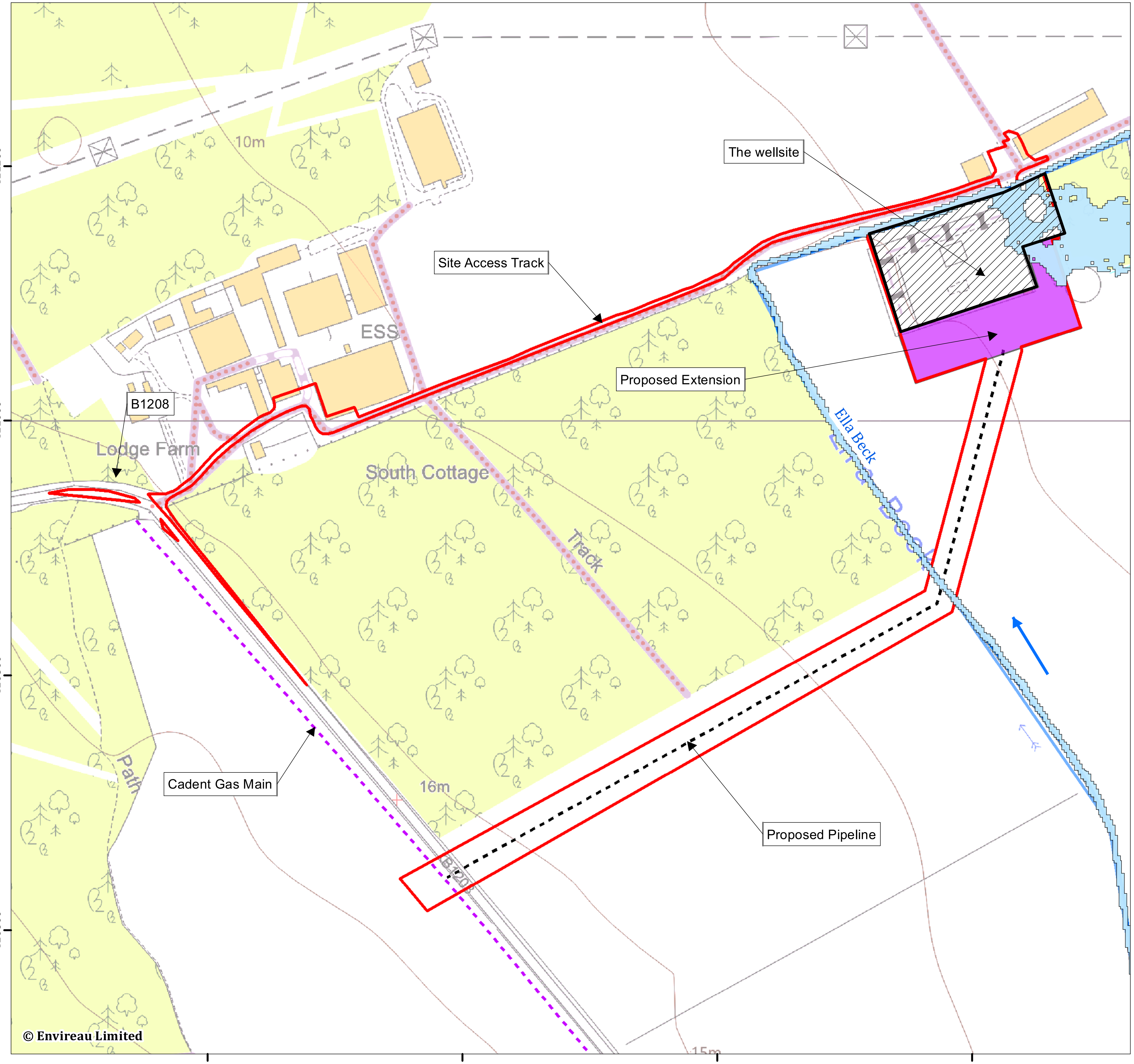
6.4.6 Risk of flooding to/from sewers

There are no proposed connections from the Proposed Development to public sewer.

Based on the rural location of the Site, it is understood that there are no public or private sewers in the vicinity. The overall risk of flooding to and from public sewers is considered 'No Risk'.

Figure 6: Reservoir Flood Risk

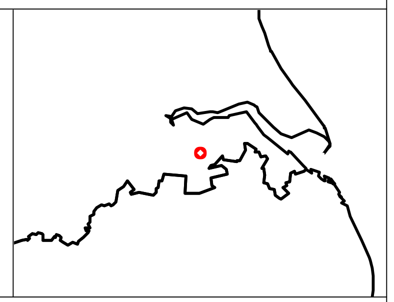
Wressle, North Lincolnshire



- Planning Application Boundary
- Existing Wellsite
- Proposed Extension
- Maximum Reservoir Flood Extent (Fluvial Contribution)
- Cadent Gas Main
- Proposed Pipeline
- Main River
- Ordinary Watercourse
- Flow Direction

Notes:

Contains Environment Agency information © Environment Agency and database right 2023.



0 25 50 75 100 Meters

Scale: 1:3,000 at A3

24 November 2023

NGR: 496,485 E / 410,916 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Reservoir Flood Risk

envireau WATER

6.4.7 Risk of flooding post-restoration

The Site will be returned to its pre-development condition. All concrete structures and hard standings will be dismantled and removed, the granular working platform and liner system will be removed. Soil will be replaced, topsoil will be back-tipped onto loosened subsoil and graded to its original profile.

The risk of flooding after the restoration of the Site will be the same as that pre-development i.e. Very Low.

6.5 Flood Risk Summary

A summary of the potential sources of flood risk to the Proposed Development is provided in Table 9.

Table 9 Flood Risk Summary

Potential Flood Source	Risk of Flooding				
	No Risk	Very Low	Low	Medium	High
Sea (Tidal)		X			
River (Fluvial)		X			
Surface Water (Pluvial)		X			
Groundwater	X				
Reservoirs (infrastructure failure)		X			
Sewers	X				
Post-Restoration		X			

The risk of flooding can be summarised as follows:

- The Proposed Development is wholly located within the Environment Agency Flood Zone 1 (Very Low risk of flooding from fluvial and tidal sources);
- The Proposed Development is an acceptable development type in Flood Zone 1 in accordance with the NPPF and PPG;
- Tidal flooding poses Very Low risk to the Proposed Development;
- The risk of surface water flooding to the Proposed Development is Very Low;
- Surface runoff over the proposed extension will be managed in accordance with the existing drainage scheme which will ensure that there is No Risk of surface flooding off-site.
- There is no risk of flooding to the Proposed Development from groundwater;
- Flooding from reservoirs poses a Very Low risk to the Site;
- Flooding from public sewers to the Site is Very Low; and
- The risk of flooding post-restoration will be the same as that pre-development i.e. Very Low.

This FRA demonstrates that the Proposed Development will result in no net loss of floodplain storage, will not impede water flows and will not increase the risk of flooding at the Site or elsewhere.

6.6 Risk of flooding from the Proposed Development

To reduce the risk of flooding from the Proposed Development, the Site has been designed to be fully sealed through the construction of the tertiary containment system and which contains incident rainfall and releases it to the environment if it is safe to do so. The design in effect acts as a Sustainable Urban Drainage Systems (SUDs) system. All new developments mitigate the risk of increasing flooding using SUDs systems, these systems work by storing rainfall runoff and releasing them slowly into the ground or to local water courses. This should act as a proxy for a natural system.

As such, the Site does not increase the risk of off-site flooding and if necessary, can hold and slowly release the volumes of water generated from an extreme storm.

6.7 Summary

An FRA has been carried out in accordance with the National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG): Flood Risk and Coastal Change.

The FRA demonstrates that the Proposed Development will not have a detrimental impact on drainage and flooding at or from the Site, provided that surface water is managed appropriately.

7 CONCLUSIONS

The relevant extant development plan policies regarding impact on the water environment are:

- 'Saved' NLLP policy DS13 which requires all development proposals to take account of the need to secure effective land drainage measures and groundwater protection and
- 'Saved' NLLP policy DS14 which states that developments will not be permitted if they "*adversely affect the quality and quantity of water resources…unless the impact is mitigated to an acceptable level*".
- 'Saved' policy M23 of the NLLP also requires all proposals for oil and gas production to incorporate protection measures adequate to mitigate their impacts.

Pre-application advice from NLC has stated that the Council's drainage officer has raised no concerns regarding Egdon's proposed development. A flood risk assessment (FRA), a surface water drainage strategy and an appropriate hydrogeological risk assessment (HRA) are required to assess risks to flooding, drainage and to groundwater from the proposed development.

This report comprises an HRA and FRA that has been carried out in accordance with current industry guidance. The assessment updates works previously undertaken in 2018/19 to support the previous planning application for the Wressle-1 wellsite.

The HRA takes account of the Environment Agency's most recent technical guidance and reconfirms the findings of the previous HRA. The HRA demonstrates that although there are identified risks to surface water and groundwater receptors, these risks are reduced through mitigation measures, resulting in there being a low, very low or no overall residual risk from the proposed development. Consequently, residual risks are not significant in planning terms.

Hydrogeological risks are mitigated by adopting a best practice approach to all phases of the Proposed Development. The success of the mitigation measures is evidenced through an existing scheme of groundwater and surface water monitoring that has been in place since 2020, which demonstrates there has been no observable impact to water resources from the previous development at the Site.

The FRA has been carried out in accordance with the current National Planning Policy Framework and Planning Practice Guidance: Flood Risk and Coastal Change. The FRA demonstrates that the Proposed Development will not have a detrimental impact on drainage and flooding at or from the Site, provided that surface water is managed appropriately.

It is considered that the risk of an adverse impact upon groundwater is very low and that there would be appropriate measures in place to ensure the protection of ground and surface water and nearby watercourses. The proposed development, appropriately mitigated, is considered to accord with the requirements of policies DS13, DS14 and M23 of the North Lincolnshire Local Plan with regard to the protection of the water environment.

REFERENCES

Abesser, C., Gonzalez Quiros, A., & Boddy, J. (2023). *Evidence report supporting the deep geothermal energy white paper : the case for deep geothermal energy - unlocking investment at scale in the UK (OR/23/032) .* Nottingham, UK: British Geological Survey. Retrieved from https://nora.nerc.ac.uk/id/eprint/535567/

Cuff, M. (2023, June 27). The hottest energy technology in town. *New Scientist (Fix the Planet)*. Retrieved from https://link.newscientist.com/view/62f686b7fc1bdc56726c1185izyb2.3kl/7f0c3748

DEFRA. (2011). *Green Leaves III - Guidelines for Environmental Risk Assessment and Management: Green Leaves III. Revised Departmental Guidance Prepared by Defra and the Collaborative Centre of Excellence in Understanding and Managing Natural and Environmental Risks.*

Department for Communities and Local Government. (2023). *National Planning Policy Framework.*

Department for Local Communities and Local Government. (2023). *National Planning Practice Guidance: Flood Risk and Coastal Change.*

Dodds, J. (2019). *Proof of Evidence of James Dodds - Hydrogeology & Water Management.*

Egdon Resources. (2023). *Active sites*. Retrieved from egdon-community.com: https://www.egdon-community.com/active-sites

Envireau Water. (2018). *Hydrogeological and Flood Risk Assessment - Wressle-1 Well, Wressle Wellsite.*

Envireau Water. (2020). *Baseline water quality data: Wressle-1 wellsite, North Lincolnshire.* Richmond, N. Yorkshire, UK: Envireau Water, for Egdon Resources UK Ltd.

Envireau Water. (2023b). *Water quality data: quarterly summary. Wressle-1 wellsite, North Lincolnshire.* Envireau Water for Egdon Resources.

Environment Agency. (2008). *The Humber Flood Risk Management Strategy: part 2.* Retrieved from https://assets.publishing.service.gov.uk/media/5a7e38b940f0b62302689f24/Humber_strategy2.pdf

Environment Agency. (2018a). *Groundwater risk assessment for your environmental permit. Environment Agency.* https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit.

Environment Agency. (2018b). *The Environment Agency's approach to groundwater protection. Version 1.0. Environment Agency.*

Environment Agency. (2023a). *Check your long term flood risk*. Retrieved from Gov.uk: https://check-long-term-flood-risk.service.gov.uk/map

Environment Agency. (2023b). *Flood Map for Planning*. Retrieved October 2017, from Gov.uk: https://flood-map-for-planning.service.gov.uk

Environment Agency. (2023c). *Historic Flood Map*. Retrieved October 2017, from Data.gov.uk: https://data.gov.uk/dataset/historic-flood-map1

Environment Agency. (2023e). Reservoir Flood Maps.

European Parliament. (2006). IRECTIVE 2006/118/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 12 December 2006 on the protection of groundwater against pollution and deterioration. *Official Journal of European Union*.

European Parliament. (2020). Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

Gale et al. (1983). *The post Carboniferous rocks if the East Yorkshire and Lincolnshire Basin, Investigation of the Geothermal Potnetial of the UK.* British Geological Survey.

Jones, D., Randles, T., Kearsey, T., Pharoah, T., & Newell, A. (2023). Deep geothermal resource assessment of early carboniferous limestones for Central and Southern Great Britain. *Geothermics, 109*, 102649. doi:10.1016/j.geothermics.2023.102649

Ministry of Housing, Communities & Local Government. (2023a). *National Planning Practice Guidance.*

Ministry of Housing, Communities & Local Government. (2023b). *Flood risk and coastal change*. Retrieved from Gov.uk: https://www.gov.uk/guidance/flood-risk-and-coastal-change

North Lincolnshire Council. (2022). *North and North East Lincolnshire Strategic Flood Risk Assessment.*

North Lincolnshire Council. (2023a). *EIA Screening Opinion (ref. PA/SCR/2023/4).*

North Lincolnshire Council. (2023b). *Pre-Application Development Advice.*

SI No. 2038. (1995). The Borehole Sites and Operations Regulations.

SI No. 913. (1996). The Offshore Installations and Wells Regulations.

UKTAG. (2011). Defining & Reporting on Groundwater Bodies.

UKTAG. (2018). *Confirmed hazardous substances list. Water Framewrok Directive.* Retrieved from https://www.wfduk.org/tagged/hazardous-substances

Walton, I. L. (2014). Containment systems fior the prevention of pollution (C736F).

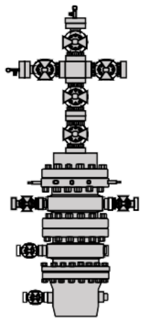
APPENDICES

Appendix A Development Plans & Well Schematics

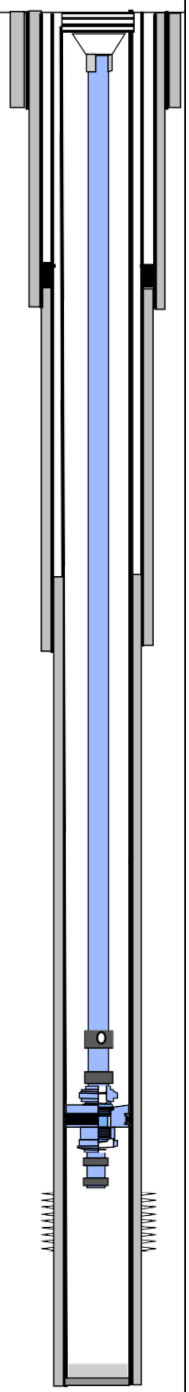
Wressle-2 and 3 Well Schematics

20-Nov-23

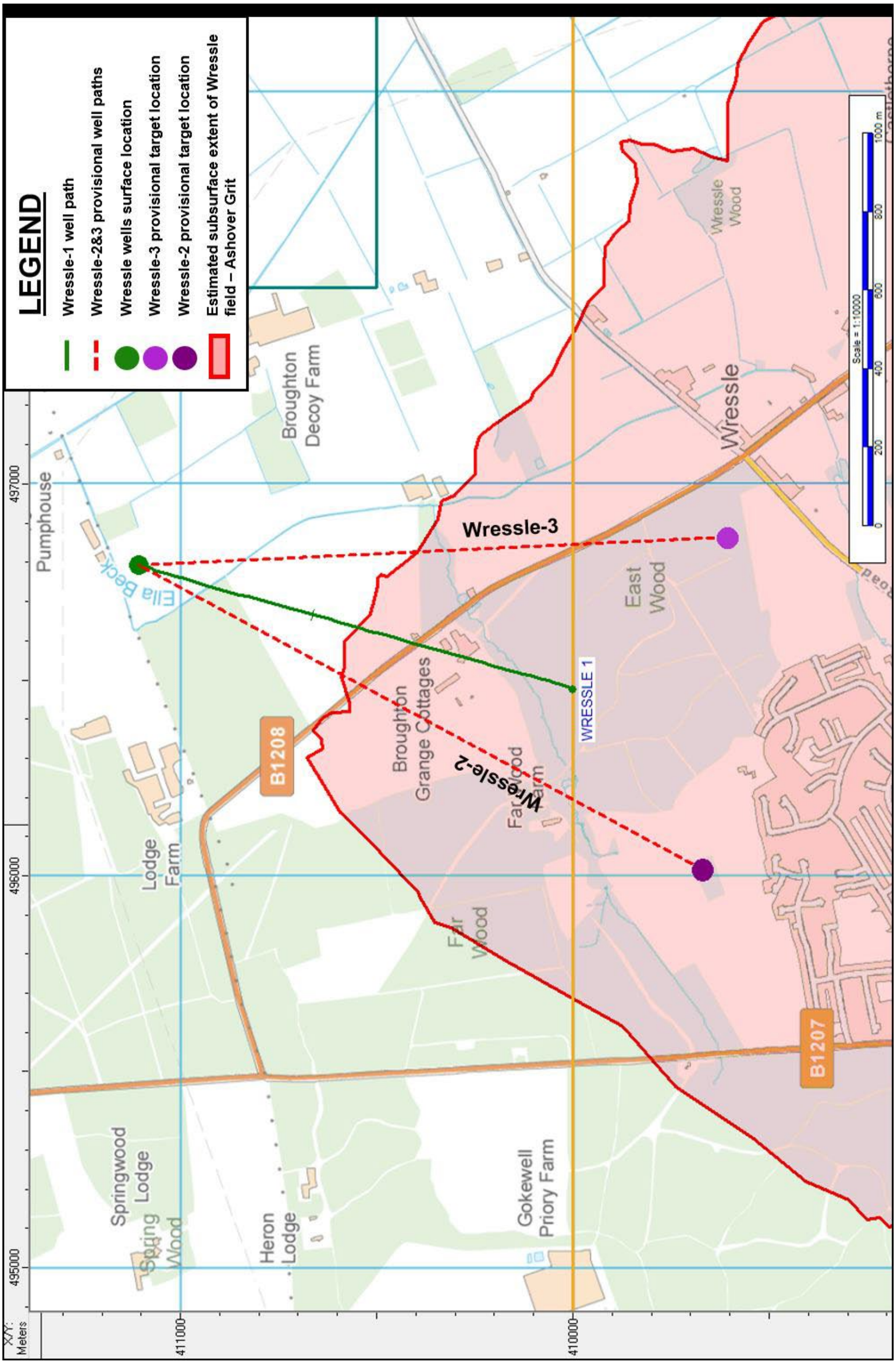
MD = Measured depth from ground level
TVD = true vertical depth from ground level
Incl = inclination at depth indicated
All depths are per current plans and subject to change



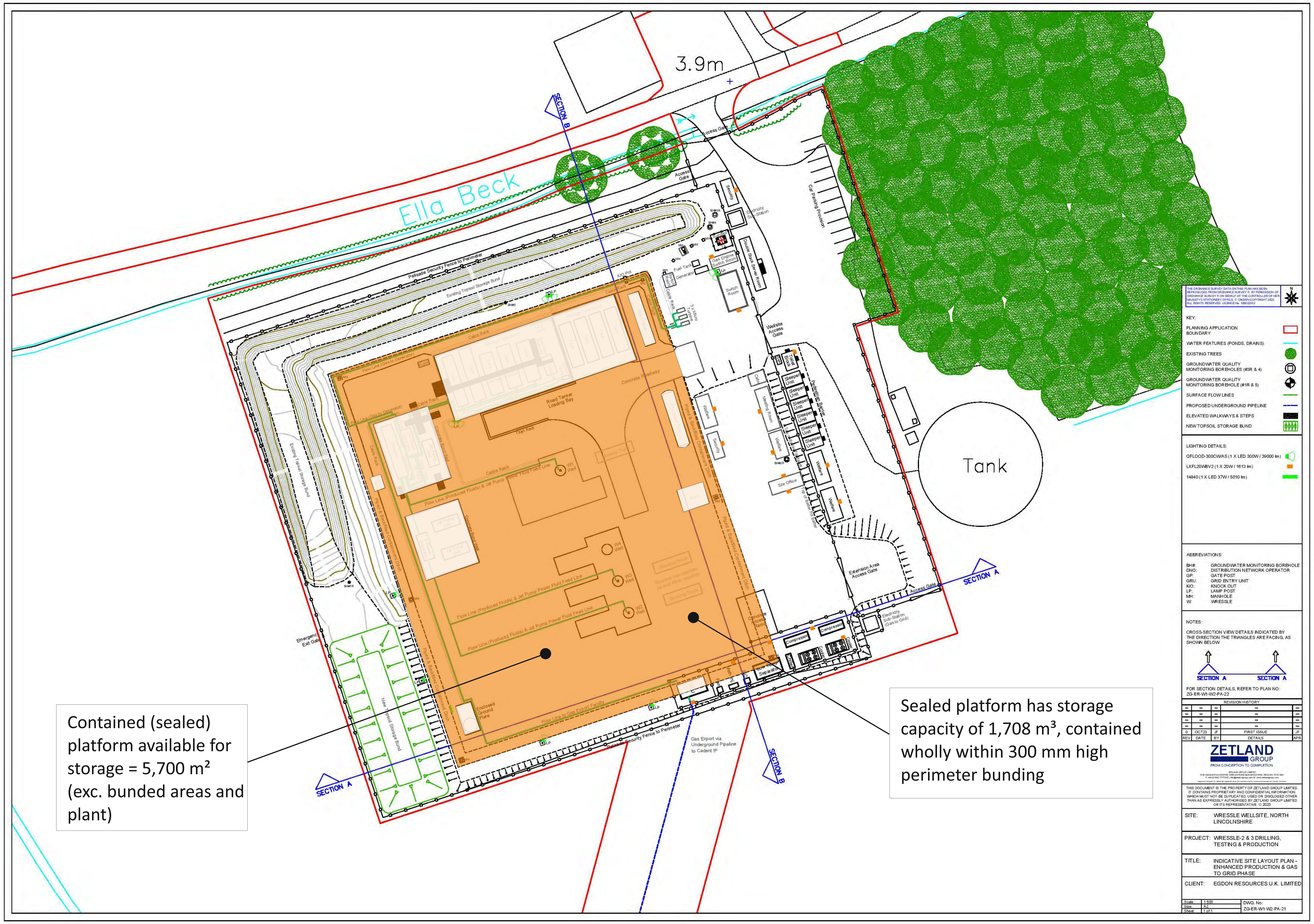
	Penistone Flags Well			Ashover Grit Well		
Component	MD (m)	TVD (m)	Incl.	MD (m)	TVD (m)	Incl.
Conductor pipe: 18-5/8" 87.5 lb/ft Casing	70	70	0°	70	70	0°
Surface casing: 13-3/8" 61-68 lb/ft (bottom of Mercia Mudstone)	510	450	54°	505	450	47°
Intermediate casing: 9-5/8" 43.5-47 lb/ft (Permian Anhydrites)	1190	854	54°	1090	851	47°
Production packer						
Target interval	2170	1435	54°	2150	1580	47°
Production casing: 7" 26-32 lb/ft (Dinantian Limestone)						



Wressle-2 and Wressle-3 indicative well paths



Appendix B Wellsite Platform Stormwater Storage Calculations



Appendix B: Wellsite Platform Stormwater Storage Area

Date: 16 January 2024
Project No. 3490616
Client: Egdon Resources
Ref: App B Platform Storage
Drawn by: MU

envireau WATER

Appendix C Baseline Conditions and Environmental Setting

C1 BASELINE CONDITIONS

This section describes the hydrological and hydrogeological water related aspects around and beneath the Site relevant to the Proposed Development. It presents information and monitoring data collected as part of the preparation of the Hydrogeological Risk Assessment to support the previous planning application for the development of the wellsite for commercial oil production (Envireau Water, 2018). Where relevant, information has been updated based on data collected since the planning permission.

The Site lies at National Grid Reference SE 968 111. Water-dependent features within a 2 km radius of the Site have been identified and presented (see 'Environmental Setting' at Section C2). Although it is not anticipated that the impacts of the wellsite will extend this far, this search radius allows the surrounding area to be appropriately characterised with regard to the water environment. In terms of the geological and hydrogeological description, a wider search area has been used to allow the characterisation of deep geological units to be undertaken which outcrop outside of this search radius.

C1.1 Soils

The soil type at the Site has been assessed using the LandIS Soilscapes site (Cranfield Soil and Agrifood Institute, 2023). There are two soil types at the Site. The western part of the Site is classified as 'freely draining very acid sandy and loamy soils' and the eastern part of the Site, where the proposed extension is to occur, is classified as 'freely draining lime-rich loamy soils'.

In the wider environment around the Site, 'Loamy and clayey soils of coastal flats with naturally high groundwater' are located to the east with numerous soil types present to the west. The soils to the west are typically all freely draining with varying composition of sands and loam; including the 'Freely draining slightly acid sandy soils', 'Naturally wet very acid sandy and loamy soils' and 'Freely draining slightly acid but base-rich soils'.

C1.2 Hydrology

C1.2.1 Watercourses

The Site lies in a low-lying area between Ella Beck and West Drain, where Ella Beck forms the northern boundary of the Site. Ella Beck is a Statutory Main River, flowing from the west to the east at elevations between 6 mAOD to 3.25 mAOD past the Site. Approximately 400 m to the north-east of the Site the Ella Beck joins the West Drain and flows north.

West Drain is a major drain in the vicinity of the Site. It is located 400 m east of the Site and flows northerly for about 10 km where it joins the New River Ancholme close to the mouth of the River Humber. The West Drain is also classified as a Statutory Main River.

The New River Ancholme is located approximately 1.5 km east of the Site and flows north through the Ancholme Valley towards the Humber Estuary. The river has been modified and is canalised from Bishopbridge in West Lindsey District to the Humber.

C1.2.2 Water Framework Directive Classifications

The Site is located within the 'Ancholme from Bishopbridge to the Humber Water Body' (Environment Agency, 2024a). It is designated as having 'artificial' hydromorphology; a designation which is largely due to the New River Ancholme being an artificial canalised navigable watercourse, (IWA, 2024) and up to which land drainage water from the surrounding terrain is pumped (Shire Group of ISBs, 2024). The Water Framework Directive (WFD) Regulations Cycle 3 Classifications (2022), indicate that the water body is classified as having 'Moderate Ecological Status'. Reasons for not achieving 'Good Ecological Status' include diffuse source pollution from agriculture and physical modification for flood protection and water level management (Environment Agency, 2024a).

C1.2.3 Hydrological Characteristics

The hydrological catchment descriptors for the closest catchment to the Site have been derived from the Flood Estimation Handbook (FEH) Web Service (UK Centre for Ecology & Hydrology, 2023) and are provided in Table C1.

Table C1 Hydrological Catchment Descriptors

Descriptor	Abbreviation	Value
Catchment Area	AREA	1.3 km^2
Mean Altitude	ALTBAR	11 mAOD
Base Flow Index associated with each HOST soil class	BFIHOST	0.732
Standard Percentage Runoff associated with each HOST soil class	SPRHOST	26.83%
Proportion of time when soil moisture deficit was equal to, or below, 6 mm during 1961-1990	PROPWET	0.26
Standard Average Annual Rainfall (1961 – 1990)	SAAR	625 mm/year
Extent of urban and suburban land within catchment	$URBEXT_{2000}$	0.0154
Description of location of urban / suburban areas within catchment	$URBLOC_{2000}$	1.151
Concentration of catchment urbanisation (quantification of connectivity of urban and suburban areas)	$URBCONC_{2000}$	0.5

The Standard Percentage Runoff (SPRHOST) value indicates that the proportion of runoff within the catchment is 26.83%, which is a moderate value. This value is consistent with the natural soil type at the Site as described in Section C1.1.

The Base Flow Index (BFIHOST) value is 0.732 which indicates that there is expected to be a high groundwater component in the discharge of local watercourses.

The urban extent registered in the year 2000 (URBEXT2000) is stated as 0.0154, reflecting the rural nature of the catchment.

Overall, the catchment descriptors are consistent with the wellsite setting and hydrogeological setting described in the following sections.

C1.3 Geology

C1.3.1 Data Sources

The geological setting of the Site has been identified using the following data sources:

- British Geological Survey (BGS) England and Wales 1:50,000 scale map sheet 89 (Brigg);
- BGS's database of water wells and boreholes (BGS, 2023);
- Geological data obtained by Egdon Resources during the installation of the Wressle-1 well; and
- Geological data from monitoring and site investigation boreholes (DSI1 and DSI2) installed at the Site in 2018.

The shallow geology is described down to formation level. Formation names are those given in the BGS Lexicon (BGS, 2023). Where lithological descriptions are given these are a summary and cover the general descriptions of the lithologies within the units that make up the formations. Due to changes in the naming of geological formations and members since publication of the BGS 1:50,000 scale map and earlier maps of different scales, there may be differences between the lexicon and the maps.

The deep geology is described at group level with a general lithological description for the group.

C1.3.2 Regional

The wellsite lies within a region dominated by the outcrop of Jurassic age strata which extends 8 km west of the wellsite and 9 km to the east and includes geological strata ranging from the Scunthorpe Mudstone Formation to the Ancholme Group. The strata strike regionally in a broadly north-south direction and dip at about 3-4 degrees to the east. In the immediate vicinity of the site, the strike appears to veer north-west to south-east at the southern edge of a fault-related graben-like structure containing a local asymmetric syncline (Gaunt, Fletcher, & Wood, 1992).

Superficial deposits cover approximately half of the region, and are formed predominately of Sutton Sand Formation, with Alluvium deposits associated with the surface water features.

The formations are described in Table C2 together with the descriptions of the lithologies from the BGS Lexicon of Named Rock Units (BGS, 2024).

Regional scale faulting is shown on the BGS mapping, the most significant of which is the Brigg Fault, located ~1 km west of the wellsite, and which trends in a northwest-southeast direction over a distance of 10 km and downthrows the strata to the north-east by up to ~ 50 m. The displacement dissipates along its length, with the throw being essentially zero at Mill Lodge near High Santon to the west of the wellsite.

There are two smaller faults located 450 m and 900 m northeast of the wellsite; trending in a northwest-southeast direction and downthrowing strata to the south-west. All of these faults are noted by (Gaunt, Fletcher, & Wood, 1992) and the faulting is described as having "produced a graben enclosing an asymmetric syncline" and as being aligned with an anticlinal structure in the underlying Carboniferous rocks.

The regional geological stratigraphy is shown on Table C2.

Table C2 Regionally recognised Geological Sequence

Formation	Parent Group	Age	BGS Lexicon Lithology
Sutton Sand Formation		Quaternary	Fine-grained silty sand.
Kellaways Formation	Ancholme Group	Middle Jurassic	Mudstone, grey, commonly silici-silty or silici-sandy, with (predominantly in the upper part) beds of generally calcareous siltstone and sandstone.
Cornbrash Formation	Great Oolite Group	Middle Jurassic	Limestone, medium- to fine-grained, predominantly bioclastic wackestone and packstone with sporadic peloids
Blisworth Clay Formation			Silicate-mudstone, grey, commonly variegated purplish red, yellow and green, poorly bedded to blocky. Formerly, Great Oolite Clay.
Blisworth Limestone Formation			Pale grey to off-white or yellowish limestones with thin marls and mudstones. Formerly, Great Oolite Limestone.
Rutland Formation			Interpreted as a succession of up to seven shallowing upward, essentially delta-type rhythms, comprising ideally of a grey marine mudstone passing up into non-marine mudstone and siltstone, with a greenish-grey rootlet bed at the top. Formerly, known as the Upper Estuarine Series. This includes the Thorncroft Sand member shown on **Figure C2**.
Lincolnshire Limestone Formation	Inferior Oolite Group	Middle Jurassic	Limestone, typically calcilutites, and peloidal wackestones and packstones in the lower part (Lower Lincolnshire Limestone) and high energy ooidal and shell fragmental grainstones in the upper part (Upper Lincolnshire Limestone). This includes obsolete unit names, shown on **Figure C2**, such as the Hibaldstow Limestone, Scawby Limestone and Kirton Cementstone Beds.
Grantham Formation			Mudstones, sandy mudstones and argillaceous siltstone-sandstone, which is commonly ferruginous, and containing generally abundant plant debris. Formerly, known as the Lower Estuarine Series.
Northampton Sand Formation			Sandy, berthierine-ooidal and sideritic ironstone, greenish grey where fresh, weathering to brown limonitic sandstone, typically displaying a box-stone structure
Whitby Mudstone Formation	Lias Group	Lower Jurassic	Medium and dark grey fossiliferous mudstone and siltstone,
Marlstone Rock Formation			Sandy, shell-fragmental and ooidal ferruginous limestone interbedded with ferruginous calcareous sandstone, and generally subordinate ferruginous mudstone beds.
Dyrham Formation			Pale to dark grey and greenish grey, silty and sandy mudstone, with interbeds of silt or very fine-grained sand (locally muddy or silty), weathering yellow.

Formation	Parent Group	Age	BGS Lexicon Lithology
Charmouth Mudstone Formation			Dark grey laminated shales, and dark, pale and bluish grey mudstones; locally concretionary and tabular limestone beds;
Scunthorpe Mudstone Formation			Grey, variably calcareous and silty, blocky or fissile mudstone with thin beds of argillaceous limestone (bioclastic or micritic) and calcareous siltstone, particularly near base and in upper part, which is ferruginous in the type area.
-	Penarth Group	Triassic	Grey to black mudstones with subordinate limestones and sandstones; predominantly marine in origin.
-	Mercia Mudstone Group		Dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas.
-	Sherwood Sandstone Group		Sandstone, red, yellow and brown, part pebbly; conglomeratic in lower part;
-	Zechstein Group	Permian	Cyclical succession of marine dolomite, limestone, evaporites, red mudstone and siltstone.
-	Conybeare Group *	Carboniferous	Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.
-	Millstone Grit Group		Fine- to very coarse-grained feldspathic sandstones, interbedded with grey siltstones and mudstones,
-	Carboniferous Limestone Supergroup		Dominated by typically bioclastic to micritic, bioturbated with common shelly, crinoidal and algal beds of limestone and coral biostromes which are darker grey, and commonly dolomitised in the lower part.

** The term Conybeare Group is introduced here for Westphalian Coal Measures and primary red beds of the Southern North Sea Gas Basin.*

C1.3.3 Local

While Table C2 provides an overview of regionally recognised geological sequence, with descriptions taken from the BGS Lexicon of Named Rock Units, Table C3 provides an overview of geology below the Wressle well site, with descriptions based on logged observations and details of formation thicknesses obtained from site investigation boreholes. Table C2 provides descriptions of lithologies that may be represented within the formations but may not have been encountered immediately below the wellsite.

In the following sections, the detail of the lithologies encountered from various boreholes on the wellsite are described within the context of the local setting. The location of the boreholes referenced are shown on **Figure C4**.

Superficial Deposits

Published geological maps show the Site to be underlain by Devensian to Holocene age blown sands of the Sutton Sand Formation. Localised iron pan close to the Site, and more extensively further north, indicates the presence of dunes within the blown sand. To the east, sporadic peat deposits give way to extensive deposits of alluvium flanking the River Ancholme. Nearby historic boreholes have recorded a mixture of sands, clays, gravels and peat in the area.

Detailed shallow site investigation work undertaken in February and March 2018 proved the superficial deposits beneath the wellsite. Made ground and topsoil including a geotextile membrane was encountered to a depth of 0.4 m. This was underlain by slightly clayey sand of the Sutton Sand Formation to a depth of 4.5 m. Within boreholes in the west of the wellsite (boreholes WS01 to WS03), sands interpreted as being the underlying Kellaways Sand Member of the Kellaways Formation were encountered below the Sutton Sand Formation.

Shallow Bedrock

The detailed geological understanding of the shallow bedrock geology has been obtained from the drilling and logging of the DSI1 and DSI2 boreholes in 2018. These two boreholes were located on the up (west) and down (east) dip edges of the wellsite respectively to check the variation in geology across the wellsite. Both boreholes were cored from rock head (the loose nature of the superficial deposits meant that coring was not possible and bulk samples were collected), and the core logged by an experienced geologist to BS 5930:1999-1 / BS EN ISO 14688 (EuroCode 7). DSI1 was designed to fully penetrate the Lincolnshire Limestone. DSI2 was sited and designed to intersect sands in the upper part of the Kellaways Formation (the Kellaways Sand Member) should it be present on the wellsite. The depth of DSI2 was specified to prove the top of the Lincolnshire Limestone.

Drillers logs of monitoring boreholes drilled at the wellsite and the geological information from these have been used to supplement the data from DSI1 and DSI2. The monitoring boreholes were sited with respect to the hydraulic gradient across the wellsite, with one on the up-gradient side (GWMBH1) and three on the down gradient side (GWMBH 2, 3, & 4). Table C3 provides more detail on the lithologies and thicknesses.

The logged descriptions provided in Table C3 vary slightly from the BGS Lexicon description terminology used in Table C2, and reflect standard logging descriptive terms.

It should be noted that, of the 16-17 m of Jurassic strata encountered above the top of the Lincolnshire Limestone in boreholes DSI1 and DS2, 15-16 m were logged as being dominated by Mudstone. No significant limestone stratum corresponding to the Blisworth Limestone was clearly recorded. Indeed, (Allen, et al., 1997) report that the Blisworth Limestone tends to be absent to the north of Brigg. Other well logs on or near the Site – for example Clapgate No. 5 borehole (SE91SE9) – record thin limestone horizons within the Great Oolite Group. Well record Clapgate No. 5 (SE91SE9) does not record any such limestone horizon of greater thickness than 2’6” (0.76 m), while Clapgate No. 6 (SE91SE10) does record a “very hard dark rock” horizon of 6 ft (1.83 m) thickness.

Table C3 Shallow geology below the Site

Formation	Parent Group	Depth at DSI1 (mbgl)	Depth at DSI2 (mbgl)	Logged Description
Sutton Sand Formation (Quaternary Deposits)		0 – 4.0	0 – 9.0	Orange to brown, fine grained, SAND, well sorted, sub-rounded, quartzitic.
Kellaways Formation	Ancholme Group	4.0 – 5.4	9.0 – 10.4	Light Greyish brown, CLAY, with occasional angular calcareous rock fragments. Kellaways Sand Member encountered above Kellaways Clay at west of Site in WS01 to WS03
Cornbrash Formation	Great Oolite Group	5.4 – 6.3	10.4 – 11.7	Light grey, SANDSTONE, highly calcareous with occasional shells.
Blisworth Clay Formation		6.3 – 15.9	11.7 – 21.2	Medium grey, MUDSTONE, calcareous with frequent shells with interbedded clays and sand.
Blisworth Limestone Formation				
Rutland Formation		15.9 – 21.3	21.2 – 24.6	Dark mottled brown, MUDSTONE, waxy with rare carbonaceous fragments.
Lincolnshire Limestone Formation	Inferior Oolite Group	21.3 – 39.2	24.6 -35.0 (End of Hole)	Dark grey, ooidal grainstone, LIMESTONE with frequent shell fragments. Rare joints with ferruginous weathering.
Northampton Sand Formation/ Grantham Formation		39.2 – 44.1	Not encountered	Dark grey, fine grained, SANDSTONE, highly calcareous with disturbed bedding and occasional peloids/pisoids. With interbedded mudstones.
Whitby Mudstone Formation*	Lias Group	44.1 – 52.5 (End of Hole) expected base of 130 m	Not encountered	Dark greyish black, thinly laminated, MUDSTONE, slightly carbonaceous, fossiliferous with occasional aragonitic shells and ammonites, slightly conchoidal fracture.

** Note that deeper Jurassic age strata below the Whitby Mudstone are not shown in this Table.*

Deep Bedrock

The Jurassic age strata (which we have taken to form part of the "shallow geology" beneath the site) are underlain by the Penarth and Mercia Mudstone Groups, and the Sherwood Sandstone Group of Triassic age, which are in turn underlain by Permian and Carboniferous age bedrock. Information on the deep geology is available from the geological data obtained by Egdon Resources during the construction of the Wressle-1 well and regional information.

Table C4 provides a summary of the deep (pre-Jurassic) geology below the wellsite together with a brief description of the main lithologies.

Table C4 Deep Geological Sequence below the Site

Group	Age	Summarised Lithology	Thickness from Wressle-1 well log (mTVD)	Approx. Depth to Base of Strata (mbgl)
Penarth Group	Triassic	Grey to black mudstones with subordinate limestones and sandstones; predominantly marine in origin.	240	478
Mercia Mudstone Group		Dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas.		
Sherwood Sandstone Group		Sandstone, red, yellow and brown, part pebbly; conglomeratic in lower part;	337	815
Zechstein Group	Permian	Cyclical succession of marine dolomite, limestone, evaporites, red mudstone and siltstone.	322	1137
Conybeare Group *	Carboniferous	Interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.	>657	>1794
Millstone Grit Group		Fine- to very coarse-grained feldspathic sandstones, interbedded with grey siltstones and mudstones,		
Carboniferous Limestone Supergroup		Dominated by typically bioclastic to micritic, bioturbated with common shelly, crinoidal and algal beds of limestone and coral biostromes which are darker grey, and commonly dolomitised in the lower part.		

** The term Conybeare Group represents the Westphalian Coal Measures and primary red beds of the Southern North Sea Gas Basin.*

C1.3.4 Structural Geology

The geological data from below the wellsite confirm that the rock formations dip at a shallow inclination to the east, and that the elevations of the formation boundaries in the wider local area are consistent with that dip. There are no faults mapped in the immediate vicinity of the wellsite by the BGS. Furthermore, the wellsite borehole data and borehole data from the British Steel Clapgate boreholes does not suggest the presence of faults local to the wellsite.

Regional scale faulting is shown on the BGS mapping, however, the most significant of which is the Brigg Fault, located ~1 km west of the wellsite, and which trends in a northwest-southeast direction over a distance of 10 km and downthrows the strata to the north-east by up to ~ 50 m. The displacement dissipates along its length, with the throw being essentially zero at Mill Lodge near High Santon to the west of the wellsite.

There are two smaller faults located 450 m and 900 m northeast of the wellsite; trending in a northwest-southeast direction and down-throwing strata to the south-west. All of these faults are noted by (Gaunt, Fletcher, & Wood, 1992) and the faulting is described as having "produced a graben enclosing an asymmetric syncline" and as being aligned with an anticlinal structure in the underlying Carboniferous rocks.

Data from Egdon's 3D seismic reflection data used to map the Wressle oilfield were reprocessed in 2015 to specifically improve the seismic imaging of the deeper subsurface stratigraphy and structural geology. These seismic data indicate that a fault (the so-called "Wressle Bounding Fault") is present in the Carboniferous strata around 700 m north of the Wressle-1 well. The seismic data is published on Figure 4 of the Hydraulic Fracture Plan produced by Egdon for proppant squeeze operations on the Wressle-1 well (Egdon Resources, 2020) and shows:

- The Wressle-1 well was drilled with a 'deviated' or 'S' shaped well trajectory;
- During the course of drilling the well penetrated a number of stratigraphic horizons; some of these have been used to map the structural extent of these sequences in the subsurface;
- The Ashover Grit reservoir is illustrated by the purple horizon marker line;
- The well reached Total Depth in the Dinantian (Carboniferous Limestone Supergroup);
- To the north of the well path, the Wressle Bounding fault is indicated on the seismic line by a bright green line. The fault terminates at an unconformity at the base of the Permian age strata, indicating that this fault has been inactive for some 300 million years; and
- The distance between the Wressle Fault and the Wressle-1 well at the Ashover Grit level is 700 m.

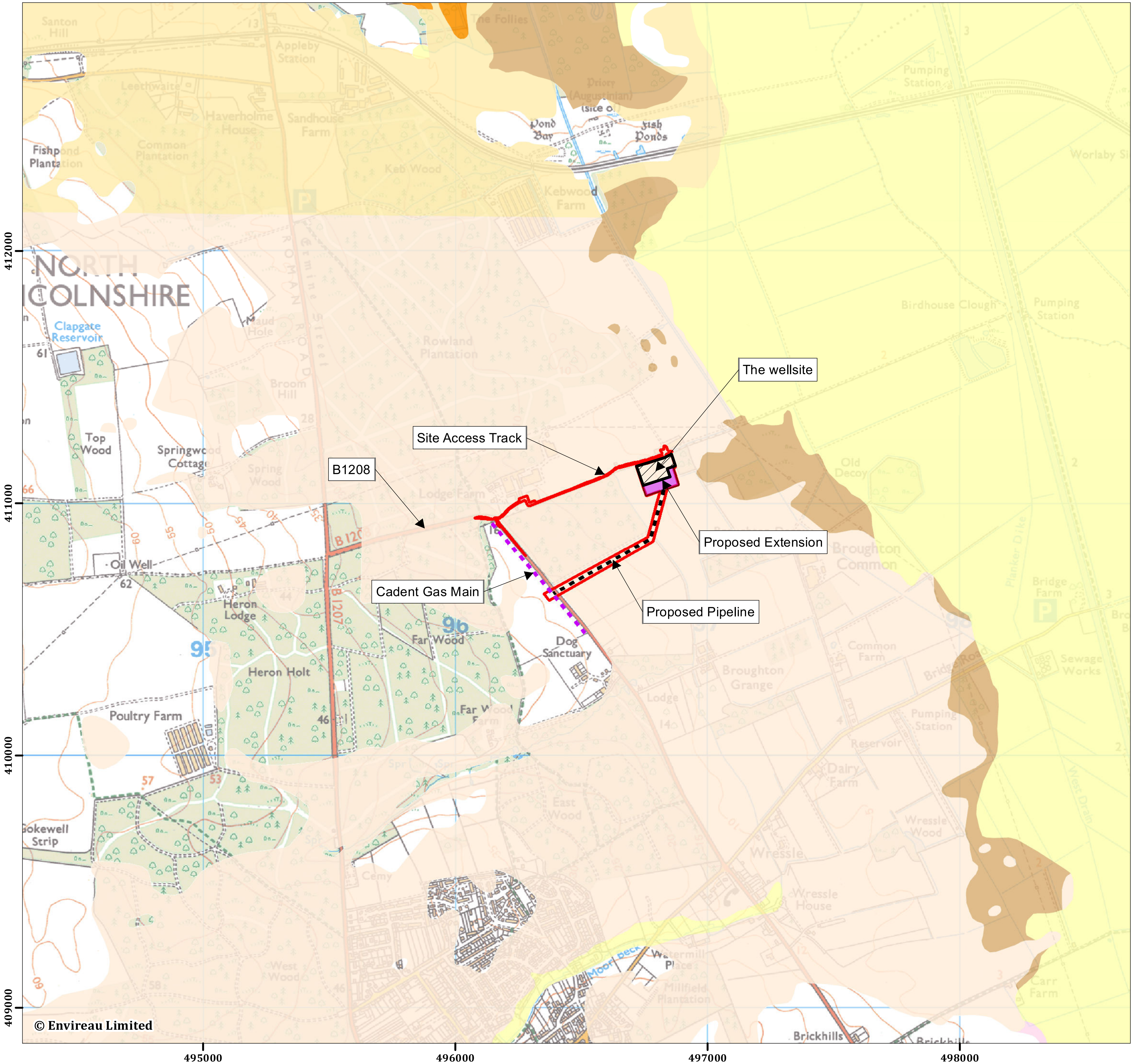


Figure C1: Superficial Geology

Wressle, North Lincolnshire

- Planning Application
- Existing Wellsite
- Proposed Extension
- Cadent Gas Main
- Proposed Pipeline

Superficial Geology

- ALLUVIUM- CLAY, SILT, SAND AND GRAVEL
- HEMINGBROUGH GLACIOLACUSTRINE FORMATION - CLAY, SILTY
- BLOWN SAND
- PEAT
- SUTTON SAND FORMATION - SAND

Notes:

0 150 300 450 600 Meters

Scale: 1:15,000 at A3

08 January 2024

NGR: 496,480 E / 410,922 N

Project No. 3490616

Client: Egdon Resurces UK Ltd

Drawn by: MT

Ref: Superficial Geology

envireau WATER

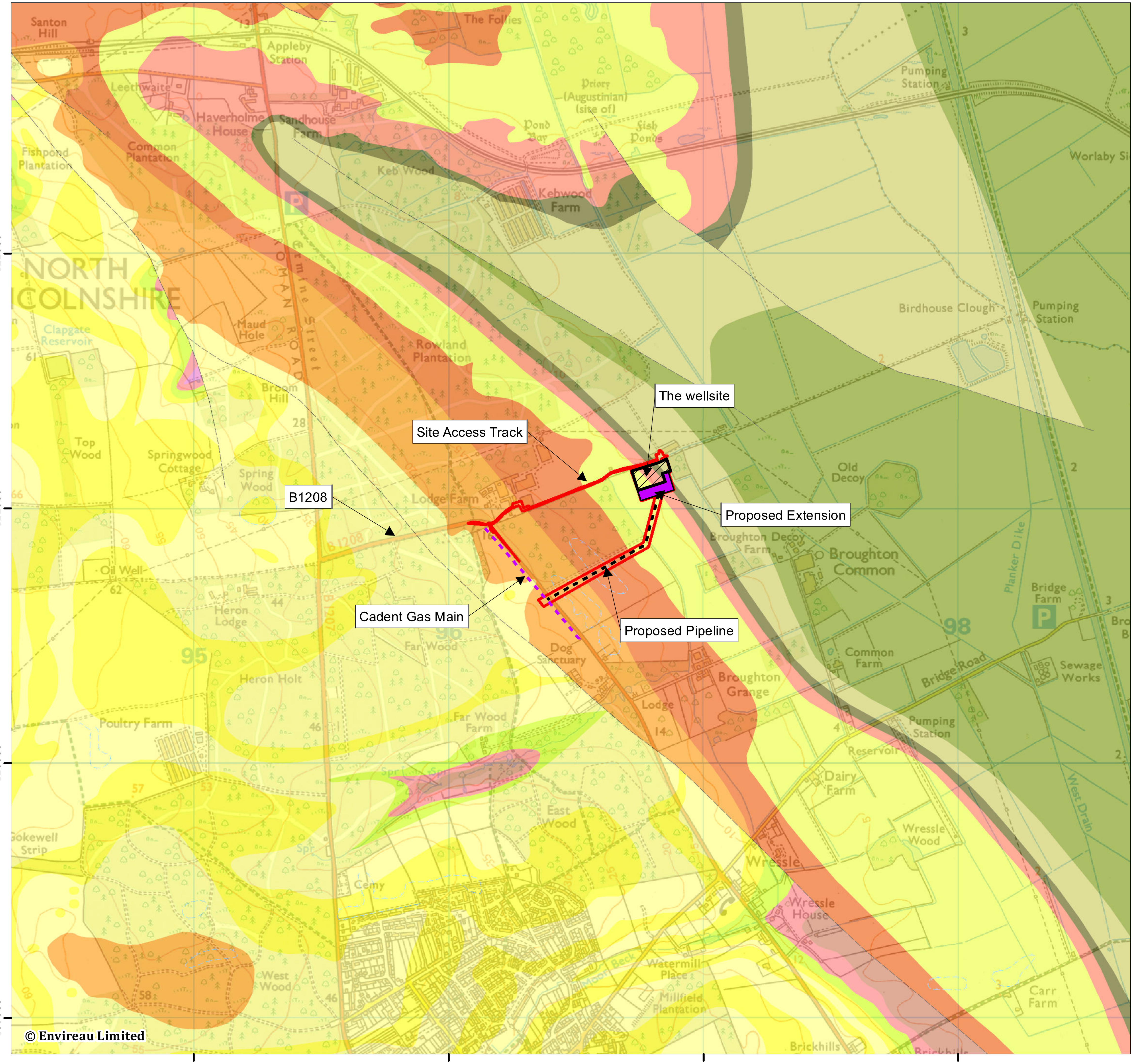


Figure C2: Bedrock Geology

Wressle, North Lincolnshire

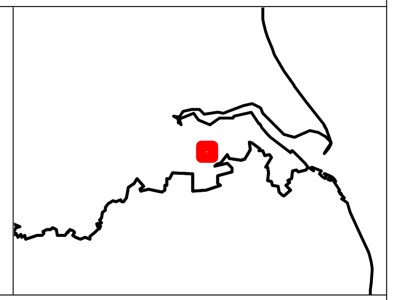
N

- Planning Application Boundary
- Existing Wellsite
- Proposed Extension
- Cadent Gas Main
- Proposed Pipeline

Bedrock Geology

- OXFORD CLAY FORMATION - MUDSTONE
- KELLAWAYS SAND MEMBER - SANDSTONE AND SILTSTONE, INTERBEDDED
- KELLAWAYS CLAY MEMBER - MUDSTONE
- CORNBRASH FORMATION - LIMESTONE
- RUTLAND FORMATION, BLISWORTH FORMATION
- THORNCROFT SAND MEMBER - SANDSTONE
- HIBALDSTOW LIMESTONE - LIMESTONE, OOIDAL
- SCAWBY LIMESTONE - LIMESTONE AND [SUBEQUAL/SUBORDINATE] ARGILLACEOUS ROCKS, INTERBEDDED
- KIRTON CEMENTSTONE BEDS - LIMESTONE
- KIRTON CEMENTSTONE BEDS - MUDSTONE AND LIMESTONE, INTERBEDDED
- GRANTHAM FORMATION - SANDSTONE, SILTSTONE AND MUDSTONE
- NORTHAMPTON SAND FORMATION - SANDSTONE
- WHITBY MUDSTONE FORMATION - MUDSTONE

Notes:



0 150 300 450 600 Meters

Scale: 1:15,000 at A3

08 January 2024

NGR: 496,480 E / 410,922 N

Project No. 3490616

Client: Egdon Resources UK Ltd

Drawn by: MT

Ref: Bedrock Geology

envireau WATER

C1.4 Hydrogeology

C1.4.1 Terminology

Geological strata can be grouped into 'hydrostratigraphic units' based on their hydrogeological properties. In this case, the hydrogeology relating to the Proposed Development fundamentally comprises:

1. a shallow system containing relatively fresh, recently recharged groundwater with a potable and environmental 'resource value'. This implies that (with modest treatment) groundwater could plausibly be abstracted for human, industrial or agricultural purposes, or that it provides baseflow or hydrological support to hydrological features such as springs, wetlands or streams.
2. a deep system containing low quality formation water with no potable / environmental resource value. It is, however, possible that such deep, saline groundwater may have some value as a low-enthalpy geothermal resource, especially in thick permeably formations such as the Sherwood Sandstone.

The terms "Groundwater", "Aquifer" and "Groundwater Body" are defined by the WFD and Groundwater Daughter Directive (GWDD) (European Parliament, 2020) (European Parliament, 2006) as follows:

- Groundwater – all water which is below the surface in the saturated zone and in direct contact with the ground or subsoil.
- Aquifer – a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.
- Groundwater Body – a distinct volume of groundwater within an aquifer or aquifers. By convention (UKTAG, 2011), a Groundwater Body is normally considered to contain relatively fresh groundwater with potable/environmental value, typically <400 m deep (see below).

The definitions of "Groundwater" and "Aquifer" do not clearly differentiate between (i) relatively shallow aquifers that contain relatively fresh, recently recharged groundwater with a 'resource value' for drinking water, support of the environment and other uses, and (ii) deeper systems containing poorer quality groundwater (typically more saline groundwater or "formation water") with 'no freshwater resource value'.

We recognise that some deep saline aquifers, which have no potable water resource value and which do not interact to any meaningful extent with the natural surface environment, may have some other "resource" value – for example, as a geothermal resource. Although the water within such aquifers can, strictly speaking, be defined as "groundwater", we tend to refer to deep, saline groundwater as "formation water" in this report. We thus use the following terms:

- **Produced water** - the saline water (brine) produced from the oil production formation in association with the extraction and separation of oil or the development of the well.
- **Formation water** - the saline water (brine) within the oil production and other deep geological horizons which can reasonably be considered as connate, or sourced from geologically old recharge.

The UK Technical Advisory Group (UKTAG) provides guidance to agencies responsible for implementing the WFD in the UK. The (UKTAG, 2011) defines a depth of 400 m as the default maximum depth at which a groundwater body loses its value as a (fresh groundwater) resource that can be either exploited for human activities and/or support surface flows and ecosystems and/or have a connection with surface water receptors. This UKTAG definition does not consider the geothermal resources value of deeper saline aquifers; nevertheless, this report adopts the convention of considering a "Groundwater Body" to be a volume of groundwater in an aquifer or aquifers, less than 400 m deep, that may have some potable resource value and which may perform some role in supporting the surface hydrological environment.

At some depth, depending on the nature of the aquifer, groundwater loses its value as a resource that can be either exploited for human activities and/or support surface flows and ecosystems and/or have a connection with surface water receptors (for example, the default maximum depth of 400 m proposed by (UKTAG, 2011)). However, default values may be subject to redefinition, based on local/site specific information. In this case, Envireau Water have selected the base of the Scunthorpe Mudstone Formation at a depth of 238 m in the Wressle-1 well, as the base of the Groundwater Body below the wellsite.

C1.4.2 Aquifer Designations

The geological units have been allocated an Aquifer Designation relating to their potential yield and properties by both the Environment Agency (Environment Agency, 2023a) and the BGS (BGS, 2023). These are provided for each of the geological units present below the wellsite in Table C5.

The Aquifers below the wellsite are defined by the Environment Agency as part of the Grimsby Ancholme Louth Limestone Unit of the Humber Groundwater Management Catchment, which in turn is part of the Humber River Basin District. The quantitative and chemical status of this catchment are both classified as Good (Environment Agency, 2024b). Aquifers can be designated "Principal" or "Secondary A / B" according to the definitions of (Environment Agency, 2017):

- secondary A aquifers comprise permeable layers that can support local water supplies, and may form an important source of base flow to rivers;
- secondary B aquifers are mainly lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks (called fissures) and openings or eroded layers.

Table C5 Hydrogeological Designation of Geological Formations

Parent Group	Formation or Group	BGS Designation	Environment Agency Designation *	Groundwater Unit and Status 2019 Cycle 2
Sutton Sand Formation		-	Secondary A	Grimsby Ancholme Louth Limestone Unit ID: GB40401G444600 Quantitative: Good Chemical: Good
Ancholme Group	Kellaways Formation	Rocks with essentially no groundwater	Secondary A	
Great Oolite Group	Cornbrash Formation	Moderately Productive	Secondary A	
	Blisworth Clay Formation		Secondary B	
	Blisworth Limestone Formation		Secondary B	
	Rutland Formation		Secondary B	
Inferior Oolite Group	Lincolnshire Limestone Formation	Highly Productive	Principal	
	Grantham Formation		Secondary Undifferentiated	
	Northampton Sand Formation		Secondary A	
Lias Group	Whitby Mudstone Formation	Rocks with essentially no groundwater	Unproductive Strata	
	Marlstone Rock Formation		Secondary A	
	Dyrham Formation		Secondary undifferentiated	
	Charmouth Mudstone Formation		Secondary undifferentiated	
	Scunthorpe Mudstone Formation		Secondary B	
New Red Sandstone Supergroup	Penarth Group	Low Productivity	Secondary Undifferentiated	Water bearing formation with no resource value **
	Mercia Mudstone Group	Low Productivity	Secondary B	
	Sherwood Sandstone Group	Highly Productive	Principal	

**The Environment Agency Designation does not take depth, formation thickness or degree of saturation into account and is not site specific.*

*** Envireau Water has selected the base of the Scunthorpe Mudstone Formation, as the base of the groundwater body below the wellsite. The Sherwood Sandstone is a productive unit with saline formation water. It has no potable/environmental resource value, but does have value as a potential future, low enthalpy geothermal resource.*

The designations in Table C5 relate to the regional hydrogeological setting. Below the wellsite, some formations are not present or are very thin, and therefore a set of Aquifer designations developed by Envireau Water, which are appropriate for the wellsite, are presented in Table C6.

Table C6 Site Specific Aquifer Designations

Formation	Thickness (m)	Aquifer Designation
Sutton Sand Formation / Kellaways Sand	4.0 – 9.0	Secondary A (if saturated)
Kellaways Clay	1.4	Unproductive Strata
Cornbrash Formation	0.9 – 1.3	Secondary B (based on limited thickness)
Blisworth Clay Formation	9.5 – 9.6	Secondary B (based on limited thickness of permeable horizons within sequence)
Blisworth Limestone Formation*		
Rutland Formation	3.4 – 5.4	Unproductive Strata
Lincolnshire Limestone Formation	17.9	Principal
Northampton Sand Formation/ Grantham Formation	4.8	Secondary A
Whitby Mudstone Formation	~86	Unproductive Strata
Marlstone Rock Formation	181	Secondary A
Dyrham Formation		Unproductive Strata+
Charmouth Mudstone Formation		Unproductive Strata+
Scunthorpe Mudstone Formation		Unproductive Strata+

Notes:

*The Blisworth Clay/Limestone Formation was proven by monitoring boreholes DSI1 & DSI2 at the wellsite to comprise a mudstone/sand/sandstone sequence with individual permeable horizons being <~1 m. Nearby well logs suggest the sequence may contain limestone horizons up to 1.8 m thick.

+Due to the depth of these formations at the wellsite (thin hardbands in these mudrocks can supply small yields where they are shallow and close to outcrop – this is not the case at the wellsite).

The Marlstone Rock Formation, through the presence of natural fractures, can transmit water and is recognised as a useful regional aquifer. In the area under consideration, however, the presence of more useful aquifers at higher stratigraphic levels means that minor, more poorly-yielding aquifers below the Lincolnshire Limestone are not generally exploited. As such, the deepest useful Aquifer, in terms of fresh groundwater supply, below the wellsite is the Lincolnshire Limestone.

It has been reported by Egdon Resources that at a depth of 180 m, when Wressle-1 was being constructed, an artesian (or natural) flow of water occurred from a sandstone / sandy limestone unit, which *may* correspond to the Marlstone Rock Formation. An artesian pressure, which causes the water to rise to, and overflow at, the surface, could be generated by recharge into the outcrop of this formation to the west. The overlying Whitby Mudstone Formation provides a low hydraulic conductivity seal, which keeps the pressure in place. An artesian head does not necessarily imply large volumes of water, but it does indicate that the overlying clay must be of sufficiently low hydraulic conductivity to contain the required artesian pressure to produce an upward hydraulic gradient below the Lincolnshire Limestone Formation (Oates, 2018).

C1.4.3 Hydraulic Properties

Each of the geological units identified underlying the wellsite have specific hydraulic properties controlled by several factors, including: grain size, interconnectivity of pore space, degree of cementation and presence of connected fractures.

Six cored samples of clay from the Blisworth Clay Formation and the Kellaways Clay Formation were obtained during the drilling of monitoring boreholes DSI1 and DSI2 in 2018. These samples were submitted to GEOLABS for hydraulic conductivity testing using a triaxial cell method (BS1377: Part 6: Clause 6: 1990). The results of this testing are provided in Table C7.

Table C7 Hydraulic Conductivity Testing

Monitoring Borehole	Sample Depth (m)	Laboratory Sample Description	Geological Unit	Hydraulic Conductivity (m/s)
DSI1	11.00-11.35	Firm dark grey thinly laminated CLAY with layers up to 1 mm thick of light brown fine to medium sand.	Undifferentiated: Blisworth Clay Formation/Blisworth Limestone Formation/Rutland Formation	1.1×10^{-11}
	13.70-14.00	Very stiff dark grey mottled white sandy CLAY with frequent shells up to 30 mm		3.5×10^{-11}
	15.05-15.25	Stiff dark grey mottled white thinly laminated CLAY with frequent shell fragments up to 6 mm		8.4×10^{-11}
DSI2	9.30-9.55	Firm dark grey slightly sandy CLAY with rare fine gravel	Kellaways Clay Formation	1.9×10^{-10}
	9.85-10.03	Stiff dark grey sandy CLAY. Sand is fine.	Kellaways Clay Formation	3.1×10^{-11}
	12.55-12.75	Soft grey mottled greenish grey slightly gravelly sandy CLAY. Gravel is fine to medium	Undifferentiated: Blisworth Clay Formation/Blisworth Limestone Formation/Rutland Formation	5.0×10^{-11}

Table C8 Hydraulic Properties of Geological Units

Formation	Hydraulic Properties
Sutton Sand	Unconsolidated sand porosity= 25-50 %, Sy = 10-30 %, k = 10^{-5} to 10^{-3} m/s (1) Estimated Transmissivity = $4x10^{-5}$ to 10^{-2} m^2/sec (5 using 1 and thicknesses of 4 and 9m)
Kellaways	Hydraulic Conductivity testing results = 3.1 x 10^{-11} to 1.9 x 10^{-10} m/s (2) - Clay Porosity ranging between 4.3 and 37.6% with an arithmetic mean of 26.9% (4) – Kellaways Sand Hydraulic Conductivity k = $3x10^{-11}$ to $3x10^{-7}$ m/s with a geometric mean of 3 $x10^{-9}$ m/s (4) – Kellaways Sand
Cornbrash	Consolidated sand porosity= 25-30 %, Sy = 5-25 %, k = $1x10^{-8}$ to $1x10^{-2}$ m/s (1) Field measurement k = 7.6 x 10^{-5} m/d = $9x10^{-10}$ m/s (4)
Blisworth Clay and Limestone	Hydraulic Conductivity testing results = 1.1 x 10^{-11} to 8.4 x 10^{-11} m/s (2) - Clay T = 0.5 to 2800 m^2/d with an interquartile range (IQR) of 105–1430 m^2/day (3) – Limestone Limestone largely absent north of Brigg (3)
Rutland (Upper Estuarine Series)	Hydraulic Conductivity testing results = 1.1 x 10^{-11} to 8.4 x 10^{-11} m/s (2) - Clay Porosity ranging between 6.5 and 36.4% with an arithmetic mean of 15.5% (4) – at c. 350 m depth Hydraulic Conductivity k = $4x10^{-11}$ to 4 $x10^{-6}$ m/s with an geometric mean of 1 $x10^{-9}$ m/s (4) – at c. 350 m depth
Lincolnshire Limestone	Porosity = interquartile range of 13.1 to 21.6% and an arithmetic mean of 18.0% (3) Laboratory permeability = interquartile range of $6x10^{-10}$ to $5x10^{-9}$ m/s. Geometric mean of $1.5x10^{-9}$ m/s. Maximum of $1.96x10^{-6}$ m/s (3) Transmissivity between Lincoln and Brigg = less than 1000 m^2/d (0.01 m^2/sec), and often around 100 m^2/d (0.001 m^2/s). Higher end of range to the north of Brigg (3) Storage coefficients : majority being between 10^{-5} and 10^{-3}.
Grantham (Lower Estuarine Series)	No Aquifer information available within major or minor Aquifers database.
Northampton Sand	Consolidated sand porosity= 25-30 %, Sy = 5-25 %, k = $1.x10^{-8}$ to $1x10^{-2}$ m/s (1) Transmissivity, where 6 m thick and fully saturated, 60 m^2/d ($7x10^{-4}$ m^2/s) (4)
Whitby Mudstone	Consolidated claystone porosity= <1-10 %, Sy = 0.5-5 %, k = $1x10^{-7}$ to $1x10^{-11}$ m/s (1) No Aquifer information available within major or minor Aquifers database.
Marlstone Rock Formation	Porosity = 23.2% to 31.2% (4) Hydraulic conductivity = $1x10^{-9}$ to $1x10^{-8}$ m/s. (4) Transmissivity = 10 – >1000 m^2/d (often in range 10-60 m^2/d) (4)
Dyrham	Porosity ranging between 8.4 and 31.2% with an arithmetic mean of 22.0% (4) Hydraulic Conductivity k = $8x10^{-9}$ to $1x10^{-10}$ m/s with a geometric mean of $4x10^{-10}$ m/s (4)
Charmouth Mudstone	Consolidated claystone porosity= <1-10 %, Sy = 0.5-5 %, k = $1x10^{-11}$ to $1x10^{-7}$ m/s (1) No Aquifer information available within major or minor Aquifers database.
Scunthorpe Mudstone	Consolidated claystone porosity= <1-10 %, Sy = 0.5-5 %, k = $1x10^{-11}$ to $1x10^{-7}$ m/s (1) No Aquifer information available within major or minor Aquifers database.

Notes:

(1) Hydrogeological text book (Misstear, Banks, & Clarke, 2017) *(2) Measured* (GEOLABS, 2018) *(3) Major Aquifers Database* (Allen, et al., 1997) *(4) Minor Aquifers Database* (Jones, et al., 2000) *(5) Calculated.*

C1.4.4 Aquifer Classification

The hydraulic properties of a geological unit, at the site scale, will control how it behaves. In the context of the wellsite, the key behaviour is the vertical transmission of water through the hydrogeological column. To aid the simplification of the conceptual model at the wellsite, the geological units have been classified based on their overall hydraulic properties as shown in Table C9 as:

- **Aquifer:** a body of rock that contains groundwater and which can store and transmit useful quantities of groundwater;
- **Aquitard**: a body of rock with a low hydraulic conductivity which effectively forms a hydraulic seal, or break, in a hydrostratigraphic succession, allowing only very limited exchange of water.
- **Water bearing formations**: A geological unit (or formation) which contains saline formation water.

This classification is specific to the geological and hydrogeological setting at the wellsite and should not be construed as a regional classification.

Table C9 Aquifer Types Below the Wellsite

Formation or Group	Classification	Comment
Sutton Sand Formation+	Aquifer	
Kellaways Formation (Sand Member)+	Aquifer	
Kellaways Formation (Clay Member)	Aquitard	Based on proven hydraulic conductivity
Cornbrash Formation	Aquifer	
Blisworth Clay Formation	Aquitard	Based on proven hydraulic conductivity
Blisworth Limestone Formation	Aquifer (where present)	Not proven present in significant thickness beneath site. Generally not considered to be present north of Brigg.
Rutland Formation	Aquitard	Based on proven wellsite geology
Lincolnshire Limestone Formation	Aquifer	
Northampton Sand Formation / Grantham Formation	Aquifer	
Whitby Mudstone Formation	Aquitard	
Marlstone Rock Formation	Aquifer	
Dyrham Formation	Aquitard	
Charmouth Mudstone Formation	Aquitard	
Scunthorpe Mudstone Formation	Aquitard	
Penarth Group	Water bearing formation, likely containing saline water of no potable or environmental resource value	
Mercia Mudstone Group	Aquitard, containing some water bearing layers, likely containing saline water of no potable or environmental resource value	
Sherwood Sandstone Group	Water bearing formation, likely containing saline water of no potable or environmental resource value. Potential future low enthalpy geothermal resource.	

+The Sutton Sand Formation and Kellaways Sand Member of the Kellaways Formation, where they are present together, form a single contiguous unconsolidated sand sequence. The two deposits while stratigraphically quite different, are composed of similar materials and it is reasonable to assume that they will have very similar hydraulic properties. Therefore, we have considered them as one hydrostratigraphic unit, which for clarity we have termed "the Unconsolidated Sands Aquifer".

As illustrated in Table C9, the hydrogeological sequence below the site is composed of formations that can and in some cases do act as aquifers, separated by clay rich or mudrock strata which act as aquitards. The ability for a layered system to transmit water vertically is controlled by the lowest hydraulic conductivity layers. As such, the clay layers within the profile below the site will restrict or prevent vertical movement of water downward within a timescale of decades.

The dip of the strata below the wellsite is toward the east and therefore aquifers which occur below the wellsite will occur at greater depth in an easterly direction.

C1.4.5 Groundwater Heads

Groundwater level data has been obtained from the construction details of GWMBH1 to 5; monitoring during and subsequent to the drilling of monitoring boreholes DSI1 and DSI2; and data obtained from drillers logs in the BGS archive.

BGS Data

Records obtained from the BGS for wells and boreholes targeting the Lincolnshire Limestone Aquifer provide information on historic groundwater levels and are provided in Table C10.

Table C10 BGS Lincolnshire Limestone Aquifer Groundwater Levels

BGS ID	BGS Reference	Name	Year	Water Level (mbgl)	Water Level (m AOD)	Pumping Condition
133943	SE91SE9	Clapgates No. 5	1918	Overflowing	> +7	Overflowing at 1.3 L/s at rest
133944	SE91SE10	Clapgates No. 6	1918	Overflowing	> + 4	Overflowing at 4.4 L/s at rest. 7.6 m bgl (-3.7 m OD) when pumping at 12.6 L/s
133947	SE91SE13	Clapgates No. 11	1938	6.09	-3.04	Rest
133956	SE91SE22	Decoy Farm Yard	1930	12.19	-8.61	Rest (part of record suggests this borehole also overflowed when first drilled)

This groundwater level data shows that overflowing artesian groundwater was present at the early part of the 20th Century, where groundwater head was at or above ground level. Artesian conditions typically occur where an aquifer outcrops in topographically high ground (i.e. west of Wressle), and then dips down below low permeability strata which "confine" the groundwater head. The wells in question (**Table C10**) penetrated to the Lincolnshire Limestone but may also have been open to the less well-defined “Great Oolite” aquifers higher up in the stratigraphic succession. The fact that artesian conditions were found in a strata-bound, high transmissivity aquifer such as the Lincolnshire Limestone, confirms that the overlying aquitards are sufficiently low permeability to prevent the artesian head from dissipating by upward leakage, and to maintain the head above ground level.

It is reasonable to surmise that increased abstraction during the 20th Century (e.g. by the Clapgate boreholes) has lowered the groundwater head in the Limestone to below sea level and reversed the naturally upward head gradient (i.e. from the Lincolnshire Limestone to the surface), to a downward head gradient. Currently, monitoring data from the onsite Lincolnshire Limestone monitoring well GWMBH4 indicates the groundwater head to be around –16.5 m OD.

Site Data

Since 2017, groundwater head and quality data have been obtained from on-site monitoring boreholes. Originally, in 2017, four such boreholes were drilled: GWMBH1 to 3 targeting the Unconsolidated Sands Aquifer and the 50 m deep GWMBH4 which specifically targets the Lincolnshire Limestone Aquifer. The monitoring zone of GWMBH4 is isolated from all the overlying strata.

The site was redeveloped for oil production in 2020 following grant of planning permission. In 2020, monitoring boreholes GWMBH1 to 3 were re-drilled as GWMBH1R, GWMBH2R and GWMBH3R. GWMBH4 was retained unchanged, and a fifth new borehole (GWMBH5), targeting the Unconsolidated Sands Aquifer, was also drilled (**Figure C4**; **Figure C5**). Each of the new shallow monitoring boreholes (GWMBH1R, GWMBH2R, GWMBH3R and GWMBH5) fully penetrated the Unconsolidated Sands aquifer and at least 0.5 m into the underlying Kellaways Clay. The old GWMBH1, 2 and 3 were decommissioned (Envireau Water, 2020a) (Envireau Water, 2020b).

The average groundwater level in these boreholes between May 2020 and March 2023 is shown in Table C11.

The data have been used to inform the hydrogeological conceptual model for the Site which is now established from an extensive programme of monitoring.

Table C11 Monitoring Borehole Average Groundwater Levels (2020-2023)

Monitoring Borehole ID	Borehole depth (m)	Monitored aquifer	Water Level (m bgl)	Water Level (m AOD)
GMWBH1R	4.6	Unconsolidated sands	2.6	3.2
GMWBH2R	9.5	Unconsolidated sands	2.7	1.4
GMWBH3R	10.5	Unconsolidated sands	2.7	1.1
GMWBH5	50	Unconsolidated sands	2.8	1.3
GMWBH4	7.65	Lincolnshire Limestone	20.8	-16.5

The monitoring data collected between 2020 and 2023 shows that the water level in the Unconsolidated Sands Aquifer is shallow at ~3 m below ground level whereas the water level in GWMBH4 is much deeper at ~21 m below ground level.

The large difference in observed water level between the shallow sands and deeper limestone again demonstrates that the Lincolnshire Limestone Aquifer is a hydraulically separate from the Unconsolidated Sands Aquifer and provides further strong evidence for the presence of a low hydraulic conductivity layer(s) between the two aquifers. This hydraulic separation between the two aquifers remains unchanged since 2017.

C1.4.6 Hydraulic Gradient

Sutton Sand / Kellaways Sand

The Hydrogeological Risk Assessment to support the planning application development of the wellsite for commercial oil production (Envireau Water, 2018), concluded from contoured groundwater level data collected from the Site monitoring boreholes that the groundwater hydraulic gradient in the Unconsolidated Sands Aquifer is towards the north-east, with a calculated value of 0.018 (i.e. 18 mm decline in water table elevation per m laterally).

Adjacent to the north of the wellsite, the base of Ella Beck is between 2 and 1.5 m AOD, with the bank top at 5 m AOD. The groundwater contours indicated groundwater falling from 3.25 m AOD to 1.5 m AOD along the same length, suggesting that there is some degree of hydraulic connection between groundwater in the Unconsolidated Sands Aquifer and the Ella Beck. Data collected since 2020 continues to support this connection.

Vertical gradient

On completion of drilling of DSI1 and DSI2 temporary standpipe piezometers were installed within the upper parts of the Blisworth Clay/Limestone and Rutland Formations (DSI1) and the lower part of the Blisworth Clay/Limestone and Rutland Formations (DSI2). In both cases the monitoring horizon was selected to be adjacent to sandy layers and therefore expected to be permeable. The monitoring horizons were sealed above and below with bentonite.

Water level elevation data recorded on the 29/03/2018 is shown in Table C12 to demonstrate the presence of vertical gradients between the various measured formations.

Table C12 Groundwater Elevations Vertical Gradient

Monitoring Borehole ID	GWL on the 29/03/2018 (m AOD)	Installation
DSI1	3.25	Blisworth Clay/Limestone and Rutland Formations
DSI2	-1.28	Blisworth Clay/Limestone and Rutland Formations
GWMBH 1	3.37	Unconsolidated Sands Aquifer
GWMBH 2	1.59	Unconsolidated Sands Aquifer
GWMBH 3	1.35	Unconsolidated Sands Aquifer
GWMBH 4	-20.73	Lincolnshire Limestone Formation

The groundwater levels in the monitoring boreholes installed into the Unconsolidated Sands Aquifer lie at between 1.4 and 3.4 m AOD, whereas the elevation of that in the Lincolnshire Limestone Formation is approximately -20.7 m AOD. This demonstrates the overall downwards vertical hydraulic gradient present below the wellsite. This is consistent with the observation made during the drilling of borehole DSI1, where groundwater levels dropped significantly as drilling intercepted the Lincolnshire Limestone.

The piezometry data from DSI1 suggests that there is hydraulic continuity between the Unconsolidated Sands Aquifer and the top of the Blisworth Clay/Limestone and Rutland Formations, on the up-dip (western) side of the wellsite. Reference to the DSI1 shows that there is 1.3 m of clay separating the Unconsolidated Sands Aquifer and the underlying Cornbrash Formation. The data from DSI2, taken from a deeper zone on the down-dip (eastern) side of the wellsite shows a significantly lower head in the Blisworth Clay/Limestone and Rutland Formations than in the Unconsolidated Sands Aquifer, on the same side of the wellsite. Taking these observations together and with the local geology, it is likely that the Cornbrash Formation sub-crops below the Sutton Sand Formation on the western edge of the site, beyond the location of DSI1. That is, either beneath the western side of the soil storage mound or immediately to the west of the western boundary of the site. The connection to the Unconsolidated Sands Aquifer in that location, would result in the observations seen.

The Unconsolidated Sands Aquifer contains groundwater at a significant elevation above the groundwater within the Lincolnshire Limestone unit, from which significant volumes of groundwater are abstracted via the British Steel boreholes at Clapgate. This provides compelling evidence for the presence of very low average vertical hydraulic conductivity in the intervening units, which enables the observed high vertical down-ward hydraulic gradient.

On the extreme western side of the wellsite the water level data suggests that there may be hydraulic connection between the Unconsolidated Sands Aquifer and the top of the Blisworth Clay/Limestone and Rutland Formations, which would include the Cornbrash Formation aquifer. However, the geological log for borehole DSI1 proves ~1.3 m of clay between the Unconsolidated Sands Aquifer and the thin sandstone making up the Cornbrash Formation, at this location. This clay layer will provide protection to the Cornbrash Formation below the wellsite.

During the drilling of the Wressle-1 well, artesian flow occurred from the Marlstone Rock Formation (in the Whitby Mudstone Formation) demonstrating that there is an upwards vertical hydraulic gradient in the strata below the Lincolnshire Limestone.

C1.4.7 Shallow Aquifers

The shallow geology is considered to be more important in terms of the presence of a significant groundwater resource than the deeper geology. The most noteworthy Aquifers in terms of water supply are the Unconsolidated Sands Aquifer and the Lincolnshire Limestone Formation. The Aquifers that are considered to be significant (Secondary A or Principal) within the shallow geology are presented in Table C13.

Table C13 Significant Aquifers identified within the Shallow Geology

Unit	Envireau Water Designation	Thickness (m)	Comment
Sutton Sand Formation	Secondary A	4.0 – 9.0	Considered one Aquifer at this wellsite (the Unconsolidated Sands Aquifer). Connected to Ella Beck
Kellaways Formation (Sand Member)	Secondary A	0 - 1.4	
Cornbrash Formation	Secondary B	0.9 – 1.3	Too thin to provide useful yield, but recognised to connect to Clapgate Boreholes
Lincolnshire Limestone Formation	Principal	17.9	Important local, regional Aquifer supplying Clapgate boreholes
Northampton Sand / Grantham Formation	Secondary A	4.8	
Marlstone Rock	Secondary B	~3	Locally important where Lincolnshire Limestone is not present

As has been discussed, while the Blisworth Limestone Formation is recognised as an aquifer, at the wellsite this formation has not been clearly identified as a discrete, effective aquifer.

Due to its significant thickness, the Lincolnshire Limestone Formation is considered to be the shallowest local Aquifer likely to be being exploited for water supplies. Although recorded with a thickness of 17.9 m below the wellsite, locally it can reach a thickness of 50 m. This is also the Aquifer that is the source of main water to the British Steel boreholes at Clapgate (although logs for the Clapgate wells do suggest that there may be some contribution from stratigraphically higher strata).

The local shallow geology also contains significant clay/mudstone layers between the shallow Aquifers. These clay layers act to provide an effective seal above and below the aquifer units including the Lincolnshire Limestone, causing the artesian groundwater conditions observed historically in this Aquifer.

The Lias Group has been considered within the shallow geology simply because, in its upper part, it contains the Marlstone Rock. However, the ~180 m thickness of this group almost entirely comprises mudrocks, which will have a very low hydraulic conductivity and can be regarded essentially as “Unproductive Strata” within the context of the wellsite.

C1.4.8 Deep Hydrogeology

The Penarth Group is classed as Unproductive strata and the Mercia Mudstone Group Secondary Aquifer can also be effectively considered Unproductive strata at this location due to its depth. When it occurs near outcrop, wells and boreholes into silty or sandy horizons within the Mudstone can yield modest quantities of groundwater. However, the depth of the Mudstone beneath the Wressle wellsite means that it is highly unlikely that any driller would target the Mudstone for water supply, partly because the cost (drilling cost) to benefit (low yield) would be unattractive, and partly because the water would likely be of poor quality (the Mercia Mudstone includes evaporite horizons).

The base of the Mercia Mudstone is located at approximately 450 m below ground level. Together, the Penarth and Mercia Mudstone groups provide a hydraulic barrier between the shallow groundwater system that has a resource value, and water bearing systems in the deeper Triassic, Permian and Carboniferous strata that contain formation water with no potable or environmental water resource value. This conclusion is documented by a geothermal investigation in the area (Gale, 1984), which shows that the Triassic Sherwood Sandstone at this location contains formation water with a brackish salinity (TDS estimated to be around 10,000 mg/L). Less than 10 km further to the east, the salinity rises to over 50,000 mg/L (brine) and within 20 km to the east it rises to over 100,000 mg/L. The Sherwood Sandstone does have potential water resource value as a low enthalpy geothermal resource. This resource is not, however, dependent on water quality *per se* and there is no reason to suppose the resource is at risk from the proposals, provided that (i) the proposed deep boreholes are securely cased throughout the Sherwood Sandstone succession, into the underlying Permian, and (ii) the boreholes as responsibly sealed and decommissioned at end of life.

The Water Bearing Formations in the underlying Permian and Carboniferous strata are also likely to contain saline water and act as potential reservoir rocks for the oil and gas.

The well operations will only be undertaken within this deep hydrogeological environment, within the Carboniferous (Namurian) strata.

C1.4.9 Summary of Risk Evaluation

Our understanding the shallow groundwater system beneath the site can be summarised as follows:

i. The shallow Unconfined Sands aquifer (and any underlying hydraulically continuous Jurassic permeable layer such as the Kellaways Sand) contains groundwater with a head of around +1 to +3 m OD, which is believed to be flowing slowly to the NE and is likely to be in hydraulic continuity with surface watercourses such as the Ella Beck.

ii. The Lincolnshire Limestone has historically exhibited an artesian groundwater head in the area. This indicates that the Lincolnshire Limestone aquifer is efficiently confined by low permeability overlying argillaceous strata.

iii. Subsequent exploitation of groundwater means that groundwater head in the Lincolnshire Limestone has fallen below sea level and now stands at around -16.5 m OD.

iv. There is thus currently a downward groundwater head from the shallow Unconsolidated Sands to the Lincolnshire Limestone.

v. Below the Lincolnshire Limestone, artesian groundwater conditions have been demonstrated, implying an upwards hydraulic gradient from deeper strata (such as the Marlstone Rock) to the Lincolnshire Limestone.

vi. This implies that the Lincolnshire Limestone represents the lowest groundwater head within the hydrostratigraphic succession. The upwards hydraulic gradient below the Lincolnshire Limestone means that any putative contamination arising at or near the surface will not penetrate below the Lincolnshire Limestone.

vii. Any putative contamination arising at or near the surface could potentially migrate short distances laterally within the Unconsolidated Sands aquifer. This risk must be controlled by surface containment and mitigating measures.

viii. Any putative contamination arising at or near the surface could potentially seep down to the Lincolnshire Limestone, under the downward head gradient. The contamination could then migrate laterally to a point of abstraction, such as the British Steel Clapgate boreholes.

ix. However, the large proportion of argillaceous (mudstone) strata between the surface and the Lincolnshire Limestone, will reduce the effective hydraulic conductance to a very low value, meaning that the magnitude of any such seepage will be very low.

The dip of the Jurassic strata below the wellsite is toward the east and therefore aquifers which occur below the wellsite will occur at greater depth in an easterly direction. As the British Steel Clapgate boreholes are located some 300 m to the east of the wellsite, they intersect aquifers that occur below the wellsite. The most important of these is the Lincolnshire Limestone, but they will also intersect the same sequence of shallower aquifers and aquitards that is present below the Wressle wellsite (as demonstrated by geological and construction logs sourced from the

BGS well records archive). However, based on the construction details for the Clapgate boreholes it is clear that the principal aquifer intersected by the Clapgate boreholes is the Lincolnshire Limestone, with a possible connection to thin horizons higher in the Great Oolite Group.

By assigning hydraulic conductivities to each stratum (Table C8) and using the thicknesses of strata from borehole DSI2 (Table C3) one can estimate the magnitude of seepage through the 15.6 m of strata between the Unconsolidated Sands and the Lincolnshire Limestone.

Using, the measured core determinations from **Table C7** for the hydraulic conductivities of the argillaceous strata and assigning relatively high values to the Cornbrash, one can estimate an "best estimate" annual downward leakage of 4 mm/yr down to the Lincolnshire Limestone (**Table C14**).

The effective hydraulic conductivity of the sequence is very sensitive to the lowest vertical conductivity stratum in the succession, so that if one assigns a high (10^{-9} m/s) "worst case" vertical hydraulic conductivity to the mudstones, a tenfold higher leakage of 44 mm/yr is calculated (**Table C14**).

In addition to the limited infiltration down to the Lincolnshire Limestone, it should be remembered that most organic and heavy metal contaminants are very efficiently retained or sorbed on clay minerals within the mudstone strata.

Table C14. Calculated effective hydraulic conductivity of sequence between Unconsolidated Sands and Lincolnshire Limestone.

	Thickness (m)	Hydraulic conductivity (m/s)		Hydraulic resistance (s)	
Unconsolidated Sand	Hydraulic head = +2 m OD				
		Best estimate	Worst case	Best estimate	Worst case
Kellaways Clay	1.4	1.90E-10	3.00E-09	7.37E+09	4.67E+08
Cornbrash	1.3	1.00E-05	1.00E-04	1.30E+05	1.30E+04
Blisworth Formation (mudstone)	9.5	8.40E-11	1.00E-09	1.13E+11	9.50E+09
Rutland Series	3.4	8.40E-11	1.00E-09	4.05E+10	3.40E+09
Lincolnshire Limestone	Hydraulic head = -16.5 m OD				
Thickness (total)	15.6	m			
Head gradient	-1.2	m/m			
Resistance (total)	s			1.61E+11	1.34E+10
Effective resistivity	s/m			1.03E+10	8.57E+08
Conductance (total)	s^{-1}			6.21E-12	7.48E-11
Effective conductivity	m/s			9.69E-11	1.17E-09
Infiltration (m/s)	m/s			1.15E-10	1.38E-09
Infiltration (mm/yr)	mm/yr			4	44

It is known that recharge can occur to the Lincolnshire Limestone via swallow holes, especially at the edge of the Rutland Series or Boulder Clay cover, which might allow infiltration to by-pass some of the argillaceous strata. No signs of swallow holes have been clearly identified in the area of Wressle however, and moreover:

- The site does not lie near the edge of Boulder Clay cover;
- The Rutland Series and overlying strata are likely to be too thick at this location to allow swallow holes to develop;
- Most Lincolnshire Limestone swallow holes are developed further south on the Limestone outcrop, between Stamford and Grantham (Griffiths, Shand, Marchant, & Peach, 2006; Roberts, 1999).

C1.5 Groundwater Quality

C1.5.1 Data Sources

Water quality data provided by the Environment Agency; published water quality data from the Hydrogeological Map of North and East Lincolnshire (BGS, 1967) and historic BGS borehole records (BGS, 2023) have been used to assess the regional and local water quality of the (hydro)geological units at the Site.

Data has also been collected by Envireau Water from five groundwater monitoring boreholes since the construction and redevelopment of the wellsite. These boreholes range from 6 m to 50 m deep targeting the Unconsolidated Sands Aquifer and the Lincolnshire Limestone/ Grantham Formation (**Figure C4**; **Table C11**).

C1.5.2 Unconsolidated Sands Aquifer

The baseline water quality data collected by Envireau Water from the four shallow groundwater monitoring boreholes in the Unconsolidated Sands reveals a surprising diversity of groundwater chemical conditions, given they all target the same aquifer within tens of metres of each other. The variety of groundwater chemistry is especially apparent in parameters such as potassium, nitrate, calcium, arsenic and sulphate. It is strongly suspected that the source of potassium, nitrate and, possibly, sulphate relates to intensive agriculture in the vicinity of the Site. The source of sulphate could also be related to the oxidation of sulphide mineral within the Kellaways Formation.

The groundwater was found to exceed drinking water standards for the following inorganic parameters:

- Nitrate - most likely due to surrounding agricultural activity;
- Manganese - most likely related to natural reductive dissolution processes;
- Nickel - presumably from a mineralogical source in the Kellaways Formation;
- Arsenic - presumably from a mineralogical source in the Kellaways Formation.

The evidence does not suggest that any of these parameters are related to activities on the Wressle wellsite.

C1.5.3 Great Oolite Group

There is little groundwater data available for the Great Oolite Group. The Blisworth Limestone Formation, if and where present, may yield local supplies of portable groundwater to shallow wells.

C1.5.4 Inferior Oolite Group

Lincolnshire Limestone Formation

Groundwater is hard near the outcrop, generally oxidising and dominated by Ca^{++} and HCO_3^- as the main ions. It is otherwise of good chemical quality, although vulnerable to contamination from agriculture-related species, such as nitrate (Griffiths, Shand, Marchant, & Peach, 2006). Progressive softening occurs in the easterly direction under cover of impermeable clays, with the water also becoming more reducing. The quality of the groundwater eventually deteriorates – becoming saline towards the east - with increasing depth and distance from the outcrop.

Data collected by Envireau Water as part of the baseline data collection from GWMBH4, showed the groundwater exceeded drinking water standards for the following parameters:

- Manganese - most likely related to natural reductive dissolution processes.

C1.5.5 Lias Group

Little groundwater data is available for the Lias group. Water chemistry data is available for the Marlstone Rock Formation and Scunthorpe Mudstone Formations. The groundwater within the Marlstone Rock Formation tends to be calcareous and ferruginous. Domestic supplies of good chemical quality may be obtainable from shallow wells (BGS, 1967).

Historic water chemistry data show the groundwater within the limestone and ironstone bands of the Scunthorpe Mudstone Formation is ferruginous with a high sodium and sulphate content and hydrogen sulphide present (BGS, 1981).

It is expected that the other units within the Lias group will be of similar groundwater quality.

C1.5.6 Triassic

Penarth Group

No groundwater data is available for the Penarth Group. The unit is confined by approximately 130 m of low permeability strata. Any groundwater is expected to be highly mineralised and poor quality.

Mercia Mudstone Group

Regional abstraction data shows that where the Mercia Mudstone Group is targeted for abstraction it produces small quantities of hard to very hard water. Groundwater contained within sandstone and siltstone horizons have elevated sulphate from gypsum dissolution and high chloride where saliferous rocks are present (BGS, 1981). Water quality is expected to be highly mineralised and poor due to the depth of burial at the Site and lack of active recharge.

Sherwood Sandstone group

Generally, Sherwood Sandstone groundwater is of good quality at outcrop, with the concentrations of various ions fluctuating seasonally in response to recharge. Total dissolved solids decrease in the direction of groundwater flow. Where the Sandstone is present at greater depths, and especially where concealed beneath Mercia Mudstone, the non-carbonate hardness increases due to the influence of gypsum in the overlying mudstone and the water eventually becomes saline (BGS, 1981).

At the Site the Sherwood Sandstone Aquifer is confined by very low permeability strata. There is no known driving head or groundwater circulation within the unit; groundwater within it has a very long residence time and is likely to have elevated salinity.

C1.5.7 Permian and Carboniferous Strata

The Permian and Carboniferous strata are very deeply buried and have no recharge mechanism in the region. Any water contained within these units is long-residence-time, saline 'formation water' containing hydrocarbons.

C2 ENVIRONMENTAL SETTING

This section describes water dependent features and other important features within the 2 km search radius around the Site. The environmental setting of the Site is shown on Figure C3. Water dependent features within a 2 km radius of the Site have been identified and presented. Although it is not anticipated that the impacts of the wellsite will extend this far, this search radius allows the surrounding area to be appropriately characterised with regard to the water environment.

C2.1 Data Sources

Groundwater and surface water abstraction/discharge data were sourced from Environment Agency through a Freedom of Information (FOI) Request submitted in October 2023.

Private Water Supply (PWS) information was sourced from North Lincolnshire County Council via an FOI in October 2023. Further data sources used include the BGS Onshore GeoIndex (water well records), Ordnance Survey (OS) mapping and the MaGIC Map (designated sites) (Natural England, 2023).

C2.2 Surface Water Features

Surface water features within 2 km of the Wressle wellsite have been identified from 1:25,000 scale Ordnance Survey mapping. The locations of the major surface water features are presented on Figure C3, and their details are summarised in Table C14.

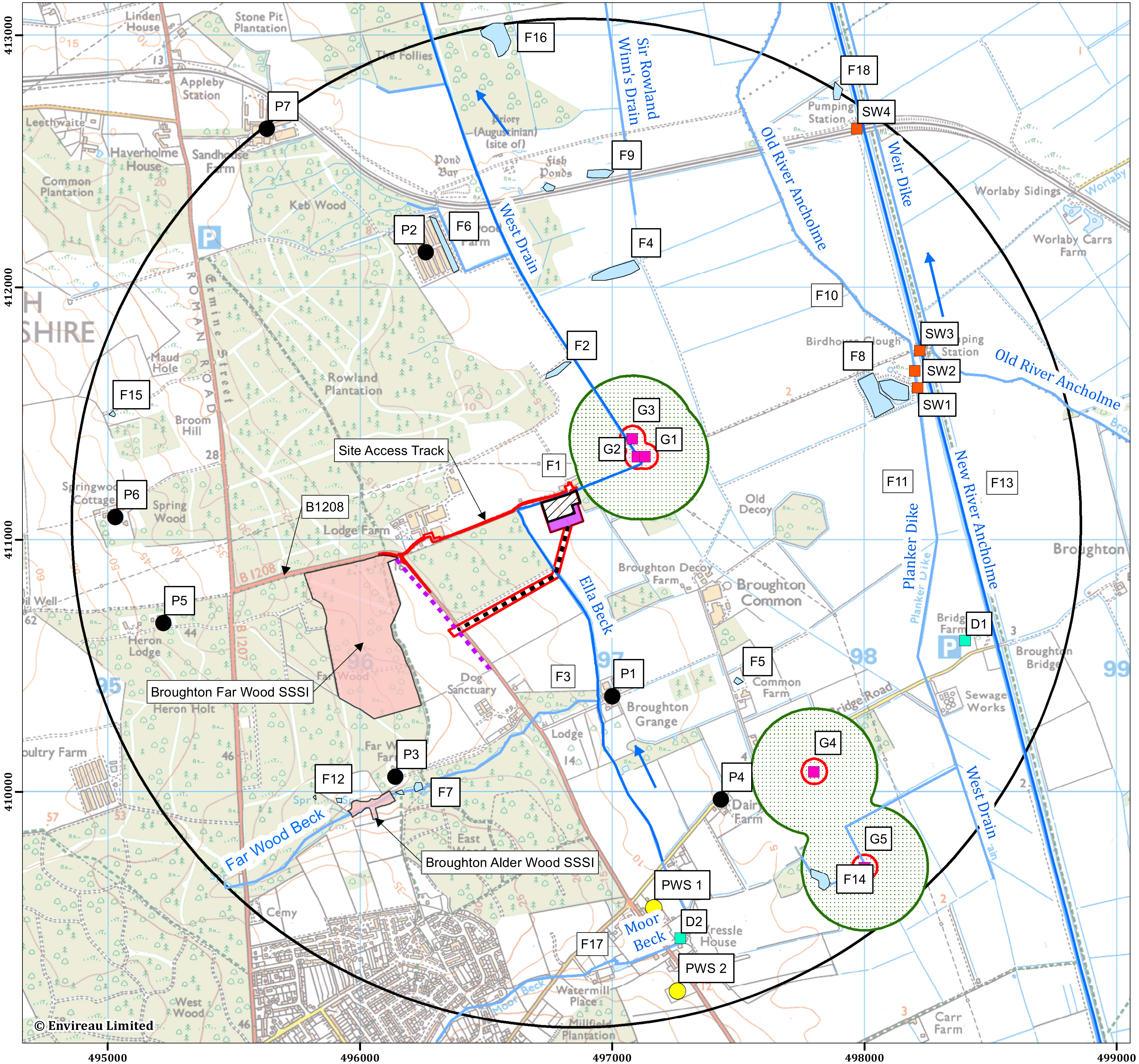
Ella Beck is the nearest surface water feature to the wellsite and is the receptor of clean rainfall runoff water discharged off site. For clarity, there is no discharge of production or process/treatments fluids from the wellsite. Ella Beck lies adjacent to the northern boundary of the wellsite is classified as 'Main River' by the Environment Agency. Ella Beck flows from the west to the east at elevations between 6 m AOD to 3.25 m AOD past the wellsite. Approximately 400 m to the north-east of the wellsite the Ella Beck joins the West Drain and flows north.

West Drain is a major drain in the vicinity of the wellsite. It is located 400 m east of the wellsite and flows northerly for about 10 km where it joins the New River Ancholme close to the mouth of the River Humber. The West Drain is also classified as a Main River.

The New River Ancholme is located approximately 1.5 km east of the wellsite and flows north through the Ancholme Valley towards the River Humber. The river has been modified for land drainage and navigation and is canalised from Bishopbridge in West Lindsey District to the River Humber.

Figure C3: Environmental Setting

Wressle, North Lincolnshire



Planning Application Boundary
Existing Wellsite
Proposed Extension
2km Search Radius
Site of Special Scientific Interest (SSSI)
Cadent Gas Main
Proposed Pipeline

Water Dependent Receptors

Surface Water Body
Main River
Ordinary Watercourse
Flow Direction
Groundwater Abstraction Licence
Surface Water Abstraction Licence
Deregulated Abstraction Licence
Registered Private Water Supply
Potential Private Water Supply

Source Protection Zones

1c- Inner Protection Zone
2c- Outer Protection Zone

Notes:

0 150 300 450 600 Meters

Scale: 1:15,000 at A3

16 January 2024

NGR: 496,858 E / 411,066 N

Project No. 3490616
Client: Egdon Resources UK Ltd
Drawn by: MT
Ref: Environmental Setting

envireau WATER

Table C15 Surface Water Features

Reference on Figure C3	Feature	Distance from Site (km)	Description
F1	Ella Beck & West Drain	0.1	"Main River". Adjacent to the Wellsite, running northwards on the western side and eastwards on the northern side and then northwards into River Humber.
F2	Small Pond	0.5	Small pond east of Rowland Plantation
F3	Far Wood Beck	0.8	Ordinary Watercourse flowing north eastwards into the Ella Beck
F4	Large Pond	1.0	Large pond
F5	Small Pond	1.0	Small ponds near Broughton Grange and Common Farm
F6	Small Pond	1.0	Small pond at Kebwood Farm
F7	Small Pond	1.3	Ponds system south of Far Wood Farm
F8	Large Pond	1.3	Large pond near Birdhouse Clough
F9	Small Pond	1.4	Small fish ponds at the Priory
F10	Old River Ancholme	1.4	Ordinary watercourse flowing northwards into the River Humber
F11	Planker Dike	1.5	Ordinary watercourse.
F12	Springs	1.5	Springs west of Far Wood Farm
F13	New River Ancholme	1.6	Bunded river, flowing northwards to River Humber
F14	Small Pond	1.8	Small pond at Wressle Wood
F15	Small Pond	1.8	Small pond at Broom Hill
F16	Large Pond	1.9	Large pond at The Follies
F17	Moor Beck	1.9	Beck flowing eastward and joining Ella Beck, associated pond near Watermill Place
F18	Small Pond	2.0	Small ponds at Appleby Carrs Pumping Station
N/A	Field Drains, including Sir Rowland Winn's Drain	N/A	Various field drains and dykes within the 2 km search radius

C2.3 Licensed Abstractions

C2.3.1 Groundwater

Environment Agency records indicate that there are 5 licensed groundwater abstractions within 2 km radius if the Site. All five licensed are British Steel for the use in industrial works, and can be subdivided into the Clapgate boreholes around 300 m ENE of the Site, and the Bridge Road boreholes, around 1.5 km SSE of the Site. The location of the abstractions are shown in Figure C3 and the license details are provided in Table C16.

Table C16 Licensed Groundwater Abstractions

Reference on Figure C3	Licence No.	Point of Abstraction	Location	Easting	Northing	Distance from Site (km)
G1	4/29/07/*G/0020	B.S.C. Borehole	Clapgate	497100	411330	0.3
G2	4/29/07/*G/0020	B.S.C. Borehole	Clapgate	497130	411330	0.3
G3	4/29/07/*G/0020	B.S.C. Borehole	Clapgate	497080	411400	0.3
G4	4/29/07/*G/0020	B.S.C. Borehole	Bridge Road	497800	410080	1.5
G5	4/29/07/*G/0020	B.S.C. Borehole	Bridge Road	498000	409700	1.8

C2.3.2 Surface water

There are 4 licensed surface water abstractions within 2 km of the Site, all are located over 1 km from the Site. Three are for the abstraction of water from the New River Ancholme and one for Planker Dyke. All four abstractions are for use in agriculture. The location of the abstractions are shown in Figure C3 and the license details are provided in Table C17.

Table C17 Licensed Surface Water Abstractions

Reference on Figure C3	Licence No.	Point of Abstraction	Location	Easting	Northing	Distance from Site (km)
SW1	4/29/07/*S/0037	Planker Dike	Worlaby	498211	411602	1.4
SW2	4/29/07/*S/0001	New River Ancholme	Birdhouse Clough	498200	411670	1.4

Reference on Figure C3	Licence No.	Point of Abstraction	Location	Easting	Northing	Distance from Site (km)
SW3	4/29/05/*S/0020	New River Ancholme	Birdhouse Clough	498220	411750	1.5
SW4	4/29/05/*S/0010	New River Ancholme	Birdhouse Clough	497970	412630	1.8

C2.4 Deregulated Licenses

Environment Agency records indicate that there are two deregulated abstractions within 2 km of the Site. These are believed to be abstractions of small quantities of groundwater which, following amendments to the licensing regime, most likely in 2005, became exempt from the licensing requirement (UK Groundwater Forum, 2024). They are both groundwater abstractions for use in agriculture. The location of the abstractions are shown on Figure C3 and the license details are summarised in Table C17.

Table C18 Deregulated Abstraction Licences

Reference on Figure C3	Licence No.	Point of Abstraction	Location	Easting	Northing	Distance from Site (km)
D1	4/29/07/*G/0012	Borehole	Bridge Road	498400	410600	1.6
D2	4/29/07/*G/0005	Borehole	Wressle	497270	409420	1.7

C2.5 Private Water Supplies

A search of North Lincolnshire Council's register of Private Water Supplies (PWS) has been undertaken. The Council has confirmed that they have two PWS recorded within the 2 km search radius. The location of the registered PWS is presented on Figure C3 and details are summarised in Table C19.

Table C19 Registered Private Water Supplies

Reference on Figure C3	Location	Easting	Northing	Distance from Site (km)
PWS 1	Bridge Road, Wressle	497163	409541	1.6
PWS 2	Bridge Road, Wressle	497258	409211	2.0

It is recognised that the local authority's PWS register may be incomplete, and that unrecorded supplies may exist at outlying properties. Based on the local geology, any unrecorded supplies in the vicinity of the Site would most likely be wells or boreholes targeting the Superficial Deposits, thin water-bearing strata within the Great Oolite

Group, the Lincolnshire Limestone Formation or the Marlstone Rock Formation. The location of the potential PWS is presented on Figure C3 and details are summarised in Table C20.

Table C20 Potential Private Water Supplies

Reference on Figure C3	Location	Easting	Northing	Distance from Site (km)
P1	Broughton Grange	497000	410380	0.8
P2	Kebwood Farm	496260	412140	1.2
P3	Far Wood Farm	496140	410060	1.2
P4	Dairy Farm	497430	409970	1.3
P5	Heron Lodge	495220	410670	1.6
P6	Springwood Cottage	495030	411090	1.7
P7	Sandhouse Farm	495630	412630	1.9

C2.6 Water Well Records

A search of the water wells database (BGS, 2023) has been undertaken, which has identified 21 well records within a 2 km radius of the Site. The BGS data are indicative of water wells that have been recorded but may no longer be used, are lost, are not accessible or have no usable yield when constructed. The well records are provided in Table C21.

The majority of the records relate to water wells or boreholes targeting the Lincolnshire Limestone Formation or the Marlstone Rock Formation, with a few shallow wells targeting the Kellaways Formation Sand Member. This formation is regarded in this report as hydraulically continuous with (and part of) the Unconsolidated Sands Aquifer.

The closest water well record (SE91/80 – Clapgates No. 5) is recorded at/close to the wellsite, close to the Ella Beck, and targets the Lincolnshire Limestone Formation. However, this borehole was not located during the construction of the wellsite and there are no signs of its presence. The deepest water well (SE91/26) is 122 m deep and is located some 1.05 km northwest of the wellsite at Rowlands Plantation and targets the Lincolnshire Limestone Formation.

Table C21 BGS Water Well Records

BGS Ref.	Location	Aquifer	Age	Depth (m)	Easting	Northing	Distance from Site (km)
SE91/80	Clapgates No. 5	Lincolnshire Limestone Formation	1918	25	496740	411130	0
SE91/11	Clapgates No. 6	Lincolnshire Limestone Formation	1918	35.7	496810	411210	0
SE91/87	Low Santon	Lincolnshire Limestone Formation	1918	18.3	496510	411240	0.2

BGS Ref.	Location	Aquifer	Age	Depth (m)	Easting	Northing	Distance from Site (km)
SE91/79	Clapgates No. 3	Lincolnshire Limestone Formation	1918	18.3	496360	411180	0.4
SE91/86	Appleby Lodge	Lincolnshire Limestone Formation	1938	54.3	497350	411410	0.5
SE91/10	Decoy Farm	Kellaways Formation	1930	42.4	497280	410800	0.5
SE91/15A	Dog Sanctuary, Wressle	Multiple Aquifers	1962	94.5	496620	410300	0.7
SE91/9	Broughton Grange	Lincolnshire Limestone Formation	1914	35.7	496840	410270	0.8
SE91/85	Clapgate Pumping Station	Lincolnshire Limestone Formation	1938	78	497770	411580	1
SE91/26	Rowlands Plantation	Inferior Oolite Group		122	495900	411700	1
SE91/7	Decoy House Farm, Wressle	Kellaways Formation	1938	42.4	497520	410360	1
SE91/58	Thornholme	Lincolnshire Limestone Formation	1940	46.6	496610	412350	1.2
SE91/57	Thornholme	Lincolnshire Limestone Formation	1939	46.9	496600	412400	1.2
SE91/53	Appleby B/H Nr. Thornholme	Lincolnshire Limestone Formation	1929	42.7	496900	412420	1.2
SE90/33	Quarry At Cross Roads	Marlstone Rock Formation	1929	61	496980	409570	1.5
SE90/9	Wressle Wood	Lincolnshire Limestone Formation	1930	45.7	497760	409740	1.6
SE90/34	W.of Wressle Wood	Lincolnshire Limestone Formation	1930	61	497540	409610	1.6
SE90/32	Wressle House Bore A	Marlstone Rock Formation		58.8	497220	409390	1.7
SE90/58	E.of Wressle Wood	Lincolnshire Limestone Formation	1935	39.6	497990	409620	1.8
SE91/78	Spring Wood Lodge	No Aquifer		86	494980	411150	1.8
SE91/13	Appleby No. 1	No Aquifer		116.3	495180	412010	1.8

C2.7 Designated Sites

Natural England's MAGiC database indicates that there are two Sites of Special Scientific Interest (SSSI) within a 2 km radius of the Site: the Broughton Far Wood SSSI and the Broughton Alder Wood SSSI. These sites are designated as SSSI due to their habitats of calcareous grassland and broadleaved, mixed and yew woodland. Neither of the SSSIs are groundwater-dependent and both are located upgradient of the Site, with respect to both surface-water and groundwater hydraulic gradients.

There are no Special Areas of Conservation (SAC), RAMSAR or other designated sites within a 2 km radius of the wellsite.

C2.8 Source Protection Zones

Source Protection Zones (SPZs) are used as a general level of protection for all drinking water sources, identifying those areas where the risk associated with any potential groundwater contamination is greatest.

Data obtained from the Environment Agency indicates that the Site does not lie within a defined SPZ (Environment Agency, 2023b). An outer protection zone (SPZ2) is located approximately 25 m east of the Site and relates to the British Steel Clapgate boreholes. The location of the SPZ is presented on Figure C3.

The second SPZ relates to the British Steel Bridge Road sources with its outer zone located 1.15 km southeast of the wellsite. Although the SPZ defined by the Environment Agency does not extend to within the wellsite boundary, the boreholes already form part of the Hydrogeological Risk Assessment as they are licensed abstractions).

A default circular source protection zone with a radius of 50 m is applied to all other groundwater abstractions intended for human consumption. However, there are no such other abstractions within 50 m of the Site.

C2.9 Drinking Water Protected and Safeguard Zones

The Drinking Water Safeguard Zone (DrWSZs) are catchment areas which influence water quality at risk of failing drinking water protection objectives. Drinking Water Protected Areas (DrWPAs) are areas where raw water is abstracted from rivers and reservoirs.

The Natural England Magic database shows the Site is within a DrWPA - Surface Water. The protected area refers to the River Ancholme from Bishopbriggs to the Humber; it is current classified as at risk.

The Site does not lie within a DrWSZ for either surface water or groundwater. An area approximately 2.8 km north of the Site lies within a DrWSZ for groundwater.

C2.10 Environmental Setting Summary

This review of water related data has identified the receptors that need to be considered within the HRA. These fall into two main groups:

Groundwater

The Lincolnshire Limestone Formation forms a Principal Aquifer with a widely recognised resource value, from which groundwater is abstracted from a number of boreholes within the 2 km search radius, including the British Steel abstractions which are an important supply to the Scunthorpe steel works. The Unconsolidated Sands Aquifer has the potential to provide unlicensed / unregistered private water supplies whilst the Marlstone Rock Formation (Secondary A Aquifer) supplies one registered private water supply and could supply others.

While it is important to ensure the integrity of the British Steel boreholes and the water supply from them, the Egdon wellsite lies outside of the subsurface SPZ associated with the British Steel abstraction boreholes.

The wellsite is located within a NVZ for both surface and groundwater, although the proposed activities will not contribute to a nitrate load.

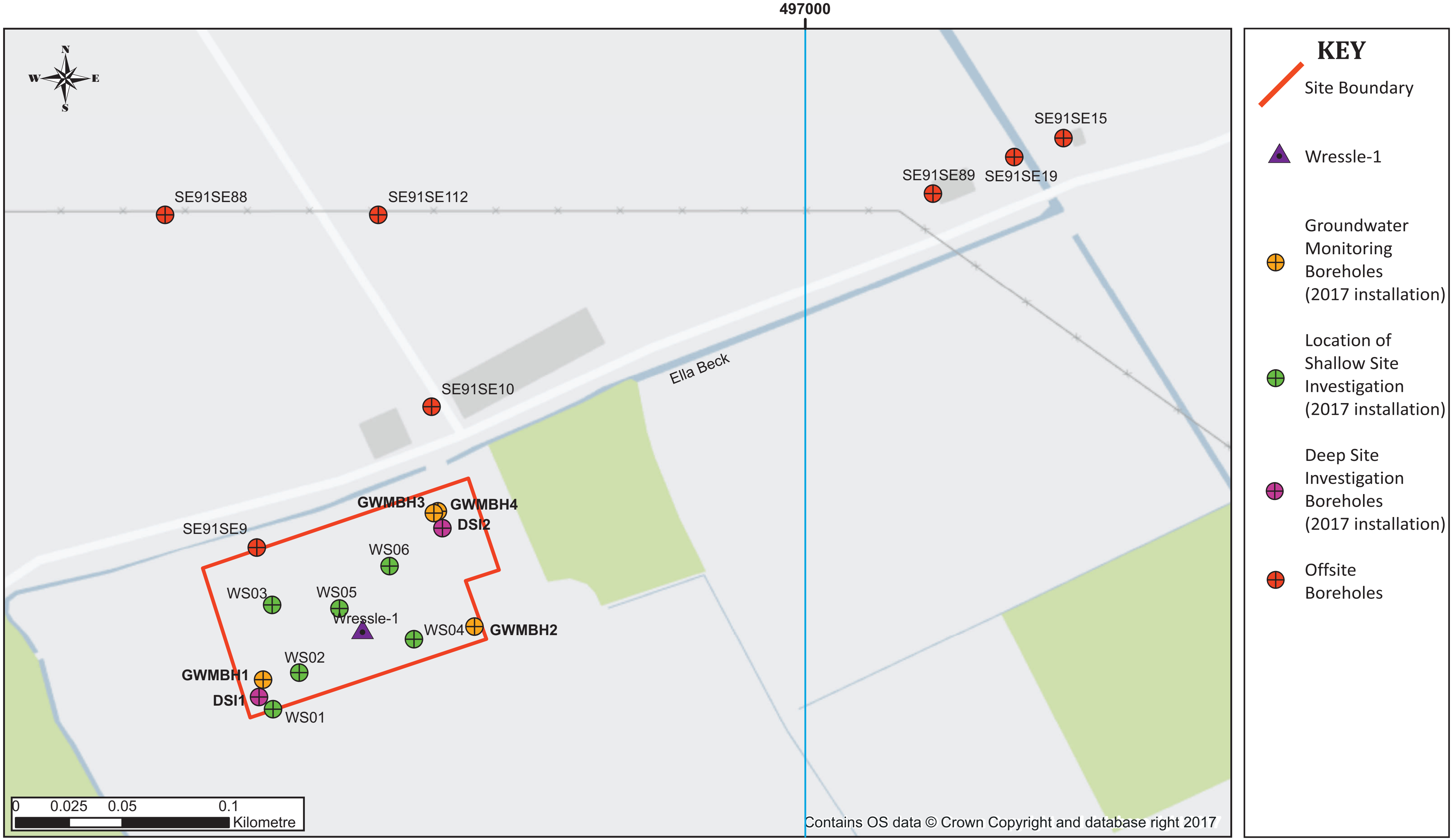
Other aquifer horizons do exist below the wellsite but are unlikely to make a significant contribution to total water supplies; however, these have also been taken into account.

Surface Water

The Ella Beck is located adjacent to the wellsite and will receive clean surface water runoff from the wellsite via (if required) a regulated and permitted discharge. It is also important to recognise that local surface water features, including the Ella Beck, are dependent on shallow groundwater within the Unconsolidated Sands Aquifer.

Groundwater Dependent Terrestrial Ecosystems (GWDTE)

Broughton Far Wood SSSI and the Broughton Alder Wood SSSI are located within the 2 km search radius around the wellsite, but they are not considered by Natural England to be groundwater-dependent. The only GWDTE features within the vicinity of the wellsite are the ditches and dykes which are connected to the shallow Aquifer system.



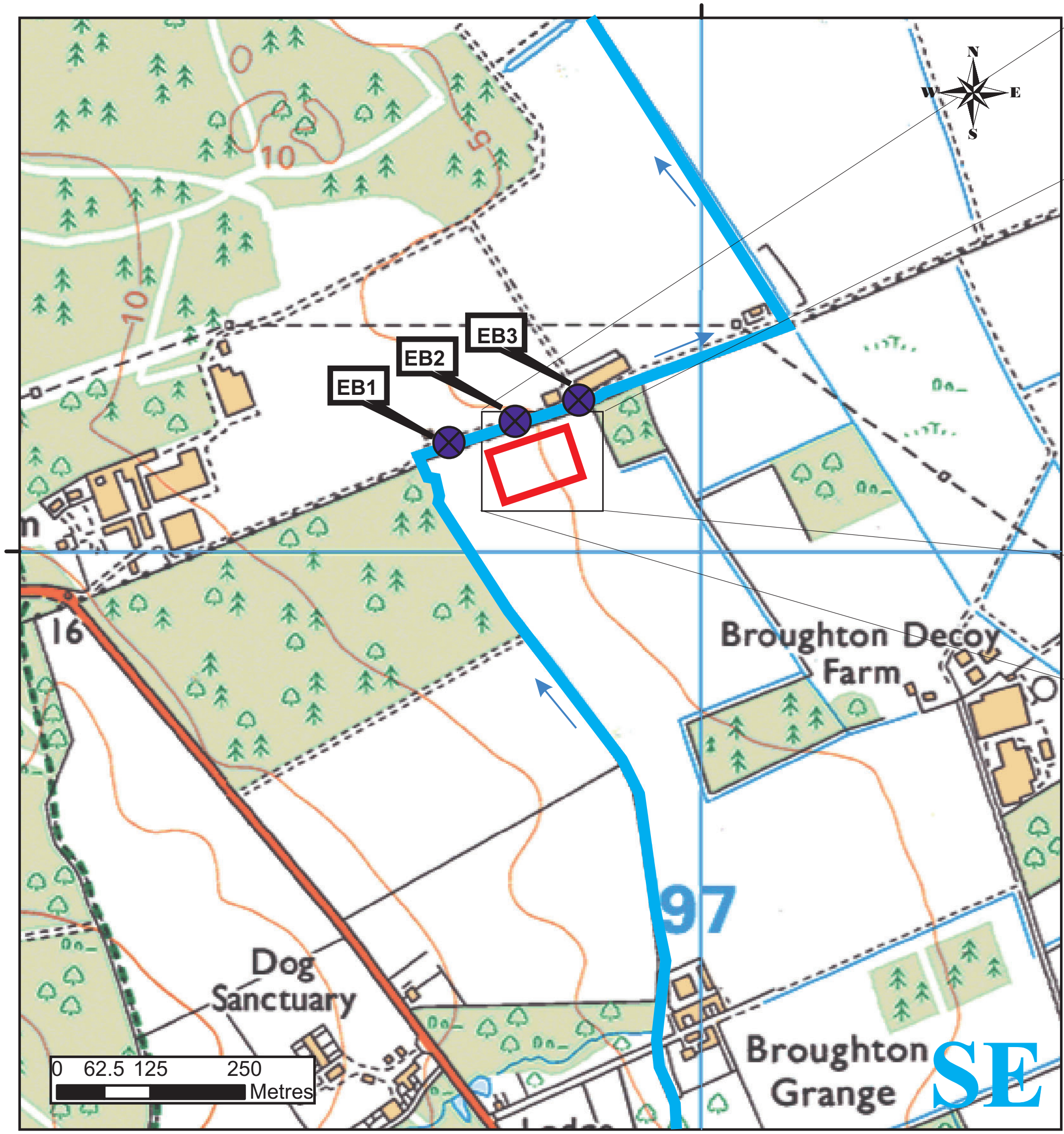
envireau WATER

P:\3490616 Egdon Wressle Ext \ FIG C4 SI Locs
Date: 06/03/2024

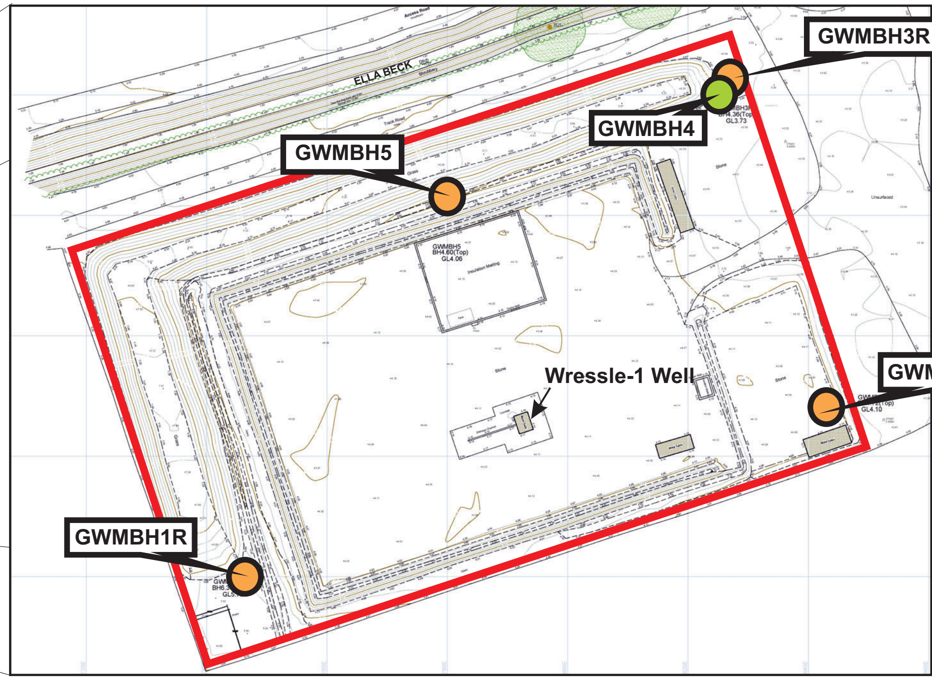
Egdon Resources UK Ltd

Figure C4

Site Investigation and Monitoring Boreholes at Wressle Wellsite (pre-2020)



Scale 1:10,000 *at A4*



KEY

- Wellsite Boundary
- Monitoring Borehole (Unconsolidated Sands Aquifer)
- Monitoring Borehole (Lincolnshire Limestone)
- Surface Water Monitoring Location
- Surface Water Feature with flow direction

Monitoring Location National Grid References:

GWMBH1R:	496745, 411080
GWMBH2R:	496843, 411108
GWMBH3R:	496827, 411162
GWMBH4:	496826, 411160
GWMBH5:	496780, 411143
EB1:	496657, 411136
EB2:	496771, 411163
EB3:	496860, 411205

envireau WATER

Ref: 3490616 Egdon Wressle Ext \ FIG C5 GW and SW mon locs
Date: 06/03/2024

Egdon Resources UK Ltd

Figure C5

Groundwater and Surface Water Monitoring Locations (2020 onwards)

REFERENCES

Allen, D. J., Brewerton, L. J., Coleby, L. M., Gibbs, B. R., Lewis, M. A., MacDonald, A. M., . . . Williams, A. T. (1997). *The Physical Properties of Major Aquifers in England and Wales.*

BGS. (1967). Hydrogeological map of North and East Lincolnshire including hydrometric areas 29, 30 and parts of 31.

BGS. (1981). Hydrogeological map of the Northern East Midlands including parts of hysometric areas 27, 28, 29 and 30.

BGS. (2023). GeoIndex (onshore). Retrieved from https://mapapps2.bgs.ac.uk/geoindex/home.html

BGS. (2024). *BGS Lexicon of Named Rock Units*. Retrieved from BGS Technologies: https://www.bgs.ac.uk/technologies/the-bgs-lexicon-of-named-rock-units/

Cranfield Soil and Agrifood Institute. (2023). Retrieved from Soilscapes: http://www.landis.org.uk/soilscapes/

Envireau Water. (2018). *Hydrogeological and Flood Risk Assessment - Wressle-1 Well, Wressle Wellsite.*

Envireau Water. (2020). *Baseline water quality data: Wressle-1 wellsite, North Lincolnshire.* Richmond, N. Yorkshire, UK: Envireau Water, for Egdon Resources UK Ltd.

Environment Agency. (2017, March 14). *Guidance: Protect groundwater and prevent groundwater pollution.* Retrieved from HM Government: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution

Environment Agency. (2023a). *Aquifer Designation Dataset for England and Wales*. Retrieved from https://data.gov.uk/dataset/616469ae-3ff2-41f4-901f-6686feb1d5b6/aquifer-designation-dataset-for-england-and-wales

Environment Agency. (2023b). *Magic Map*. Retrieved from https://magic.defra.gov.uk/magicmap.aspx

Environment Agency. (2024a, January 16). *Gov.uk*. Retrieved from Catchment Data Explorer: https://environment.data.gov.uk/catchment-planning

Environment Agency. (2024b, January 08). *Classifications data for Grimsby Ancholme Louth Limestone Unit Operational Catchment*. Retrieved from Gov.uk: https://environment.data.gov.uk/catchment-planning/OperationalCatchment/1097/classifications

European Parliament. (2006). IRECTIVE 2006/118/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 12 December 2006 on the protection of groundwater against pollution and deterioration. *Official Journal of European Union*.

European Parliament. (2020). Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

Gaunt, G., Fletcher, T., & Wood, C. (1992). *Geology of the country around Kingston upon Hull and Brigg : Memoir for 1:50000 geological sheets 80 and 89 (England & Wales).* British Geological Survey.

GEOLABS. (2018). *Results of Hydraulic Conductivity Testing. Determination of Permeability in a Trixial Cell. Project Number: GEO / 27276. Project Name: Egdon, Wressle 16071.*

Griffiths, K., Shand, P., Marchant, P., & Peach, D. (2006). *Baseline Report Series 23: the Lincolnshire Limestone.* British Geological Survey. Retrieved from https://nora.nerc.ac.uk/id/eprint/3557/1/CR06060N.pdf

IWA. (2024). *River Ancholme*. Retrieved from Inland Waterways Association: https://waterways.org.uk/waterways/discover-the-waterways/river-ancholme

Jones, H. K., Morris, B. L., Cheney, C. S., Brewton, L. J., Merrin, P. D., Lewis , M. A., . . . Robinson, V. K. (2000). *The Physical Properties of minor aquifers in England and Wales.* British Geological Survey Technical Report, 234 pp. Environment Agency R&D Publication 68.

Misstear, B., Banks, D., & Clarke, L. (2017). *Water Well and Boreholes.*

Natural England. (2023). *MAGiC Map Application*. Retrieved from https://magic.defra.gov.uk/magicmap.aspx

Oates, M. (2018). *Stratigraphy and Lithology of two Geotechnical Boreholes, Wressle-1 Wellsite, Lincolnshire.*

Roberts, S. C. (1999). *Surface/groundwater interactions affecting the Lincolnshire Limestone aquifer.* PhD thesis, University College, London. Retrieved from https://discovery.ucl.ac.uk/id/eprint/10106644/1/Surfacegroundwater_interactio.pdf

Shire Group of ISBs. (2024, 2 13). *Ancholme IDB*. Retrieved from https://www.shiregroup-idbs.gov.uk/idbs/ancholme/about/

UK Centre for Ecology & Hydrology. (2023). *Flood Estimation Handbook Web Service*. Retrieved from https://fehweb.ceh.ac.uk/

UK Groundwater Forum. (2024). *Modernising the regulation of water resources*. Retrieved from UK Groundwater Forum: http://www.groundwateruk.org/Modernising-the-regulation-of-water-resources.aspx

UKTAG. (2011). Defining & Reporting on Groundwater Bodies.

Appendix D Hydrogeological Risk Assessment

Hazard	Construction Phases								Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Mitigation/Justification	Likelihood of Occurrence	Risk Analysis (with embedded mitigation)
	Phase 1 - Construction of extension	Phase 2 - Drilling of Wressle-2 and Wressle-3 wells	Phase 3 - Production Testing	Phase 4 - Proppant Squeeze/Nitrogen lift	Phase 5 - Site Civils Work	Phase 6 - Production	Phase 7- Gas to grid	Phase 8 - Well decommissioning and site restoration										
Mobilisation of Contaminated Soils	X							X	Made ground and contaminated soils	Runoff to surface waters; downwards leakage through underlying deposits.	Surface water drainage system and Ella Beck	Y	High	High	Major	Site construction and operations are simple controllable activities; extension area is virgin arable land. No excavation operations to be carried out during heavy rain; good construction practice to be used. Temporary bunds will be formed to prevent run off of soils. Site soils will be tested for contamination on decommissioning of the site, any contaminated material will be removed.	Unlikely	Low
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	Y	High	High	Major		Unlikely	Low
											Potential Private Water Supplies	Y	High	High	Major	Despite the prevailing downward hydraulic gradient from the surface and Unconsolidated Sands Aquifer to the Lincolnshire Limestone, the low hydraulic conductivity of the intervening clayey strata (Appendix C) will reduce the magnitude of any vertical water and contaminant transport to a negligible quantity.	Very Unlikely	Very Low
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	Y	Very High	High	Major		Very Unlikely	Very Low
											British Steel Abstraction Boreholes	Y	High	High	Major		Very Unlikely	Very Low
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor	These units are hydraulically separated from surface operations by a large thickness of very low permeability strata.		
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			
	X							X	Made ground and contaminated soils	Creation of vertical pathways through construction of drilling cellars and drainage infrastructure	Surface water drainage system and Ella Beck	Y	High	High	Major	Site construction and operations are simple controllable activities; extension area is virgin arable land. No excavation operations to be carried out during heavy rain; good construction practice to be used. Temporary bunds will be formed to prevent run off of soils. Site soils will be tested for contamination on decommissioning of the site, any contaminated material will be removed.	Unlikely	Low
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	Y	High	High	Major		Unlikely	Low
											Potential Private Water Supplies	Y	High	High	Major	Despite the prevailing downward hydraulic gradient from the surface and Unconsolidated Sands Aquifer to the Lincolnshire Limestone, the low hydraulic conductivity of the intervening clayey strata (Appendix C) will reduce the magnitude of any vertical water and contaminant transport to a negligible quantity.	Very Unlikely	Very Low
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	Y	Very High	High	Major		Very Unlikely	Very Low
											British Steel Abstraction Boreholes	Y	High	High	Major		Very Unlikely	Very Low
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor	These units are hydraulically separated from surface operations by a large thickness of very low permeability strata.		
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			

Hazard	Construction Phases								Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Justification	Likelihood of Occurrence	Risk Analysis (with embedded mitigation)
	Phase 1 - Construction of extension	Phase 2 - Drilling of Wressle-2 and Wressle-3 wells	Phase 3 - Production Testing	Phase 4 - Proppant Squeeze/Nitrogen lift	Phase 5 - Site Civils Work	Phase 6 - Production	Phase 7- Gas to grid	Phase 8 - Well decommissioning and site restoration										
Fuel spillage/leaks	X	X	X	X	X	X	X	X	Plant and machinery, staff vehicles, fuel storage containers and infrastructure	Runoff to surface waters; downwards leakage through underlying deposits	Surface water drainage system and Ella Beck	Y	High	High	Major	Site construction and operations are simple controllable activities; extension area is virgin arable land. No excavation operations to be carried out during heavy rain; good construction practice to be used. Temporary bunds will be formed to prevent run off of soils. Site soils will be tested for contamination on decommissioning of the site, any contaminated material will be removed.	Unlikely	Low
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	Y	High	High	Major		Unlikely	Low
											Potential Private Water Supplies	Y	High	High	Major	Despite the prevailing downward hydraulic gradient from the surface and Unconsolidated Sands Aquifer to the Lincolnshire Limestone, the low hydraulic conductivity of the intervening clayey strata (Appendix C) will reduce the magnitude of any vertical water and contaminant transport to a negligible quantity.	Very Unlikely	Very Low
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	Y	Very High	High	Major		Very Unlikely	Very Low
											British Steel Abstraction Boreholes	Y	High	High	Major		Very Unlikely	Very Low
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor	These units are hydraulically separated from surface operations by a large thickness of very low permeability strata.		
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			
Loss of fluids / additives during drilling and workover activities		X	X	X		X			Drilling fluids, chemicals and additives used in well construction and operation	Migration from the wellbore into permeable formations	Surface water drainage system and Ella Beck	Y	High	High	Major	Drilling will be carried out using water based muds in the formations above the Permian bedrock, in the same way as water supply boreholes. Any drilling losses will be temporary. Wells will be constructed with a series of cemented steel casings between surface and the top fo the Permian bedrock. Construction will be carried out in accordance with oil and gas industry best practice and regulations. Once the casings are in place, the pathway between all receptors will be broken.	Unlikely	Low
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	Y	High	High	Major		Unlikely	Low
											Potential Private Water Supplies	Y	High	High	Major		Unlikely	Low
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	Y	Medium	High	Moderate		Unlikely	Very Low
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	Y	Very High	High	Major		Unlikely	Low
											British Steel Abstraction Boreholes	Y	High	High	Major		Unlikely	Low
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	Y	Medium	High	Moderate		Unlikely	Very Low
											Sherwood Sandstone geothermal reservoir	Y	Medium	Low	Minor		Unlikely	None
											Deep formation water systems below the Lias (no potable/environmental resource value)	Y	Low	Very Low	Negligible	Drilling fluids will be weighted to avoid loss into the formations. Lost circulation materials will be used to plug any fluid loss zones as required.	Unlikely	None

Hazard	Construction Phases								Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Justification	Likelihood of Occurrence	Risk Analysis (with embedded mitigation)
	Phase 1 - Construction of extension	Phase 2 - Drilling of Wressle-2 and Wressle-3 wells	Phase 3 - Production Testing	Phase 4 - Proppant Squeeze/Nitrogen lift	Phase 5 - Site Civils Work	Phase 6 - Production	Phase 7- Gas to grid	Phase 8 - Well decommissioning and site restoration										
Leakage/spills of hydrocarbons, fuels, produced water and other fluids stored on, or transported to/from, the wellsite during operational activities		X	X	X		X	X		Storage tanks and infrastructure used during operations	Runoff to surface waters; downwards leakage through wellsite liner and underlying deposits	Surface water drainage system and Ella Beck	Y	High	High	Major	Site construction and operations are simple controllable activities; extension area is virgin arable land. No excavation operations to be carried out during heavy rain; good construction practice to be used. Temporary bunds will be formed to prevent run off of soils. Site soils will be tested for contamination on decommissioning of the site, any contaminated material will be removed.	Unlikely	Low
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	Y	High	High	Major		Unlikely	Low
											Potential Private Water Supplies	Y	High	High	Major	Despite the prevailing downward hydraulic gradient from the surface and Unconsolidated Sands Aquifer to the Lincolnshire Limestone, the low hydraulic conductivity of the intervening clayey strata (Appendix C) will reduce the magnitude of any vertical water and contaminant transport to a negligible quantity.	Very Unlikely	Very Low
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	Y	Very High	High	Major		Very Unlikely	Very Low
											British Steel Abstraction Boreholes	Y	High	High	Major		Very Unlikely	Very Low
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	Y	Medium	High	Moderate		Very Unlikely	None
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor	These units are hydraulically separated from surface operations by a large thickness of very low permeability strata.		
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			
Migration of fluids, gases and formation water from the wellbore, including during the proppant squeeze		X	X	X		X			Fluids injected into the wellbore	Horizontal and vertical migration of fluids; transmission along faults	Surface water drainage system and Ella Beck	N	High	High	Major	Robust mitigation breaks the pathway between all the potential receptors. Wells will be constructed with a series of cemented steel casings between surface and the top fo the Permian bedrock. Construction will be carried out in accordance with oil and gas industry best practice and regulations. Very low permability bedrock at the top of the Permian sequence provides vertical hydraulic seperation between the production formation and shallower formations. Fluid injection rates will be designed and controlled to ensure no excessive overpressure that could cause transmission between units or along faults. In addition, the planned proppant squeeze is a low volume activity that will be carried out to improve near bore permability (<50m). All proposed chemical additivies are non-hazardous.		
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	N	High	High	Major			
											Potential Private Water Supplies	N	High	High	Major			
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	N	Medium	High	Moderate			
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	N	Very High	High	Major			
											British Steel Abstraction Boreholes	N	High	High	Major			
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	N	Medium	High	Moderate			
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor			
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			

Hazard	Construction Phases								Source (S)	Pathway (P)	Receptors (R)	S-P-R Linkage	Receptor Sensitivity	Magnitude of Impact	Significance of Effect	Justification	Likelihood of Occurrence	Risk Analysis (with embedded mitigation)
	Phase 1 - Construction of extension	Phase 2 - Drilling of Wressle-2 and Wressle-3 wells	Phase 3 - Production Testing	Phase 4 - Proppant Squeeze/Nitrogen lift	Phase 5 - Site Civils Work	Phase 6 - Production	Phase 7- Gas to grid	Phase 8 - Well decommissioning and site restoration										
Migration of fluids, gases and formation water from the wellbore		X	X	X		X	X	X	Produced fluids (oil, gas, water)	Leakage through well casings and along anullii	Surface water drainage system and Ella Beck	N	High	High	Major	Robust mitigation breaks the pathway between all the potential receptors. Wells will be constructed with a series of cemented steel casings between surface and the top fo the Permian bedrock. Construction will be carried out in accordance with oil and gas industry best practice and regulations. Very low permability bedrock at the top of the Permian sequence provides vertical hydraulic seperation between the production formation and shallower formations. Fluid injection rates will be designed and controlled to ensure no excessive overpressure that could cause transmission between units or along faults. In addition, the planned proppant squeeze is a low volume activity that will be carried out to improve near bore permability (<50m). All proposed chemical additivies are non-hazardous.		
											Shallow, Unconsolidated Sands Aquifer (Secondary A aquifer)	N	High	High	Major			
											Potential Private Water Supplies	N	High	High	Major			
											Secondary A and Scondary B bedrock aquifers above LLF, including Cornbrash Formation	N	Medium	High	Moderate			
											Lincolnshire Limestone Formation (LLF) (Principal aquifer)	N	Very High	High	Major			
											British Steel Abstraction Boreholes	N	High	High	Major			
											Secondary A and Secondary B bedrock aquifers below LLF, including Marlstone Rock Formation	N	Medium	High	Moderate			
											Sherwood Sandstone geothermal reservoir	N	Medium	Low	Minor			
											Deep formation water systems below the Lias (no potable/environmental resource value)	N	Low	Very Low	Negligible			

Appendix E Development Plan Policies

The following planning policies have been taken into account in preparing this Hydrogeological and Flood Risk Assessment.

North Lincolnshire Local Plan 2003

Policy DS13 - Groundwater Protection and Land Drainage

All development proposals must take account of the need to secure effective land drainage measures and ground water protection in order to control the level of water in the land drainage system.

Policy DS14 – Foul Sewage and Surface Water Drainage

The Council will require satisfactory provision to be made for the disposal of foul and surface water from new development, either by agreeing details before planning permission is granted, or by imposing conditions on a planning permission or completing planning agreements to achieve the same outcome.

Policy DS15 – Water Resources

Development will not be permitted which would adversely affect the quality and quantity of water resources or adversely affect nature conservation, fisheries and amenity by means of: i) pollution from the development; or ii) water abstraction unless adequate measures are undertaken to reduce the impact to an acceptable level.

Policy DS16 – Flood Risk

Development will not be permitted within floodplains where it would: i) increase the number of people or buildings at risk; or ii) impede the flow of floodwater; or iii) impede access for the future maintenance of watercourses; or iv) reduce the storage capacity of the floodplain; or v) increase the risk of flooding elsewhere; or vi) undermine the integrity of existing flood defences unless adequate protection or mitigation measures are undertaken.

M23 – Oil and Gas Production

Proposals for oil and gas production facilities will be permitted, provided that the proposal incorporates environmental protection measures that are adequate to mitigate the impacts arising from a long term or permanent site.

Core Strategy 2011

Policy CS19: Flood Risk

The council will support development proposals that avoid areas of current or future flood risk, and which do not increase the risk of flooding elsewhere. This will involve a risk based sequential approach to determine the suitability of land for development that uses the principle of locating development, where possible, on land that has a lower flood risk, and relates land use to its vulnerability to flood. Development in areas of high flood risk will only be permitted where it meets the following prerequisites:

3. It can be demonstrated that the development provides wider sustainability benefits to the community and the area that outweigh flood risk.

4. The development should be on previously used land. If not, there must be no reasonable alternative developable sites on previously developed land.
5. A flood risk assessment has demonstrated that the development will be safe, without increasing flood risk elsewhere by integrating water management methods into development.

Development within the Lincolnshire Lakes area will comply with the flood management principals set out in the Western Scunthorpe Urban Extension Exception Test Strategy. Any further flood management proposals will have to be agreed by both the council and the Environment Agency during the process of the Lincolnshire Lakes Area Action Plan. Development proposals in flood risk areas which come forward in the remainder of North Lincolnshire shall be guided by the Strategic Flood Risk Assessment for North Lincolnshire and North East Lincolnshire. This will ensure that proposals include site specific flood risk assessments which take into account strategic flood management objectives and properly apply the Sequential and, where necessary, Exception Tests. In addition, development will be required, wherever practicable, to incorporate Sustainable Urban Drainage Systems (SUDS) to manage surface water drainage. The Council will also seek to reduce the increase in flood risk due to climate change through measures to reduce carbon dioxide emissions.

Emerging Development Plan Policies

NLC submitted its Proposed Submission North Lincolnshire Local Plan 2020 to 2038 to the Secretary of State in November 2022. A Schedule of Proposed Main Modifications were subsequently submitted in October 2023. The policies in the emerging North Lincolnshire carry only limited weight at this stage. A date for the Examination of the Plan has yet to be agreed.

DQE5: Managing Flood Risk

1. The risk and impact of flooding will be minimised through:

a. directing new development to areas with the lowest probability of flooding;
b. ensuring that all new development addresses the effective management of all sources of flood risk;
c. ensuring that development does not increase the risk of flooding elsewhere; and
d. ensuring wider environmental benefits of development in relation to flood risk.

A site-specific flood risk assessment (FRA) should be provided for all development in Flood Zone 2 and 3. In Flood Zone 1, a FRA should accompany all proposals for development of sites of 1 hectare or more or land which has been identified by the Local Lead Flood Authority as having critical drainage problems or land that may be subject to other sources of flooding where development would introduce a more vulnerable use.

2. The Council will support development proposals within areas at risk of flooding (flood zones 2 and 3 or at risk as shown on the flood hazard maps in the Strategic Flood Risk Assessment), where it meets the following prerequisites:

a. it can be demonstrated that there are no other sites available at a lower risk of flooding (i.e. that the sequential test is passed). The sequential test will be based on a districtwide area of alternative sites unless local circumstances relating to the catchment area for the development justify a reduced search area, i.e. there is a specific need for the development in that location. The sequential test is not required for sites allocated in the Local Plan, for minor development (as defined in Planning Practice Guidance, paragraph 046 (Reference ID:7-046-20140306) or for change of use (except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site);

b. it can be demonstrated that the development provides wider sustainability benefits to the community and the area, that outweigh flood risk;
c. a flood risk assessment has demonstrated that the development will be safe for its lifetime, taking into account the latest guidance and allowances for climate change, without increasing flood risk elsewhere, has integrated water management methods into the development, and incorporated mitigation measures in line with the Standing Advice set out in the SFRA, which has been agreed between the Council and the Environment Agency;

3. All development proposals, including proposals in flood zone 1, will be permitted providing it is demonstrated that:

a. the peak rate of runoff over the lifetime of the development, allowing for climate change, is no greater for the developed site than it was for the undeveloped site;
b. the post-development volume of runoff, allowing for climate change over the development lifetime, is no greater than it would have been for the undeveloped site. If this cannot be achieved, then the maximum discharge from the site should not exceed the calculated greenfield runoff rate for all rainfall events, up to and including the 1% annual probability event plus allowance for climate change;
c. the development incorporates appropriate mitigation so that flooding of property in and adjacent to the development would not occur for 1% annual probability event, with appropriate allowance for climate change, and exceedance flood flow paths are taken into account;
d. the proposals in the first instance consider water re-use measures to encourage the conservation of water before infiltration to manage surface water, wherever this is feasible;
e. the proposal should consider the full separation of foul and surface water flows within the development.
f. the final discharge locations have the capacity to receive all foul and surface water flows from the development into water bodies and into sewers, including discharge by infiltration. Where capacity is not currently available within the public sewer network and/or receiving wastewater treatment facility it can be demonstrated that it can be made available in time to serve the development;
g. there is a management and maintenance plan for drainage and flood risk management infrastructure (where appropriate) for the lifetime of the development, which includes the implementation arrangements for adoption by any public authority, statutory undertaker or management company and any other arrangements to secure the operation and mitigation measures of the scheme throughout its lifetime; the final destination of the discharge complies with the following priority order to: water re-use at point of run-off; i. ground via infiltration; ii. a water body; surface water sewer.
h. where appropriate, SuDS have been included in line with the requirements of Policy DQE6 Sustainable Drainage Systems of this Plan.

Policy DM1: General Requirements

1. All new development, including extensions and alterations to existing buildings must achieve high quality sustainable design that contributes positively to local character, landscape and townscape, and supports diversity, equality and access for all.

2. Development proposals will be assessed against the following relevant design and amenity criteria: Design Principles

3. All development must respect and enhance the character and local distinctiveness of the area and create a sense of place. As such, proposals will be required to:

- Incorporate Sustainable Drainage Systems and the Drainage Hierarchy.

Policy DM3: Environmental Protection

1. Development proposals as appropriate to their nature and scale, should demonstrate that environmental impacts on receptors have been evaluated and appropriate measures have been taken to minimise the risks of adverse impacts to air, land and water quality, whilst assessing vibration, heat, energy, light and noise pollution.

Water Environment

9. Development will not be permitted where it would have an adverse effect on the quality or quantity of groundwater sources or watercourses or water bodies. Proposals will be supported where it can be demonstrated in a hydrogeological/water quality risk assessment that there are no unacceptable impacts on surface water quality and flows or groundwater quality and levels at or in the vicinity of the site.

10. Development will not be permitted where it would have an adverse effect on the quality or quantity of groundwater resources or watercourses and water bodies. Opportunities for environmental improvement are encouraged and should be considered at an early stage. Development proposals should include an assessment to demonstrate that:

a. there is adequate water available to support the development (making reference to the appropriate Environment Agency Abstraction Licensing Strategy for non-mains supply);
b. the capacity to effectively and sustainably manage foul and surface water exists or can be provided within an appropriate timescale to serve the development;
c. sustainable drainage systems are included (in accordance with Policy DQE6) unless there is evidence to demonstrate these are inappropriate;
d. water efficiency measures are incorporated (including that the higher standard of water efficiency of 110 litres/person/day is met, as required by Policy DQE7);
e. access to infrastructure and water environments for the purpose of maintenance and monitoring is not impeded; f. protecting aquifers and groundwater are protected in sensitive locations by preventing potentially polluting activities being located in the most sensitive locations for groundwater; and,
f. the requirements of the Water Framework Directive can be satisfied.

11. In order to promote natural solutions to climate change, reference should also be made to the requirements of Policy DQE3: Biodiversity and Geodiversity in this Plan.