H2Teesside Project

Environmental Statement

Volume III – Appendices

Appendix 10D: Geotechnical Risk Register

Document Reference: 6.4.14

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended)

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 - Regulation 5(2)(a)

Rev: 0

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10D.0 GEOTECHNICAL RISK REGISTER

10D.1.1 A geotechnical risk register for the proposed works has been developed; identifying the ground hazards and risks associated with the current condition of the Proposed Development Site and typical construction risks relating to the proposed improvement options. The geotechnical risk register is a live document and will need to be updated as risks are identified in subsequent stages of the scheme.

10D.1.2 A number of geotechnical hazards have been identified for the site. In order to quantify the risks associated with the proposed works, a preliminary geotechnical risk assessment has been conducted. To do this, an estimate is made of:

- the potential severity of the risk (consequence); and
- the likelihood of the risk occurring.

10D.1.3 The likelihood and severity of the risk are classified according to the criteria in Table 10D-1.

10D.1.4 An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 10D-2.

10D.1.5 The geotechnical risks associated with the proposed works for the Proposed Development Site are summarised in Table 10D-3.

10D.1.6 Risks indexes are provided before mitigation measures are implemented and after.

10D.1.7 The Proposed Development Site will be subject to confirmatory ground investigation (GI). The mitigation measures outline will be secured through the Framework Construction Environmental Management Plan.

Table 10D-1: Scoring Rationale Describing Likelihood and Severity of Geohazards

LIKELIHOOD (L)		SEVERITY (S)	
Frequent	5 Likely regular occurrence in relevant period	Very High	5 Death or major loss; total systems failure
Probable	4 Likely to occur several times in relevant period	High	4 Major injury, major damage to property/infrastructure, or major environmental effect.
Occasional	3 Likely to occur in relevant period	Medium	3 Lost time, injury or illness; minor damage to property/ infrastructure or significant environmental effect.
Remote	2 Unlikely to occur in relevant period	Low	2 Minor first aid incident or requiring routine maintenance repair.
Improbable	1 Extremely unlikely to occur in relevant period	Very Low	1 Unlikely to have impact on works

Table 10D-2: Geohazard Risk Index Ranges

INDEX = LIKELIHOOD (L) X SEVERITY (S) (SEE ALSO CIRIA SP125)		
16 – 25	Very High Risk	Unacceptable. Re-examine activities to provide lower risk.
9 – 15	High Risk	Further mitigation measures required and/or alter method of work. Seek approval from all stakeholders if risk cannot be reduced.
6 – 8	Medium Risk	Tolerable only if further mitigation is not reasonably practical and there is need to continue activity with identified controls.
1 – 5	Low Risk	Broadly acceptable if all reasonably practicable control measures in place.

Table 10D-3: Geotechnical Risk Register

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
MAIN SITE									
Inadequate bearing resistance – shallow foundations	Thick various types of Made Ground, of variable, (sometimes very loose and loose) density and chemical composition underlain by low strength, potentially highly compressible Tidal Flat Deposits and Glacio- lacustrine Deposits.	5	4	20	Collapse - Structural failure of buildings supported on shallow pad or spread foundations. Injury to site workers, development users.	Confirmatory Ground Investigation (GI) (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground conditions proved on site. If necessary, adopt piled foundations to transfer structure loads to soils or bedrock of adequate strength.	1	4	4
Excessive total and / or differential ground displacement (settlement and / or heave)	Thick various types of Made Ground, of variable, (sometimes very loose, loose to very dense) density and chemical composition underlain by low strength,	3	4	12	Excessive total and / or differential settlement. Structural damage caused by excessive ground displacement. Serviceability problems leading to structural	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground conditions proved on site. If necessary, adopt piled foundations to transfer structure loads to soils or	1	4	4

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	potentially highly compressible Tidal Flat Deposits and Glacio-lacustrine Deposits.				damage / long term maintenance.	bedrock of adequate strength.			
Excessive ground displacement (vertical and / or lateral heave) and difficult foundation construction	Physical expansion of material resulting from chemical changes in slag-dominant material.	3	4	12	Unexpected axial tensile actions imposed on buried shallow foundations, slabs and utilities leading to serviceability problems and possibly, structural damage / integrity problems. Unexpected transverse compressive actions imposed on buried pile foundations.	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground conditions proved on site. If necessary, adopt piled foundations to transfer structure loads to soils or bedrock of adequate strength. If necessary, consider use of sleeved piles to accommodate lateral expansion and / or heave.	1	4	4
Collapse settlement	Infiltration of surface water. Inundation of poorly compacted Made	3	4	12	Collapse - Structural failure. Excessive total and / or differential settlement.	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	4	4

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Ground due to a permanent rise in groundwater levels.					Adequate design for the groundwater and ground conditions proved on site. Excavate process and recompact made ground to minimise collapse risk. If necessary, adopt piled foundations to transfer structure loads to soils or bedrock of adequate strength.			
Unexploded ordnance (UXO)	UXO undiscovered ordinance following WWI and / or WWII.	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Adequate assessment and design. Provision of detailed report for site from specialist UXO data provider. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints. The UXO procedure is secured via the Framework CEMP (EN070009/APP/5.12).	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Difficult construction conditions –buried relict infrastructure – General	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, very dense material, relict buried foundations, walls, ground slabs, tunnels and possibly pile foundations from former infrastructure.	5	3	15	Structural damage (cracking / spalling) to driven concrete or steel piles or loss of plan position and verticality tolerances. Unable to construct shallow foundations, ground slabs, road / hardstanding areas for utilities as planned. Possible redesign, construction delay, increase in cost.	Confirmatory GI including geophysics (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the viability of undertaking targeted excavation and replacement of obstructions and processing and re-use of the materials in the works. Advanced probing / clearance works at proposed pile foundation positions. Remediation works undertaken by STDC to remove obstructions within 2.5m of ground level and/or mapping of any deeper features not demolished.	1	3	3
Difficult foundation construction – pile foundations	Soft, variable, compressible and / or saturated soils	4	4	16	Ground squeezing leading to ‘necking’ of pile shafts formed using	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	4	4

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
					continuous flight auger (CFA) techniques.	Adequate design for the ground conditions proved on site. Appropriate techniques selection, which may include balancing of pore water pressures at pile toes during construction if required. Consider adopting cased rotary bored piled foundations. Use of trained and experienced rig operators.			
Difficult foundation construction – pile foundations	Natural obstructions within the glacial drift soils present below the Main Site.	3	2	6	If piling required, unable to achieve pile design toe levels. Construction results in damage to piles if required, or piles which do meet specified out of plan and / or verticality tolerances. Construction delay; increase in cost and possible redesign.	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground conditions proved on site. Appropriate pile technique selection if required. Carry out advanced magnetometer probing at any required pile positions if necessary. Consider use of cased rotary bored or Overburden Drilling Excentric	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						(ODEX) piling techniques as alternative to contiguous flight auger (CFA) or driven precast concrete segmental piles if necessary.			
Difficult construction conditions – buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried infrastructure / services.	4	5	20	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider. Litigation resulting from damage caused to third party infrastructure.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities. Use best practice for diversion of utilities if required. At the main site, it is anticipated that STDC shall remove all known relict utilities during their proposed remediation.	1	2	2
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline	5	3	15	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection.	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design.	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	pH in soil or groundwater.				Sulphate attack on buried concrete resulting in a reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	Consideration to the provision of permanent sleeving to protect any piles installed through the most aggressive material (Slag dominant material). Consideration to the provision of Additional Protective Measures (APM) to provide additional protection against sulfate attack. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and polyethylene (PE) barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.			
Contamination of controlled waters – groundwater	Piled foundations may create source – pathway – receptor between contaminated	3	5	15	Release of leachable contaminants into underlying aquifers: Superficial – Secondary 'A' Aquifers (Blown Sand,	Confirmatory GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	groundwater and the underlying superficial and bedrock aquifers.				Tidal Flat Deposits (sand and silt). Bedrock - Secondary 'B' Aquifer (Mercia Mudstone Group & Penarth Group) and the Secondary Aquifer (undifferentiated) Redcar Mudstone Formation. Construction delays; increase in cost. Fines and / or enforcement action from Regulator. Reputational damage.	Adequate design for the ground conditions proved on site. Consultation with the EA and Redcar and Cleveland Borough Council (as part of the production of the Final CEMP(s)). Preparation of a Foundation Works Risk Assessment (prepared as part of the Final CEMP(s)). If piling required, consider adopting cased rotary bored piled foundations to remove potential pathway between Made Ground and underlying aquifers.			
Material re-use – unacceptable excavated soils	Material excavated to form development platforms not suitable for re-use as bulk earthwork fill. Soft spots or areas exposed at	5	3	15	Disposal off site or in landscape / development screening mounds. Excavate soft spots / soft areas and replace with well compacted acceptable material.	Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Assessment of earthworks volumes required / minimise surplus and create earthwork balance.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	development platform sub-formations. Material excavated during bulk earthworks undertaken on site is contaminated.					Cost / risk allowance for waste disposal of contaminated soils as a last resort including non-hazardous and hazardous waste to be allowed for in the Construction Risk Register. Development of a Remediation Design Strategy and implementation of Materials Management Plan (MMP) allowing risk-based re-use of contaminated soils, Final CEMP(s), Asbestos Management Plan (AMP) and Verification Report on completion of the works.			
Groundwater Flooding	High groundwater table.	3	4	12	The flooding of the development. A high groundwater table may also lead to inundation of excavations.	Groundwater monitoring for a 12-month programme to determine the groundwater levels during the dry and wet seasons, undertaken as part of the Confirmatory GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	4	4

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Drainage if required.			
Frost susceptible soils	Silty materials present in Made Ground	3	3	9	Shrinking and swelling of the surface materials and potential for differential settlement.	The California Bearing Ratio (CBR) values and frost susceptibility of the sub-grade soils and groundwater conditions will need to be further assessed by means of intrusive ground investigations and laboratory testing (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	3	6
CO_2 Export CORRIDOR									
Unexploded ordnance	UXO dropped during WWII [Mapping shows a historical Luftwaffe Target adjacent to the northern boundary (approximately 50 m), therefore there may be a possibility of UXO	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints.	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	being present at the corridor.]					The UXO procedure is secured via the Framework CEMP (EN070009/APP/5.12).			
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels and possibly pile foundations associated with demolished former buildings.	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Include cost / risk allowance for impeded construction progress in the Construction Risk Register.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent third-party infrastructure.	3	3	9	Construction delay; increase in cost and possible redesign. Litigation resulting from damage caused to third party infrastructure.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction if necessary with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Contamination of controlled waters	Surface water runoff into controlled waters. Contaminated groundwater generated / released during construction.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife. Construction delay; increase in cost and possible redesign. Fines and / or enforcement action from Regulator. Regulatory damage.	GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Include measures for preventing adverse impacts on controlled waters as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Development and adherence to the Final CEMP(s). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility.	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and then tankered offsite and would be subject to treatment prior to discharge.			
Difficult construction conditions – buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried infrastructure / services.	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider. Litigation resulting from damage caused to third party infrastructure.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or groundwater.	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection. Sulphate attack on buried concrete resulting in a reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if BRE SD1 assessment indicates Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.	1	3	3
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk-based criteria.	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	backfill above buried service utilities.					Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Cost / risk allowance for waste disposal of contaminated soils as a last resort to be allowed for in the Construction Risk Register. Materials discarded as Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of an MMP, AMP, Final CEMP(s) and Verification Report on completion of the works.			
NATURAL GAS CONNECTION CORRIDOR									

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Unexploded Ordnance	UXO dropped during WWII. [Mapping shows an area to the north of Corridor was a historical Luftwaffe Target (approximately 400 m N)]	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints. The protocol for UXO is secured through the Framework CEMP (EN070009/APP/5.12).	1	5	5
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels and possibly pile foundations	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	associated with demolished former buildings.					Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems. If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Examine potential for utilising the existing intake and associated abstraction licence from the former Redcar Steelworks to supply water to the Proposed Development.			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	3	3
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent	3	3	9	Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	third-party infrastructure.				Litigation resulting from damage caused to third party infrastructure.	Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction, if necessary, with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.			
Contamination of controlled waters	Surface water runoff into controlled waters. Contaminated groundwater generated / released during construction.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife. Construction delay; increase in cost and possible redesign.	GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Include measures for preventing adverse impacts on controlled waters as part of the remediation	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
					Fines and / or enforcement action from Regulator. Regulatory damage.	strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Development and adherence to the Final CEMP(s). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and then tankered offsite and would be subject to treatment prior to discharge.			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Difficult construction conditions – buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried infrastructure / services.	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider. Litigation resulting from damage caused to third party infrastructure.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.	1	3	3
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or groundwater.	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection. Sulphate attack on buried concrete resulting in a reduction in concrete strength.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if BRE SD1 assessment indicates	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
					Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.			
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk backfill above buried service utilities.	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk – based criteria. Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Cost / risk allowance for waste disposal of contaminated soils as a last resort to be allowed for in the Construction Risk Register. Material discarded as Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of an MMP, AMP, Final CEMP(s) and Verification Report on completion of the works.			
WATER CONNECTION CORRIDOR									
Unexploded Ordnance	UXO undiscovered ordinance following WWI and/or WWII. [Mapping shows an area to the west of Corridor was a historical Luftwaffe	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints.	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Target (approximately 300 m W)]					The protocol for UXO is secured via the Framework CEMP (EN070009/APP/5.12).			
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels and possibly pile foundations associated with demolished former buildings.	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Examine potential for utilising the existing intake and associated abstraction licence from the former Redcar Steelworks to supply water to the Proposed Development. Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Difficult construction conditions - buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	infrastructure / services.				Litigation resulting from damage caused to third party infrastructure.	of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent third-party infrastructure.	3	3	9	Construction delay; increase in cost and possible redesign. Litigation resulting from damage caused to third party infrastructure.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction if necessary with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.	1	3	3
Contamination of controlled waters	Surface water runoff into controlled waters.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife.	GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Contaminated groundwater generated / released during construction.				Construction delay; increase in cost and possible redesign. Fines and / or enforcement action from Regulator. Regulatory damage.	Include measures to mitigate risk to controlled waters as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Development and adherence to the Final CEMP(s). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and then tankered offsite and would be			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						subject to treatment prior to discharge.			
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or groundwater.	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection. Sulphate attack on buried concrete resulting in a reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if BRE SD1 assessment indicates Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk backfill above buried service utilities.	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk-based criteria. Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Cost / risk allowance for waste disposal of contaminated soils to be allowed for in the Construction Risk Register. Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of an MMP. AMP,	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Final CEMP(s) and Verification Report on completion of the works.			
ELECTRICAL CONNECTION CORRIDOR									
Unexploded Ordnance	UXO undiscovered ordinance following WWI and/or WWII.	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints. The protocol for UXO is secured via the Framework CEMP (EN070009/APP/5.12).	1	5	5
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	and possibly pile foundations associated with demolished former buildings.					Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems. If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Examine potential for utilising the existing intake and associated abstraction licence from the former SSI Redcar Steelworks to supply			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						water to the Proposed Development. Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent third-party infrastructure.	3	3	9	Construction delay; increase in cost and possible redesign. Litigation resulting from damage caused to third party infrastructure.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction if necessary with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.	1	3	3
Contamination of controlled waters	Surface water runoff into controlled waters.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife.	GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Contaminated groundwater generated / released during construction.				Construction delay; increase in cost and possible redesign. Fines and / or enforcement action from Regulator. Regulatory damage.	Development and adherence to the Final CEMP(s). Include measures to mitigate risks to controlled waters as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and then tankered offsite and would be			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						subject to treatment prior to discharge.			
Difficult construction conditions – buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried infrastructure / services.	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider. Litigation resulting from damage caused to third party infrastructure.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.	1	3	3
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or groundwater.	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection. Sulphate attack on buried concrete resulting in a	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
					reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	BRE SD1 assessment indicates Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.			
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk backfill above buried service utilities.	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk-based criteria. Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						to a Requirement of the Draft DCO (EN070009/APP/4.1). Cost / risk allowance for waste disposal of contaminated soils to be allowed for in the Construction Risk Register. Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of MMP, AMP, Final CEMP(s) and Verification Report on completion of the works.			
HYDROGEN PIPELINE CORRIDOR									
High Groundwater Flood Risk Areas	High risk of groundwater flooding in areas close to pipeline crossing route area north of River Tees.	3	4	12	Risk of uplift to the pipeline or erosion of backfill to pipeline.	Adequate assessment and design.	1	4	4

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Unexploded Ordnance	UXO undiscovered ordinance following WWI and/or WWII. [North of River Tees – The majority of the Corridor is within an area of Moderate risk. South River Tees – small portion of Trunk Road to the south, being within an area of Moderate risk. Refer to Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)) for Decoy Sites, Strategic Targets and Luftwaffe Targets]	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints. The protocol for UXO is secured via the Framework CEMP (EN070009/APP/5.12).	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Difficult construction conditions – peat / alluvium	Presence of peat / alluvium locally in or below utilities excavations. [Figure 10-2: Superficial Geology (ES Volume II, EN070009/APP/6.3) shows an elongate area of peat present across the route south-east of Reservoirs near Saltholme].	3	2	6	Compressible formation susceptible to ground displacements (heave / settlement) during and after construction. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground conditions proved on site. Removal of soft spots and replacement with suitable compacted engineered fill material. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	2	2
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels and possibly pile	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	foundations associated with demolished former buildings.					Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems. If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Examine potential for utilising the existing intake and associated abstraction licence from the former SSI Redcar Steelworks to supply			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						water to the Proposed Development. Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent third-party infrastructure.	3	3	9	Construction delay; increase in cost and possible redesign. Litigation resulting from damage caused to third party infrastructure.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction if necessary with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.	1	3	3
Contamination of controlled waters	Surface water runoff into controlled waters.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife.	GI and groundwater quality testing and monitoring (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1).	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Contaminated groundwater generated / released during construction.				Construction delay; increase in cost and possible redesign. Fines and / or enforcement action from Regulator. Regulatory damage.	Include measures to mitigate risks to controlled waters as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Development and adherence to the Final CEMP(s). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and then tankered offsite and would be			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						subject to treatment prior to discharge.			
Difficult construction conditions – buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to existing buried infrastructure / services.	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider. Litigation resulting from damage caused to third party infrastructure.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.	1	3	3
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	groundwater.				Sulphate attack on buried concrete resulting in a reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	BRE SD1 assessment indicates Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.			
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk backfill above buried service utilities.	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk-based criteria. Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						to a Requirement of the Draft DCO (EN070009/APP/4.1). Cost / risk allowance for waste disposal of contaminated soils to be allowed for in the Construction Risk Register. Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of an MMP, AMP, Final CEMP(s) and Verification Report on completion of the works.			
OTHER GASES CONNECTION CORRIDOR									
Unexploded Ordnance	UXO undiscovered ordinance following WWI and/or WWII.	3	5	15	Explosion, injury or fatality (site personnel and / or the public). Damage to on site and third-party infrastructure. Construction delay; increase in cost and possible redesign.	Provision of detailed report for site from specialist UXO data provider. Adequate assessment and design. Specialist UXO clearance surveys undertaken as part of all future below ground works. If necessary, re-route sections to avoid known UXO constraints.	1	5	5

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						The protocol for UXO is secured via the Framework CEMP (EN070009/APP/5.12).			
Difficult construction conditions – relict buried infrastructure	Obstructions in the Made Ground including gravel, cobble and boulder sized pieces of slag, relict buried foundations, walls, ground slabs, tunnels and possibly pile foundations associated with demolished former buildings.	5	3	15	Not possible to construct in-ground sections to depth or vertical alignment as planned. Construction delay; increase in cost and possible redesign.	Development specific GI targeted at suspected relict buried foundations, walls, slabs and tunnels etc (identified from historical land use review) including non-intrusive geophysical surveys along proposed in-ground services corridor (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design, including identification of in-ground constraints from the review of historical land use carried out as part of the Summary Report (Appendix 10A (ES Volume III, EN070009/APP/6.4)). Assess feasibility of re-routing sections to avoid problems.	1	3	3

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		L	S	R (L X S)			L	S	R (L X S)
						If re-routing is not practical, carry out advanced works ahead of main construction including probing and / or limited earthworks to remove identified relict buried structures by undertaking targeted excavation and replacement of obstructions. Examine potential for utilising the existing intake and associated abstraction licence from the former SSI Redcar Steelworks to supply water to the Proposed Development. Include cost / risk allowance for slow construction progress in the Construction Risk Register.			
Difficult construction conditions - buried utilities	Disused redundant and / or live buried services associated with past land use. New construction causes damage to	4	3	12	Severing / damaging utility. Settlement of utility / services. Restricted maintenance access to utility provider.	Adequate service survey / drawings to confirm status of utility. Non-intrusive geophysical survey and / or intrusive trial excavations to confirm presence and status of utilities (pursuant to a Requirement	1	3	3

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		L	S	R (L X S)			L	S	R (L X S)
	existing buried infrastructure / services.				Litigation resulting from damage caused to third party infrastructure.	of the Draft DCO (EN070009/APP/4.1). Use best practice for diversion of utilities if required. Use of existing above / below ground service conduits where possible.			
Difficult construction conditions – tidal groundwater control	Shallow groundwater inflows [from wet, coarse soils].	4	3	12	Groundwater inflows into excavations, side slope instability, slumping or ravelling of slopes dug below ground, liquefaction or pumping of silts and / or sands under loading from earth moving plant. Construction delay; increase in cost and possible redesign.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for ground and groundwater conditions proved on site. Temporary groundwater control measures could be required, such as sump pumping, well pointing, vacuum extraction systems, and provision of temporary sheet pile cut off. Include cost / risk allowance for slow construction progress in the Construction Risk Register.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Dewatering	Prolonged pumping of groundwater induces ground settlement and damages adjacent third-party infrastructure.	3	3	9	Construction delay; increase in cost and possible redesign. Litigation resulting from damage caused to third party infrastructure.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design for the ground and groundwater conditions proved on site. If dewatering is required, assess feasibility of relocating pumping to avoid settlement sensitive infrastructure. Design / implement a programme of geotechnical monitoring during construction if necessary with appropriate controls / actions. Liaison with third party infrastructure owner (and technical advisors) during design and construction if required.	1	3	3
Contamination of controlled waters	Surface water runoff into controlled waters.	3	2	6	Adverse impact on water quality, with resultant impact on wildlife.	GI and groundwater quality testing and monitoring (pursuant to a	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
	Contaminated groundwater generated / released during construction.				Construction delay; increase in cost and possible redesign. Fines and / or enforcement action from Regulator. Regulatory damage.	Requirement of the Draft DCO (EN070009/APP/4.1). Development and adherence to the Final CEMP(s). Include measures to mitigate risks to controlled waters as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Obtain appropriate discharge permit to allow discharge to existing sewerage network, system, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, wastewater will be collected and taken off site by tankers for disposal at a permitted waste treatment facility. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and			

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						then tankered offsite and would be subject to treatment prior to discharge.			
Aggressive ground conditions	Aggressive elevated concentrations of sulphate and chloride and acidic or alkaline pH in soil or groundwater.	3	3	9	Corrosion of buried steel leading to a loss in strength and / or excessive structural deflection. Sulphate attack on buried concrete resulting in a reduction in concrete strength. Serviceability problems leading to long term maintenance liability. Corrosion of polyethylene (PE) and polyvinyl chloride (PVC) plastic pipes.	Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Adequate design. Consideration to the provision of APM to provide additional protection against sulfate attack if BRE SD1 assessment indicates Design Sulfate Class DS-5 conditions are present. Utilities to be installed within clean inert pipe bedding material. Consider the use of wrapped steel, wrapped ductile iron, copper and PE barrier pipe with an aluminium barrier layer (PE-Al-PE) for services and water supplies in contaminated soils.	1	3	3

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
Material re-use	Material excavated may be contaminated and / or unacceptable for re-use as bulk backfill above buried service utilities.	4	2	8	Disposal offsite.	Soils may be unlikely to be acceptable for re-use unless remediated to risk based criteria. Development specific GI (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Contamination assessment of all chemical data. Develop risk-based materials re-use criteria as part of the remediation strategy (pursuant to a Requirement of the Draft DCO (EN070009/APP/4.1). Cost / risk allowance for waste disposal of contaminated soils to be allowed for in the Construction Risk Register. Waste may be contaminated with hazardous materials. Development of a Remediation Design Strategy and implementation of MMP, AMP,	1	2	2

IDENTIFIED GEOTECHNICAL HAZARD / RISK	CAUSE	RISK BEFORE MITIGATION			CONSEQUENCE	MITIGATION MEASURES	RISK AFTER MITIGATION		
		L	S	R (L X S)			L	S	R (L X S)
						Final CEMP(s) and Verification Report on completion of the works.			