

Technical Note

Project:	P17-480 Indurent Park, Newport, Units 15 - 18
Subject:	Units 15-18 - Piling Risk Assessment
Report Ref:	17480-RLL-25-XX-DR-O-1332-P01
Date:	08 August 2025
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1 Introduction

Rodgers Leask Ltd (RLL) has been commissioned by Indurent Management Ltd to prepare a piling risk assessment pursuant to the discharge of Planning Condition 32 for the proposed Units 15 - 18 within Phase 6a, 6b & 7 of Indurent Park Newport (shown on Roberts Limbrick Drawing 10317-011-RLA-25-XX-PL-A-0001 REV J, attached). This Technical Note has been prepared to support the application to discharge the planning condition relating to the risks posed to groundwater underlying the Site from piling operations.

Units 15 - 18 (the 'Site') are situated on the western and central areas of Indurent Park, Newport, which comprises part of the former Llanwern Steelworks. The proposed commercial units, due to the nature of the underlying geology, require columns or driven piles to be installed through the Tidal Flat Deposits and into the underlying Mercia Mudstone Group.

This Technical Note provides a summary of the Site setting and background in order to assess the risks of installing displacement columns to the groundwater receptors beneath the Site. The Site has previously been assessed in accordance with the procedures identified in the Environment Agency's Land Contamination Risk Management (LCRM, updated from CLR11 'Model Procedures for the Management of Land Contamination') guidance; this document builds on the findings of those previous reports. This assessment has considered the Natural Resources Wales (NRW) and Welsh Local Government Association's document 'Development of Land Affected by Contamination: A Guide for Developers', the Environment Agency's guidance 'Piling into Contaminated Sites' (in the absence of specific NRW guidance) as well as the 2025 CL:AIRE guidance on Piling and Penetrative Ground Improvement Methods on land Affected by Contamination: Guidance on Pollution Prevention.

2 Sources of Information

The following reports (in chronological order) have been read in preparation of this risk assessment.

- Llanwern, Site Wide Controlled Waters Detailed Quantitate Risk Assessment, ref. 5111373-LLA-OUT-0257 rev 3.0, Atkins, dated 2017 (first issue date June 2016).

- Glan Llyn CWDQRA Update, RLL ref. 18669-RLL-19-XX-RP-O-0006_Rev A, dated August 2019.
- Phase 6a, 6b & 7 Desk Study & Phase 2 Geo-Environmental Assessment Report, ref 17480-RLL-23-XX-RP-O-1224-P03, dated October 2023.
- Glan Llyn, Phase 6a, 6b & 7 Remediation Strategy, ref 17480-RLL-24-XX-RP-O-1256-P02 dated July 2024.
- Phase 6a, 6b & 7 Geotechnical Validation Report, RLL, ref. 17480-RLL-23-XX-RP-O-1226-P01, dated October 2023.
- Indurent Park, Newport, Phase 6a, 6b – Earthworks Validation Update, RLL, ref. 17480-RLL-25-XX-RP-O-1303-P01 (Ref. 7)
- Glan Llyn: Soils Validation Strategy for Protection of Controlled Waters Hannah Fraser Consulting Ref. 30937 R2, dated December 2024
- Glan Llyn Phase 6a 6b & 7 Chemical Validation Report, RLL, ref. 17480-RLL-25-XX-RP-O-1317, dated July 2025
- Glan Llyn, Llanwern: Soil Quality Validation Report U11 – 16, H Fraser Consulting, ref: 30984, dated July 2025

3 Site Description and History

The Site is located within Indurent Park Newport, at the former Llanwern Steelworks, Newport, Wales. The Site is approximately 6km to the east of Newport city centre at approximate National Grid Reference 337034E, 486839N. The Site is irregular in shape, covers an area of approximately 6.50ha, and is located in the approximate western central part of the wider Indurent Park, Newport development. The Site historically housed railway sidings, slag pits, a cast house, a boiler plant, a S30 turbo blower plant, tanks, conveyors, hoppers, pipelines and electro station precipitators.

Historically, the Site comprised agricultural land segregated into part seven fields by hedgerows and drains, until 1967 when the Site formed part of Llanwern Steelworks, and housed railway sidings to the east, slag pits, a cast house, electro station precipitators across the north to central sections of the Site; conveyors, a boiler plant and S30 turbo blower plant to the south and pipelines, tracks and tanks on the western side. The Site was partially demolished by 2004 and fully demolished by 2021.

Remediation comprising removal of unsuitable material identified as part of the ground investigation has been undertaken and this was followed by a turnover of all Made Ground to circa 5.30mAOD to prepare a reengineered plot suitable for onward commercial development.

4 Ground Conditions

4.1 Published Information

Information pertaining to underlying ground conditions has been obtained via the British Geological Survey's (BGS) Onshore Geoindex¹.

The published geological information shows the Site to be void of Made Ground. However, due to the Site's history, Made Ground is likely to be present associated with the previous development and subsequent demolition.

Superficial deposits are shown to comprise Tidal Flat Deposits.

Tidal Flat Deposits are described by the BGS as '*unconsolidated sediment, mainly mud and/ or sand. They may form the top surface of a deltaic deposit. Normally a consolidated soft silty clay, with layers of sand, gravel and peat.*'

The underlying bedrock is shown to be the Mercia Mudstone Group.

The Mercia Mudstone Group is described by the BGS as comprising '*predominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite bearing units in some basal areas. Thin beds of gypsum/anhydrite are widespread; sandstones are also present.*'

There is a fault approximately 480m northwest of the Site which trends roughly north to south and extends northwards away from Site.

4.2 Proven Ground Condition Summary

The ground conditions encountered prior to remedial earthworks comprised Made Ground overlying Tidal Flat Deposits, overlying the Mercia Mudstone Group. Concrete structures, piles and areas of fused slag were encountered during the investigations across the phase.

Ground investigations works were undertaken by Atkins in 2016 and 2018, and RLL in May to July 2018 and are summarised in the RLL Geotechnical Assessment Report, October 2023 (Ref. 17480-RLL-23-XX-RP-O-1226-P01). The ground investigation works generally identified the following conditions across the Site (wider site Phase 6a, 6b & 7):

- Surfacing of asphalt or concrete at thicknesses of 0.00m to 0.60m, encountered locally.
- Made Ground to thicknesses of between 0.10m to 5.30m, comprising red-brown-grey, gravelly-silty clay to gravelly sand with occasional cobbles of concrete, clinker, brick, bedrock, slag, iron ore and rebar.

¹ <http://mapapps2.bgs.ac.uk/geoindex/home.html> (accessed May 2025)

- Tidal Flat Deposits were encountered immediately below Made Ground, comprising very soft to firm, bluish grey to grey, silty, occasionally peaty clay, or brown fibrous peat.
- Merica Mudstone Group in two locations from a minimum encountered depth 9.50m to a maximum encountered depth 10.50 (where the borehole was concluded), comprising very stiff, silty clay.

Since the ground investigation, in line with the Remediation Strategy for the Site, earthworks have been completed whereby Made Ground was excavated to a level of $\leq 5.3\text{mAOD}$, then re-engineered to formation levels. The earthworks facilitated the removal of obstructions (excluding supporting piles and sheet piles) whilst forming a consistent development platform.

4.3 Earthworks Summary

Remedial earthworks were undertaken in two separate stages, the first by ACS Construction Group between June 2021 and January 2022 and the second phase by McCarthy Contractors (Bridgend) Ltd between March and June 2025.

The first phase of earthworks generally comprised:

- Site clearance;
- Excavation of Made Ground to $\leq 5.30\text{mAOD}$ or natural underlying Tidal Flat Deposits;
- Removal of Made Ground from site with evidence of gross visual and olfactory contamination;
- Removal of below ground obstructions including, but not limited to, concrete obstructions and hard fused slag;
- Cropping of piles to a minimum of 5.3mAOD , or the base of excavation;
- Re-engineering of Made Ground;
- In situ geotechnical testing;
- Soft spot excavation/ removal; and
- Monitoring for compliance with relevant specifications.

The second stage of earthworks generally comprised the remaining uplift work at the northern part of the Site. These works involved the uplift of material to raise the formation levels to 7.25mAOD , in accordance with the RLL earthworks specification.

Full information on the earthworks undertaken on the Site are presented in the Phase 6a, 6b & 7 Geotechnical Validation Report, information relating to the recent uplift works is presented in the Phase 6a, 6b – Earthworks Validation Update. Information relating to the chemical provenance of the re-engineered Made Ground is presented within the RLL Chemical Validation report and the HF Consulting Soil Quality Validation Report.

5 Groundwater

5.1 Published Information

Reference to National Resource Wales interactive map website² indicates that the underlying Tidal Flat Deposits are classified as Unproductive Strata, which are defined by the Environment Agency as ‘*deposits with low permeability that have negligible significance to water supply base flow*’. The Mercia Mudstone Group is classified as a Secondary B Aquifer, which is defined as comprising ‘predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of former non-aquifers’.

5.2 Recorded Conditions

The Controlled Waters Risk Assessment for the wider site concluded that regional groundwater flows towards the River Severn estuary, existing within the base of the Tidal Flat Deposits (confined to the basal sand layers) and the Mercia Mudstone; and is likely hydraulically confined from the shallow perched waters of the Made Ground due to the low permeability of the upper clay-rich Tidal Flat Deposits (TFD).

The shallow perched waters of the Made Ground was reported to flow towards the drainage reën that runs through the wider site.

Monks Ditch, a main river, flows across the wider site discharging into the River Severn estuary and is considered to be the controlled water receptor as the approved drainage strategy for the Site discharges to Monks Ditch. There is no existing surface connection to Monks Ditch.

Regional groundwater was encountered during Atkins 2016 ground investigation within CWCP36 at a depth of 9.10m. The water strike was recorded as sub-artesian within the granular material at the base of the TFD. Numerous shallow perched water strikes were encountered during the RLL 2018 ground investigations and one in the Atkins 2016 ground investigation, all encountered within the Made Ground, overlying the low permeability of TFD.

It should be noted that the Site does not lie within a groundwater Source Protection Zone. Furthermore, the local groundwater is likely to be impacted by intrusion from estuarine water and potentially by the industrial legacy of the wider surrounding area.

5.3 Controlled Waters Risk Assessment

It is understood that the Controlled Waters Risk Assessment report for the wider site concluded that the regional groundwater beneath the Site was considered to be a pathway, with the Severn Estuary as the nearest receptor.

In summary, previous reports have shown that there is not a viable groundwater resource below the Site. Groundwater within the Site area is understood to exist as follows:

² [Natural Resources Wales / Browse map of data about the natural environment](#)

- Shallow perched groundwater – sporadic across the Site within the Made Ground, perched above the cohesive Tidal Flat Deposits.
- Regional groundwater – within the basal sand at the base of the Tidal Flat Deposits and Mercia Mudstone Group.

The shallow perched groundwater described above was recorded during pre-reclamation conditions. The earthworks on the phase include the reengineering of the Made Ground, this shallow perched groundwater shall no longer be present.

6 Piling Risk Assessment

6.1 Human Health

Human health risks for end-users will be mitigated through the presence of construction materials overlying the Made Ground (i.e. hardstanding and sub-base) or clean cover in any limited areas of landscaping. The creation of extensive hardstanding will reduce the risk of future infiltration and mobilisation of contaminants. Furthermore, residual Made Ground has been recompacted to reduce its permeability.

6.2 Controlled Waters

The engineering works and installation of hardstanding and drainage infrastructure will reduce the risk of future infiltration and mobilisation of contaminants. Due to the soft, compressible nature of the underlying TFDs, a controlled modulus columns (CMC) approach was proposed as the foundation solution for the development.

It is understood that historical piles, which remain in place, were used during the construction of the former steelworks and they have been used throughout recent developments within the surrounding area. More recently, Controlled Modular Columns (CMCs) have been used (Units 4, 5, 6 & 7) as an alternative to the standard driven piles. A method statement prepared by Vibro Menard and a layout example has been appended to this note.

The CMC installation process involves the penetration of a rotary displacement auger into the ground to the required depth via a high torque capacity and high static down thrust rig. As the drilling tool withdraws, grout is injected through the hollow stem of the drilling tool³. The rotary displacement auger laterally displaces the surrounding material (Tidal Flat Deposits), increasing local density as the material cannot return to the surface. The grout, under the head of pressure, creates a lateral seal as the concrete flows into the small fissures and pore spaces surrounding the column. Each column is completed in one action.

The installation of CMC's is not considered to create new pathways for the following reasons.

³ Nguyen H.H., Khabbaz H., Fatahi B., Vincent P., (2014) Sustainability Considerations for Ground Improvement Technique using Controlled Modulus Columns. *AGS Symposium*.

- No spoil is generated during the installation of the piles and the installation process will densify the surrounding geology as it is displaced laterally during insertion, resulting in reduced permeability around the piles, effectively creating a seal and reinforcing soft soils.
- Disturbance to the surrounding soft ground is possible but the impact should be limited as the concrete flows into localised joints and fissures. The CMC methodology and geology of the Site effectively creates a seal around the piles thus preventing vertical movement between the shallow and deeper groundwater bodies.
- There is the possibility of some contamination being dragged down on the toe of a pile. This is likely to be a very small amount of material, it is unlikely to reach a depth where it may come into contact with regional groundwater; and the regional groundwater is considered to be a pathway to the estuary and not a receptor (thus its environmental setting will not have been significantly altered).
- The combination of the low permeable concrete, bulb-shaped base of the column and the strong bond formed between the concrete and surrounding soil, significantly reduces the risk of contaminants moving downward into deeper aquifers or soil gases migrating upward.
- Further evidence for an effective seal is demonstrated by the sub-artesian regional groundwater being unable to travel upwards via existing piles; the evidence comes from the lack of groundwater seepage observed around pre-existing piles during reclamation works for previously erected Units 4, 5, 6 and 7, when it is known that water is confined within the Tidal Flat Deposits.

The CMC concrete is injected filling the fissures and the column void. This creates a seal, inhibits the vertical movement of water maintaining the competency of the Tidal Flat Deposits in confining regional sub artesian groundwater.

Once constructed, the potential for the columns to create new pathways is considered to be negligible due to the cohesive nature of the surrounding geology.

6.3 Ground Gas

With respect to risks from ground-borne gas, typically associated with the peat layers of the Tidal Flat Deposits, it is not considered that CMCs will act as a pathway. This is due to the increased density of soils around the column and the injection of grout creating a seal as it fills available spaces within the soils surrounding the columns. Therefore, it is considered that the pathway for ground borne gas is unchanged.

The assessment of gas protection measures is recommended prior to development to ensure the gas mitigation is appropriate for the remediated site conditions. Gas protection measures across the wider site have previously been in accordance to Characteristic Situation 2 and are likely to be similar for Units 15, 16, 17 and 18. These will be designed and the installation validated in accordance with the requirements of BS8485:2015+A1:2019 (i.e. ventilation, gas resistant membrane and reinforced concrete floor slab).

7 CL:AIRE– Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention

7.1 Introduction

The guidance published in 2025 builds on recent research into the effects of piling on contamination migration and includes a better understanding of the risk posed by increased turbidity in aquifers caused by piling works. This guidance includes bearing pilers such as controlled modulus columns proposed for this site.

7.2 Pollution Scenarios

The guidance defines seven potential pollution scenarios related to foundation works and considers the generic and method-specific risks that may arise under each of these scenarios. Table 14.1 from the guidance is reproduced below and confirms that in general penetrative ground improvements such as vibro-concrete columns and CMCs carry relatively low risks, compared to other methods (In the table A indicates negligible risk, B low risk, C moderate and D is high risk.). Nevertheless, risks vary from scenario to scenario and from method to method, so additional assessment is provided below.

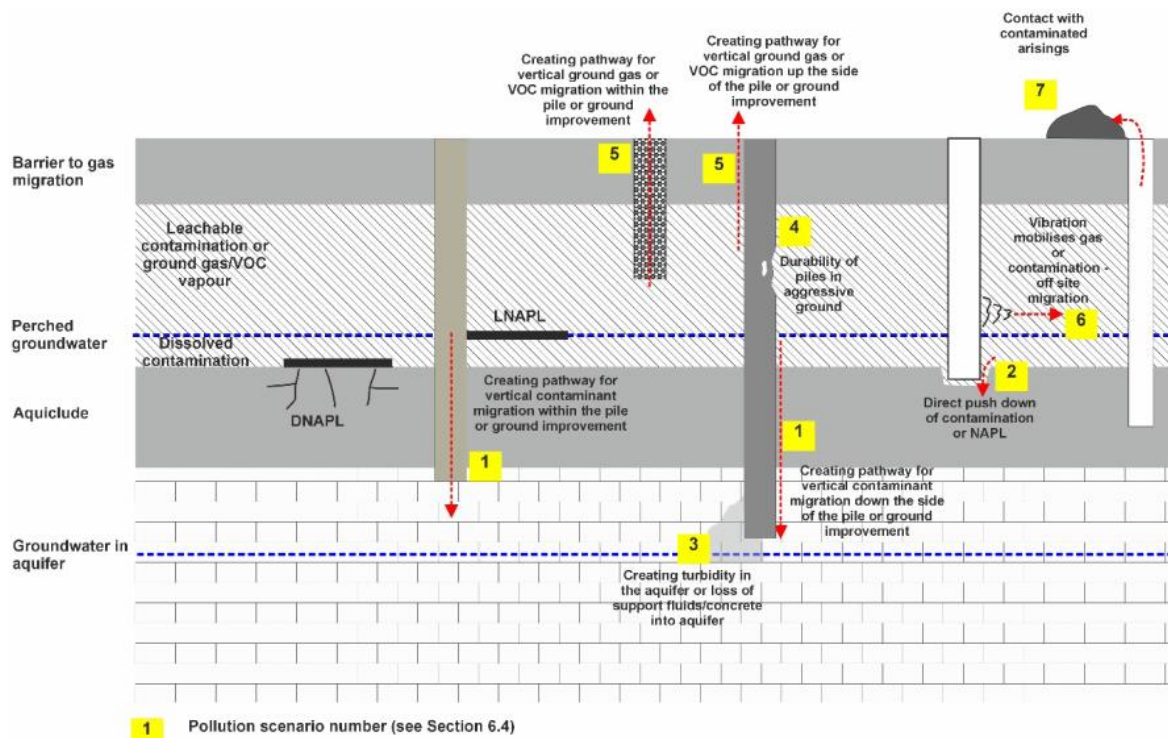
Table 14.1 extracted from CL:AIRE Guidance presenting indicative hazards for piling and ground improvement

Pollution scenario	Displacement piles	Replacement piles	Sheet piles	Penetrative ground improvement	Prefabricated vertical drains
1: Creation of preferential pathways, through a low permeability layer, to cause contamination of groundwater in an aquifer.	A-D (dependent on details of method)	A-C (dependent on details of method)	A-B	D (stone columns) A (vibro concrete columns)	D
2: The driving of solid contaminants down into an aquifer during pile driving.	A-B	A	A	A	A
3: Contamination of groundwater and, subsequently, surface waters by concrete, cement paste or grout.	A	C-D (dependent on details of method)	A	A (stone columns) D (vibro concrete columns)	A
4: Direct contact with contaminated soil or leachate causing degradation of pile materials.	A-C (dependent on pile materials and contaminants)	A-C (dependent on pile materials and contaminants)	A-C	A-B (dependent on pile materials and contaminants)	A
5: Creation of preferential pathways to allow migration of landfill gas or contaminant vapours to surface.	A	A	A	C (stone columns) A (vibro concrete columns)	D
6: Causing off site migration of ground gas or increased vertical emissions as a result of vibration or other effects from the pile installation process.	A-B	A	A	A-B	A
7: Direct contact with contaminated soil arisings which have been brought to the surface.	A	B-C (dependent on contaminants)	A	A	A

7.3 Assessment of Specific Risks

Section 5 of the guidance sets out the range of potential hazards from piling, which are summarised in the diagram below, taken from Figure 5.1 of the guidance.

Figure 5.1 repeated from the CL:AIRE Guidance indicated potential hazards



Using figure 5.1 we can assess the risk pathways for each of the seven pollution scenarios.

No.	Mechanism	Assessment	Ref from CL:AIRE Guidance ⁴	Risk
1	Vertical pathway within pile or beside a pile	CMC consists of concrete placed under pressure and leaves no void space within the pile. The mechanism therefore does not allow for the creation of this kind of pathway.	7.5	Insignificant
2	Direct push down	CMC is advanced using a displacement auger, with subsequent emplacement of concrete. According to CL:AIRE (2025), literature indicates that this does not displace significant quantities of material downwards and that downward displacement distances are very limited. Furthermore, the nature of the (well tested) fill material is such that the soils contain relatively minor concentrations of contaminants, and that the contaminants of concern (hydrocarbons and metals) are highly sorbed and, in the case of hydrocarbons, degradable. The risk of any significant transport in the	8.2, 8.5	Very Low

No.	Mechanism	Assessment	Ref from CL:AIRE Guidance ⁴	Risk
		mudstone bedrock proven beneath the site is therefore very low. ⁵		
3	Groundwater affected by turbidity or loss of concrete to the aquifer	These pathways are considered viable only under conditions of fast groundwater flow – fissured aquifers or very permeable granular aquifers. The Mercia Mudstone formation does not provide these conditions.	9.1	Insignificant
4	Degradation of piles in aggressive ground leading to pathways opening	Acid ground could degrade the CMC concrete. However, the Tidal Flat Deposits that provide the barrier to vertical groundwater movement are not acidic, and the plastic clay nature of the deposits would tend to close up any openings that might appear in the event of concrete degradation.	10.1	Very Low to Insignificant
5	Vapour migration to surface	The ground is not known to contain significant gas or VOC concentrations. As noted at no.1, CMCs do not foster the creation of vertical pathways. Any pathway that might be created would in any case be broken by gas protection measures in the building design.	11.1	Insignificant
6	Off-site migration or increased vertical emission of gas	As noted at no.5, the ground does not contain significant ground gas or VOC concentrations. Any vertical migration would in any case be dealt with by gas protection measures.	12.5	Very Low to Insignificant
7	Direct contact with contaminated arisings	The CMC method produces no arisings and there is therefore no source to maintain this contaminant linkage.	13.1	Insignificant

⁴ Relevant reference in CL:AIRE (2025), copied below for convenience.

⁵ CMCs sometimes have wick drains placed between them to increase the rate of sediment consolidation. However, these can provide a pathway for contaminant migration. They are not proposed for use in this case.

CL:AIRE 7.5

Ground improvement methods are installed by displacement methods so soil surrounding the columns will be densified, reducing the permeability of the surrounding soil. With vibro concrete columns the infill concrete is effectively impermeable and cast in contact with the surrounding soil and formation of preferential pathways is not likely. Rigid inclusions will also be formed from material that has a lower permeability than the surrounding ground and will not create pathways.

CL:AIRE 8.2

Driven displacement piles may potentially drag down contaminated material as they penetrate underlying strata. [This] is not a problem with screw piles.

CL:AIRE 8.5

Penetrative ground improvement methods involve horizontal displacement and densification of the soil through which the column is constructed. In normal circumstances this will not lead to soil being dragged downwards.

CL:AIRE 9.1

Loss of wet concrete, cement paste or grout may occur, but only in fast-flowing groundwater.

CL:AIRE 10.1

There are examples where aggressive ground conditions have caused structural issues in below ground concrete, predominantly associated with high sulphates and acidity, but no known examples where this has caused contaminant migration.

CL:AIRE 11.1

There are no known sites where the installation of piles or ground improvement has resulted in an incident with increased gas or vapour concentrations inside buildings or other structures off site. On sites with low gas generation potential, the main limitation is the source itself in that it is not likely to be able to generate sufficient gas to sustain the rate of gas migration required to pose a risk to off site receptors (gas has to be continuously replenished to support off site migration).

CL:AIRE 12.5

Ground improvement is designed to densify the ground and therefore there is the risk of reduced volume of space for gas. The gas is far more likely to migrate up the stone columns than any distance horizontally. Therefore, gas migration off site is not considered to be a significant risk when installing stone columns. For other types of improvement, the vibration is not sufficient or prolonged enough to cause significant volumes of gas to migrate off site.

CL:AIRE 13.2

Displacement piling will not generally create arisings that need to be managed.

8 Conclusion

The hydrogeological setting (shallow, perched water not being in continuity with deeper groundwater and lack of a sensitive groundwater receptor) combined with the proposed CMC methodology are such that the potential for creating a preferential pathway between a source and the deeper lying groundwater bodies is considered negligible. Furthermore, the completed development will significantly reduce the potential for infiltration of rainwater into the Made Ground, with the building and associated hardstanding intercepting a significant proportion of the surface water.

The upper layer of the Mercia Mudstone Group below the Site, was noted in the Atkins 2016 ground investigation to comprise stiff, silty clay, rather than one of the sand dominated layers within the group. This silty clay/ mudstone portion of the Mercia Mudstone Group is not anticipated to yield abstractable volumes of water in its uppermost layers. The TFDs overlying the Mercia Mudstone Group are classed as Unproductive Strata, although sub-artesian groundwater was encountered at the base of the strata

Therefore, it is considered that the risks posed from CMC ground improvement at the Site to the underlying groundwater are negligible and the ground gas risk unchanged. The discussion can be summarised as follows:

- A competent foundation solution will be required due to the significant depth to competent strata, and so CMCs have been proposed as a form of ground improvement.
- No spoil will be generated during CMC installation as soils are displaced laterally. Additionally, the density of the superficial geology is increased, further reducing the permeability of the deposit and reinforcing any soft soils.
- Disturbance to the surrounding soft ground is possible but the impact should be limited as the concrete flows into localised joints and fissures. The CMC methodology and geology of the Site effectively creates a seal around the piles thus preventing vertical movement between the shallow and deeper groundwater bodies.
- Perched water volumes will be reduced as further infiltration is greatly reduced by the construction of hardstanding and drainage, resulting in an overall reduction in the mobilisation of contaminants from the Made Ground.
- Whilst groundwater is present within the base of the Tidal Flat Deposits (and possibly locally in the Mercia Mudstone Group), there are no known potable abstraction wells within the vicinity of the Site and industrial abstractions are all listed as 'historical'; the Site is not within a groundwater Source Protection Zone and the shallow geology is classed as Unproductive Strata. Furthermore, there is a very low likelihood of the Mudstone aquifer being used as a resource and its location on the edge of the estuary.
- The Mercia Mudstone underlying the Site, has not shown in the ground investigation to contain water-bearing strata in its uppermost layers and may also be considered Unproductive Strata.
- The building will benefit from appropriate gas protection measures likely to be CS2. Hence, will be designed to be protective of ground borne gases from the Tidal Deposits and potential sources within the Made Ground.

As a result, RLL do not believe that CMCs will create a pathway between perched water and deeper groundwater. The risk of gas migration is thought to be low but will be mitigated with appropriate protection measures as part of the building design.



Drawings

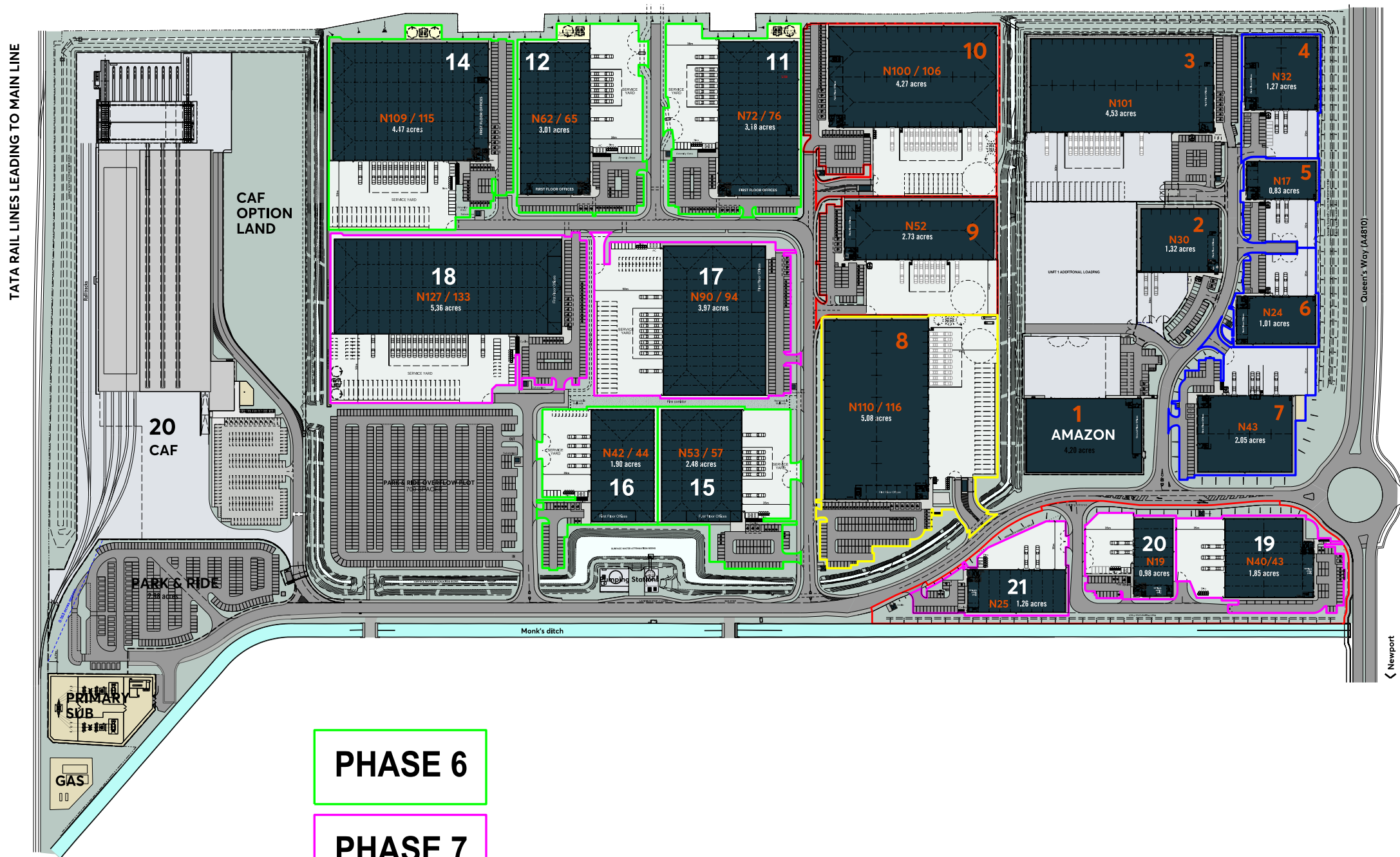
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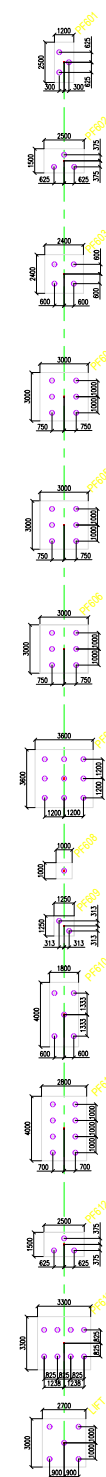
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Drawing Revisions

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CMC Methodology

4 TECHNICAL

4.1 Description of the ground reinforcement technique

The Controlled Modulus Columns soil reinforcement technique is intended to improve the soil globally and to reduce its deformability by the use of rigid concrete inclusions. It does not aim to bypass the compressive ground or to build piles that will directly support the entire load from the structure. The objective is to reduce global and differential settlement by relieving the soil from a part of the loads imposed by the structure.

These columns distribute the loads uniformly throughout the soil mass that thus behaves as a composite [concrete column + surrounding soil material]. The entire process is vibration free and operates in-the-dry without spoils, which allows for cleaner project sites.

Controlled Modulus Columns can be considered as a particular type of Rigid Inclusions that can be carried out with a various number of execution method (rotation, vibration, percussion...).

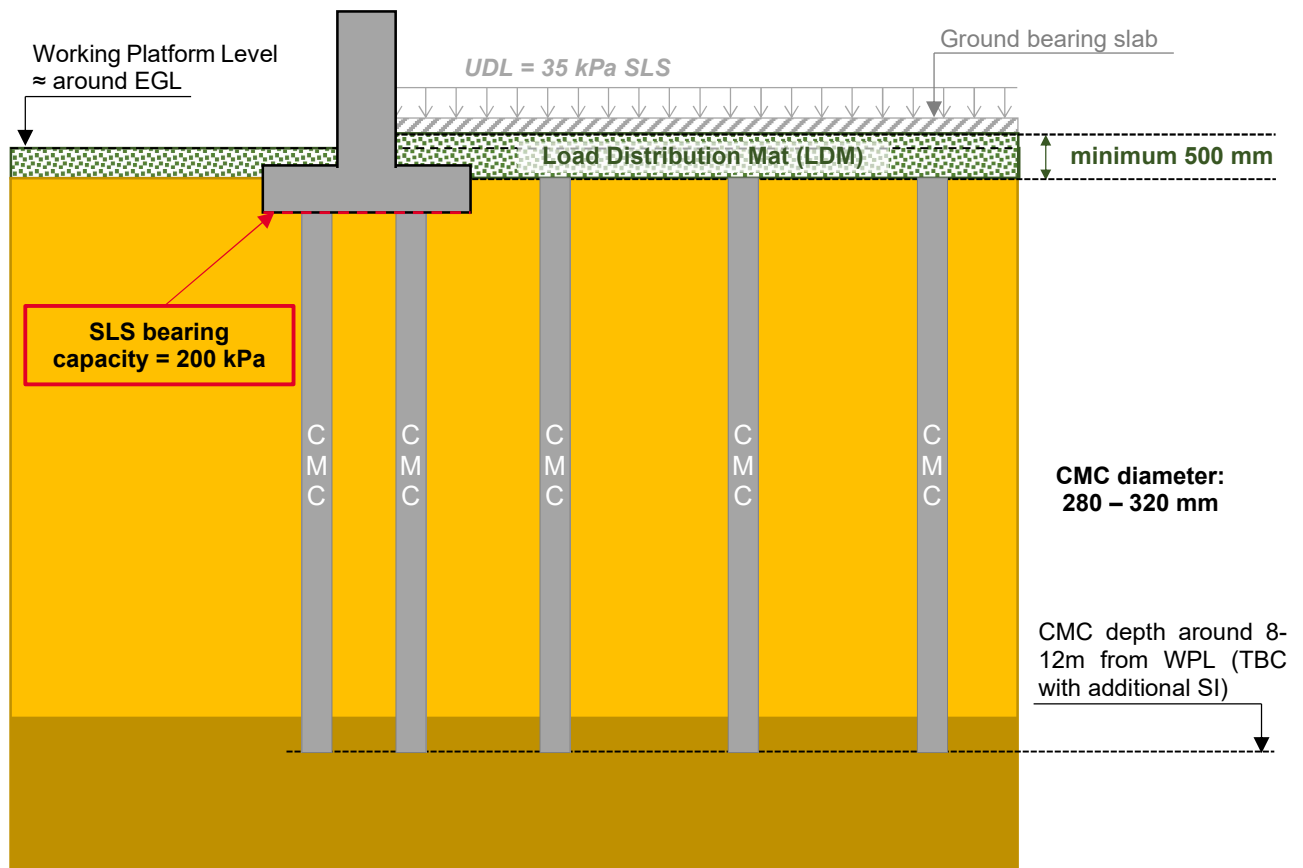


Figure 2 - Typical cross section of footing and ground bearing slab on CMC

4.2 Method of execution

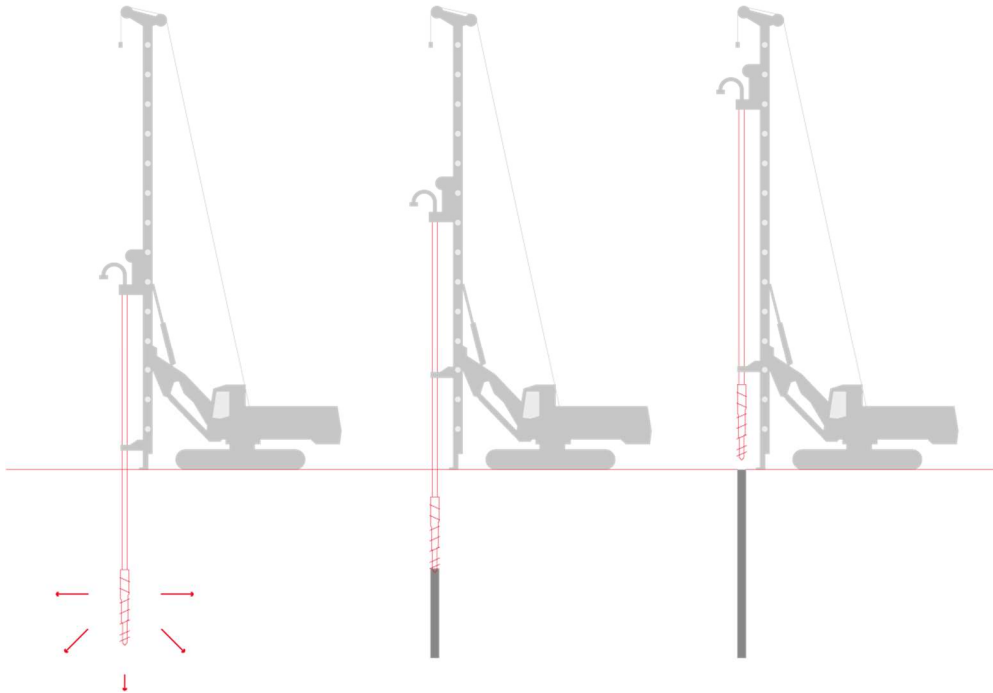


Figure 3 - CMC installation process

A specially designed auger, powered by equipment with large torque capacity and high static down thrust, displaces the soil laterally, with virtually no spoil or vibration. The displacement auger is pushed into the ground to the required depth resulting in a local increment of the density of the surrounding soils around the auger. *In the case that one or several layers to drill are too compact, a regular CFA auger can be used.*

During the auger extraction process, a column is developed by grouting under controlled limited pressure (less than 5 bars) through the stem of the displacement auger to achieve a predetermined stiffness ratio with the surrounding soil. The result is a composite soil/concrete ground improvement system. Current practice is to install columns with diameter varying between 280 and 450 mm.



Figure 4 - CMC setup on site