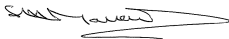


Design Note

Project OVG Manchester
Subject Grouting Works: Groundwater Risk Assessment [BRA-BHE-XX-XX-DN-CG-0001]
Project no 0042841
Date 7 October 2020

Revision	Description	Issued by	Date	Approved (signature)
P01	For Information	FG	25/09/2020	HM
P02	For Information	FG	07/10/2020	HM 

1 Introduction

1.1 Background

It is proposed to undertake grouting works on mine workings underlying the Project Bradford site to provide efficiencies in the pile design. A geoenvironmental risk assessment report (BRA-BHE-XX-XX-RP-CG-0004 P04) [1], a Coal Mining Risk Assessment report (BRA-BHE-XX-XX-RP-CG-0005) [2] and a Remediation Strategy [3] have been prepared with respect to the proposed development do not specifically consider the risk to groundwater associated with the proposed grouting operations.

Accordingly, this Design Note has been prepared to assess those potential risks. It has been prepared on the basis of the contractor's proposals for grouting, taking account of all of the information in the above report and in accordance with guidance provided in the Environment Agency Regulatory Position Statement (RPS 108) [3] and by CIRIA (in particular Chapter 13) [4].

1.2 Aim and objectives

The overall aim of this assessment, together with the contractor's contingency procedures) is to ensure that the proposed grout works (which include some injection below the water table), will not have a detrimental impact on controlled waters (the groundwater regime in the Coal Measures) and the nearby surface water (River Medlock).

The specific objectives of this Design Note are addressed in two Parts in the following text:

Part A

1. To review and summarise data with respect to the site's conceptual site model, including mining (Section 2),
2. To describe the proposals for grouting (Section 3),
3. To carry out a risk assessment and identify appropriate mitigation measures (Section 4 and Table 1).

Part B

1. To provide a direct response to the 'Our Approach' section set out by the EA in the Regulatory Position Statement (RPS) 108 – Grouting Media; and
2. To address the 'Appropriate Assessment Record' as set out by the EA in Appendix 1 of the RPS 108.

This text is supported by Drawings (referred to in the text) and by particular information presented in two Appendices;
Appendix A – Groundwater level monitoring proposal (subject to approval by the EA)
Appendix B – Grouting Philosophy by Skanska Cementation Ltd and BAM Construction Ltd.

Part A

2 Conceptual site model

2.1 Geology

The ground conditions comprise variable thicknesses of Made Ground (Fill), ranging between 1.3m up to 17.2m thick. Typically, Made Ground was recorded to greater depths in the north and western parts of the site. The variations can be attributed to the development history (e.g. Bradford Road Gas Works), treatment to mine workings and numerous phases of enabling works across the site. Below the Made Ground the natural geological sequence is formed of Alluvium and/or River Terrace Deposits (<0.5m to 3.0m thick) to the west and north; Glacial Till (0.9m to 12.0m thick) to the east and south; the Pennine Upper, Middle and Lower Coal Measures (base not proven). The Coal Measures comprise interbedded layers of predominantly mudstone, with sandstone, siltstone and coal. Faulting has been recorded within the area, the nature and extent of the faulting is not known. This geological sequence is illustrated on Drawing (see drawings within the Remediation Strategy [3])

2.2 Summary of mining (coal seams and mine shafts)

The type of mine working that has taken place on site is coal mining associated with Bradford Colliery. Bradford Colliery was formerly located to the south of the site beyond Ashton Canal. Abandoned mining plans indicate that worked shallow seams sub-crop within the site, namely the Bradford Three Quarter Seam and the Bradford Four Foot Seam. More detail on this can be found within the Coal Mining Risk Assessment report [1]. Based on review of previous reports and the geological maps, both seams strike in a NW-SE direction and dip between 15° and 25° southwest. Other coal seams (which were not known to be worked) also sub-crop within, or near to, the site at a similar orientation both up and down dip of the known worked seams (Bradford Three Quarter and Bradford Four Foot). Based on the latest site investigations, these shallow coal seams were identified within 60m depth of the current ground levels (between approximately +56.0m OD and +60.0mOD).

Coal abandonment plans show further coal seams (Crombouke and Roger) which were worked at depth (>700mbgl) beneath the site, associated with Bradford Colliery. The method of working for the Roger seam is long wall and for Crombouke it is not clearly shown but is also assumed to be long wall. Further details on these seams can be found within the Coal Mining Risk Assessment report [1].

There are multiple mine shafts within the site confines. The Coal Authority and historic shaft plans all show three shafts, namely:

- **386398-004** (also referred to as Shaft A or Shaft 12, and possibly Shaft 21). Drilled, grouted and capped in 1986 by Ward Ashcroft and Parkman.
- **386398-003** (also referred to as Shaft B, 13 and possibly 22). Drilled, grouted and capped in 1986 by Ward Ashcroft and Parkman. Further grouted in October 2010 using 55 tonnes of cement-based mix. Capping was estimated as being 300mm thick and positioned some 11mbgl.
- **386398-010** (also referred to as Shaft C and possibly shaft 23). Shaft searched for in 1977 but not located. Searched and located in 2010 using a series of probe holes. The shaft was pressure grouted using 5.5 tonnes of pulverised fly ash (PFA) / cement mix grout. A grout plug using a 5:1 mix of PFA / cement was installed above the shaft.

A mining abandonment plan shows approximate locations of potential adits located across the site. These are presented within drawing BRA-BHE-XX-XX-DR-GE-0105. One entrance point to the network of possible adits ties in with the former location of the River Medlock, where it previously passed through the north-west corner of the site.

2.3 Summary of site investigation information

Based on the recent site investigation cross sections have been developed (see drawings within the Remediation Strategy [3]) illustrating the approximate extent and thickness of the various coal seams identified below the site. Groundwater levels are also shown within these sections.

During the ground investigation, extensive Made Ground was encountered, particularly in the north-western part of the site (circa 17m). Within this area the Made Ground is directly underlain by the Coal Measures bedrock. There is a potential that where coal sub-cropped in the area, opencast mining methods may have been used. This area is also where the River Medlock previously passed through the site and an adit entrance point may also be present (see drawing BRA-BHE-XX-XX-DR-GE-0105).

The site was previously grouted in 2011 by BWB, targeting the worked seams, namely Bradford Three Quarter and Bradford Four Foot. No significant grout takes were encountered, see the Coal Mining Risk Assessment report [1] for more details. However, minor voids were still encountered in localised areas during the recent site investigation. These voids have been highlighted on the constraints plan (BRA-BHE-XX-XX-DR-GE-0101).

A six-week programme of ground gas and groundwater monitoring was carried out following the recent site investigation. Details of this monitoring can be found within the Geoenvironmental and Geotechnical Interpretative Report [2]. The groundwater levels have been summarised below in Figure 1 with the distribution shown in drawing BRA-BHE-XX-XX-SK-GE-0005. Shallow perched groundwater was encountered at various depths (up to 15mbgl) within the Made Ground. The Coal Measures groundwater table is between +37m OD and +39.0mOD (i.e. greater than 20m below current ground levels) and there is no evidence of a consistent / substantial groundwater flow direction. All coal seams, based on the dip and dip direction, are to some extent below this groundwater level.

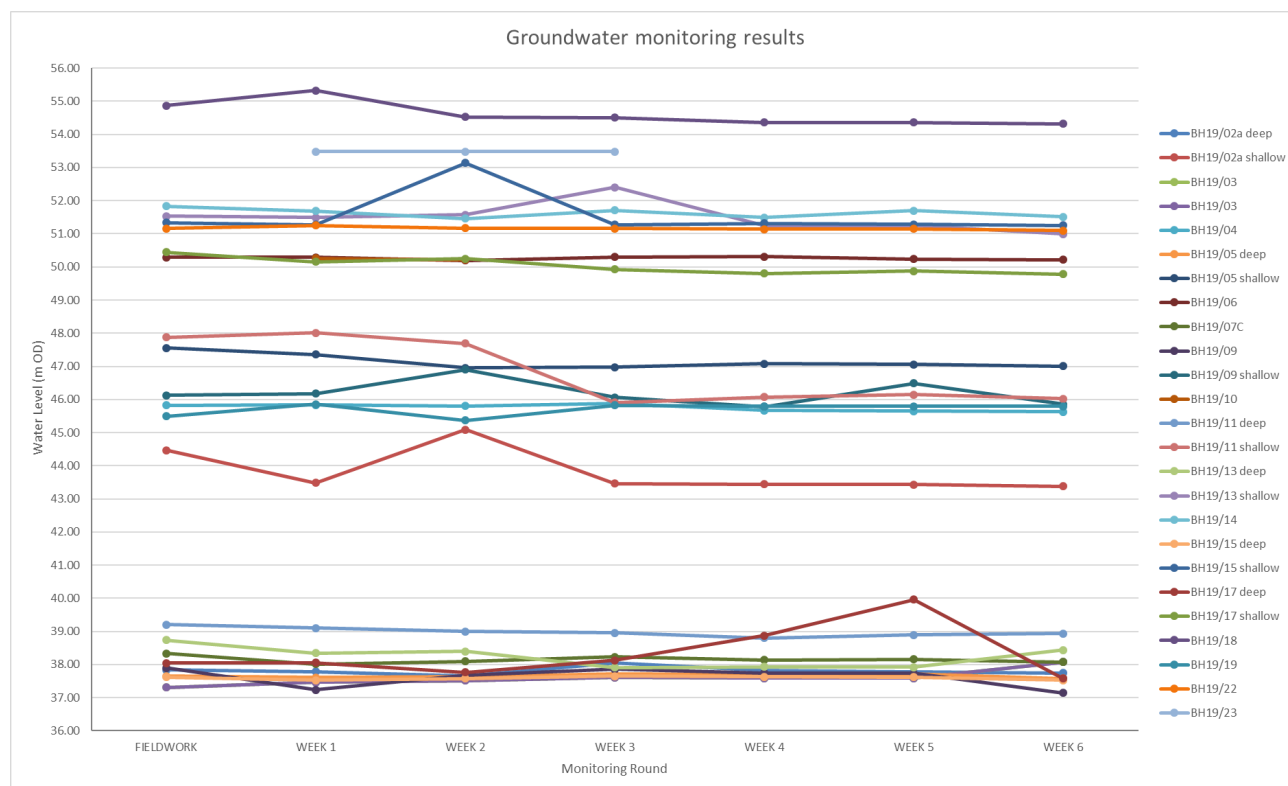


Figure 1 Groundwater levels (perched in the Made Ground and Coal Measures)

3 Grouting Proposal

The full detailed grouting proposal has not yet been produced by the sub-contractor. This note is based on the following preliminary documents:

- Cementation Skanska Ltd (2020). "Method Statement for Proposed Grouting Works, Project Bradford, Manchester".
- BAM (2020). "Project Management Plan for: OVG Manchester, Site Investigation and Remediation for Historic Coal Mining".

3.1 Treatment Objectives

The grout treatment work is proposed to allow suitable and safe design and build of an arena across the site. The site is currently open land with some vegetation at the periphery. The treatment objective is to fill any voids present due to the historic mining to reduce the risk of self weight collapse settlement and facilitate a more economic pile design scheme.

3.2 Grout treatment proposals

A summary of the current proposal is provided below:

- The site will be probed to determine the area requiring treatment
- The triangular grid undertaken will be determined by the conditions encountered on site, however the maximum grid spacing will be 5m
- Where necessary holes will be inclined to avoid vegetation and existing services
- Temporary casing will be installed to the depth of rockhead (varies between 11.5mbgl and 18mbgl)
 - Casing will be 76mm and drill rods 48mm
- Drilling will be progressed using water flush
 - Settlement skips will be utilised to deal with water flush returns and prevent surface run off causing drainage contamination and blockage
 - Slurry and grout run off will be dealt with using sandbags, discharge routes and catchment areas for collection by a specialist waste contractor
- Validation of these operations is to undertake one validation hole per 1,000m² (total area proposal area is approx. 21,000m²)

The following plant will be utilised in these works:

- Mini piling rig
- Grout mixer, silo and pump
- Compressors
- Telehandler
- JCB
- Fuel Bowser
- Ancillary Tools (Drilling)

4 Groundwater risk assessment and mitigation

A full description of the groundwater testing and analysis undertaken is provided in the Buro Happold Interpretive Report (BRA-BHE-XX-XX-RP-CG-0004 P04) [2]. A conceptual site model has been produced (see drawing BRA-BHE-XX-XX-SK-GE-0004) to illustrate potential pollutant linkages (specifically the River Medlock).

4.1 Receptors

The Secondary A Aquifer - The Secondary A Aquifer within the Coal Measures is not considered as a sensitive receptor at this location (but it does have the potential to be a plausible migration pathway). The aquifer is not considered a sensitive receptor with respect to contamination as its quality has already been degraded due to the mining and industrial history, the nature of the Coal Measures aquifer itself, the apparent the absence of local abstractions and the absence of a consistent / substantial groundwater flow direction. In addition, the previous grouting will have affected its capacity, although, records from those works indicate that this impact was relatively limited (grout take was limited). However, as described above, minor voids were encountered in localised areas during the recent site investigation. On the basis of all of the above, the proposed grouting up of these remaining voids is most unlikely to have any significant or measurable effect upon the quality or properties of the aquifer.

River Medlock - The groundwater table within the Coal Measures was consistently between +37.0m OD and +39.0m OD, see Figure 1 above (distribution shown in drawing BRA-BHE-XX-XX-SK-GE-0005). Previously the River Medlock passed through the northwest corner of the site, today it passes through a culvert 24m north of the site boundary. The culverted River currently sits at approximately +41.7m OD and the flow direction is south-west. Entrance points to the culvert are located 120m north within Philips Park and 340m west. It is most unlikely that there is hydraulic continuity between the culverted River and the groundwater in the Coal Measures aquifer. There does not appear to be any discernible pattern relating to groundwater flow direction on the site. There is no evidence that groundwater flow is in the direction of the river or to other surface water features. Nonetheless the water in the River Medlock is considered as a sensitive receptor with respect to the proposed grout works and therefore is subject to assessment below.

Perched Water - Perched water was recorded in localised areas within the Made Ground and at the boundary between the Glacial Till or Alluvium and Made Ground, see Figure 1. There is no evidence that these bodies of water are in continuation with one another or with offsite receptors, they appear to be present due to depressions in low permeability materials which inhibit downward percolation of rainwater. A small number of the wells also encountered water within the Glacial Till, these pockets of water will likely be confined to more granular lenses within the Glacial Till, also not in continuation with one another. Perched water is not considered as a sensitive receptor with respect to the proposed grout works and therefore is not considered further within this assessment.

Ashton Canal - The Canal is located along the southern boundary of the site (8m south). The canal climbs for 10.8km through 18 locks toward Ashton-under-Lyne. Lock No.9 is located adjacent to the site resulting in approximately 3.5m ground level change. To the east side of Lock No. 9 (SE of the site) the level is at approximately +60.4mOD and to the west of the lock (SW of the site) the ground drops to +56.7mOD. A steep embankment up to the site is present on the west side with the site at approximately +59.0mOD. The water in the Ashton Canal is considered as a sensitive receptor with respect to the proposed grout works and therefore is subject to assessment below.

Mine shafts - On occasion, the change in below ground circumstances can trigger a mine shaft to collapse or seams to collapse (induced stress to roof strata or pillars of lower seams). The existing shafts on site have previously been grouted and either plugged or capped. Grout works in 2011 by BWB confirm the extent of the fill within these shafts, the details can be found within the Coal Mining Risk Assessment report [1]. Based on this information it is not possible for the mine shafts to collapse due to groundwater displacement. Mine shaft collapse has not been considered further within this assessment.

Existing utilities - All existing utilities drains have been identified (see Drawing BRA-BHE-XX-XXX-DR-C-0020). Grout has the potential to travel long distances in flowing water and, once cured, is very difficult to remove. All existing drains will be removed prior to the grout works taking place with the exception of the existing United Utilities sewer running N-S centrally through the site, this will form part of the grout works and be infilled. The existing utilities are considered a sensitive receptor with respect to the proposed grout works and therefore are subject to assessment below.

Occupiers of neighbouring land - Infill grouting can drive contaminated waters to the surface, or beneath neighbouring property, thereby creating a potential hazard. As described above, there are no local groundwater abstractions that could be adversely affected by the proposed grouting. There is also no plausible potential for the contaminated waters within the Secondary A Aquifer to reach the surface and cause harm to occupiers of neighbouring land as a result of the proposed grouting. On this basis occupiers of neighbouring land have not been considered further within this assessment.

4.2 Pollutant linkages

With respect to the proposed grout works and in accordance with the relevant CIRIA guidance, C758D [3] a groundwater risk assessment has been produced to determine the nature and extent of the risks from the proposed grouting upon the controlled waters (River Medlock and Ashton Canal), mine shafts and existing utilities.

Consideration has been given to dissipation rates of groundwater. The rate of filling below the groundwater table is dictated by the rate at which water is displaced and the type and nature of the fill dictates the potential for introduction of pollutants from the grouting operation. The permeability of the strata, extent of the voids and in the case of the shafts, the lining details will dictate how and where grout, displaced water and mobilised fill will migrate. Groundwater monitoring and sampling, installation of a perimeter boundary and possible groundwater/mine water pumping may be required during grouting to ensure sufficient grout take and infill.

All potential pathways and receptors associated with the grout works have been considered below within the groundwater risk assessment (Table 1) in general accordance with C758D [3] and consistent with C552 risk evaluation tables [4].

Design Note

Table 1 Groundwater Risk Assessment and proposed mitigation

Source	Potential Pathway	Sensitive Receptor	Consequence	Probability	Risk	Hazard realisation and mitigation	Completion / actions
Grout works within previously mined coal seams to infill voids (i.e. Bradford Four Foot and Bradford Three Quarter Seams)	Infill grout driving contaminated waters to surface or via permeable horizons (Coal Measures, River Terrace Gravels)	River Medlock	Medium	Unlikely	Low	No significant grout takes were encountered during the previous grout treatment works and only minor voids encountered during the recent site investigation. Hydraulic continuity between culverted River and groundwater in the Coal Measures aquifer is unlikely. No evidence of consistent groundwater flow in direction of the River. Mitigation Continuous inspection of River Medlock entrances and culvert during works (see Appendix A). Further specific groundwater level monitoring should be carried where any significant voids are encountered / grout takes recorded (see Appendix A and drawing BRA-BHE-XX-XX-SK-0005). Contingency / management plan in the event monitoring records displaced groundwater and/ or substantial grout takes (refer to Appendix B – Grouting Philosophy).	All records should be compiled and included within the Contractors completion report.

Source	Potential Pathway	Sensitive Receptor	Consequence	Probability	Risk	Hazard realisation and mitigation	Completion / actions
	Surface water run-off (i.e. surface handling of grout, temporary stockpiles, fluidised drill flush returns)	Ashton Canal	Medium	Unlikely	Low	Canal is adjacent to site boundary and down gradient. Continuous monitoring should be carried out to inspect Ashton Canal. Mitigation Control of surface operations: Locate potentially hazardous materials away from sensitive location. Ensure any temporarily stockpiled material/fluid is lined and confined. Detail to be provided Contractors method statements. Implementation of standard good practice (spill control measures).	All records should be compiled and included within the Contractors completion report.
	Grout travelling with water flow	Existing utilities	Minor	Low likelihood	Very Low	Utilities on-site present in locations with potential for impact Mitigation Existing drainage routes and manholes have been investigated and identified. All existing drains will be removed prior to the grout treatment work with the exception of the United Utilities Sewer which will form part of the grout work and be sealed and infilled. Contingency / management plan in the event monitoring records displaced groundwater and/ or substantial grout takes (refer to Grouting Philosophy in Appendix B).	CCTV carried out, see Drawing BRA-BHE-XX-XXX-DR-C-0020 for drain locations and detail. All records of the sewer grout infill should be compiled and included within the Contractors completion report.

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Part B

5 Response to Regulatory Position Statement (108)

The EA require a response to the following criteria as set out in the RPS 108 – Grouting Media under ‘Our Approach’:

1. The location does not fall within a groundwater Source Protection Zone 1.
 - a. No, the site does not fall within a groundwater Source Protection Zone 1.
2. The injection is solely below the ground surface.
 - a. Yes, the injection of grout will be below rock head level (>11.5mbgl) and down to approximately 38.0mbgl (anticipated deepest probes of this depth in NW corner).
3. The activity complies with the requirements of any necessary planning approvals.
 - a. Yes.
4. You have carried out an assessment of the ground conditions and potential receptors and are able to confirm the pollution will not occur from your operation.
 - a. Yes, a full assessment of the ground conditions is presented within the Buro Happold Interpretative Report (BRA-BHE-XX-XX-RP-CG-0004 P04) [2] which confirms there are limited pollution pathways to sensitive receptors (i.e. River Medlock). This has been further clarified by the risk assessment presented in Table 1 of this report.
5. The operation does not involve the discharge of hazardous substances or non-hazardous pollutants other than those inherently part of the solid content of the grout or other media essential additives.
 - a. No, see Appendix B (Skanska Cementation Ltd Grouting Philosophy) for details of the solid content of the grout media.
6. The materials forming the grout or other media comply with all relevant waste protocols, such as the quality on use of PFA, and any other relevant code of practice.
 - a. Confirmed. See Appendix B (Skanska Cementation Ltd Grouting Philosophy).
7. There will be no liquid discharge other than slurry formed by grout or other media in admixture with water.
 - a. Confirmed. See Appendix B (Skanska Cementation Ltd Grouting Philosophy).
8. The activity does not constitute or form part of another regulated facility such as an installation, waste or mining waste operation as listed in EPR 2010 Regulation 8.
 - a. No.

6 Appropriate Assessment Record (as set out in RPS 108 Appendix 1)

Table 2 Relevant contact details

Name	Address	Contact
Buro Happold Ltd (Company)	230 Lower Bristol Rd Bath BA2 3DQ	0122 532 0600 Francesca.Gould@burohappold.com Hugh.Mallett@burohappold.com
Cementation Skanska Ltd (Company)	Maple Cross House Denham Way Maple Cross Rickmansworth Hertfordshire WD3 9SW	0797 160 9584 Caroline.Rookes@Skanska.co.uk Jody.Parkins@Skanska.co.uk
BAM Construction Ltd (NW) (Company)	Metro, 2 nd Floor 33 Trafford Rd Exchange Quay 2 Salford M5 3NN	0776 874 5900 PLondon@bam.co.uk
Turner & Townsend (Company)	6 th Floor 55 Spring Gardens Manchester M2 2BY	0161 237 7750 Ross.Cuming@turntown.co.uk

Address and National Grid Reference:

The proposed grout works will take place on the site located at National Grid Reference SJ 86841, 98878, off Sportcity Way, Manchester M11 3DU.

Nature of activity or discharge:

The proposed work includes injection of grout along the former worked coal seams beneath the site (Bradford Three Quarter and Bradford Four Foot). These seams were previously grouted in 2011 therefore this work is being carried out to validate this previous works.

Read and understood full text of the Position Statement (RPS 108):

The full text of the Regulatory Position Statement 108 has been read and understood by Buro Happold Ltd on behalf of the above listed names (see Table 2) to ensure compliance when carrying out the proposed grout works.

Specify codes of practice, waste protocols or other standards relevant to the discharges of our activities into groundwater:

The proposed work will comply with British Standards (namely, BS EN 1008:2002, BS EN 197-1:2000, BS EN 12620:2002) and the regulatory position statement [4] relevant to the discharges of grout into groundwater. To confirm compliance of such activities, all works will be documented (see Appendix A for proposed groundwater level monitoring) and evidence compiled within the Contractors completion report and the verification report.

Compliance with the requirements in those specified standards:

A full assessment of the ground conditions is presented within the Buro Happold Interpretative Report (BRA-BHE-XX-XX-CG-RP-0004 P04) [2]. The assessment was carried out in general accordance with the CIRIA Contaminated Land Risk Assessment (C552) [4], the Environment Agency (EA) / Department for Environment, Food and Rural Affairs (Defra) Model

Procedures for the management of Contaminated Land [5], the relevant British Standards (BS) [6] and [7], the EA Guiding Principles for Land Contamination [8], Groundwater Protection Policy [9] and other good practice guidance.

Methodology of assessment to the ground conditions and relevant receptors:

An initial conceptual site model assessing the potential pollutant linkages (source-pathway-receptor) was developed within the Desk Study Report (BRA-BHE-XX-XX-CG-RP-0001) [10] in general accordance with C552 [4]. This desk-based research informed the design of the site investigation, carried out late 2019. A detailed land contamination risk assessment was completed following the site investigation with the findings presented within the Buro Happold Interpretative Report [2].

Outcome of the assessment and reasons why risks of causing pollution to groundwater is low:

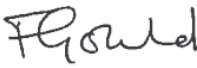
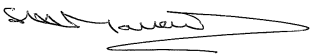
The relevant pollutant linkages associated with the injection of grout below the groundwater table have been reassessed in general accordance with relevant CIRIA guidance ([3] and [4]) within Part A of this Groundwater Risk Assessment, the assessment is presented within Table 1. All potential pollutant linkages were assessed as low due to the following:

- the nature and extent of the proposed grout work activity (see Appendix B – Grouting Philosophy);
- the potential for the pollutant to travel off site and impact sensitive receptors; and
- the mitigation measures in place to ensure any alterations to groundwater level is identified and works stopped where such changes occur (see Appendix A – Groundwater level monitoring proposals and drawing BRA-BHE-XX-XX-SK-GE-0005).

Confirmation full compliance with the requirements set out in the Position Statement (RPS 108):

All works detailed within this groundwater risk assessment have been carried out in conjunction with the Regulatory Position Statement 108 as provided by the Environment Agency on the 18th September 2020.

RPS 108 compliance, signed and dated:

Author: Francesca Gould (Geoenv. Engineer)		25 th September 2020
Reviewed: Hugh Mallett (Technical Director)		25 th September 2020

7 Conclusions and Recommendations

7.1 Risks and mitigation

The risks associated with the proposed grout works have been assessed above in general accordance with relevant guidance, namely the Environment Agency RPS 108 [4] and CIRIA C552 [4] and CIRIA C758D [3] .

It is not anticipated that the proposed grouting will adversely impact upon the Coal Measures Secondary A aquifer. This conclusion reflects the evidence from the previous grouting works, the nature and quality of the aquifer / groundwater and the absence of local abstraction.

The potential risks to the River Medlock associated with the proposed grouting works are assessed as Low. This conclusion primarily reflects the expected nature / extent of the grouting works (i.e. limited grout take), the likely limited effect on groundwater levels both on and off site, and lack of direct hydraulic continuity between culverted River and groundwater in the Coal Measures aquifer. The potential risks to the Ashton Canal associated with the potential for contaminated run-off from the proposed grouting works are also assessed as Low. This conclusion reflects the relatively short and direct migration pathway in one location of the site, but also the ease of locating hazardous materials away from sensitive locations and the adoption of standard good practice measures to prevent uncontrolled run off. These residual risk are capable of mitigation (see below).

The risk to existing utilities has been assessed as Low. This conclusion reflects the planned removal of these facilities prior to the commencement of the proposed grout treatment works (except the United Utilities sewer which is planned for seal and infill as a part of the works).

All risks are assessed as low providing implementation of standard good practice (groundwater control measures) as set out in the contractor's method statement (Appendix B), and suitable groundwater monitoring (see Appendix A) are carried out during and post grout treatment. All records will be compiled and included within the Contractors Completion Report and verified by competent persons.

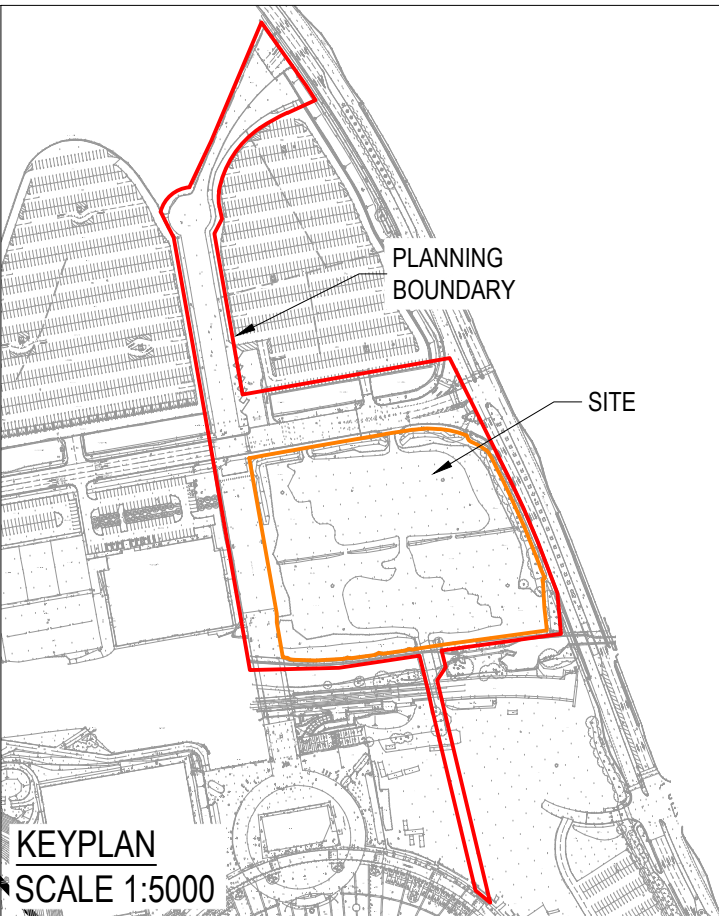
7.2 Environmental Permit

In accordance with the Environmental Permitting (England and Wales) Regulations, the Contractor may be required to obtain an environmental permit for grouting works below the groundwater table. Appropriate liaison with the relevant regulator (Environment Agency) – which should include submission of this groundwater risk assessment may remove the requirement of such a permit.

It is concluded that the assessment presented above, including the contractor's contingency procedures and the proposed monitoring of groundwater levels will ensure that the proposed grout works (which include some injection below the water table), will not have a detrimental impact on controlled waters (the groundwater regime in the Coal Measures) and the nearby surface water (River Medlock). Accordingly, the Environment Agency are invited to agree with the assessment and the conclusions reached and thus determine that the proposed grouting works on the site do not require an Environmental Permit.

Drawings

Drawing Reference	Drawing Title
BRA-BHE-XX-XX-DR-GE-0101	Constraints Plan
BRA-BHE-XX-XX-SK-GE-0004	Conceptual Site Model
BRA-BHE-XX-XX-SK-GE-0005	Groundwater Level Monitoring
BRA-BHE-XX-XX-DR-GE-0402	Contour Plot - Groundwater Secondary A Aquifer
BRA-BHE-XX-XXX-DR-C-0020	Existing Utilities Sheet 1



P03 PLANNING	31.01.20	NG	FG
P02 DRAFT PLANNING	20.12.19	NG	FG
P01 DRAFT STAGE 3	27.11.19	NG	FG
Rev Description	Date	Drn	Ch'd

PLANNING

Status of drawing	
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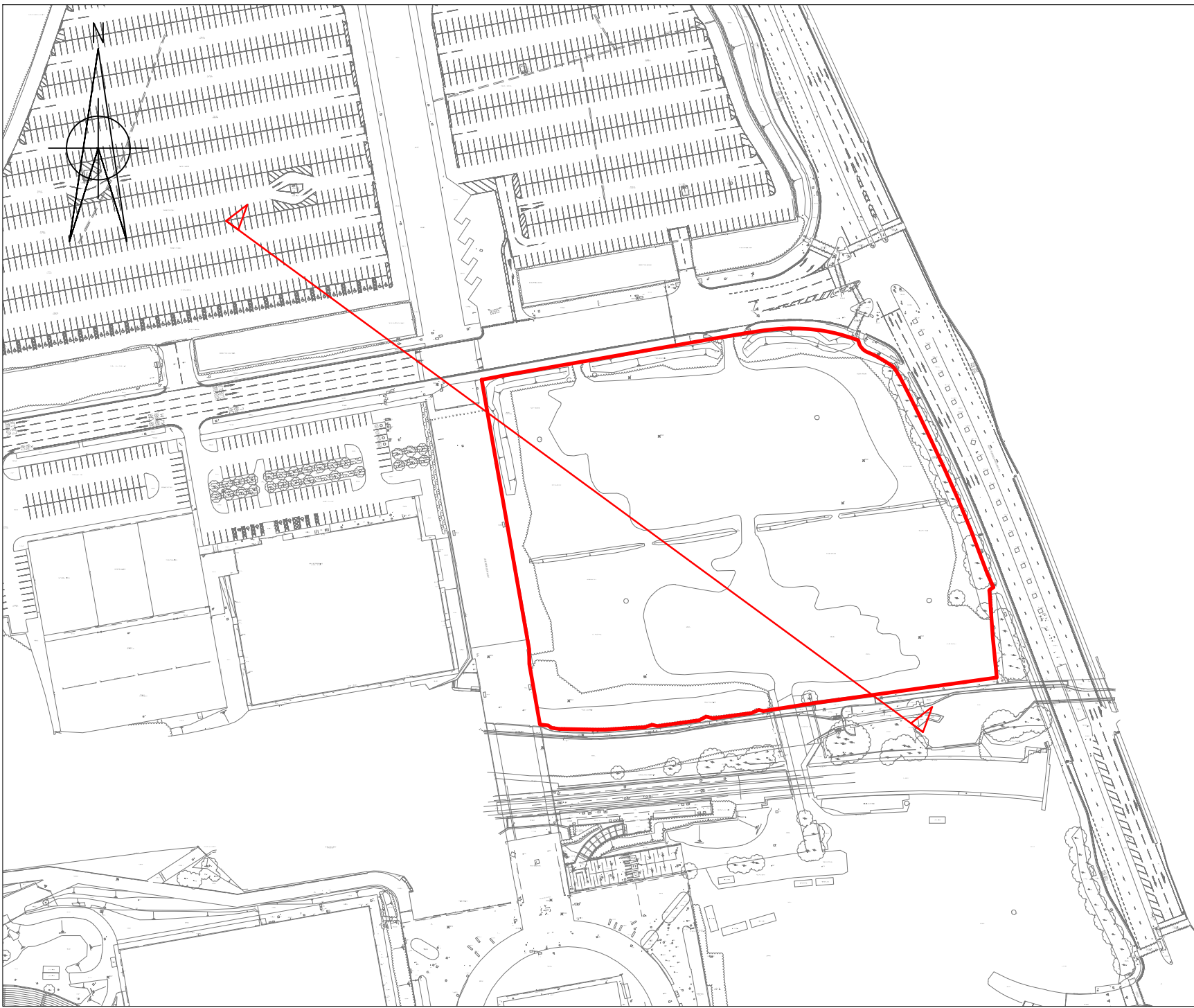
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Architect *POPULOUS*
Project **OVG MANCHESTER**
Drg Title **CONSTRAINTS PLAN**

Scales@A1 1:500	Job No. 004284
Drawn by NG	Date NOV 2019
Checked by FG	Rev P03

Drawing No. BRA-BHE-XX-XX-DR-GE-0101



- INFERRED COAL SEAM
- MG MADE GROUND
- ALV ALLUVIUM
- RTG RIVER TERRACE DEPOSITS
- GT GLACIAL TILL
- CM COAL MEASURES
- COAL SEAM FROM GROUND INVESTIGATION DATA
- APPROX. CHANGE IN TOPOGRAPHICAL LEVEL SINCE 1986
- ASSUMED ZONE OF CORE LOSS
- GROUNDWATER - PERCHED (MADE GROUND/GLACIAL TILL) mOD
- GROUNDWATER - SECONDARY A AQUIFER (COAL MEASURES) mOD
- BASE OF DRILL & GROUT TREATMENT

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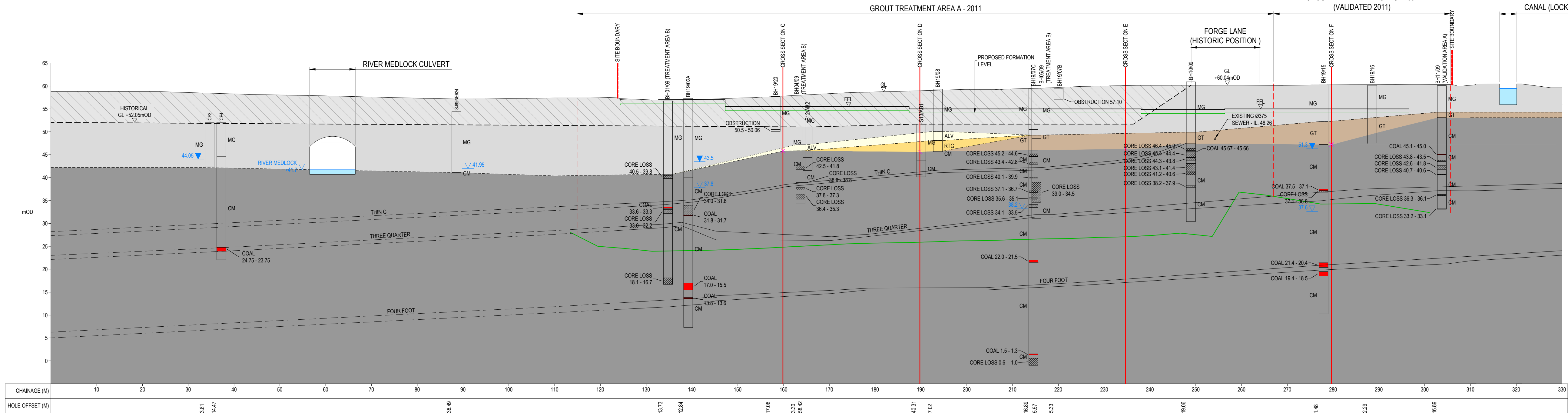
MAINTENANCE/CLEANING/OPERATION.

DECOMMISSIONING/DEMOLITION.

Notes

NW

SE



P01 INFORMATION		23.09.20	NG	FG
Rev	Description	Date	Dm	Ch'd

INFORMATION

Status of drawing

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Camden Mill
Lower Bristol Road
Bath BA2 3DQ
UK

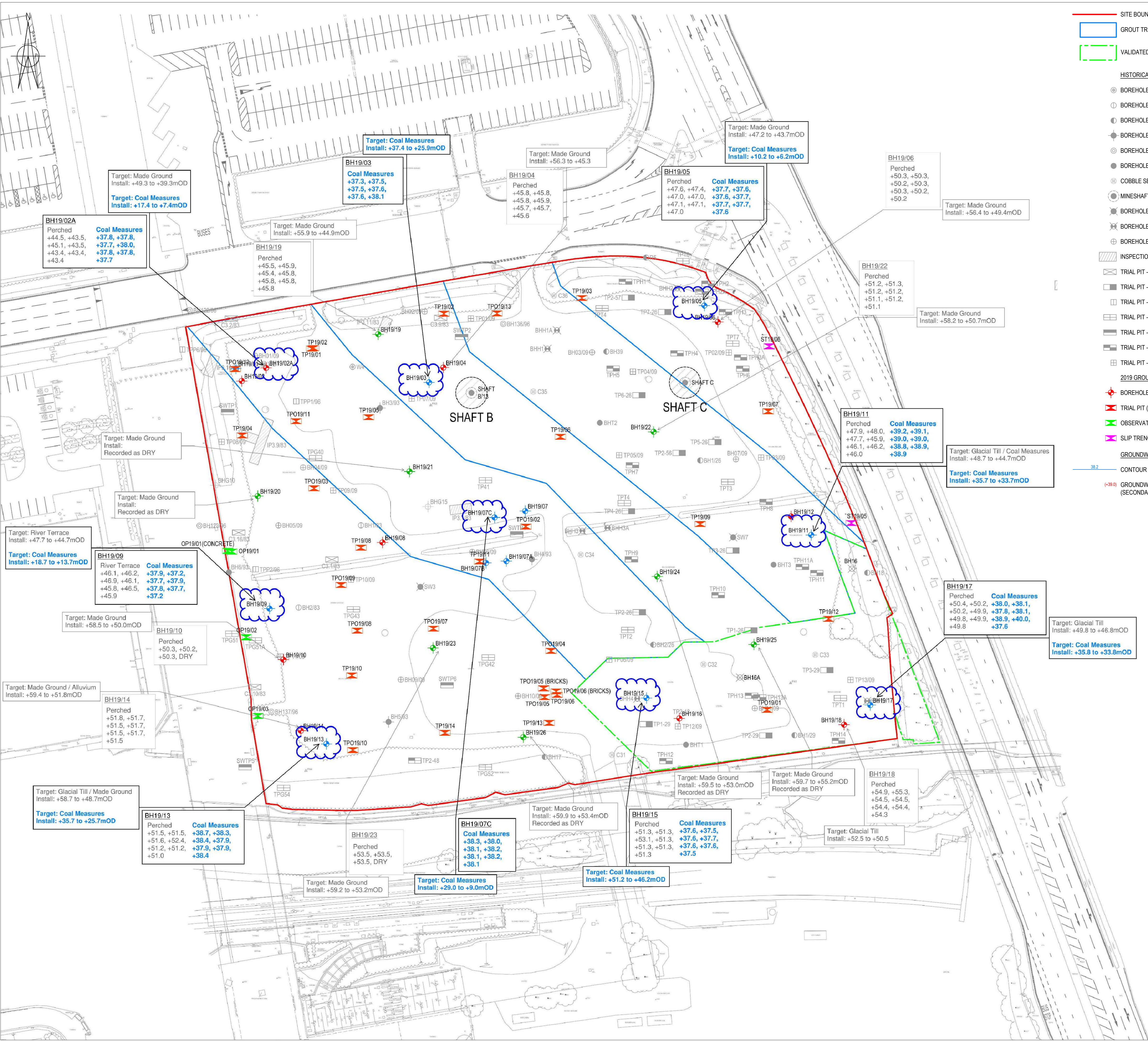
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Architect **POPULOUS**
Project **OVG MANCHESTER**
Drg Title **CONCEPTUAL SITE MODEL**

Scales@A1 1:500
Drawn by NG
Checked by FG

Job No. **0042841**
Date **SEPTEMBER 2020**
Rev **P01**

Drawing No. **BRA-BHE-XX-XX-SK-GE-0004**



- SITE BOUNDARY

GROUT TREATMENT WORKS - 2011

VALIDATED AREA - 2011
- HISTORICAL GROUND INVESTIGATION

BOREHOLE - I.G.S 1954

BOREHOLE - WARD ASHCROFT & PARKMAN 1983

BOREHOLE - NORTHERN FOUNDATIONS 1991

BOREHOLE - NORTHERN FOUNDATIONS 1993

BOREHOLE - PARKMAN 1996

BOREHOLE - NORWEST HOLST 1999

COBBLE SEARCH - NORWEST HOLST 1999

MINESHIFT INVESTIGATION - SOIL MECHANICS 2000

BOREHOLE - SOIL MECHANICS 2000

BOREHOLE - SOIL MECHANICS 2003

BOREHOLE - MAY GURNEY 2009

INSPECTION PIT - WARD ASHCROFT & PARKMAN 1983

TRIAL PIT - WARD ASHCROFT & PARKMAN 1983

TRIAL PIT - NORTHERN FOUNDATIONS 1991

TRIAL PIT - PARKMAN 1996

TRIAL PIT - NORWEST HOLST 1999

TRIAL PIT - SOIL MECHANICS 2000

TRIAL PIT - SOIL MECHANICS 2003

TRIAL PIT - MAY GURNEY 2009

2019 GROUND INVESTIGATION

BOREHOLE

TRIAL PIT (UP TO 5 mBGL)

OBSERVATION PIT (UP TO 2 mBGL)

SLIP TRENCH (UP TO 2 mBGL)

GROUNDWATER

38.2

CONTOUR - GROUNDWATER (SECONDARY A AQUIFER) mOD

(+39.0)

GROUNDWATER LEVEL RECORDED IN EXPLORATORY HOLE (SECONDARY A AQUIFER) mOD

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CONSTRUCTION

MAINTENANCE/CLEANING/OPERATION

DECOMMISSIONING/DEMOLITION

Notes

KEYPLAN

SCALE 1:5000

P01 INFORMATION		25.09.20	NG	FG
Rev	Description	Date	Dm	Ch'd

INFORMATION

Status of drawing

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Architect
Project
Drg Title

POPULOUS
OVG MANCHESTER
GROUNDWATER LEVEL MONITORING
LOCATIONS

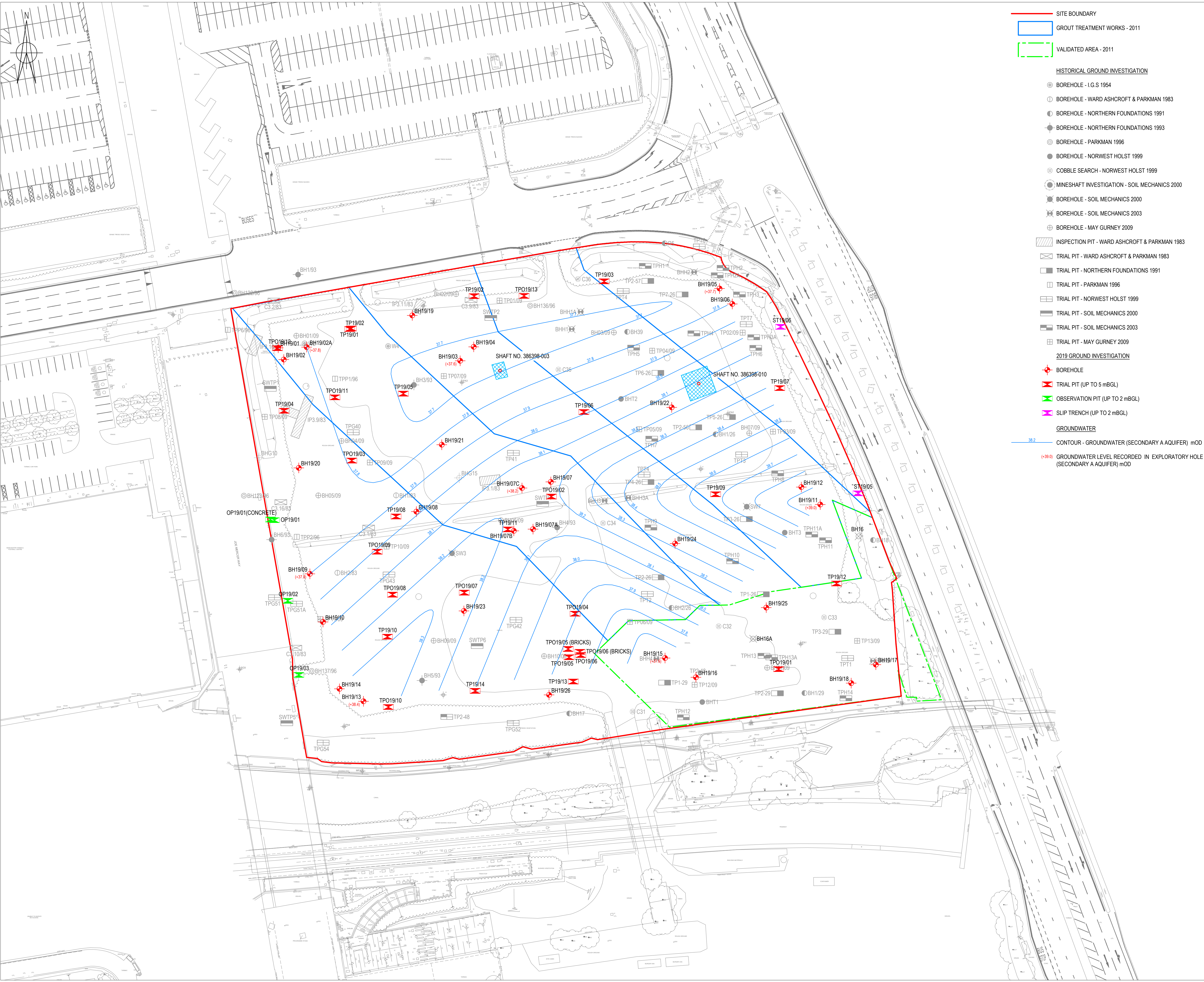
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Drawn by NG
Checked by FG

Job No.
Date
Rev

0042841
SEPTEMBER 2020
P01

Drawing No.

BRA-BHE-XX-XX-SK-GE-0005



- SITE BOUNDARY

GROUT TREATMENT WORKS - 2011

VALIDATED AREA - 2011
- HISTORICAL GROUND INVESTIGATION

●

BOREHOLE - I.G.S 1954

①

BOREHOLE - WARD ASHCROFT & PARKMAN 1983

●

BOREHOLE - NORTHERN FOUNDATIONS 1991

◆

BOREHOLE - NORTHERN FOUNDATIONS 1993

◎

BOREHOLE - PARKMAN 1996

●

BOREHOLE - NORWEST HOLST 1999

◎

COBBLE SEARCH - NORWEST HOLST 1999

⊙

MINESHIFT INVESTIGATION - SOIL MECHANICS 2000

⊙

BOREHOLE - SOIL MECHANICS 2000

⊙

BOREHOLE - SOIL MECHANICS 2003

⊙

BOREHOLE - MAY GURNEY 2009

INSPECTION PIT - WARD ASHCROFT & PARKMAN 1983

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TRIAL PIT - SOIL MECHANICS 2003

TRIAL PIT - MAY GURNEY 2009

2019 GROUND INVESTIGATION

◆

BOREHOLE

✕

TRIAL PIT (UP TO 5 mBGL)

✕

OBSERVATION PIT (UP TO 2 mBGL)

✕

SLIP TRENCH (UP TO 2 mBGL)

GROUNDWATER

CONTOUR - GROUNDWATER (SECONDARY A AQUIFER) mOD

GROUNDWATER LEVEL RECORDED IN EXPLORATORY HOLE (SECONDARY A AQUIFER) mOD

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MAINTENANCE/CLEANING/OPERATION.

DECOMMISSIONING/DEMOLITION.

Notes

PLANNING BOUNDARY

SITE

KEYPLAN

SCALE 1:5000

P01 INFORMATION

25.09.20

NG

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Rev

Description

Date

Dm

Ch'd

INFORMATION

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Architect

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Project

OVG MANCHESTER

Dwg Title

CONTOUR PLOT

GROUNDWATER - SECONDARY A AQUIFER

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Drawn by NG

Checked by FG

Job No.

0042841

Date

SEPTEMBER 2020

Rev

P01

Drawing No.

BRA-BHE-XX-XX-DR-GE-0402

Rev

0042841

Project

0042841

Drawn by

NG

Checked by

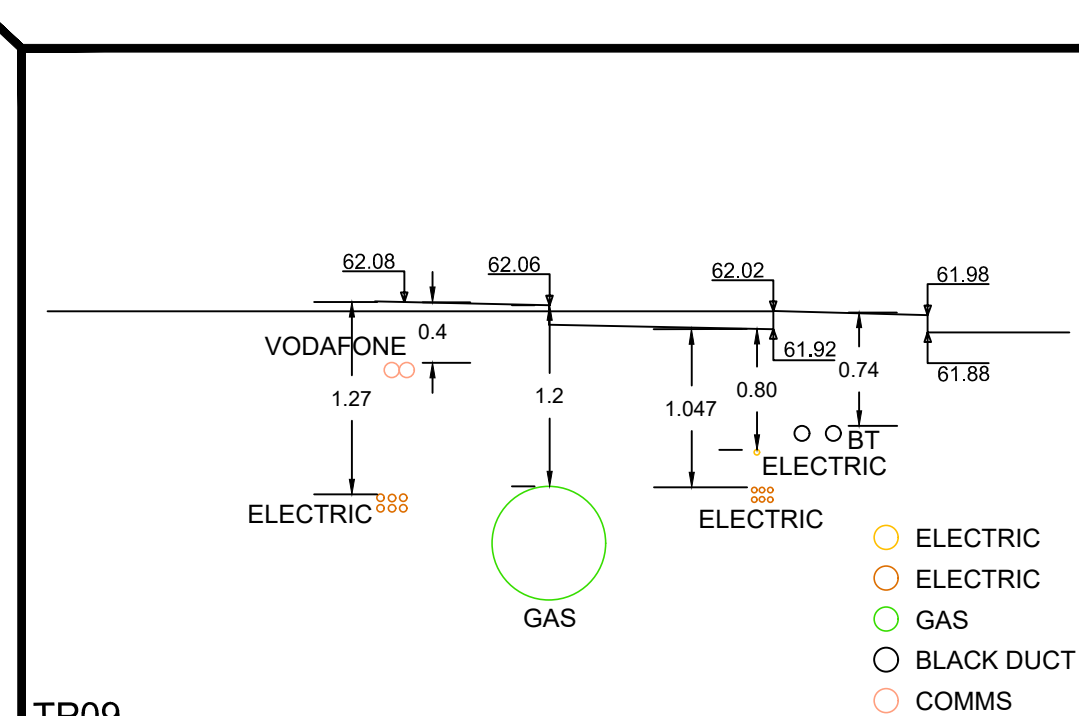
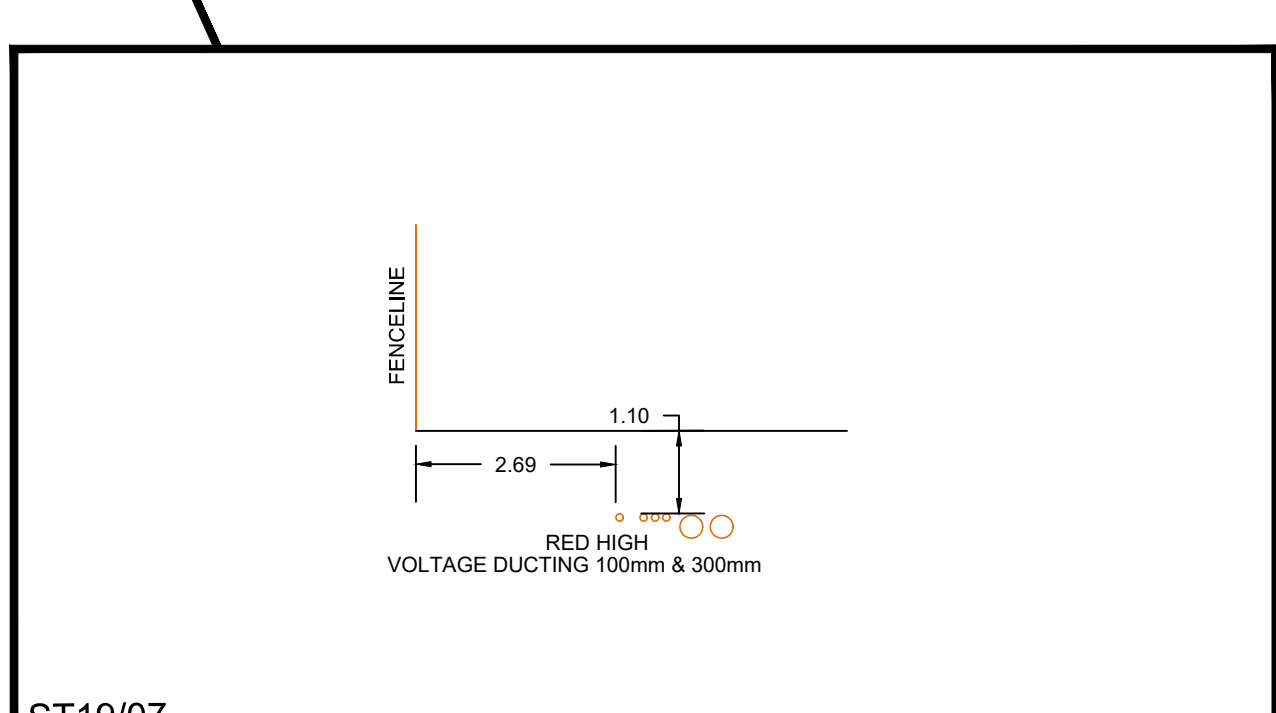
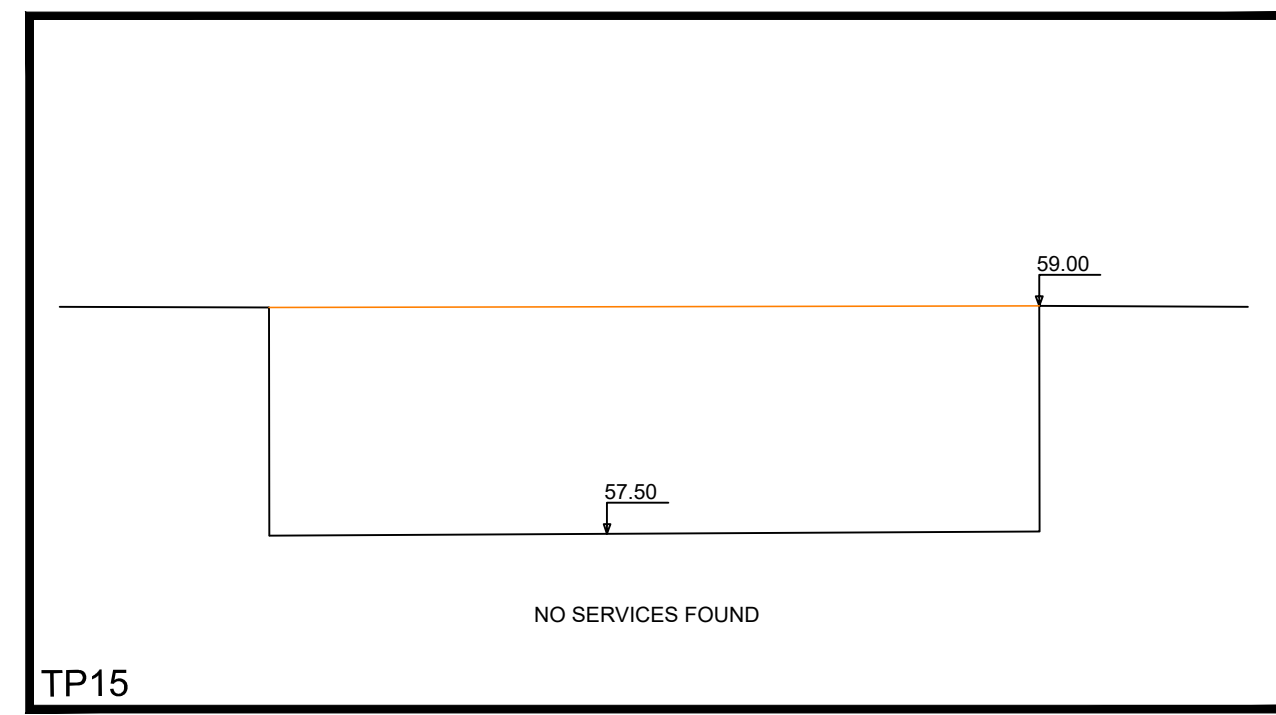
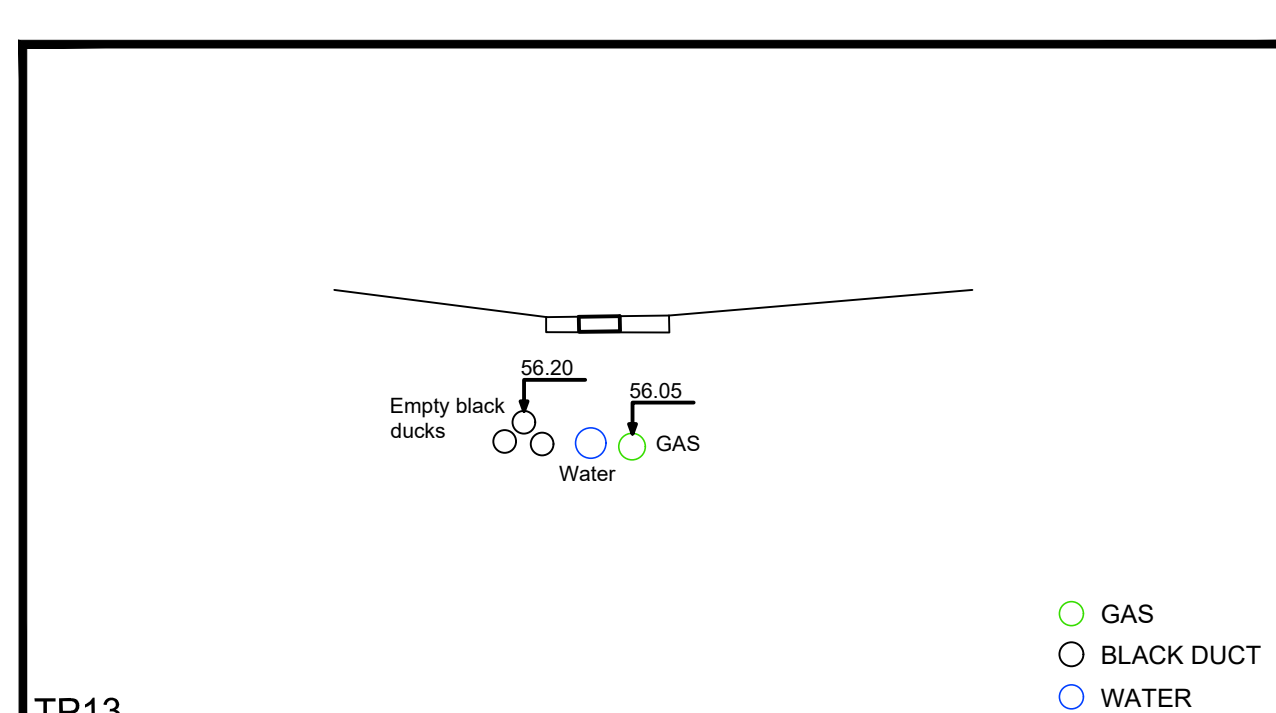
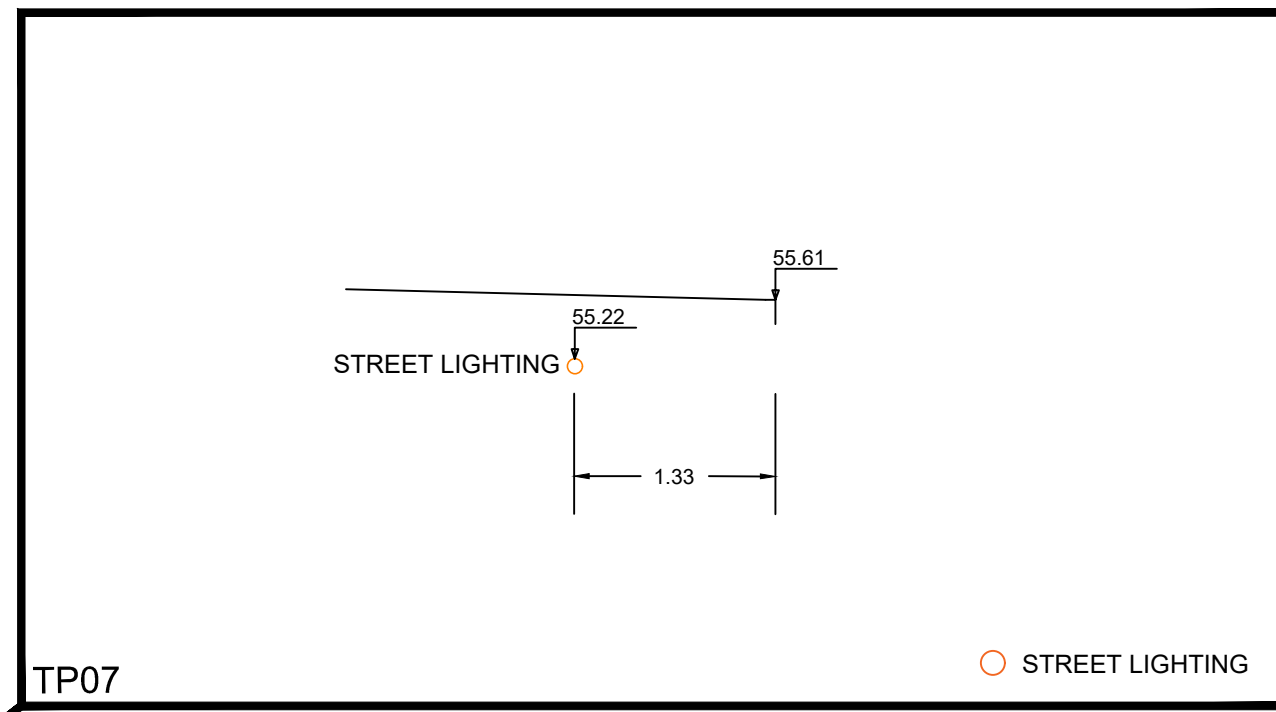
FG

Date

25.09.20

Rev

P01



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date	Jun-19	checked	SR	0042841	S4		
project code	originator	volume	level	type	role	number	rev.
reference	BRA-BHE-XX-XX-DR-C-0020						P08

Appendix A

Groundwater level monitoring proposals

Groundwater level measurement

- Measurement and recording of groundwater levels with a dipmeter (i.e. not sampling for chemical analysis).
- Prior to the start of grouting:
 - An initial 4 week programme of “baseline” monitoring. This will involve measurement and recording of the groundwater level from each of the nine wells (see BRA-BHE-XX-XX-SK-GE-0005 for locations, installation details presented below in Table 3) on one occasion per week [preferably the same day of the week each time].
- During grouting (anticipated 9 week programme):
 - Measurement and recording of groundwater levels with a dipmeter carried out at the beginning and end of every working day from each of the nine monitoring wells (see BRA-BHE-XX-XX-SK-GE-0005 for locations, installation details presented below in Table 3).
- Provision should be made for additional monitoring in areas where grout takes are higher than expected and / or where there is a consistent and suspect rise in groundwater levels. In such circumstances monitoring of groundwater levels in relevant wells (i.e. wells in vicinity of grout injection) should be undertaken at hourly intervals for up to one day [Note: Other management action will also be undertaken in such circumstances as detailed within the Contractor’s method statements].
- At the completion of the works, all groundwater level monitoring data to be provided to form a part of the Verification Report

Table 3 Groundwater level monitoring installations

Borehole	Response Zone top (m OD)	Response Zone bottom (m OD)	Response zone in mbgl	Additional installation detail
BH19/02a	+17.4	+7.4	40.0 - 50.0	Two installations present, ensure deeper installation is monitored as targets the Coal Measures.
BH19/03	+37.4	+25.9	20.0 – 31.5	One installation
BH19/05	+10.2	+6.2	47.0 – 50.0	Two installations present, ensure deeper installation is monitored as targets the Coal Measures.
BH19/07c	+29.0	+9.0	30.0 – 50.0	One installation
BH19/09	+18.7	+13.7	40.0 – 45.0	Two installations present, ensure deeper installation is monitored as targets the Coal Measures.
BH19/11	+35.7	+33.7	24.0 – 26.0	
BH19/13	+35.7	+25.7	25.0 – 35.0	
BH19/15	+25.2	+15.2	35.0 – 45.0	
BH19/17	+35.8	+33.8	25.0 – 27.0	

Surface water [culvert] inspection

- Visual inspection and recording of quality of the surface water at two locations (see Figure 2) in conjunction with the groundwater level monitoring. That is once a week for the 4 weeks prior to the grouting works and twice a day during the works – with provision for additional inspection.
- The surface water monitoring record shall consist of a photo and note of condition at each location (SW 1 and SW 2) on every occasion.
- At the completion of the works, all surface water condition monitoring records to be provided to form a part of the Verification Report.



Figure 2 Extract from Google Earth showing surface water monitoring points (entrance and exit to the culvert) up and down stream of the site.

Appendix B

Skanska Cementation Ltd Grouting Philosophy

Cementation

SKANSKA

Revision: Draft

Dated: 23/09/2020

Client:

Originator:



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Grouting Philosophy Preliminary Draft

Location: Manchester

Project: Project Bradford

Document Status:

Draft – EA review

Issue / Revision Description:

Date: 23 September 2020

Cementation Section	Title	Name [Print]	Signature	Date
Author	Business Stream Director	Caroline Rookes		23/09/2020
Reviewer				
PC Review Section	Title	Name [Print]	Signature	Date
Approver:				
Acceptor:				

Format	Document Number	Revision	Date of issue
A4	22D990 / XXX / 001	P01	23/09/2020

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11.0 GROUT TESTING

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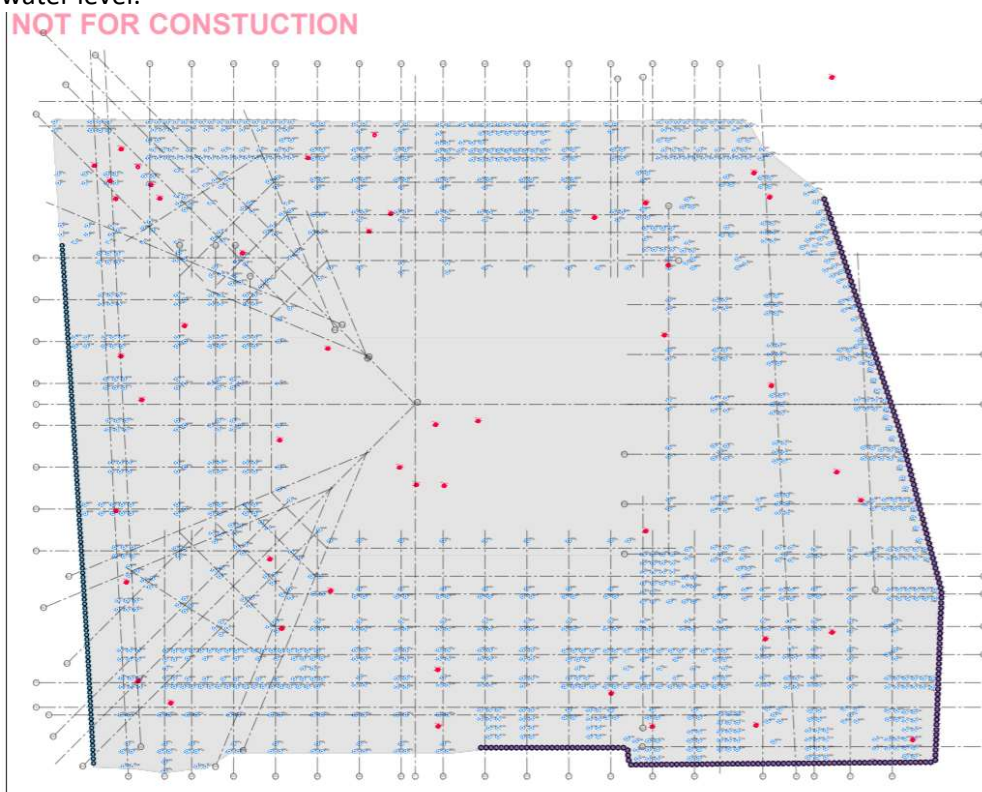
1.0 INTRODUCTION

The Project Bradford site is approx. 21,000m². The site is roughly rectangular in shape and bounded to the south by the Ashton Canal, to the east by Alan Turing Way (A6010), to the west by Joe Mercer Way, which is a pedestrian walk way leading to the City of Manchester Stadium.

The site is located above two main coal seams, the Bradford Four Foot and the Bradford Three-quarter seams. Consideration / confirmation of the 18 inch seam will be needed for the deeper pile toes. Historically 2 No shafts have been located on the site and treated, there is potentially a third shaft, however previous investigations have been unable to locate it.

There have been several previous grouting contracts on areas of site to treat the coal seams, however the validation of these works cannot be adequately assessed and there could be a risk that should any remaining voids be encountered during the proposed piling works this will impact on the installation of the piling. The proposed drilling and grouting works are to validate the previous grout works and treat any open voids encountered.

Currently the longest proposed piles, are in the north west corner of the site and have a toe level of 26.6m AOD, with a seam indicated around 16.98m AOD, we are therefore anticipating 38m deep probes in this area. From the meeting with the EA and the ground water levels given in BH Appendix B Ground Water Risk Assessment in association with proposed grouting work, both the piling and the grouting will be installed below ground water level.



2.0 SCHEDULE OF DRAWINGS

TBC

3.0 GROUTING PHILOSOPHY

TBC

4.0 SEQUENCE OF DRILLING AND GROUTING

4.1.1 The anticipated sequence of drilling and grouting is as follows;

4.1.2 Initial probe drilling shall be undertaken on a 21m grid, to determine the effectiveness of the previous grouting on the site. The depth of the probe holes will be based on the Stage 4 pile lengths, the requirement for rock cover of ten times the seam thickness beneath the toe of the piles and the depth and thickness of the seams indicated in the Site Investigation. The assumptions made in the design of the grouting works will be reviewed and any necessary amendments made to the grouting layout as works progress.

4.1.3 Drilling and grouting of holes will be carried out within the Bradford Four Foot and the Bradford Three-quarter seams and potentially the 18 inch seam. The holes will be installed to the predetermined infill pattern, progressing to a 7m grid with a 3.5m grid where workings are encountered. Hole layouts will be amended following the initial drilling / review and as works progress.

4.1.4 It should be noted that perimeter grouting is not envisaged at this stage, however should open voids in excess of 0.5m height be encountered in close proximity to the site boundary this will be subject to reviews as the works progress.

5.0 CONSTITUENT MATERIALS FOR GROUTING

5.1.1 Water to be used in grout shall be from the public supply of potable water and shall be at least to the quality specified in BS EN 1008:2002.

5.1.2 Ordinary Portland Cement (OPC) will comply with BS EN 197-1:2000.

5.1.3 PFA will be conditioned hopper ash, or dry powder ash, to BS3892: Part 3 of a type suitable as a constituent for grout and obtained from an approved supplier.

5.1.4 Whilst the use of sand is not currently proposed should a localised perimeter cut off be considered the following will apply. Sand shall generally comply with BS EN 12620:2002 and be of a grading suitable for use in the Contractor's plant.

6.0 STORAGE AND USE OF MATERIALS

6.1.1 Cement will be delivered in bulk and stored in a silo to prevent contamination and deterioration.

6.1.2 Bulk delivered of PFA will be stored and handled such that a dust hazard is not created. The PFA will be contained within storage area set consisting of storage containers. Water spray to douse stockpiles will be employed where necessary.

6.1.3 Materials with a limited shelf life will be disposed of off the site immediately, following expiry of the manufacturer's time limit for their use

7.0 GROUT MIX

7.1 Grouting Plant

7.1.1 Grout materials shall be introduced into the mixer via approved weight batching equipment. The grout mixer shall comprise a two component mechanically agitated colloidal grout mixer capable of producing a homogenous mix, all particles being thoroughly wetted without segregation occurring. Mixing time shall not be less than 5 minutes. A positive displacement grout pump shall be used for all grouting operations.

7.1.2 Provision shall be made for monitoring the quantity of grout being delivered from the grouting plant using calibrated flow meters or similar approved. The Contractor shall supply details of the method of monitoring and calibration of equipment.

7.2 Grout Mix Design

7.2.1 The grout mixes to be employed in the execution of the works are as detailed below, subject to satisfactory performance in the grouting trial. All proportions are presented by weight and are based on neat OPC cement: water mixes. Should PFA or other pozzolans be substituted for OPC the contractor should submit detailed grout mix design information to the Designer for review and comment.

7.3 Infill Grout

7.3.1 Infill grouting will commence with 10 :1 PFA Cement grout mix. Subject to grout takes this may be reviewed and thickened progressively to prevent excessive grout flow

7.3.2 Grouting in any hole shall be terminated at a maximum take of 5m³. Thereafter grouting may recommence after a period of 6 hours.

7.4 Perimeter curtain wall grout (if required)

7.4.1 Cement : PFA : 1 : 9 (Cement: PFA: Sand = 1 : 6 : 1, where cavities exceeding 500 mm in height are found).

7.4.2 Sand may be added in place of PFA where grout consumption or spread is required to be limited.

7.4.5 Cubes will be taken for testing at 3, 7, 14 and 28 day to confirm the strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m² at 28 days.

7.5 Grout Flow Properties

7.5.1 The water : cement ratio shall range between 0.5 : 1 - 2.0 : 1. Grout flow properties will vary significantly with water : cement ratio but will be ascertained during initial grout trials and monitored routinely during production / injection operations.

8.0 PREPARATION WORKS

8.1.1 Prior to the grouting works the ground will be stripped (as may be necessary) and a stable working platform established, taking cognisance of the potential for subsidence due to collapse of mine workings. This will be undertaken by BAM prior to Cementation Skanska mobilising to the work area.

9.0 DRILLING PROCEDURES

9.1.1 All drill holes used for the injection of grout into rock will be drilled by rotary percussive techniques down to 1.0m below the pavement of the target workings. Holes will be installed with 76mm casing and 48mm button bit rods.

9.1.2 Grout injection holes will be cased through the superficial deposits to 1.0m depth below rockhead. Grout holes will be kept open by means of a series of temporary steel casings placed to rock head until grout injection into the workings is complete.

9.1.3 Where a hole proves abortive because it becomes obstructed, or because of the failure to progress the hole, a new hole drilled and cased in close proximity. The amended position of the hole will be recorded

9.1.4 Where vegetation, existing services and structures are present on site, drill holes will be raked to ensure exclusion zones are maintained whilst the target treatment area is drilled

9.1.5 A noise and vibration assessment will be carried out by others to determine services and structures that may require monitoring during the works. An additional requirement will be agreed prior to works commencing on site

10.0 GROUTING PROCEDURES

10.1 General

10.1.1 Immediately prior to grouting each hole, the grouter will check that the tremie and/or temporary casing is unobstructed to the required depth to receive the tubing or pipe for grout. Obstructions shall be dealt with as described in section 9.1.3 above.

10.1.2 Grout will be tremied into position down each hole via a series of steel/alkathene tubes placed to the bottom of the hole. The grout line at the surface is attached to an approved T-connection with an attached pressure gauge fixed to the top of the drill hole. The quantity of grout being delivered in the line will be recorded so that both the flow rate and total injected volume are known. Grouting pressures will be monitored at ground level close to the point of injection.

10.1.3 The grout shall be injected into rock until either

- (a) A limiting pressure of 50kN/m² is reached (or a lower pressure if the base of the drill hole casing is within 5m of ground level),
- (b) A maximum grout take of 5m³ is attained, or
- (c) Grouting is terminated in the event of grout being expelled from the ground.

10.1.4 If the selected refusal pressure (typically 50kN/m²) is not attained after the injection of 5m³ of grout, the grout tube or pipe will be removed from the hole and injection suspended.

After a period of at least 6 hours, up to a further 5m³ of grout shall be injected. Injection shall again be suspended for at least 6 hours and the process shall be repeated with further quantities of 5m³.

If the hole is still accepting grout after a total of 20m³ of material has been injected without any sign of the hole being completed, a review will be undertaken to determine whether the injection is to be continued or other measures such as secondary or test holes are required.

10.1.5 Care shall be taken to ensure that uplift pressures are not allowed to develop under the railway track, any adjacent services, during grout injection. Dependent on the sensitivity of the structure is required monitoring will be undertaken by others

10.2 Infilling

10.2.1 The grouting of infill holes will proceed systematically from the deepest point of the workings. Once the down dip perimeter has been confirmed, sequencing of the drilling maybe amended to meet operational requirements (test piles, preparations works) This will be agreed with BAM in advance of works commencing.

Whilst a perimeter curtain in not currently envisaged this will be determined by initial probing. If required a localised perimeter will be installed to ensure that grout does not migrate off the site footprint.

10.2.2 Grout injection will be carried out as described under the general procedure, but immediately the grout tubes, or pipes are withdrawn, the T-connection shall be attached to the top of the casing lining the hole down to rockhead, and further grout shall be injected up to the specified pressures.

10.2.3 Upon completion of the grout holes it will be backfilled to surface

11.0 GROUT TESTING

11.1.1 The viscosity of the grout on site will be monitored during injection operations. A minimum of two tests will be undertaken every 24 hours for each grout mix used.

11.1.2 Grout bleed will be recorded at hourly intervals from 2 hours after monitoring starts for not less than 6 hours, until settled conditions occur.

One test shall be carried out each day on each grout mix used. Bleed capacity will be measured in a clear plastic or glass graduated cylinder, which has an internal diameter not less than 50 mm, with a volume of approximately 1000ml. Bleed capacity will not exceed 5%.

11.1.3 For strength testing, a sets of six test cubes will be taken from the grouting pipe at surface positions every 24 hours.. The cubes shall be marked, handled, stored and tested by an approved independent testing laboratory in accordance with BS 1881. The Contractor shall provide projected 3, 7, 14 and 28 day strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m² at 28 days.

11.1.4 For each test there shall be a record of the results including:

1. Date.
2. Contract Title.
3. Area Identification.
4. Test position, co-ordinates and level.
5. Method of Test used.
6. All information required by the appropriate British Standard test procedure

12.0 IN SITU TESTING

12.1.1 Grout acceptance testing will be checked by drilling validation holes in positions to be agreed with the BAM / BH. An allowance of 1No validation hole per 1000m² has been allowed for.

Grout will be injecting through casings set into rockhead, under typical pressures of 50kN/m² as outlined in the requirements for infill grouting.

The injection pressure will be held for an appropriate period of time (approximately 5 minutes). Appropriate casing, capable of sustaining the test pressures, will be used. Unacceptable voidage will be determined as present within the ground should grout takes into the ground exceed 1 tonne. If this is encountered additional validation hole will be drilled and grouted in the immediate vicinity.

12.1.2 After satisfactory testing, validation holes will be back filed in accordance with the requirements for grouting infill holes.

13.0 RECORDS

13.1.1 The following records are to be provided by the Contractor:

1. Drilling Records (to be provided for each shift);
2. Grouting Records (to be provided for each shift);

13.1.2 As work proceeds, separate records will be maintained for 'Drilling', for 'Grouting' and for 'Materials and Plant Received'. The records will be submitted to BAM within 24 hours of the completion of each shift.

13.2 Daily Drilling Records

13.2.1 The following daily drilling records will be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
5. Plant in use, crew members and hours worked.
6. Method of boring or drilling, flushing medium and type of drill bit.
7. Type, diameter and depth of casing used.
8. Diameter and depth of hole at the beginning and end of each working day or shift.
9. Nature of flush returns to surface.
10. Loss of any flushing medium during drilling.
11. Standing time, with reason, or time lost overcoming obstructions.
12. Details of underground services located.
13. Details of any settlement or ground heave.
14. Daily and cumulative length drilled.
15. Description, with identification, of the stratum and whether it is intact or broken.
16. Depths at which groundwater is encountered (if apparent).
18. Details of any voids or suspended workings.
19. Details of any emissions of gas, water etc.
20. Depth of completed hole.

13.3 Daily Grouting Records

13.3.1 Daily grouting records shall be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
4. Contractor's name.
5. Plant in use, crew member and hours worked.
6. Details of type of injection and grout-line dimensions (e.g. tremie injection through 25mm diameter line).
7. Type of grout mix and volumetric quantity injected.
8. Bleed Capacity Readings as outlined in Section 11.2.

9. Grout viscosity readings.
10. Grout pressures recorded, with the corresponding depths.
11. Details of casing abandoned.
12. Completion status of the grouting operation.

13.4 Material and Plant Records

13.4.1 The records of 'Materials and Plant Received' shall show in particular that shifts quantities by weight of each type of material and the cumulative quantities from the commencement of the Works.

13.4.2 Notwithstanding the information listed above, the Contractor shall provide any other information required by Designer.

14.0 METHOD STATEMENTS

14.1.1 Prior to commencing works on site a Works Execution Plan (including method statements and risk assessments will be submitted to BAM for approval.

The following aspects of the works will be covered by the method statements

1. Method and types of access arrangements.
2. Safe working procedures including fail safe methods for working in proximity to railway Overhead Line Equipment.
3. Drilling methods.
4. Grouting methods (materials, mixes, mixing and injection arrangements).
5. Record-keeping formats.
6. An outline sequence of working covering the formation of perimeter and primary grout holes and secondary check holes.