A1 Birtley to Coal House

Scheme Number: TR010031

Applicant's Responses to ExA's Second Written Questions – Appendix 2.3B – Technical Note on Grouting

Planning Act 2008

Rule 8(1)(c)(i)
The Infrastructure Planning
(Examination Procedure Rules) 2010

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Infrastructure Planning

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The A1 Birtley to Coal House Development Consent Order 20[xx]

Technical Note

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1. EXECUTIVE SUMMARY

1.1.1. The grouting works are necessary to deliver the Scheme and the assessment summarised in this technical note demonstrates that the extent of the land and associated rights necessary to deliver those works is justified.

1.1.2. The extents of proposed grouting works have been assessed based on the results of the intrusive ground investigation (Appendix 9.2a to 9.2e of the Environmental Statement [APP-138 to 142]) and the Coal Mining Risk Assessment (Appendix 9.3 of the Environmental Statement [APP-143]) for the Scheme. The assessment was carried out using a conventional interpretation of the relevant published guidance at the time (CIRIA Special Publication 32) using common assumptions and precedent experience.

1.1.3. This is considered to provide a conservative assessment of the lateral extent of grouting works that may be required for the scheme. The extents of land and associated rights proposed are considered to represent the maximum lateral extents over which grouting is intended to occur as part of the works. A summary table is included within this technical memo detailing the coal mining risk and rationale for grouting within each Plot where temporary possession and use of land is required, together with permanent acquisition of rights over subsoil.

2. INTRODUCTION

2.1.1. This technical note provides a response to Question 2.3.8 posed by the Examining Authority in advance of Deadline 4:

2.1.2. *'Grouting works* under *land are proposed in several locations across the scheme (e.g. Plot Nos. 4/7b and 4/7b) [REP2-037]. Please provide further details of the need for and the extent of proposed grouting works and the justification for the extent of land and associated rights required for these works'.*

3. REFERENCED WORK

3.1.1. Reference should be made to the Scheme's intrusive ground investigation (Appendix 9.2a to 9.2e of the Environmental Statement [APP-138 to 142]) and 'Coal Mining Risk Assessment (Appendix 9.3 of the Environmental Statement [APP-143])' (**"CMRA"**) (ref: HE551462-WSP-VGT-ZZ-RP-VG-00001 rev 1, dated January 2019) for further detail regarding the coal mining risk and mitigation options. This demonstrates the nature of the ground conditions in the area in which the Scheme will be carried out and hence the need for grouting to take place.

4. REQUIREMENT FOR GROUTING WORKS

4.1.1. The Scheme lies within an area underlain by coal bearing rock strata in an area of the UK where historically extensive underground coal mining has taken place. This has resulted in some of the coal seams below parts of the Scheme having been subject to underground mining, some of which pre-dates historical mining records. Intrusive investigation has found evidence of mining voids and collapsed ground beneath several parts of the Order limits.

4.1.2. The presence and depth below ground level of these underground voids is variable, due to changes in underlying geology and topography across the scheme. The risk that mine workings pose to the Scheme is linked to the depth of those workings beneath the proposed works. Generally, the deeper the historical underground workings are, the less likely they are to lead to a risk of surface subsidence/damage.

4.1.3. The requirement or otherwise for treatment/grouting works is a function of the depth below rockhead of coal seam workings and the nature of the structures/infrastructure proposed above. In addition, instability risk associated with underground workings does not just affect land or structures immediately above the workings, as the effect radiates outwards from the point of workings due to 'angle of draw' effects, as discussed further below.

4.1.4. Where the workings are or may be shallow, and a risk of surface subsidence is present, mitigation is required to manage the potential for damage to proposed structures/infrastructure. Such mitigation usually includes infilling of the mining voids with cement grout. The purpose of void filling is to reduce the risk of upward migration of mining voids due to progressive roof collapse and to consolidate already collapsed broken ground.

4.1.5. The majority of the anticipated grouting works are proposed to be completed within/beneath areas of permanent land take, with some localised areas anticipated outside areas of permanent acquisition.

4.1.6. The anticipated grouting works fall into two main categories (as per the CMRA):

- Areas where investigation by drilling and treatment by grouting is expected to be necessary to reduce the risk -
    - This applies to proposed aspects of the scheme assessed as having a high risk of being impacted by mining related hazards (generally, potential collapse of shallow mine workings); and,
- Areas where investigation by drilling and treatment by grouting may be necessary to reduce the risk rating and is assumed to be required on a precautionary basis -
    - This applies to proposed aspects of the scheme assessed as having a medium or low risk of being impacted by mining related hazards, but that risk cannot be sufficiently excluded.
    - The decision on whether these areas are treated must be based on the level of risk identified to subsist as the design of the Scheme

progresses and the findings of any additional proof drilling during construction.

5. RATIONALE FOR DETERMINING EXTENT OF MINE WORKINGS TREATMENT ZONE

5.1.1. Guidance on good practice for treatment of shallow mine workings has over the past 35 years been provided within 'CIRIA Special Publication 32 / PSA Civil Engineering Technical Guidance 43 'Construction over Abandoned Mineworkings' 1984 (referred to as 'SP32'). This document provides guidance on the recommended lateral extent of treatment of shallow mineworkings below a structure and was still in publication when the coal mining risk for the scheme was assessed (in 2018 / early 2019) and provides guidance on the recommended lateral extent of treatment of shallow mineworkings below a structure.

5.1.2. SP32 was replaced by 'CIRIA C758D Abandoned Mineworkings Manual' 2019 (referred to as 'C758D') in May 2019. Guidance within C758D has been discussed below, but is less detailed, so the conventional and established approach described in SP32 is still considered appropriate in this instance.

5.1.3. The recommended lateral extent of treatment of shallow mineworkings below a structure is intended to avoid unacceptable ground movement of the ground bearing the structural loads or foundations. In this context a 'structure' (as referred to in SP32) is considered to be the carriageway, and any structure or earthwork carrying or supporting the carriageway or any ancillary structure (such as gantry, underpass, retaining wall etc.).

5.2. General

5.2.1. Both documents conclude that there is a risk of surface instability where the thickness of competent rock cover above mine workings is less than ten times the thickness of the mineworking void (often referred to as a ratio of 10:1 or 10t). Some variation in this ratio is required to account for certain geotechnical conditions, such as rock type, soil thickness, nature of workings, groundwater etc. This 10:1 ratio has generally been used in the risk assessments included in the CMRA to establish those parts of the scheme which may be at risk from surface instability and where mitigation may be required.

5.2.2. Due to the incomplete nature of mining records, consideration has been given to risks from both recorded mineworkings (i.e. from Coal Authority plans or investigation borehole records) and unrecorded workings (i.e. where a named coal seam of workable thickness is present or expected, but there are no published records for workings in that seam at that location).

5.3. Lateral Extent of Treatment

5.3.1. The recommended lateral extent of treatment of shallow mineworkings below a structure is intended to avoid unacceptable ground movement beneath structural loads or foundations. In this context a 'structure' (as referred to in SP32) is considered to be the carriageway, and any structure or earthwork carrying or supporting the carriageway or any ancillary structure (such as gantry, underpass, retaining wall etc).

5.3.2. As old mineworkings voids collapse, upwards migration of the void through the overlying strata results in a zone of ground movement above the workings which widens as it advances upwards. This effect is often referred to as 'draw' and the 'angle of draw' is the angle of this widened zone. Hence underground workings which are some distance laterally from the footprint of a structure can still present a risk of ground movement (dependant on their depth) and may require stabilisation treatment.

5.3.3. An assessment of the lateral treatment distance from the footprint of a structure is based on a projection of the 'angle of draw' up from the top of the underground workings to the bearing level of the structure. For embankments or shallow foundations this bearing depth is typically close to the ground surface but for piled foundations the bearing depth would be the level of the toe of the piles.

5.4. Grout Spread Beyond Grouting Extents

5.4.1. During treatment grout is injected into the workings and spreads laterally from the point of injection. The distance of spread is a function of the spacing of the injection holes, the condition of the workings (i.e. open voids, backfilled or collapsed strata), the dip of the seam, the method of injection and the grout mix properties. It is common to assume that grout spread of approximately 2.5m is typical, although may be more in open workings and less in tightly packed or collapsed workings. This effect has the benefit that some edge treatment occurs beyond the injection zone, although this spread of grout beneath third party land must be acknowledged. As the extent of this spread is difficult to guarantee it is often ignored when considering planning treatment areas but should be considered in land boundary assessments.

5.4.2. Additionally, inclination of treatment drillholes (typically up to 25°, but can be as much as 45° from the vertical) enables grout injection into workings beyond the surface position of the drillholes. Thus, the area of treatment at depth can be greater than the physical extents of the surface area required for drill rig operation. This approach may be adopted on this scheme to reduce the areas of land needed to be accessed by the drill rig.

5.5. CIRIA SP32 Treatment Extent Estimation Methods

5.5.1. SP32 acknowledges that the angle of draw is influenced by the nature of the strata above the workings. Within typical coal measures rock strata (interlayered sandstone, siltstone, mudstone and coal) SP32 advises this angle of draw (θ) can be taken as 15° or 20° from the vertical (15° is typically used in northeast England).

5.5.2. In saturated or unconsolidated overburden, SP32 advises the angle of draw (θ) can be taken as 90°- Ø/2 where Ø is the angle of internal shearing resistance of the soil. For dense granular soils, BS 1377 indicates a typical angle of internal shearing resistance of 40°, hence the angle of draw (θ) for such strata would typically be 70°.

5.5.3. Although no guidance is provided in SP32 for unsaturated or consolidated

soils (such as Glacial deposits) it has become common practice, generally accepted by the Coal Authority, to adopt an angle of draw (θ) of 45°. This reflects the properties of consolidated Glacial deposits and avoids unnecessarily wide extents of treatment where thick Glacial deposits occur above rockhead. Where different strata are present above the works (i.e. rock and soil), the widths are determined separately for each strata using the appropriate angle of draw and then combined.

5.5.4. So, the method to calculate the width of recommended treatment (for Glacial deposits over rock) becomes (as illustrated below):

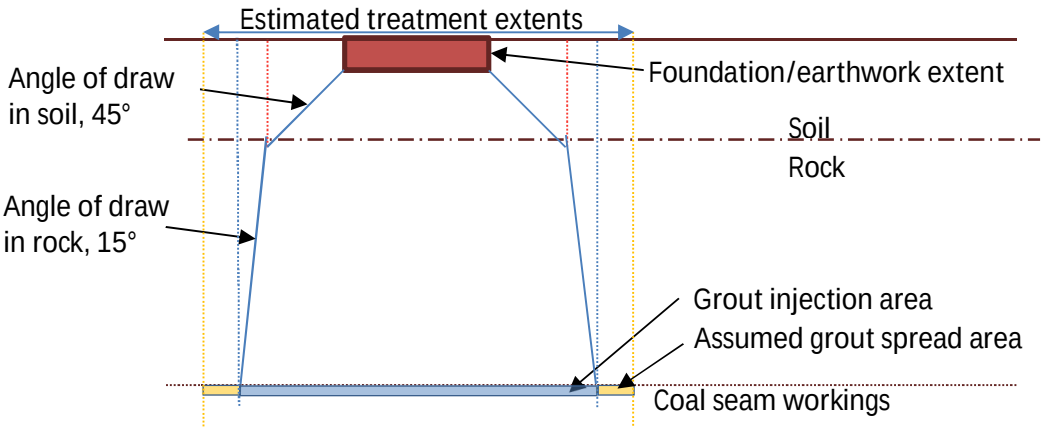
$$\textit{Treatment width} = (\textit{Tan } 15° \times Z_r) + (\textit{Tan } 45° \times Z_s)$$

Where:

Z_r = thickness of rock strata between top of workings and foundation bearing depth; and,

Z_s = thickness of soil strata between top of workings and foundation bearing depth

5.5.5. Greater widths may be applicable if soil strata are loose, saturated or unconsolidated.



5.5.6. As the thickness of soil and the thickness of rock above the workings varies considerably throughout the scheme, some approximations of the ground conditions have been made to simplify the assessment.

5.5.7. Three typical ground models have been used to illustrate the recommended widths of treatment based on this method:

Thickness of rock above workings	Thickness of soil above workings	Draw in rock (Tan 15 °)	Draw in soil (Tan 45 °)	Total draw	Assumed grout spread	Total treatment width (incl. grout spread allowance)
10m	10m	2.5m	10m	12.5m	2.5m	15m
10m	20m	2.5m	20m	22.5m	2.5m	25m
10m	30m	2.5m	30m	32.5m	2.5m	35m

5.5.8. This method was adopted to assess the lateral extent of proposed grouting works for the scheme.

5.5.9. Other empirical methods for determining appropriate angles of draw are noted in SP32, including that the extent of treatment should extend to 0.75 times the depth to the workings (i.e. 7.5m width above workings at 10m depth, and 15m width above workings at 20m depth). However, it is noted that this 'rule of thumb' does not give differing results depending on whether the strata above the workings is predominantly rock or soil.

5.6. Comment on CIRIA C758D Treatment Extent Estimation Methods

5.6.1. CIRIA C758D, published shortly after completion of the CMRA assessment, advises a slightly different approaches, although still based on the same principles of load spread and angle of draw. Initially the load dispersal spread of a foundation (or effective foundation in the case of embankments or pile groups) is determined by striking a line from the 'foundation' edge at 2V:1H. Thus, underground workings at 10m below the foundation level should be treated to an area 5m beyond the foundation perimeter, increasing to 10m beyond the foundation perimeter for workings at 20m below the foundation level, and 15m beyond the foundation perimeter for workings at 30m below the foundation level. It is noted that this approach makes no distinction between soil or rock cover.

5.6.2. It is noted that the C758D approaches would result in smaller extents of treatment beyond the foundation footprint than using the SP32 method, with the difference becoming more pronounced as the thickness of soil increases.

5.7. Concluding Summary

5.7.1. It is apparent that selection of a treatment width in compliance with industry guidance involves some element of engineering interpretation and this should be informed by the results of investigation of actual ground conditions in each case. Discussion and agreement with the relevant regulator and stakeholders, including The Coal Authority and Highways England will be required to seek agreement on the treatment widths prior to finalisation of the temporary and permanent land strategy.

5.7.2. The treatment extents are based on a conventional interpretation of the relevant published guidance at the time (SP32) using common assumptions and precedent experience. This is considered to provide a conservative assessment of the lateral extent of grouting works that may be required for the Scheme. However, as can be seen from the table at Section 5.5 above, the lateral spread of grout from workings can be as much as 35m.

5.7.3. The following three broad categories (based on simplified extents of the treatment zones using the SP32 method of estimation) have been adopted for the grouting extents and subsequently the Land Plans:

- Estimated 15m wide treatment zone beyond a proposed foundation/earthwork footprint – adopted in areas where rockhead is <10 mbgl and rock cover <10 times seam thickness, plus an allowance for grout spread; and,
- Estimated 25m wide treatment zone beyond a proposed foundation/earthwork footprint – adopted in areas where rockhead is >10 and <30 mbgl and rock cover <10 times seam thickness, plus an allowance for grout spread;
- Estimated 35m wide treatment zone around a proposed foundation/earthwork footprint – adopted in areas where rockhead is >30 mbgl and rock cover <10 times seam thickness, plus an allowance for grout spread.

5.7.4. The following table provides a summary of the coal mining risk and the anticipated grouting works within each Plot where temporary possession and use of land is required, together with permanent acquisition of rights over subsoil.

5.7.5. The treatment extents are based on a conventional interpretation of the SP32 guidance using common assumptions and precedent experience. These distances should not be considered as definitive or final and may require re-assessment on completion of any additional ground investigation or probe drilling during treatment works. Therefore, a margin required for additional spread is assumed. Based on the details outlined above, the extents of land and associated rights required are intended to represent the maximum lateral extents over which grouting will be undertaken/spread.

Rationale for the requirement for '*Permanent acquisition of rights over subsoil including temporary possession and use of land*' specifically in relation to the proposed coal mine grouting works (* details summarised from Table 6 of the '*Statement of Reasons'*)					
Plot Number from the Land Plans*:	**DCO Work No. (*for ref only*) *:**	**Purpose for which the land is required*:**	**Specific coal mining risk being targeted by grouting works (from CMRA):**	**Anticipated grouting works:**	**Rationale for grouting area extending beyond the permanent land take area:**
3/3e, 3/3f, 3/3i, 3/3z, 3/3dd, 3/3gg, 3/3pp, 3/3qq, 3/3tt	Work Nos. 1a, 1b, 3a, 3b, 3c and 3d	Grouting works associated with the construction within and around junction 67 (Coal House) Roundabout, including widening of the existing Kingsway Viaduct.	CMRA Section 2: Recorded workings on the Harvey seam beneath this location, although no evidence recorded during the GI. Low risk, relating to the proposed piled foundations for the widened Kingsway Viaduct abutments/piers. Although, potential higher risk if proposed piled foundations for the widened Kingsway Viaduct extend beyond 5m below rockhead.	Investigation by drilling and treatment by grouting ***may be necessary*** to reduce the CMRA risk rating, particularly if piled foundations are longer than anticipated during preliminary design. Treatment extent 3 assumed: *estimated 35m wide*.	Conservative assessment of possible grouting extents. Likely to be less in this area given piled foundations and anticipated low mining risk.
3/3mm, 3/6d, 3/6f	Work Nos. 3c, 10, 13, 14 and 15	Grouting works associated with the widening of junction 67 (Coal House) northbound off slip road and embankment.	CMRA Section 2: Recorded workings on the Harvey seam beneath this location, although no evidence recorded during the GI. Low risk, relating to the proposed embankment widening.	Investigation by drilling and treatment by grouting ***may be necessary*** be conducted to reduce the CMRA risk rating to very low. Treatment extent 3 assumed: *estimated 35m wide*.	Conservative assessment of possible grouting extents. Only required if risks cannot be satisfactorily reduced.
3/3ww, 3/3aaa, 3/6k, 3/10d, 3/10h, 3/12b	Work No. 4b, 5a, 5b, 11, 22 and 23	Grouting works associated with the construction within replacement Allerdene Bridge and associated embankments.	CMRA Section 3: Recorded workings on several seams beneath this location and unrecorded workings encountered during the GI. High risk, relating to the proposed Allerdene bridge/viaduct. Low risk, relating to the proposed embankment widening.	Investigation by drilling and treatment by grouting ***is expected to be necessary*** to reduce the CMRA risk rating. Treatment extent 2 assumed to east of railway: *estimated 25m wide*. Treatment extent 3 assumed to west of railway: *estimated 35m*.	Conservative assessment of possible grouting extents. Only required in parcels 3/3aaa, 3/6k, 3/10h if risk cannot be satisfactorily reduced to very low beneath new earthworks as well as structures.
3/3kkk, 3/3nnn, 3/4q	Work Nos. 6a and 6b	Grouting works associated with the widening of the highway and associated earthworks around Smithy Lane.	CMRA Section 4: Potential is still present for unrecorded shallow mine workings to exist in this area. Medium risk, relating to the new areas of carriageway and earthwork widening.	Investigation by drilling and treatment by grouting ***may be necessary*** to reduce the CMRA risk rating to very low. Treatment extent 1 assumed: *estimated 15m wide.*	Conservative assessment of possible grouting extents. Extents to be confirmed following investigation drilling.
4/3b, 4/4b	Work Nos. 6a and 7b	Grouting works associated with the construction within	CMRA Section 5: Unrecorded workings encountered during	4/3b: Investigation by drilling and treatment by grouting ***is expected to be necessary*** to	Conservative assessment of possible grouting extents.

Rationale for the requirement for '*Permanent acquisition of rights over subsoil including temporary possession and use of land*' specifically in relation to the proposed coal mine grouting works (* details summarised from Table 6 of the '*Statement of Reasons'*)					
Plot Number from the Land Plans*:	**DCO Work No. (*for ref only*) *:**	**Purpose for which the land is required*:**	**Specific coal mining risk being targeted by grouting works (from CMRA):**	**Anticipated grouting works:**	**Rationale for grouting area extending beyond the permanent land take area:**
		and around junction 66 (Eighton Lodge), including widening of the existing bridges and embankments.	the GI on the High Main seam beneath this location. 4/3b: High risk, relating to the proposed widening of Eighton Lodge North bridge. 4/4b: Low risk, relating to the new areas of carriageway and earthwork widening.	reduce the CMRA risk rating. Treatment extent 1 assumed: *estimated 15m wide.* <u>4/4b:</u> Investigation by drilling and treatment by grouting ***may be necessary*** to reduce the CMRA risk rating to very low. Treatment extent 2 assumed: *estimated 25m wide.*	Only required in 4/4b if mining risk cannot satisfactorily be reduced to very low beneath new earthworks as well as structures.
4/2d, 4/3q, 4/6b, 4/7b, 4/7e, 4/13b, 4/13d	Work Nos. 6a, 7b and 19	Grouting works associated with the extension of Longbank Bridleway Underpass and construction/modification of highway earthworks between Longbank Bridleway Underpass and North Dene Footbridge.	<u>CMRA Section 6:</u> Potential is still present for unrecorded shallow mine workings of the High Main seam to exist in this area. Medium risk, relating to the new areas of carriageway and earthwork widening.	Investigation by drilling and treatment by grouting ***may be necessary*** to reduce the CMRA risk rating to very low. Treatment extent 1 assumed: *estimated 15m wide.*	Conservative assessment of possible grouting extents. Extents to be confirmed following investigation drilling. Only required in these plots if mining risk cannot satisfactorily be reduced to very low beneath new earthworks.
4/12b, 4/14b	Work Nos. 6a, 6b and 18	Grouting works associated with the construction of the replacement North Dene Footbridge.	<u>CMRA Section 6:</u> Potential is still present for unrecorded shallow mine workings of the High Main seam to exist in this area. Low risk, relating to North Dene Footbridge. Low and Medium risk, relating to the new areas of carriageway and earthwork widening.	Investigation by drilling and treatment by grouting ***is expected to be necessary*** to reduce the CMRA risk rating. Treatment extent 1 assumed: *estimated 15m wide.*	Conservative assessment of possible grouting extents. Extents to be confirmed following investigation drilling.
5/3b, 5/4b, 5/4d, 5/5a, 5/6, 5/7, 5/8, 5/9, 5/11	Work No. 6a and 8a	Grouting works associated with the widening of the main highway works and junction 65 (Birtley) southbound off slip.	<u>CMRA Section 6:</u> Potential is still present for unrecorded shallow mine workings of the High Main seam to exist in this area. High risk, relating to J65 south bound offslip retaining wall. Low risk, relating to the new areas of carriageway and earthwork widening.	<u>J65 south bound offslip retaining wall</u>: Investigation by drilling and treatment by grouting ***is expected to be necessary*** to reduce the CMRA risk rating. Treatment extent 1 assumed: *estimated 15m wide.* <u>New carriageway and earthworks</u>: Investigation by drilling and treatment by grouting ***may be necessary*** to reduce the	Conservative assessment of possible grouting extents. Extents to be confirmed following investigation drilling. Only required in 5/3b, 5/9 and 5/11 if Client requests mining risk to be reduced to very low beneath new earthworks as well as structures.

Rationale for the requirement for '*Permanent acquisition of rights over subsoil including temporary possession and use of land*' specifically in relation to the proposed coal mine grouting works (* details summarised from Table 6 of the '*Statement of Reasons'*)					
Plot Number from the Land Plans*:	**DCO Work No. (*for ref only*) *:**	**Purpose for which the land is required*:**	**Specific coal mining risk being targeted by grouting works (from CMRA):**	**Anticipated grouting works:**	**Rationale for grouting area extending beyond the permanent land take area:**
				CMRA risk rating to very low. Treatment extent 1 assumed west of retaining wall: *estimated 15m wide.* Treatment extent 2 assumed east of retaining wall: *estimated 25m wide.*	