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GRANGETOWN PRAIRIE AREA, FORMER STEELWORKS, REDCAR

Remediation Options Appraisal and Enabling Earthworks and Remediation Strategy Report

South Tees Development Corporation

REPORT NO. 10035117-AUK-XX-XX-RP-ZZ-0066-01-Prairie ROA and Strategy

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Grangetown Prairie Area, Former Steelworks, Redcar

Remediation Options Appraisal and Enabling Earthworks and Remediation Strategy Report

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APPENDICES

1 INTRODUCTION

1.1 Project Aims and Objectives

The Grangetown Prairie (Prairie) Area (the site) is a land parcel situated at the Former Redcar Steelworks located within the Redcar, Lackenby, Grangetown and South Bank conurbations of the Borough of Redcar & Cleveland, within the industrial area generally known as 'South Tees'.

The South Tees Regeneration Masterplan has been developed detailing the industrial-led regeneration of the Former Redcar Steelworks into a world class employment-generating zone and economic growth enabler for the Tees Valley.

The Masterplan has identified the Prairie Area (also known as Cleveland South) as being located within the Southern Industrial Zone. The site is a priority development area and Arcadis understands this report is to be used within a detailed planning application scheduled for submission in June 2020.

The overarching aim of the works was to deliver a sustainable ground remediation strategy for the contract sites which is compliant with regulatory needs (Local Authority and Environment Agency) and has their approval in principle. As technical consultant, the specific objectives of this phase of works were to review the output of the environmental and geotechnical risk assessment and identify applicable remediation options for the site.

1.2 Contract Details

Arcadis (UK) Limited (Arcadis) were appointed by South Tees Development Corporation (STDC) to conduct a remediation options appraisal and develop a remediation strategy to address environmental constraints relating to ground conditions identified by the physical ground investigation works conducted at the Prairie site.

The work was carried out in accordance with the proposal "Redcar Steelworks, Prairie Remediation and Reclamation Strategy and Specification" dated 17th April 2020.

Figure 1 in Appendix A provides details of the facility location.

1.3 Report Aims

The aim of this remediation options appraisal (ROA) and strategy document is to use the available information to assess feasible remediation strategies to address the active source-pathway-receptor linkages identified by the site condition report and the development constraints identified by the geotechnical risk assessment within the conceptual site model (CSM) for the contract area in order to develop the final remediation technology selection and design. The remediation strategy has been formulated to support the planning process for the development of the Grangetown Prairie site.

1.4 Previous Information

The following reports have been prepared for or include the Grangetown Prairie Area:

- TS3 Grangetown Prairie – Phase 1 Geo-Environmental Desk Study, prepared by CH2M Hill for the Homes and Communities Agency, report ref. 678079_TS3_001 dated August 2017 and marked Final [CH2M2017].

In addition STDC also supplied the following documents:

- Former Steelworks Land, South Tees Outline Remedial Strategy, Prepared for South Tees Development Corporation by Wood, Ref 41825-wood-XX-XX-RP-OC-0001_S0_P01 dated25th June 2019 [Wood 2019]
- Prairie Site, Off Clay lane – Ground Investigation Factual Report, Prepared for One North East by Shadbolt Environmental dated July 2011.
- Former Corus Cleveland Prairie Site: Land off Clay Lane – Ground Investigation Interpretative Report, prepared by MD2 for One North East, Ref MD2_113 dated 25th July 2011

- Phase II Geo-environmental Assessment at Corus Cleveland Prairie Teesside Site, prepared by Enviros Consulting Ltd. for Graphite Resources, Ref. GR1280001 dated March 2008
- Corus Cleveland Prairie Teesside Site Phase I Environmental Review, prepared by Enviros Consulting Ltd. for Graphite Resources, Ref. GR1280001 dated August 2007
- Soil and Groundwater Baseline Characterisation Study, Teesside Works, prepared by Enviros for Corus UK Ltd [Enviros 2004], Comprising:
  - Volume 1 – Factual Report, Ref. Rlp250604corusteessidefactual.Doc dated 25th June 2004 and marked Final;
  - Volume 2 – Interpretive Report Ref. Mwicorusdraftinterpretivemmdv#2.Doc dated 25th June 2004 and marked Final; and,
  - Volume 3 – Summary Report dated June 2004
- AEG Factual Report Project 4251 (Grangetown Prairie) [in Press]
- Arcadis, The Former Steelworks Redcar: Grangetown Prairie Areas, Phase II Environmental Site Assessment Report 10035117-AUK-XX-XX-RP-ZZ-0062-01-Prairie_ESA, dated June 2020.
- Arcadis, The Former Steelworks Redcar: Grangetown Prairie Areas, Detailed Quantitative Risk Assessment Report in [press].

At the time of issue AEG's final factual ground investigation report was not available for review. This report has been completed based on **draft data** and will be updated when the final ground investigation factual report is available.

This ROA and Strategy document should be read in conjunction with the aforementioned reports.

1.5 Reliability / Limitations of Information

A complete list of Arcadis' Study Limitations is presented in Appendix B.

It should be noted that ground conditions between exploratory holes may vary from those identified during the ground investigations that this report is based upon; any design should take this into consideration. It should also be noted that groundwater levels may be subject to diurnal, tidal, seasonal, climatic variations and those recorded in this report are solely dependent on the time the ground investigation were carried out and the weather before and during the investigation work.

2 Environmental Setting and Development Constraints

This section incorporates a review of the above reports listed in Section 1.4.

2.1 Site Description and Setting

The site is approximately 54 hectares in size. The Darlington to Saltburn Railway is located along the northern boundary of the site and the SSI3A/TRLS landholding the bulk of the southern boundary.

With the exception of a small relic Oxygen Plant and a former Loco Repair Shop the site has been demolished to slab level with concrete foundations, roadways and crushed aggregate including steelmaking biproducts forming the bulk of the site surfacing which is covered by scrub in places. The site is broadly level with the exception of isolated bunds and mounds (particularly associated with the former blast furnaces, where a large metal rich boulder is present, and the coke ovens) and two prominent features, namely:

- A large embankment running north south in the south west of the site which reaches a hight of approximately 15m above the surrounding land. The existing structures are at the base of the embankment; and,
- A depression running north south adjacent to the main western boundary where the topography dips down to an underpass beneath the railway.

Two surface water features are culverted beneath the site, Holme Beck in the west and the Knitting Wife beck in the east. A number of utilities are present on site including the Redcar Steelworks Coke Oven Gas (COG) main which crosses the site above ground from south east to north west. The GOC main is currently in the process of being decommissioned but at the time of writing is still considered a top tier COMAH asset. Overhead pylons run along the northern and eastern edge of the site and a Northumbrian Water Sewer runs along the northern edge of the site.

The site setting and layout are shown on Figure 2 below and in Appendix A.

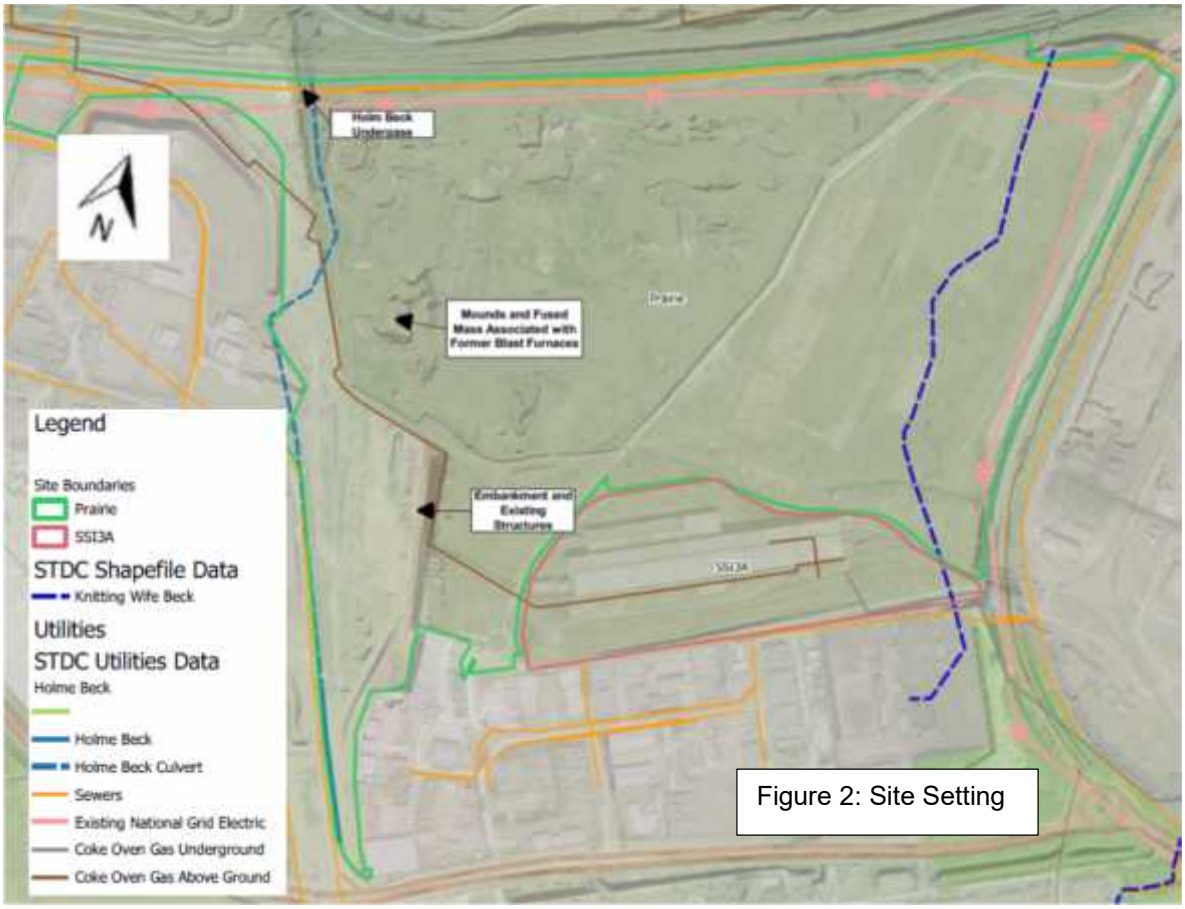


Figure 2: Site Setting

2.2 Geology

The geological setting of the Prairie site is discussed in detail within the ESA and a summary is provided below.

Made Ground covered the entire site footprint ranged in depth between 0.6 and >5.0 mbgl (below ground level) with the majority of the site covered by between 1 and 3m of Made Ground. Areas of deeper Made Ground were noted, particularly in the area of the Former Cleveland Coke Ovens and No. 3 Primary Mill. Obstructions including slabs and foundations prevented the base of the Made Ground being proven in approximately 50% of locations. Large areas of concrete surfacing are present particularly in the east of the site, a second large concrete slab was identified in the area of the former coke ovens, this was noted to be underlain by a large void approximately 2-3m deep.

Three types of Made Ground were noted:

- **Slag-dominant material (>50% slag):** Identified in 20% of locations and generally ranging from gravel to cobble and occasional boulder size fragments. The slag was generally vesicular and grey-green in colour with some white crystallisation/discolouration often noted on the outer surface along with occasional iron rich areas.
- **Granular Made Ground:** Identified widely across the site of varying composition, most frequently a sandy gravel with varying cobble content, although occasionally also clayey. Gravel and cobbles include brick (including refractory), concrete and other demolition materials, slag was not the dominant constituent although often still present within the soil matrix.
- **Cohesive Made Ground:** Frequently identified below the granular Made Ground and comprising a sandy and or gravelly clay with demolition materials within the matrix.

The Made Ground deposits are generally underlain by a sequence of superficial deposits comprising Tidal Flat Deposits over Glaciolacustrine Deposits, over Glacial Till. The Tidal Flat Deposits were absent in a small number of locations and no Glaciolacustrine Deposits were identified in a small number of separate locations.

Three solid geological units are present on site, to the south the Redcar Mudstone Formation is present, to the north the Mercia Mudstone, between the two units is a thin band of the Penarth Group. All three units were identified by the site investigation with bedrock noted to dip to the north west.

2.3 Hydrogeology

Groundwater was noted within the Made Ground in approximately 50% of locations at depths between 0.3 and 3.5 mbgl; inflow rates ranged between low to heavy. The groundwater is considered to be locally confined within sub surface structures and more permeable granular Made Ground and not considered to represent a consistent groundwater body across the site.

Groundwater was identified in both the Superficial Deposits and bedrock, inferred groundwater flow is outlined in the table below:

Geology	Aquifer **Classification**	**Groundwater** flow
Tidal Flat Deposits	Secondary (A) Aquifer	Not confirmed, aquifer of limited thickness
Glaciolacustrine Deposits	Non-aquifer	Flow dictated by localised preferential pathways
Glacial Till	Non-aquifer	
Redcar Mudstone Formation	Secondary (B) Aquifer	North to north-east
Penarth Group	Secondary (undifferentiated) Aquifer	
Mercia Mudstone	Secondary (undifferentiated) Aquifer	

2.4 Hydrology

The closest surface water feature to the site is the Holme Beck which runs along the western edge of the site, the watercourse is culverted as it passes through the site as both an open and covered feature. The Knitting Wife Beck is culverted below ground down the eastern side of these site. Both features flow south to north, and ultimately discharge into the River Tees via the SLEMS.

Works to daylight Holme Beck as part of the site redevelopment are to be confirmed.

2.5 Contaminant Distribution

The extent of contamination is summarised below based on the findings of the Generic Qualitative Risk Assessment (GQRA) completed as part of the ESA. Given the size of the site sampling was conducted (as far as practical given surface obstructions) on a grid to provide an appropriate level of resolution of contaminant distribution for risk assessment and remediation design purposes. Additional locations were advanced around the coke ovens to further delineate findings in this area.

During the implementation of any remediation approach additional testing is likely to be required to refine the contaminant distribution and maximise the efficiency of remediation implementation.

2.5.1 Human Health

Asbestos in Soils

Asbestos was identified in approximately 33% of samples. The asbestos distribution across the site is shown on Figure 3 below (and contained within Appendix A) and is not localised in particular areas of the site although is noted to be more prevalent in the west.

The asbestos identified within the Made Ground was primarily in the form of free fibres. The asbestos was present at levels up to 0.02% by mass although 50% of samples were below the limit of quantification (0.001%).

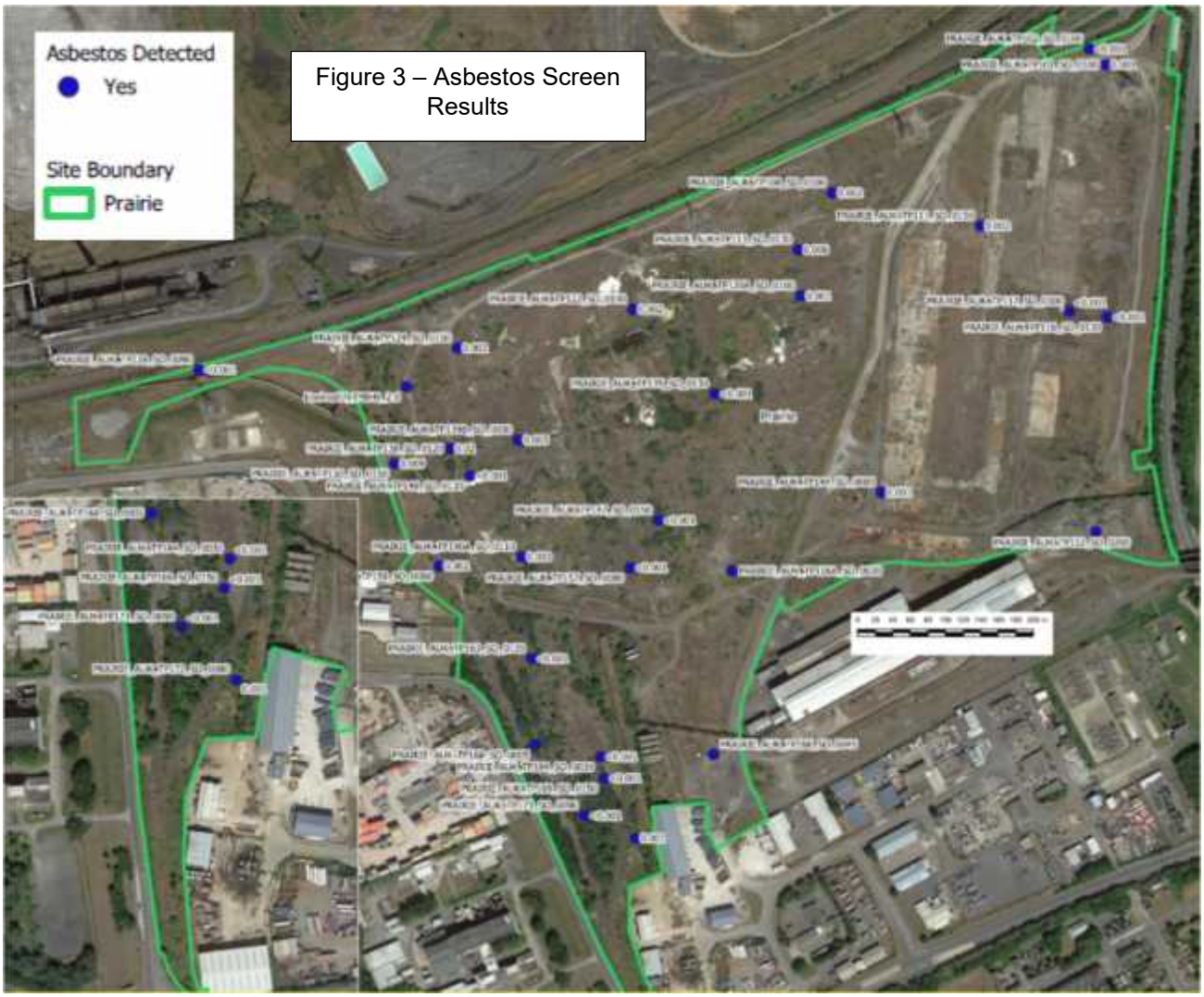
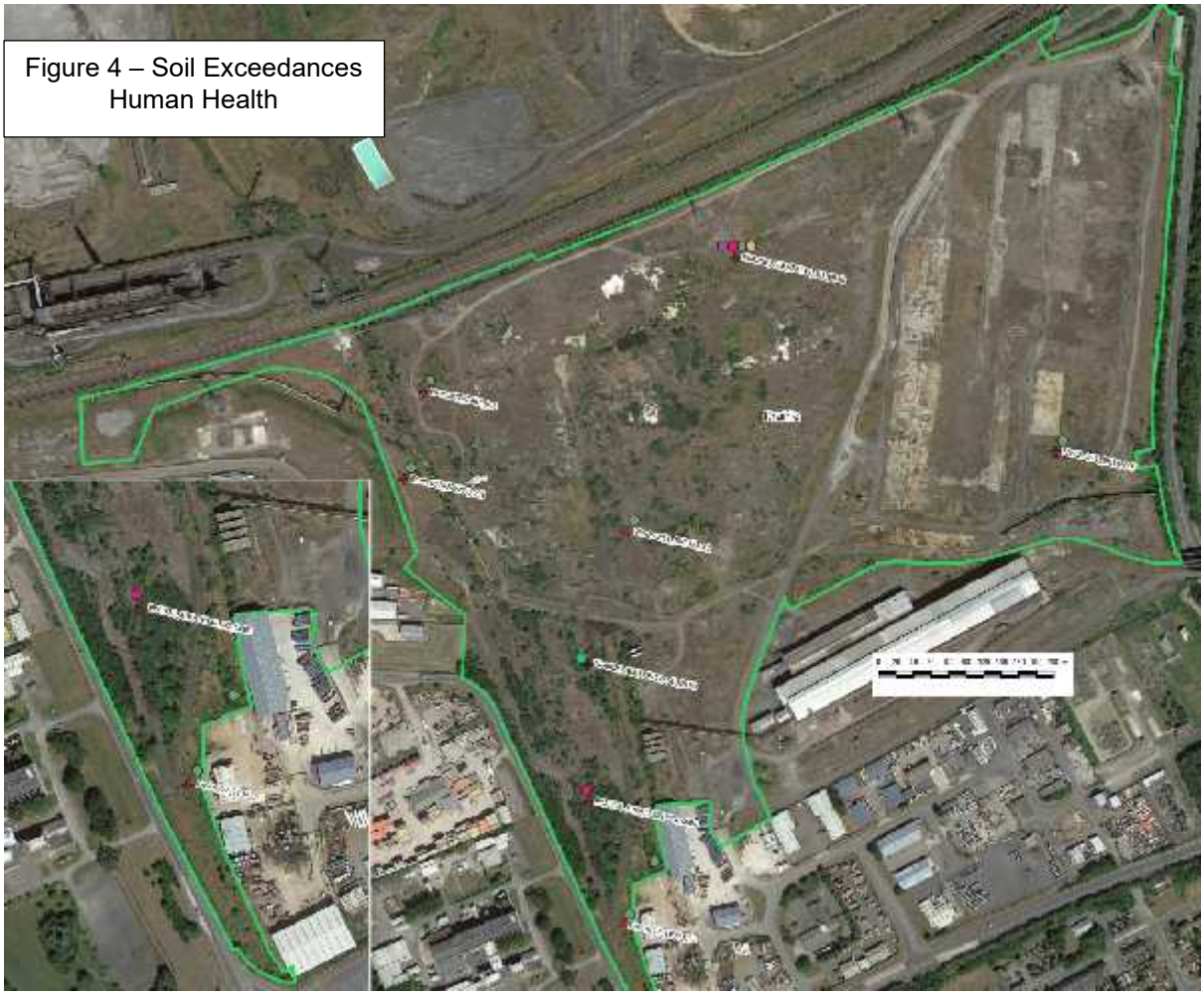


Figure 3 – Asbestos Screen Results

Organic Contaminants

Only a limited number of samples were found to contain levels of arsenic, cyanide, or PAH above the adopted screening criteria (Figure 4 below and in Appendix A), these were generally associated with areas were visual or olfactory evidence of contamination with hydrocarbons had been noted. The majority of the exceedances were for PAH and were in the area of the Cleveland Coke Ovens and Biproducts Plant.

Figure 4 – Soil Exceedances Human Health



2.5.2 Water Resources

Several exceedances of Water Quality Standards (WQS) were recorded in soil leachate samples from Made Ground and groundwater samples. A DQRA (Detailed Quantitative Risk Assessment) is in progress to further asses the significance of these exceedances with respect to both ground and surface water receptors. For the purposed of this ROA it has been assumed that the DQRA will conclude that the current site condition does not pose a significant risk to water resources and therefore no remediation is required for the protection of groundwater resources.

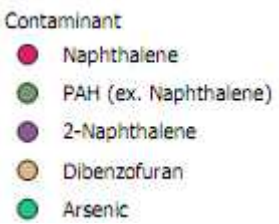
2.6 Conceptual Site Model

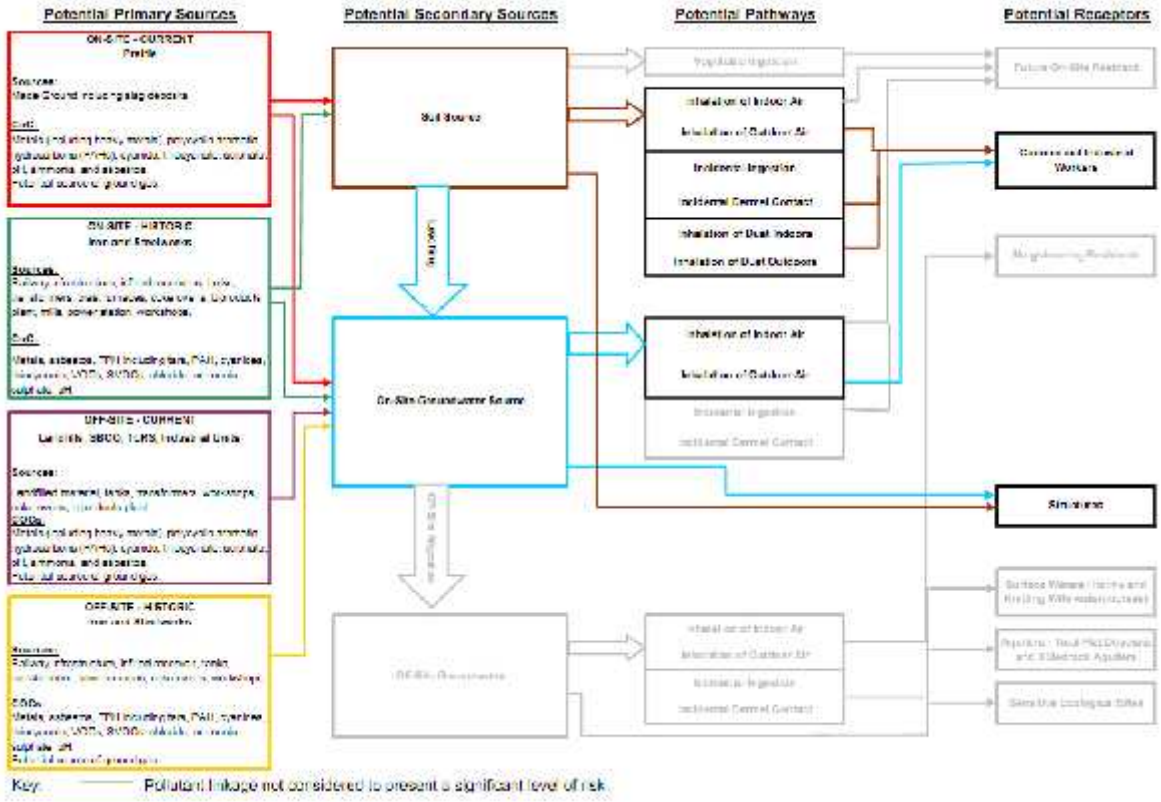
2.6.1 Environmental

The ESA developed a conceptual site model (CSM) based on ground investigation findings. The CSM identified a number of potentially active source-pathway-receptor (SPR) linkages the significance of which was assessed by comparison to appropriate generic screening criteria. The identified SPR linkages were:

- Human Health - Risk to commercial workers via inhalation of asbestos fibres, originated from shallow Made Ground across the site.
- Human Health - Risk to commercial workers via dust inhalation and direct contact with soils for arsenic, cyanide, and selected PAH, originated from shallow soils across the site.
- Water Resources - It has been assumed that the in progress DQRA will conclude that the current site condition does not pose a significant risk to water resources and therefore no remediation is required

The identified SPR linkages for the site are shown within the CSM presente





2.6.2 Ground Gas

The ESA did not identify an unacceptable risk to human health or built receptors from the accumulation of ground gas. However, as the ground investigation was not designed with a particular redevelopment scenario in mind, the gas data monitoring was limited and may not be representative of the entire extent of the site under a particular redevelopment.

Additional ground gas monitoring at greater density is recommended prior to any specific redevelopment to determine the risk from ground gases on the site, the scope of this investigation would depend on the proposed redevelopment scenario. Arcadis understand from STDC that it is expected this would be the responsibility of the developer.

2.6.3 Geotechnical

It is not the specific intention of this ROA to address geotechnical risks however these works have identified the following which may present significant development constraints at the site:

- Expansive slag deposits and refractory bricks may lead to disruption and damage of structures, hardstanding etc.;
- Due to long term creep settlement, the Made Ground and underlying Tidal Flat Deposits may possess inadequate bearing capacity to support proposed structures;
- Lateral and vertical changes in ground conditions;
- Anticipated total and differential settlement / heave in excess of the tolerable limits may occur due to changes in loading or groundwater regime;
- Potential collapse or inundation settlement as a result of surface water infiltration and groundwater movement;
- Sulphate attack on subsurface concrete; and,
- Obstructions within the made ground (boulder size fragments of slag and buried underground structures);

2.7 Unexploded Ordnance and Magnetic Anomalies

Desktop Unexploded Ordnance (UXO) assessment has been completed for the STDC boundary. The outcome of the assessment indicates a Medium risk from UXO for borehole and excavation activities.

In addition, magnetic anomalies have been encountered elsewhere on STDC landholdings which may represent potential UXO risk. Should redevelopment require the installation of piled foundations or deep ground improvement, clearance of locations for potential UXO is recommended.

2.8 Archaeology

Archaeological surveys and assessment have not been made available to Arcadis at the time of writing this document. These documents should be reviewed when available to develop an appropriate mitigation and management strategy. It is understood archaeological development constraints may be present in areas of the site.

2.9 Ecology

Ecological surveys have been conducted and it is understood that a Habitat Risk Assessment (HRA) is planned. However, at the time of writing this report the results of any HRA are not known to Arcadis.

The site is approximately 1km south of the Teesmouth and Cleveland Coast SPA, Ramsar and SSSI site. At the time of writing this report it is not known if the site is currently being used by designated bird species from the Teesmouth and Cleveland Coast SPA (Special Protection Area).

The ESA [Arcadis 2020] Based on the distance from the site the risk to ecological receptors is considered low. In addition potential discharges from the site to the Teesmouth and Cleveland Coast SPA and RAMSAR via the River Tees are likely to be limited by tidal exchange and the large volume of the River Tees receiving water. This is in line with the findings of Wood 2019.

2.9.1 Onsite Habitats

Open Mosaic Habitat are present within the Prairie site. Open Mosaic Habitats on previously developed land are identified in the UK Biodiversity Action Plan (UK BAP) as a Priority habitat listed on Section 41 of the Natural Environment and Rural Communities Act 2006 (NERC Act).

A number of ponds are present on the Prairie site which are extensively used by the Common Toad (Bufo bufo) which are a Species of Principal Importance and protected in the UK under the Wildlife and Countryside Act, 1981. Priority Species under the UK Post-2010 Biodiversity Framework.

2.9.2 Invasive / non-native species

An ecological survey conducted in 2018 identified the following non-native species

- Small-leaved Cotoneaster (Cotoneaster microphylla). Species is listed on Schedule 9 of the Wildlife & Countryside Act (1981) making it illegal to spread or cause to grow in the wild. It was recorded in the most north west corner of the site.
- Sea buckthorn – considered to be non-native in the Teesside area so spread or replanting should be avoided.

Ecological surveys and assessment have not been made available to Arcadis at the time of writing this document. These documents should be reviewed when available to develop appropriate mitigation and management strategy.

2.10 Proposed Redevelopment and Enabling Works

No detailed redevelopment design is currently available for the site. Arcadis understand STDC are to complete enabling works to create an environmentally suitable development platform for future redevelopment. These works will include turnover of the Made Ground within the subsurface to a depth of up to 2.5 m bg) (assuming ground level is the foundation level) including removal and crushing of relic structures and obstructions, removal and treatment of environmental contamination as required and replacement of treated material to formation levels for development.

In some areas of the Site large relic structures are expected, where these or identified environmental contamination extend below 2.5m bgl, any requirement for deeper excavation works will be assessed on a case specific basis following consultation with stakeholders.

Anticipated maximum excavation depths are shown on Figure 6 below and in Appendix A.

Figure 6: Anticipated Maximum Excavation Depths

It is not STDC's intention to remove piles to depth, excavate slag deposits below 2.5m bgl, or address the potential for future slag expansion. The preparation of a geotechnically suitable development platform for a specific redevelopment is the responsibility of the developer.

This ROA has been conducted on the assumption that any redevelopment of the site will be for a generic commercial industrial end use. Remediation technologies have been selected based on Arcadis' professional judgement and experience of large-scale redevelopments of brownfield sites. The site is part of a wider STSC landholding and Arcadis recommends the remediation approach to the Prairie Area is considered holistically with the wider redevelopment of the Landholding.

2.11 Materials Management

Given that remediation measures may involve the movement of materials around the Prairie and the wider STSC site it is important that they are not classified as a waste (as defined by Waste Framework Directive) on completion of the works.

2.11.1 Achieving Non-Waste Status

There are several different waste regulatory options available, the suitability of which is dependent upon the complexity of the site and the quantity/composition of the material to be reused. Based on the complexity of the site Arcadis recommend the most suitable option is via an application in accordance with CL:AIRE guidance 'Definition of Waste: Development Industry Code of Practice' (DoWCoP).

2.11.2 Definition of Waste: Development Industry Code of Practice

The Environment Agency (EA) has worked with industry through CL:AIRE to prepare the DoWCoP (Definition of Waste: Development Industry Code of Practice The purpose of the DoWCoP is to allow industry to regulate itself with respect to determining whether excavated materials have achieved non-waste status. The EA states that 'When a signed Declaration is sent to us (the EA) by a Qualified Person showing that excavated materials are to be dealt with as set out in the DoWCoP, we (the EA) will take the view that the materials on the site where they are to be used will not be waste.'

If materials are dealt within in accordance with the DoWCoP then the materials are unlikely to be waste. This is either due to the fact that the materials were never discarded in the first place or because they have been submitted to a recovery operation and have been completely recovered so that they have ceased to be waste.

In order to demonstrate that the four factors have been fulfilled will require preparation of various reports including:

- Site investigation report (Site Condition Report / Environmental Site Assessment).
- Quantitative Risk Assessment (QRA);
- Remediation Strategy or Design Statement;
- Materials Management Plan (MMP); and,
- Verification report (on completion of the works).

In addition to the risk assessment, an MMP will be required detailing where soils will be moved to and how they will be tracked. Approvals will also need to be sought from the Local Authority and the Environment Agency (groundwater team) with respect to the remediation strategy. Planning permission may also be required.

Once this documentation is in place a Qualified Person will review the overall strategy and ensure that everything is in place prior to submitting a formal declaration to the Environment Agency (waste team), via CL:AIRE (the scheme administrators). On completion of the work a verification report will need to be completed.

2.11.3 Materials Management Plan

An MMP shall be prepared in accordance with CL:AIRE DoWCoP and authorised by a Qualified Person registered with CL:AIRE. Excavated materials will be segregated and sorted into the following categories:

- Materials suitable for re-use on site (without needing additional treatment);
- Materials that require treatment in order to be suitable for re-use on site;
- Soils that require off-site disposal/treatment (not treatable);
- Refractory bricks and potentially expansive slag materials,
- Soils containing asbestos for treatment and reuse or for off-site disposal;
- Excavated hard materials (such as concrete and brick) that may be crushed to produce suitable material for use as infill in the Work; and
- Other materials that require off-site disposal (household waste, electrical goods, vegetation etc).

Where appropriate, existing concrete, brick and other suitable building materials will be crushed to 6F2 as specified by the Highways Specification to allow for reuse on-site. Materials destined for re-use must meet the criteria proposed within the MMP.

For site-based contaminants the Re-use Criteria and Assessment Criteria should be developed following the Detailed Quantitative Risk Assessment [in press].

2.12 Quantitative Risk Assessment

At the time of writing of this Remediation Options Report and Strategy a GQRA has been completed asn a Detailed Quantitative Risk Assessment (DQRA) is in process. Although the finalised outcome of

the DQRA has not been determined, Arcadis consider that the following conclusions are likely to form part of the assessment;

2.12.1 Human Health

2.12.1.1 Soils

Concentrations of arsenic, cyanide and PAHs were measured in excess of the GAC in soil, driven by direct contact exposure and dust inhalation. Contaminants without GACs were qualitatively reviewed and no potentially significant risks were identified. Therefore, concentrations of arsenic, total cyanide, free cyanide and PAHs will need to be considered in the remedial strategy for the site.

Asbestos in shallow soils will require remedial intervention to prevent fibres becoming airborne and available for inhalation, particularly during construction, posing chronic risks to human health

2.12.1.2 Groundwater

Concentrations of contaminants were not measured above the GAC derived for the protection of human health in groundwater.

2.12.1.3 Ground Gas

This ROA has not been completed to address risks from ground gas (if present). No detailed redevelopment design is currently available for the site, it is considered that a ground gas assessment should be conducted by the developer with a specific redevelopment scenario in mind. Additional ground gas monitoring is recommended prior to redevelopment to determine the risk to a particular redevelopment from ground gases on the site.

2.12.2 Controlled Waters

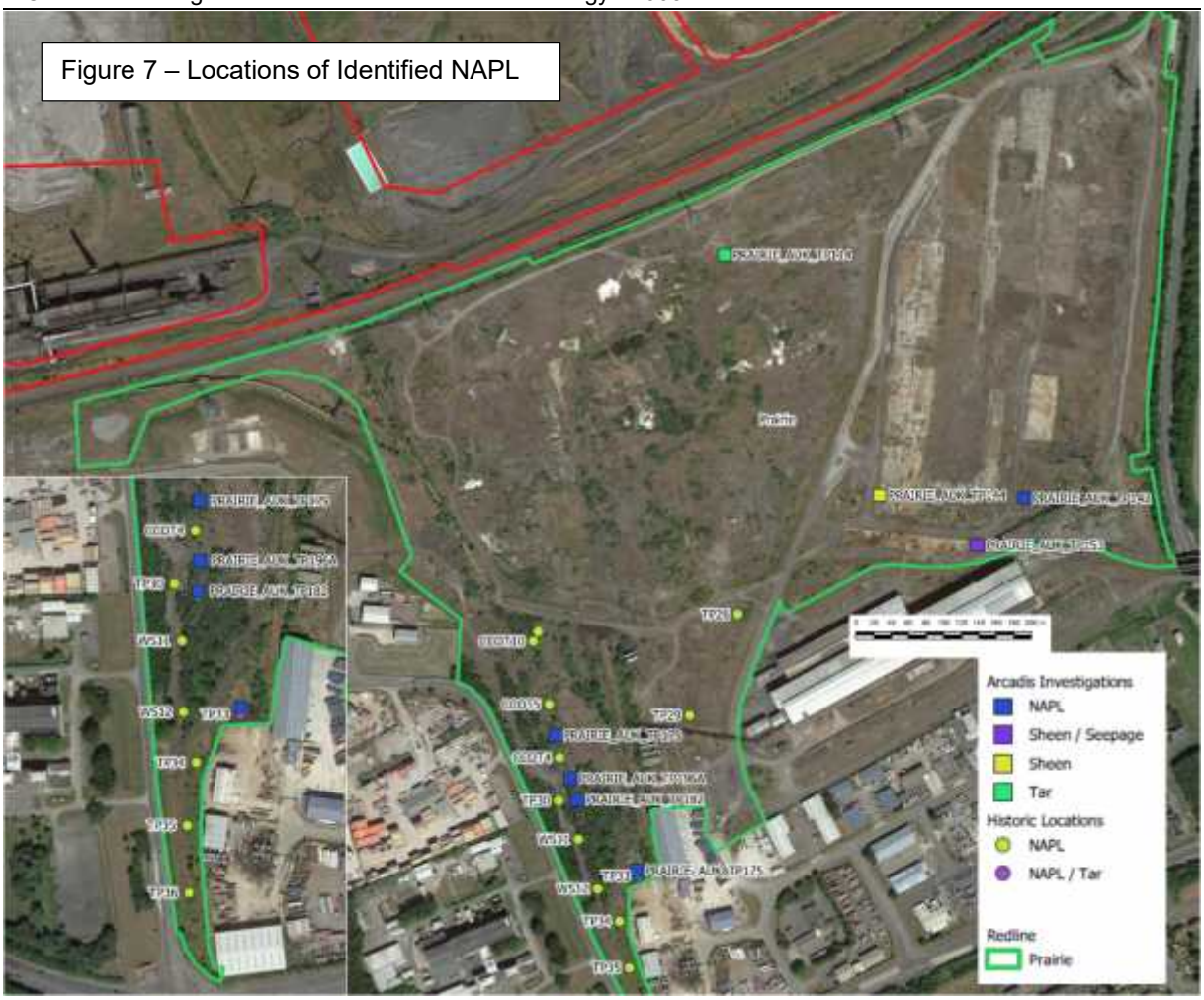
A detailed assessment of remediation options for water resources has not been conducted as part of this ROA. A DQRA is being progressed for the Prairie site and is anticipated to conclude that the risk to the water resources receptor is not considered to be significant. This will be confirmed in an update document following issue of the DQRA.

2.12.3 Materials Impacted with Non-Aqueous Phase Liquids

NAPL and tar has been identified primarily within the Made Ground and associated with subsurface or former above ground structures and plants. Further consideration of the NAPL with respect to the risk to human health will be needed as part of the remedial strategy.

Materials impacted with NAPL and tar should not be reinstated due to being a primary source of contamination. The impacted materials will be required to be consigned to a treatment process to remove the NAPL element or disposed of at an appropriate waste facility under duty of care.

The distribution of NAPL identified at the site is shown on Figure 5 below and in Appendix A.



Arcadis estimate between 5% and 10% of the Made Ground excavated may by impacted with NAPL.

3 Remediation and Excavation Objectives

The aim of the remediation works at the site is to address the identified development constraints pertaining to environmental ground conditions and to facilitate redevelopment for a generic future commercial / industrial end use.

The remediation works will be undertaken as the same time as enabling earthworks (detailed in Section 2.10) to create a suitable formation level, and therefore should be considered holistically with these works.

3.1 Remediation Objectives

The remediation objectives will be achieved by controlling or breaking the identified SPR linkage in order to mitigate identified risks to the identified environmental receptors. The remediation objectives are to:

- Manage the contamination in excess of screening levels identified in the ESA and that are likely to be present following completion of the DQRA, including NAPL containing soils.
- Manage the identified pollutant linkage identified between asbestos in shallow Made Ground such that that exposure pathway for on-site commercial workers are inactive.
- Maximise the reuse of excavated soils by making them suitable for use under DoWCoP.
- To develop an unexpected contamination strategy in order to mitigate the risks of presented in the preparation of historical brownfield land.

3.2 Excavation Objectives

As the enabling earthworks are to be conducted alongside the environmental remediation it is considered prudent to incorporate the objective of the earthworks into the ROA. The enabling earthworks objective are to:

- Remove sub-surface obstructions within the Made Ground to a depth of 2.5m bgl. Where obstructions extend below this depth their removal will be conducted on a case by case basis following consultation with stakeholders;
- Creation of a formation layer suitable for a generic commercial / industrial redevelopment;
- Manage perched and confined groundwater within the Made Ground encountered during excavations;
- Management of risk to external hardstanding, culverted waterways and utilities; and,
- Development of a UXO mitigation strategy.

Arcadis recommends the following excavation objectives are considered as part of the earthworks strategy and therefore require consideration as part of the ROA:

- Consideration of the management and placement of expansive slag deposits and refractory materials excavated as part of the enabling earthworks; and,
- Protection of sub surface structures and utilities from attack due to aggressive ground conditions;

The excavation objectives are considered as part of this ROA but the specific options associated with the required process are not formally assessed.

It is not the intention of this ROA to fully address geotechnical development constraints at the site as these are the responsibility of the developer and dependent on a specific redevelopment scenario.

4 Remediation Technology Selection

4.1 Pre-screening of Remediation Technologies

The overall aim of the remediation and parallel enabling earthworks strategy is to prepare the site for a generic development, a key part of the enabling works will involve the turning over of Made Ground deposits and the removal of relic foundations and structures (Section 2.10) across the Site. Remediation technologies that are deployed in-situ have therefore been excluded from the Remediation Options Appraisal due to the incompatibility with the required reclamation works.

As detailed plans have not been submitted for the specific development at the Site, the requirements for managing potentially aggressive ground conditions and management / protection for ground gas are currently unknown. The selection of remediation technologies therefore excludes consideration of these conditions and they will therefore be required to be managed at site redevelopment phase.

4.2 Selection Procedure

The selection procedure for the remediation options appraisal broadly follows the decision making process outlined by Land Contamination: Risk Management 2019 (LCRM 2019) and the Construction Industry Research and Information Association (CIRIA), incorporating guidance raised by the EA for the selection of remediation strategies. Site specific remediation objectives are broken down into the following areas:

- Technical Feasibility;
- Operational Parameters; and
- Commercial Parameters.

The objectives and site-specific constraints are prioritised in order to reconcile potential conflicts, and a ranking procedure is used to identify and evaluate potential remediation options. The remediation design selection procedure involves the following stages:

Stage 1: Review of the available technologies and a preliminary assessment of their suitability, based on technical feasibility;

Stage 2: Identification/assessment of appropriate technologies based on operational practicability; and,

Stage 3: Evaluation of appropriate technologies based on commercial feasibility.

Following the identification and evaluation of the appropriate technologies, professional judgement is applied to the final design of remediation strategies. This involves incorporating the design decisions along with principles such as practicability, effectiveness, durability and efficiency in order to determine the most appropriate strategy for tackling the pollutant linkages identified.

4.3 Stage 1 - Technical Feasibility

The first stage of the selection process is review and consideration of a wide range of remediation techniques, and use of a ranking system to select those techniques that are most feasible given the following factors:

- **Contaminant Properties**;
- **Extent of Contamination** e.g. Magnitude of contaminant concentrations, presence of NAPL, lateral extent and depth of contamination etc.; and,
- **Geology/Hydrogeology** e.g. Aquifer hydraulic conductivity, groundwater flow velocity, permeability, porosity, subsurface geochemistry.

Each remediation technique is ranked with a score of 0 to 3 on its technical feasibility given consideration of the above factors. Also, above factors are weighted at level 3 (maximum weighting) in order that those technologies which are the most technically suited and likely to achieve the required contaminant treatment at the Site are promoted. The multiplication of rank and weight gives the relevant score for each technology. The results are combined to provide a single Technical Score and, therefore an overall Technical Ranking. The scoring rationale is as follows:

- Technology not suitable;

- Technology may work (50%);
- Technology will probably work (70%); and
- Technology very suitable (>90%).

Table 1 provide an evaluation of the technical suitability of the potential remediation strategies. Where a remediation technology has been identified as being technically unsuitable, it has been eliminated further from the options appraisal and not been considered in terms of commercial and operation suitability.

4.4 Stage 2 and 3 – Operational & Commercial Factors

The second and third stages of the selection process builds consideration of additional key factors (operational and commercial) into the options appraisal process, using a ranking system which includes the following factors:

Operational Factors

- Operational Implementation
- Long Term Operation Demands
- Operational Requirements;
- Permissions / Permits;
- Health & Safety / Nuisance; and,
- Track Record / Development Status;

Commercial Factors

- Residual Liability;
- Commercial Availability;
- Implementation Timescale;
- Remediation Timescale;
- Capital Cost;
- Sustainability; and,
- Operation and Maintenance Cost.

Project specific operational and commercial factors were also incorporated to enable technologies that are most suited to implementation within the identified project constraints i.e. desire to enable future site development in a short time frame without disruption to future site use following redevelopment, to be better identified.

Each remediation technique is ranked from 1 to 3 given its likely suitability. Also, above factors are weighted from 1 to 3. The multiplication of rank and weight gives the relevant score for each technology. Table 1 provide an evaluation of the operational and commercial suitability of the potential remediation strategies.

4.4.1 Stage 2 - Operational Factors

4.4.1.1 Operational Implementation

The Site is currently inactive with only limited site buildings remaining (to be demolished as part of the enabling works), therefore it is anticipated that the majority of remediation techniques could be implemented while the Site is in its current state with minimal disruption.

4.4.1.2 Long Term Operational Demands & Implementation Timescales

Arcadis have prioritised remediation technologies which are able to be implemented within a short time frame prior to redevelopment, without significant long-term operation demands.

4.4.1.3 Operational Requirements

The operational requirements for each remediation technology have been assessed and scored based on how demanding the technology is with regard to technical plant, electrical power and other utilities required.

4.4.1.4 Permission/Permits

Each remediation technology has been considered with respect to likely requirements for operational permission/permits, for example environmental permits or abstraction consents and the difficulty of obtaining such permits for each technology. Technologies which are likely to require a lengthy permitting, licensing or consenting process have a lower score.

4.4.1.5 Track Record/Development Status

The rate of success for application of each remediation technique, primarily based on experience from across the UK, is provided with an appropriate score.

4.4.2 Stage 3 - Commercial Factors

4.4.2.1 Residual Environmental Liability

Residual environmental liability is a key consideration in the development of the remediation strategy. Technologies that break pathways, leaving contamination in place (e.g. barrier systems), as opposed to reducing contaminant mass within the source typically have a lower score.

4.4.2.2 Commercial Availability

The need for specialist equipment, and whether the equipment is readily available in the UK, is considered when assigning a score to each remediation technique.

4.4.2.3 Remediation Timescale and Capital Costs

Remediation technologies have been assessed giving a high priority to the overall timescale of remediation technologies (i.e. time to achieve remediation objectives following implementation) as well as overall costs given the understood need to minimise any future disturbance to post-redevelopment Site operations and to maximise the return on divestment.

4.4.2.4 Operation and Management Costs

The likely operation and management costs associated with each technique are considered when assigning a score.

4.5 Summary

Based on the results of the ranking process, each technology has been given a final technical, operational and commercial score and, therefore, a ranking. The output of the ranking process for both soil and NAPL impacts has been used to develop the likely remediation strategies for the Site, as discussed in the next section.

The top selected technologies for soil in excess of the Human Health risk-based screening targets and/or NAPL are presented below and discussed in Section 5.1.

Technology	Materials for treatment
Ex situ Bioremediation	Soils in excess of Human Health screening targets and NAPL impacted soil requiring treatment to make suitable for use.
Capping in situ	Soils in excess of Human Health screening targets.
Stabilisation / Solidification	Soils in excess of Human Health screening targets and NAPL impacted soil requiring treatment to make suitable for use.
StarX or Thermopiles	Soils in excess of Human Health screening targets and NAPL impacted soil requiring treatment to make suitable for use.

Technology	Materials for treatment
Excavation and Disposal	Soils in excess of Human Health screening targets and NAPL impacted soil requiring treatment to make suitable for use.

5 Discussion of Selected Remediation Technologies

This section presents a brief review of the selected remediation technologies which were highlighted as the most likely to be technically, operationally and commercially feasible to meet the remediation objectives at the site.

5.1 Technologies for Materials Unsuitable for Reuse

5.1.1 Ex situ Bioremediation

Ex-situ bioremediation through windrows or landfarming involves the excavation and treatment of contaminated materials through bioaugmentation or the use of existing populations of microorganisms to breakdown contaminants through co-metabolisation as an energy source. The soil piles are placed on hardstanding or an impermeable layer with drainage to prevent leachate from entering the ground and to also facilitate the collection of contaminated liquids from the soil. Amendments can be introduced and the materials are routinely turned to aerate, homogenises and break up the soils. A geomembrane cover is required to prevent the soil from becoming saturated by rain. Once successfully treated the material can be reinstated and reused on site.

Advantages:

- A proven technique with a large track record of successful applications;
- Applying an ex-situ process over an in-situ process means that, at the point of excavation, a soil sorting process can be put in place which will remove active sources (e.g. solid or liquid chemical waste), deleterious / untreatable waste materials (e.g. lumps of clay, concrete, wood etc.) prior to treatment, resulting in a more efficient and effective application of the processes.
- Excavated material will be more permeable and homogenised, enabling the treatment application to be made more uniformly applied;
- Increased airflow and a high pore volume exchange rate is an extremely effective mechanism to remove contaminants cost-effectively within a relatively short time frame;
- Remediation rates could be enhanced using low thermal enhancement through the soil piles, or by use of low thermal *in situ* remediation (TISR) technology; and,
- Soil sampling can also be conducted to verify residual concentrations in soil during treatment.

Disadvantages:

- Prior to remediation works commencing, an appropriately sized treatment area for the ex-situ bioremediation works needs to be constructed. Whilst there is potentially plenty of space on Site these works are an additional cost;
- Treatment of the soil piles could take a reasonable amount of time depending on concentrations of contaminants present, organic nature of soil and reduction in contaminant mass required Concentrations of hydrocarbons and Heavy Metals could be toxic to microorganisms. A pilot trial would to help assess treatment success, timeframe and therefore full-scale remediation costs;
- Does not manage SPR linkage associated with ACM, therefore materials impacted with asbestos containing materials (ACM) above screening criteria would require further treatment or an appropriate cover system;
- Dust, air quality, noise and vibration monitoring will be required to manage potential risk to site operatives and remediation workers. Excavation and soil sorting of material will create a Health and Safety risk by exposing workers to excavated material which will have high hydrocarbon concentrations and potentially contain other hazardous such as ACM; and,
- A water treatment / containment system is required to capture leachate / fluids within the soil pile.

5.1.2 Capping in situ

Capping in situ is a process whereby a barrier is placed between the contaminated material and the receptor in order to break the exposure pathway. A temporary capping system may be installed to

enable development plans to be finalised prior to the installation of permanent capping in areas not covered in hardstanding. The permanent cap design would be dependent on the redevelopment scenario but would likely include a geotextile liner overlain by clean imported material. Encapsulating material below new infrastructure (such as additional buildings, roads or car parks) constructed as part of any redevelopment would also be considered an appropriate capping method.

Advantages:

- Capping will address asbestos identified in the shallow unsaturated soils;
- Minimises exposure to construction workers during remediation activities as material is left in situ; and,
- Sustainable remediation approach.

Disadvantages:

- Contaminated material remains on site and therefore liability is retained;
- Would not permit soils impacted with NAPL to be reused without further treatment;
- The lifespan of the cap will likely be significant but may need replacement in the future;
- Future ground works will need to be planned to avoid breaching the cap; and
- A cap would be installed based on a specific redevelopment scenario, additional remediation works may be required if additional redevelopment occurs in the future.

5.1.3 Stabilisation and/ or Solidification

Soil Stabilisation/Solidification (S/S) is a remediation process that relies of the physical and chemical reactions between the stabilisation or solidification agent and the contaminated materials. These reactions reduce the mobility or availability of the contaminant through immobilisation through chemical reaction or physical encapsulation.

A range of reagents can be considered dependant on the site-specific conditions and the contaminant present, but they typically include;

- Cement-based materials like Portland cement
- Clays including organo-clays
- Pozzolanic-based materials like fly ash, kiln dust, pumice, or blast furnace slag

Advantages:

- Scalable to quantities and rates of material generation;
- Short treatment timescales enabling materials to be available for reuse in a timely manner and,
- Sustainable remediation approach.

Disadvantages:

- Contaminated material remains on site and therefore liability is retained;
- Depending on final design reagent costs can be expensive,
- Requires laboratory and pilot testing to develop formulation of mixture; and
- Long term performance must be demonstrated to stakeholder and regulators.

5.1.4 Smouldering Combustion or Thermopile

A number of novel thermal remediation technologies are commercially available which offer a more sustainable approach than traditional thermal rotary kilns. The basis of the technology is using the contaminant as a primary fuel source or secondary fuel source for the thermal process. Ex-situ treatment cells are constructed with proprietary heaters to thermally degrade contaminants or initiate the smouldering process

Advantages:

- High levels of contaminant reduction in a more sustainable manner than traditional thermal approaches.
- Batch process allowing for materials to be treated as they become available.
- Fast treatment process allowing materials to be made available for reuse in a short timeframe.
- Modular approach that can be expanded and reduced to match requirements.

Disadvantages:

- Prior to remediation works commencing, an appropriately sized treatment area for the ex-situ Smouldering Combustion or Thermopile works needs to be constructed. Whilst there is potentially plenty of space on site these works are an additional cost.
- Excess moisture content in soils to be treated will increase costs and treatment timeframe,
- Does not manage SPR linkage associated with ACM, therefore materials impacted with ACM above screening criteria would require further treatment or an appropriate cover system.
- Dust, air quality, noise and vibration monitoring will be required to manage potential risk to site operatives and remediation workers. Excavation and soil sorting of material will create a Health and Safety risk by exposing workers to excavated material which will have high hydrocarbon concentrations and potentially contain other hazardous such as asbestos containing materials.

5.1.5 Excavation and Disposal

Excavation and disposal involves the removal of contaminant material from site and disposal at an appropriately licensed waste management/treatment facility. Imported material is used to backfill the excavation. Excavation of saturated Made Ground deposits is possible but would require additional dewatering operations. Excavation and disposal is not considered appropriate for a main remediation technology approach due to the inherent low sustainability of the technology, it is however recognised that isolated materials considered difficult to treat or not suitable for the main selected remediation technology may require disposal off site to meet remediation criteria or development timescales.

Advantages:

- Soil excavation will address all the asbestos identified in the shallow unsaturated soils;
- Contaminant hot spots identified as part of redevelopment can be excavated rapidly; and
- Would allow simultaneous removal of obstructions within the Made Ground;

Disadvantages:

- Excavation and off-site disposal of impacted soils to landfill will involve significant vehicle and traffic movements on and off-site, and likely affect neighbouring residents;
- Below ground utilities on-site may be affected and require replacement;
- Groundwater management and treatment may be required where excavation of saturated Made Ground is required;
- Although there may be scope to re-use excavated material elsewhere on the STDC site plant, haulage, and disposal costs would still be significant;
- Excavation activities can lead to excessive noise, dust and odour generation without proper controls; and,
- Large scale excavation and disposal (landfilling) is not considered to be a sustainable or cost effective remediation approach.

5.2 Management of Potentially Expansive Slags and Refractory Materials

It is beyond the scope of this ROA to assess technologies to manage expansive slag and refractory materials as these are to be the responsibility of the developer and tailored to a specific redevelopment scenario. However, if slag rich or refractory materials are required to be excavated as part of the enabling works either to facilitate removal of contamination and / or relic structures the following management approach is recommended.

5.2.1 Excavation, Separation and Reuse

This approach involves the excavation of the slag rich or refractory materials, the material is crushed, screened and before being re-used on site in areas considered by STDC to be low risk (eg. green corridors or biodiversity enhancement areas). Screening would involve the separation of slag dominant material from other Made Ground; laboratory testing could then be used to separate higher risk steel slag deposits from those comprised of blast furnace slag.

It may be possible to accelerate the expansion of slags by crushing and hydration however this has not been considered at this point within this assessment.

Advantages:

- Risks from expansive slag can be reduced
- Material can be sustainably reused on site as part of the redevelopment;
- Contaminant hot spots identified as part of redevelopment can be excavated rapidly; and,
- Would allow removal of obstructions within the Made Ground.

Disadvantages:

- Screening and separation of materials would require additional plant and analysis costs;
- Given the mixed nature of the slag deposits on site, segregation may not be capable of removing all of the slag and refractory materials. This may therefore reduce the magnitude of expansion but will not fully remove the risk.
- Significant tracking will be required to ensure processed materials are not classified as waste;
- Hydration of slag will require stockpiling of material on the medium term;
- Material containing asbestos would have to be used below a cover layer;
- Groundwater management and treatment may be required where excavation of saturated Made Ground is required;
- Excavation activities can lead to excessive noise, dust and odour generation without proper controls; and,
- Excavation below the groundwater table may not be feasible / cost effective.

6 ROA Conclusions

6.1 Environmental Remediation

The overall aim of the remediation and parallel enabling earthworks strategy is to prepare the site for a generic development, a key part of the enabling works will involve the turning over of Made Ground deposits and the removal of relic foundations and structures (Section 2.10) across the Site.

Arcadis have conducted a ROA to:

- Provide a robust environmental constraint management strategy for the Prairie Area, considering residual liabilities, reputational issues and statutory requirements, which evaluates the risks from the identified contamination and ground conditions at the site; and
- Evolve potential remediation strategies, minimising the environmental legacy of STDC and positioning the site footprint for redevelopment as a generic commercial / industrial end use, in a manner that will comply with applicable HSE, and waste regulations while minimising life-cycle costs to STDC.

As part of the ROA, Arcadis have summarised the current contaminant distribution, site conditions, hydrogeology, and active pollutant linkages based on the available data collected to date.

Based on a review of the results of the ranking process, site specific knowledge, consideration of the key remediation objectives, and view that the risk to human health receptors is the key driver for remediation at the site, Arcadis identified **capping *in situ*** as a preferred remediation strategy for the Human Health exceedances and asbestos identified at the site

6.2 Excavation Waste Reduction

Materials impacted with NAPL are likely to be excavated as part of the enabling earthworks. The most sustainable use of these materials is to facilitate their reuse on site and as such treatment is required to make them suitable for use such that they do not represent a potential ongoing source of contamination The volumes of materials for treatment have been estimated at between 5-10% of the predicted soil arisings, however due to the discrete nature of these impacts, materials will potentially be generated throughout works and in variable amounts.

Treatment of the materials impacted with NAPL would be influenced by the volume of material, contaminant properties and timescale but would include **Ex Situ Biological Treatment, Stabilisation / Solidification or Thermal technologies** as primary treatment options with **Excavation / Disposal** for materials not suitable for primary treatment or for isolated difficult to treat materials.

The implementation of these technologies could be considered as part of the remediation and enabling earthworks of the Site or potentially as a hub and cluster treatment centre for the wider Redcar Steel Works site.

6.3 Slags and Refractory Materials

Ground conditions at the site present a number of potential geotechnical constraints. It is anticipated that the majority of these can be dealt with by adopting appropriate engineering controls at the development phase.

However Arcadis recommend where potentially expansive slags and refractory materials are excavated as part of the enabling excavations these be managed by **Excavation, Separation, and Reuse** in low risk areas of the site as defined by STDC**. Treatment** may also be undertaken if this is identified as feasible for the materials in the given timescale.

The above is intended to reduce rather than eliminate the risks from these materials. Additional management through the use of **engineering controls** are likely to be required depending on the final redevelopment, these are to be the responsibility of the developer.

6.4 Flood Risk

The risk of flooding from rivers and the sea has been assessed by reviewing Environment Agency flood maps for the area which indicate the risk of flooding is “Very Low” with a less than 0.1% chance of flooding in any year.

The Wood “Flood Risk Assessment and Drainage Strategy Flood Risk Assessment and Drainage Strategy” (Ref. 41825-WOOD-XX-XX-RP-OW-0001_A_P01) concluded that the potential import of up to 500mm mudstone onto the site did not increase the surface water flood risk.

The proposed remedial strategy comprises the excavation and crushing of hardstanding and other impermeable obstructions within the Made Ground and their backfill within the excavation. As such, Arcadis considers that following removal of hardstanding this approach will increase surface water infiltration rates and therefore the risk or surface water flooding will be no higher than identified by Wood. The proposed enabling works will not therefore increase the flood risk at the site.

7 Enabling Earthworks and Remediation Strategy

The strategy for the enabling earthworks and remediation of the Prairie site should be considered within the wider context of the Redcar Steelworks reclamation and remediation. The excavated materials identified as not suitable for direct reuse will be consigned to a remedial process in order to meet the criteria for reuse after treatment. The exact technology is dependent on the volume and availability of the material and the timescale required to complete the remediation. The treatment of materials could be undertaken on the Prairie site as a single location or as part of a hub and cluster set up for the wider Redcar Steelworks site.

7.1 Aim

The aim of the works is to:

- Remove underground relic structures and foundations;
- Processing Made Ground materials in order to make suitable for use as backfill materials,
- Make the site suitable for future commercial / industrial end-use through SPR linkage breaks from materials impacted with PAHs, asbestos, cyanide, and arsenic; and,
- Reduce the geotechnical risks from slags and refractory materials removed as a consequence of the excavation works.

7.2 Overview of Required Works

In overview the enabling earthworks and remediation will comprise the following activities.

Enabling Earthworks

- Removal and processing of relic underground structures and foundations for reuse, to a depth of 2.5 m bgl. The requirement to remove areas of deeper structures or foundations, if encountered, will be assessed on a case by case basis.
- Screening and crushing of Made Ground materials in order to make suitable for reuse.
- Treatment of soils impacted with NAPL in line with recommended processes identified within the ROA.
- Segregation of soils with ACM for treatment and reuse;
- Segregation and processing of refractory materials and potentially expansive slag deposits for reuse.
- Dewatering of below ground structures and excavations with management, treatment and disposal of water; and,
- Backfill of excavations to leave the site safe and level, with validated made ground, certified demolition arising, crushed concrete or imported fill.

Remediation

- Remediation of soils impacted with contaminants above target levels through capping of materials to manage SPR linkages.

7.3 Works Approach

7.3.1 Enabling works

Prior to mobilisation and commencing the enabling earthworks and remediation the following documentation, notifications, permits and approvals shall be obtained and in place:

- Approved Schedule;
- Construction Phase Health and Safety File;
- Method Statements and Risk Assessments;
- Occupational Health Plan;

- Environmental Permit;
- Temporary Trade Effluent Discharge Consent;
- Traffic Management Plan;
- Construction Environmental Management Plan;
- Materials Management Plan;
- Emergency Response Plan; and,
- Surface water management plan.

A site compound, including welfare facilities and parking will be required to be established in a suitable area on Site. Temporary buildings, structures, equipment and facilities shall be properly maintained for so long as it is in use, and the compound, welfare and parking facilities cleared away on completion. Appropriate site fencing, signage and security shall be implemented to protect the works.

7.3.2 Environmental Permit

An Environmental Permit (EP) Mobile Treatment Licence is likely to be required in order to conduct works comprising the treatment and reuse of site won material identified as requiring remediation and the treatment of any contaminated waters recovered during the works.. This is typically held and deployed by the party responsible for designing and managing the execution of the remediation who are responsible and accountable for compliance with regulatory requirements.

An EP deployment form will need to be submitted to and approved by the EA (Environmental Permit Team) detailing the remedial approach and associated engineering controls, prior to treatment being undertaken.

The excavation of site won materials which do not require treatment for environmental purposes does not need to be conducted under an EP. If uncontaminated made ground is to be processed and an EP for mobile plant is not n place then an EA Standard Rules Permit for the low risk crushing and screening of materials will also be required.

7.3.3 Materials Management

Remediation measures will involve the movement of materials. It is important that they are not classified as a waste (as defined by Waste Framework Directive) on completion of the works.

7.3.3.1 Achieving Non-Waste Status

As discussed in Section 2.11.2, there are several different waste regulatory options available, the suitability of which is dependent upon the complexity of the site and the quantity/composition of the material to be reused. It has been concluded the most suitable option is via an application in accordance with CL:AIRE guidance ‘Definition of Waste: Development Industry Code of Practice’ (DoWCoP).

7.3.3.2 Definition of Waste: Development Industry Code of Practice

The Environment Agency (EA) has worked with industry through CL:AIRE to prepare the DoWCoP. The purpose of the DoWCoP is to allow industry to regulate itself with respect to determining whether excavated materials have achieved non-waste status. The EA states that ‘When a signed Declaration is sent to us (the EA) by a Qualified Person showing that excavated materials are to be dealt with as set out in the DoWCoP, we (the EA) will take the view that the materials on the site where they are to be used will not be waste.’

If materials are dealt within in accordance with the DoWCoP then the materials are unlikely to be waste. This is either due to the fact that the materials were never discarded in the first place or because they have been submitted to a recovery operation and have been completely recovered so that they have ceased to be waste.

In addition to the risk assessment, an MMP will be required detailing where soils where excavated from, where they will be moved to and how they will be tracked. Approvals will also need to be sought from the Local Authority and the Environment Agency (groundwater team) with respect to the remediation strategy. Planning permission may also be required.

Once this documentation is in place a Qualified Person will review the overall strategy and ensure that everything is in place prior to submitting a formal declaration to the Environment Agency (waste team), via CL:AIRE (the scheme administrators). On completion of the work a verification report will need to be completed.

7.3.3.3 Materials Management Plan

An MMP shall be prepared in accordance with CL:AIRE Code of Practice (Definition of Waste) and authorised by a Qualified Person registered with CL:AIRE. Excavated materials will be segregated and sorted into categories as defined in Section 2.11.3

7.3.4 Soil Sampling

Soil sampling will be undertaken by an STDC appointed representative and at the frequency proposed Sections 7.3.7 and 7.3.8.

Composite sampling from stockpiles will be undertaken in order to collect a representative sample. Stockpiles will be subdivided to representative sections, each section will be sub divided to 6 sub-sections, soils shall be collected from each subsection and homogenised in order to create the representative sample.

Further information on the proposed sampling strategy, including sampling frequency and testing schedule will be provided within the Enabling Earthworks and Remediation Implementation Plan and the Materials Management Plan.

7.3.5 Excavations

7.3.5.1 General Excavations

The scope of the excavation works is outlined in Section 2.10. Where practicable obstructions will be removed and crushed for re-use on site. Materials which are impacted with contaminants to levels above the defined reuse criteria shall be treated using the remediation strategy or if treatment is not considered possible disposed of offsite under full duty of care.

Made Ground materials will require size screening and crushing to enable reuse. Any deleterious materials not suitable for incorporation into the fill material, such as rebar, wood, plastic, putrescible materials etc will be segregated and stored separately on site. Such materials will then be disposed offsite under full duty of care.

7.3.5.2 Segregation and Stockpiling

Excavated materials identified by laboratory analysis as chemically unsuitable for direct reuse will be stockpiled for treatment. Stockpile and treatment areas will be required to be placed on impermeable surfaces with covers and suitable drainage to collect and dispose of waters. Validation testing of these areas will be undertaken to prove the land quality pre- and post-remediation.

7.3.5.3 Surveying

All excavations shall be surveyed by the appointed Remediation Contractor to allow for accurate measurement of excavation extents and to establish remedial verification sample locations.

7.3.5.4 Relic Underground Structures and Services

The following shall be implemented with respect to relic structures:

- Relic structures shall be removed where encountered within the upper 2.5m of the Made Ground. Where relic structures are encountered within 2.5m bgl but continue below 2.5m bgl confirmation on the requirement to remove them below this depth shall be required from the STDC. If removal is not required a record of the residual foundation shall be made recording the topographical coordinates, size and type.
- Where encountered, piled foundations shall be removed to a maximum extent of 2.5m bgl. A record of the residual foundation shall be made recording the topographical coordinates, size and type.

- Redundant pipework is likely to be encountered within the excavations which may be preferential pathways for the migration of contamination. Where encountered redundant pipe work will be removed from the excavations and sealed at the edges of excavations.
- It is anticipated that at least two solidified metal masses are present on site resulting from the residual ore in decommissioned blast furnaces. Confirmation on the requirement to remove them shall be required from the STDC.

No specific development plans have been made available at the time of writing this remediation strategy and any future development plans may need to account for structures remaining in-*situ* or partially removed following these works depending on the specific redevelopment.

7.3.5.5 Boreholes

There are existing borehole installations across the Prairie site. Where possible boreholes within defined excavation areas should be protected, however if this is not practicable they are required to be decommissioned in accordance with the relevant British Standards and EA guidance.

7.3.5.6 UXO

A desktop UXO assessment has been completed for the STDC boundary. The outcome of the assessment indicates a Medium risk from UXO for borehole and excavation activities. Further mitigation activities such as detailed risk assessment or site mitigations are considered essential to reduce the UXO risk on the site to As Low As is Reasonably Practicable (ALARP). These additional mitigating factors should be defined within the Remediation Implementation Plan (RIP).

7.3.5.7 Utilities and Services

A review of the available data sources provided to Arcadis has highlighted a number of live services and utilities cross and bound the site:

- Overhead electric (National Grid);
- Below ground electric;
- Coke Oven Gas Main;
- Large diameter sewer (Northumbria Water);
- Culverted surface water features Holme Beck and Knitting Wife Beck;
- Railway to the north;
- Oxygen pipeline; and
- Water supply pipeline

There is the potential for other utilities to be crossing the site including redundant gas pipes, water pipes and electrical cables as well as live 3rd party utilities.

At the time of writing a constraints plan is not available which would identify which site services and 3rd party utilities are required to remain and be protected during the remediation and reclamation works. The constraints plan would need to be reviewed and accounted for within the Remediation and Reclamation Implementation Plan.

7.3.6 Groundwater Management

Groundwater and accumulated water is anticipated to be encountered within excavations and subsurface structures, this will require removal to facilitate excavation and backfilling works.

The Contractor shall minimise the quantity of water requiring to be pumped, through backfilling excavations as soon as practicable and avoiding the potential for accumulation of rainwater in open excavations. Recovered groundwater will be sampled and classified to allow appropriate disposal, either via direct disposal to site foul drainage under discharge consent, *via* on site treatment and discharge to foul drainage under consent, or by tankerage and disposal from site. Any temporary storage of groundwater or accumulated water shall be within storage vessels, which are to bunded and equipped with drain-down and sampling valves.

7.3.6.1 Removal of NAPL on Groundwater

If NAPL is encountered on the groundwater during excavation works its recovery will be required prior to groundwater discharge. Recovery will continue until no visible NAPL is observed or further recovery is not reasonably practicable (evidenced by diminishing recovery quantities i.e. base of asymptotic curve). Where there is evidence of the presence of NAPL in the unsaturated zone, excavations will be extended to expose the groundwater table and identify if it is impacted by the above material and if groundwater treatment is required.

7.3.7 Remediation Criteria

The following Remediation Criteria have been developed for Human Health receptors at the Site (in order of priority):

- LQM/CIEH Suitable for Use Levels (S4UL) (LQM / CIEH, 2015),
- Department of Environment Food and Rural Affairs (DEFRA) Category 4 Screening Levels (C4SL) (DEFRA, 2012),
- Arcadis derived generic assessment criteria based on CLEA v1.07,
- United States Environmental Protection Agency (U.S. EPA) Regional Screening Levels (RSLs)

Wood derived GAC based on CLEA v1.07 were presented in the Wood 2019 report for benzo(a)pyrene and naphthalene. It is understood that these values and the use of the LQM S4Uls were acceptable to the regulator for this site.

Remediation Criteria for water resources will be defined following the completion of the DQRA.

Remediation Criteria Point	Remediation Objective	Compliance Criteria [1]
Excavation Extents	Ensure that concentrations of asbestos within soils within the uppermost 0.1m of materials do not have asbestos concentrations that exceed the defined risk-based thresholds	Composite soil samples do not exceed the Remediation Criteria. Samples collected at the following frequency • One sample per 25 linear metres of excavation from within the top 0.6m
	Ensure that soils remaining in-situ do not contain contaminant concentrations in excess of the remediation and reclamation criteria	Composite soil samples do not exceed the Remediation Criteria. Samples collected at the following frequency • One sample per 25 linear metres of excavation; and, • One sample per stratum or at 1.0m vertical intervals (whichever is the greater) • One sample per 625m^2 of excavation base
Imported Materials	Ensure that materials imported and used at the site do not introduce environmental or human health risks	Soil samples collected at a frequency of one sample per 1,000 m^3 of imported material (with a minimum of three samples per source) do not exceed the Remediation Criteria.
Accumulated NAPL	Ensure that no NAPL is present on groundwater as far as is reasonably practicable	No visible NAPL to be recorded on groundwater or accumulated water as far as reasonably practicable[2]

[1] Sampling frequency to be formalised and agreed as part of Remediation and Reclamation Implementation Plan and MMP

[2] To consider that further free phase recovery is not reasonably practicable, it should be demonstrated that free phase recovery rates have diminished to asymptotic conditions.

7.3.8 Suitability for Use Criteria

For excavated materials the following reuse criteria will apply:

Reuse Criteria Point	Objective	Compliance Criteria [3]
Reuse	To ensure that concentrations of contaminants within materials proposed for reuse do not exceed agreed reuse criteria.	Composite soil samples collected at a frequency of one sample per 500 m^3 of material proposed for re-use. Human Health - Laboratory analysis confirms concentrations of contaminants are below the criteria set out in Wood 2019 (LQM S4UL and Wood GAC). Water Resources – Reuse criteria to be confirmed by the DQRA Geotechnical – Backfill inline with Highways Specification. Exact specification to be confirmed in Earthworks Specification

7.3.8.1 Management of Contaminated Soils

In order to address the identified pollutant linkage in section 2.6.1 it is proposed that remediation should be undertaken to break the pathway between the contaminants and the receptor (Section 6.1). This should comprise placement of protective cover layers in areas, where contaminants in soils are identified above the reuse criteria.

In order to facilitate development a temporary cover system should be installed across the footprint of the site, this temporary cover system should comprise 100mm of certified imported materials. The presence of the cover system should be considered when the final construction phase planning and design are finalised

As part of the future developer led re-development works, where hardstanding is not present and providing the required cover system, such as areas of soft standing, the following permanent cover system should be incorporated into the design and installed:

- Geotextile marker layer over soils containing exceedance of the reuse criteria; and
- 450-600 mm thickness of suitable imported materials.

Where soils are visibly impacted with NAPL or onsite screening / testing indicated the presence of NAPL they shall be consigned for treatment via one of the identified remediation approaches in order to make them suitable for re use.

7.3.8.2 Management of Asbestos Containing Materials

Asbestos fibres have been identified in a number of locations across the site in made ground during the investigative works. No ACM hotspots have been identified, with fibre concentrations generally in the range of <0.001% to 0.02%. During excavation works to remove underground structures there is the potential for ACM to be encountered. In the event that suspected materials are observed associated with excavations, sampling will be undertaken to confirm the asbestos type and quantification. Where ACM has to be removed to facilitate removal of structures it shall be separately stockpiled and covered to control potential dust generation. Soils containing asbestos in excess of the reuse criteria will not be subject to mechanical screening where free fibres have been detected or are suspected. All soils containing asbestos will be managed by maintaining mist sprays to keep the soils wet whilst handled and covered when stockpiled.

[3] Sampling frequency to be formalised and agreed as part of Remediation and Reclamation Implementation Plan and MMP

Soils which have been identified as containing asbestos (or suspected to) will be stockpiled separately from all other excavated materials. These materials will be characterised by sampling and laboratory analysis.

In the event that materials are impacted with visible fragments of ACM, the ACM materials shall be handpicked by a suitably licenced asbestos contractor with additional control measures implemented based on the sampling results.

Where soils containing CoC in excess of the reuse criteria and, due to the presence of asbestos cannot be safely handled or successfully treated, they will be disposed of offsite. Where concentrations are below the reuse threshold soils may be reused as infill to excavation voids at depths below 0.6 m of final ground level.

7.3.8.3 Management of Potential Expansive Slags and Refractory Materials

If these materials are excavated as part of the enabling earthworks they should be separated from other materials as far as practicable and stockpiled separately. Material should be crushed to 6f2 and reused in areas identified by STDC as low risk such as biodiversity enhancement areas.

7.3.9 Unexpected Contamination

Changes to the remediation strategy may be required during the remediation works, as a result of encountering unexpected contamination[4]. Should unexpected contamination be encountered, then further characterisation and risk assessment will be undertaken as required. An addendum to the strategy will be prepared detailing how this contamination will be dealt with. Written agreement with the regulators will be required prior to implementation of any amendments to the agreed strategy. Any such amendments shall be required to be fully documented within the Verification Report.

7.3.10 Anticipated Enabling Earthworks and Remediation Extents and Quantities

The extent and quantities of the enabling earthworks and remediation have been estimated based on current site information and will be refined following the completion of the DQRA. Anticipated excavation extents are presented on Figure 5 below and in Appendix A.

[4] This is defined as any contamination source which is distinct in its chemical or physical composition from the type of source material considered within the conceptual site model.

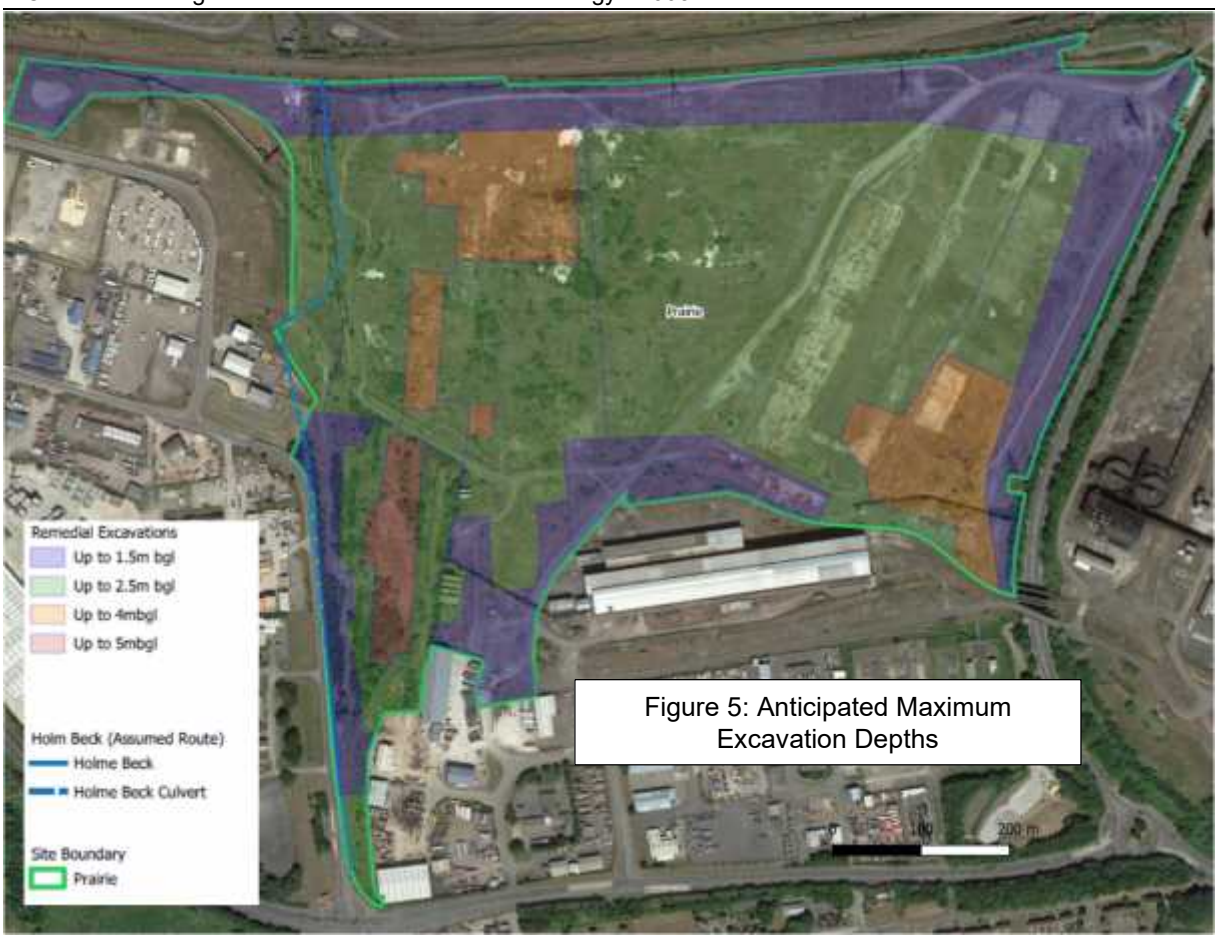


Figure 5: Anticipated Maximum Excavation Depths

Material Type	Estimated Volume Ranges for Prairie Site *
Made Ground requiring turning over to remove relic structures and identify contaminated materials	1,225,000m^3
Concrete and hard materials requiring breaking out and processing	100,000 – 120,000m^3
Materials containing expansive slag or refractory bricks that require processing	10,000 - 30,000 m^3
Materials impacted above Human Health Criteria and/or impacted with NAPL requiring treatment	60,000 – 120,000 m^3

(*) Excludes above ground portion of railway bund, volume to be update on receipt of updated LIDAR data.

7.3.11 Verification of Excavations and Materials for Reuse

Materials identified for reuse will be required to be tested prior to placement to demonstrate compliance with the reuse criteria. Testing will be undertaken on a proposed frequency identified in Section 7.3.7.

7.3.12 Backfill

All Made Ground will be excavated and screened to remove oversize or deleterious material. Oversize material will be crushed for reuse, while deleterious material will be removed from site. All remaining material will be placed into stockpiles and subjected to testing and grading to ensure suitability as defined in series 600 of the Specification for Highways. Where the material does not meet the suitability criteria, it will be subjected to physical treatment, modification or stabilisation as required to achieve the necessary degree of compaction.

No detailed redevelopment design is currently available for the site and therefore no groundworks model with cut and fill levels is available. In addition, the geotechnical specification for backfilling is not provided as a development ready platform but to provide a level access to and around the site.

At the time of writing the Earthworks Specification is yet to be completed. Following the completion of the Earthworks Specification, the excavation, processing and backfilling specifications of this document will be required to be updated to reflect the changes.

Where required imported materials shall be used to fulfil any materials deficit. Imported material must be certified free of asbestos and other deleterious material. For each source of imported material for backfill, a material statement shall be provided detailing the chemical testing results, geotechnical testing material classification, destination of material deposition on site and proposed method of compaction. Site won materials that are re-used on site must be demonstrated as suitable for use in accordance with the MMP. Prior to backfill, excavations will be dewatered. Excavations will be backfilled in layers in accordance with the Highway Specifications.

7.3.13 Environmental Controls and Management

A Construction Phase Environmental Management Plan (CPEMP) should be prepared for the Works and shall consider the following environmental aspects.

7.3.13.1 Surface Water Management

A surface water management plan shall be developed and implemented as a component of the CPEMP to provide temporary drainage facilities and protection measures (such as silt fences) as necessary to ensure the site, the Remediation Works, the adjacent land and existing facilities are adequately drained and run-off managed during the course of the Work.

Surface water and other water generated as part of the Works shall be monitored and treated via a drainage silt trap / settlement tank, or similar, to remove solids and fines from water. Any further treatment necessary to effect compliance with the consent limits shall be designed, installed and maintained.

7.3.13.2 Dust, Noise and Vibration

Air Quality and Dust Management Plan

An Air Quality and Dust Management Plan (AQDMP) will be prepared as a component of the CPEMP. Baseline data will be collected as part of this plan to allow the impact of the works on the surrounding environment to be determined and allow the success of control measures undertaken to protect the site workforce and neighbouring receptors to be assessed. Trigger levels for remedial action will be defined within this plan.

Dust control measures will be implemented through the works including the use of damping down, sealing of stockpiles and vehicle wash facilities to prevent the transport of mud and debris from the site onto public roads.

Noise

Prior to commencement on site noise data will be taken to establish baseline conditions. Trigger levels to prevent unacceptable impacts to receptors shall be identified within the CPEMP and agreed with the Regulators. Noise monitoring stations will be implemented to monitor the impact of the Works against background levels and allow measures to be implemented to ensure noise levels remain below these limits.

Vibration

Prior to commencement on site vibration levels will be taken to establish baseline conditions. Trigger levels to prevent unacceptable impacts to receptors shall be identified within the CPEMP and agreed with the regulators. The Contractor shall implement vibration monitoring stations to monitor the impact of the Works against background level and these limits.

7.3.13.3 Ecology/Invasive Species

The site is approximately 1km south of the Teesmouth and Cleveland Coast SPA, Ramsar and SSSI site. At the time of writing this report it is not known if the site is currently being used by designated bird species from the Teesmouth and Cleveland Coast SPA. Onsite habitats have been surveyed and have identified protected species and priority habitats, at the time of writing the full details of the surveys have not been made available to Arcadis.

An ecological survey conducted in 2018 identified the following non-native species

- Small-leaved Cotoneaster (Cotoneaster microphylla). Species is listed on Schedule 9 of the Wildlife & Countryside Act (1981) making it illegal to spread or cause to grow in the wild. It was recorded in the most north west corner of the site.
- Sea buckthorn – considered to be non-native in the Teesside area so spread or replanting should be avoided.

A more recent ecological survey has been conducted, but at the time of writing this report the results of survey are not known to Arcadis.

Control of cotoneaster species includes mechanical and chemical measures.

- Mechanical methods of control - Excavating seedlings and root mass. Any material from the cotoneaster/containing cotoneaster waste must be chipped on site or removed to licensed landfill as controlled waste.
- Chemical methods of control - Spraying plants with herbicide and treating stumps of larger plants to prevent regrowth.

Control of Sea buckthorn should be through mechanical excavation of the plant and root mass. Any waste must be chipped on site or removed to licensed landfill as controlled waste.

Following the completion of the ecological surveys and HRA, control measures and mitigation identified within shall be adopted in relations to the remediation and restorations works and future development.

7.3.14 Surface Water Features

Should the redevelopment require the realignment of Holme Beck, Knitting Wife Beck or the Cross Connector the engineering design for the new route will need to consider the condition of soil and or groundwater in the area of the proposed diversion and determine if measures to break the potential pathway between ground and surface water are required within the design.

7.3.15 Surface Water Management

During groundworks the Contractor shall take measures to prevent surface water and sediment run off from the excavation and treatment areas and prevent its entry into surface water features.

8 Reporting

8.1 Pre-commencement

8.1.1 Enabling Earthworks Remediation Implementation Plan

The specific objective of the Enabling Earthworks and Remediation Implementation Plan (EERIP) is to produce a site-specific plan detailing the design and methodology of the selected remediation approach to be applied at the site. This will incorporate remediation programme and the monitoring and validation requirements.

The EERIP will be undertaken in accordance with the requirements of LCRM guidance and will include the following tasks:

- Review of the site characteristics – in particular any variation from currently known conditions;
- Development of remediation technical specification;
- Development of implementation methodology;
- Discussion of any additional regulatory requirement; and,
- Details on methodology for verification of remedial works.

8.1.2 Materials Management Plans

An MMP shall be prepared by the appointed Contractor in accordance with CL:AIRE DoWCoP and authorised by a Qualified Person registered with CL:AIRE.

8.1.3 Construction Phase Environmental Management Plan

The appointed Contractor will prepare a construction phase environmental management plan (EMP)_for the works. This will consider the potential impacts that the works will have on the environment and include any monitoring and control measures required.

The plan will set out the monitoring and recording process for the management and minimisation of waste, including the storage and transport of waste on-site. This will include a recording mechanism for required waste documentation such as Waste Transfer or Consignment Notes (dependent on the waste stream) in order to confirm the assessment of the waste impact and to implement embedded mitigation measures.

The EMP will include their methodologies for controlling and monitoring the following aspects of the works:

- Waste Management Procedures
- Noise and vibration
- Air quality and dust management
- Any ecological mitigations required
- Surface water drainage
- Spills and environmental releases
- Monitoring and measuring procedures
- Relevant policies, legal requirements and key stakeholders

8.2 Implementation

During remediation implementation, regular meetings will be held and minuted by the remediation contractor to provide robust control of the work. Meetings are proposed to include:

- Pre-start Meeting
- Daily Site Briefings

- Weekly Site Progress Meetings
- Fortnightly Contract Review meetings
- Risk Reduction/Change Management Meetings
- Project Close Out Meeting

Data types to be collected and reviewed during the remediation implementation period are described in Section 8.3 below. Records will be produced to detail progress of the works. Should site conditions vary from those currently known, resulting in a change to the proposed remediation strategy, this will be communicated to relevant stakeholders at the earliest opportunity to allow for an amended approach to be developed and approved.

8.3 Remediation Works Verification Report

Verification of remediation will be based on a number of lines of evidence collected during the works and tracked through the implementation phase. These will be documented within the final Verification Report as follows:

8.3.1 Field records

Field records to verify the works may include the following

- Excavation extents and depths supported by topographic survey data;
- Field screening / onsite analysis of soil samples;
- Volumetric records of water and free phase hydrocarbons recovered from excavations; and,
- Photographic records.

8.3.2 Laboratory Results

Soil and water sampling and accredited laboratory analysis data will be provided to confirm that:

- On completion of excavations contaminant concentrations within remaining in situ soil meets the reuse criteria, as far as is reasonably practicable (laboratory results).
- Contaminant concentrations within excavated soil that may be re-used onsite as infill to excavations, meet the reuse criteria.
- Laboratory analysis of recovered groundwater / treated groundwater to support off-site disposal, re-infiltration or disposal under consent to foul drainage network.
- Laboratory analysis results of material imported onto site as backfill will be obtained to demonstrate material meets the reuse criteria.

Geotechnical testing of reinstated material to ensure compliance with Earthworks Specification. Laboratory analysis will be undertaken by a UKAS accredited laboratory.

8.3.3 Topographic Survey Records and Drawings

Site drawings and topographic plans will be developed to demonstrate that:

- Source areas have been removed (if identified) and provide records of excavation extents during the Works;
- Records of below ground obstructions left in-situ following the works
- Site levels have been restored to the agreed formation levels;
- Thickness and extent of capping layer placed on the site; and,
- Re-used materials have been located in the correct place through as-built drawings showing locations of remedial works and records of residual hazards

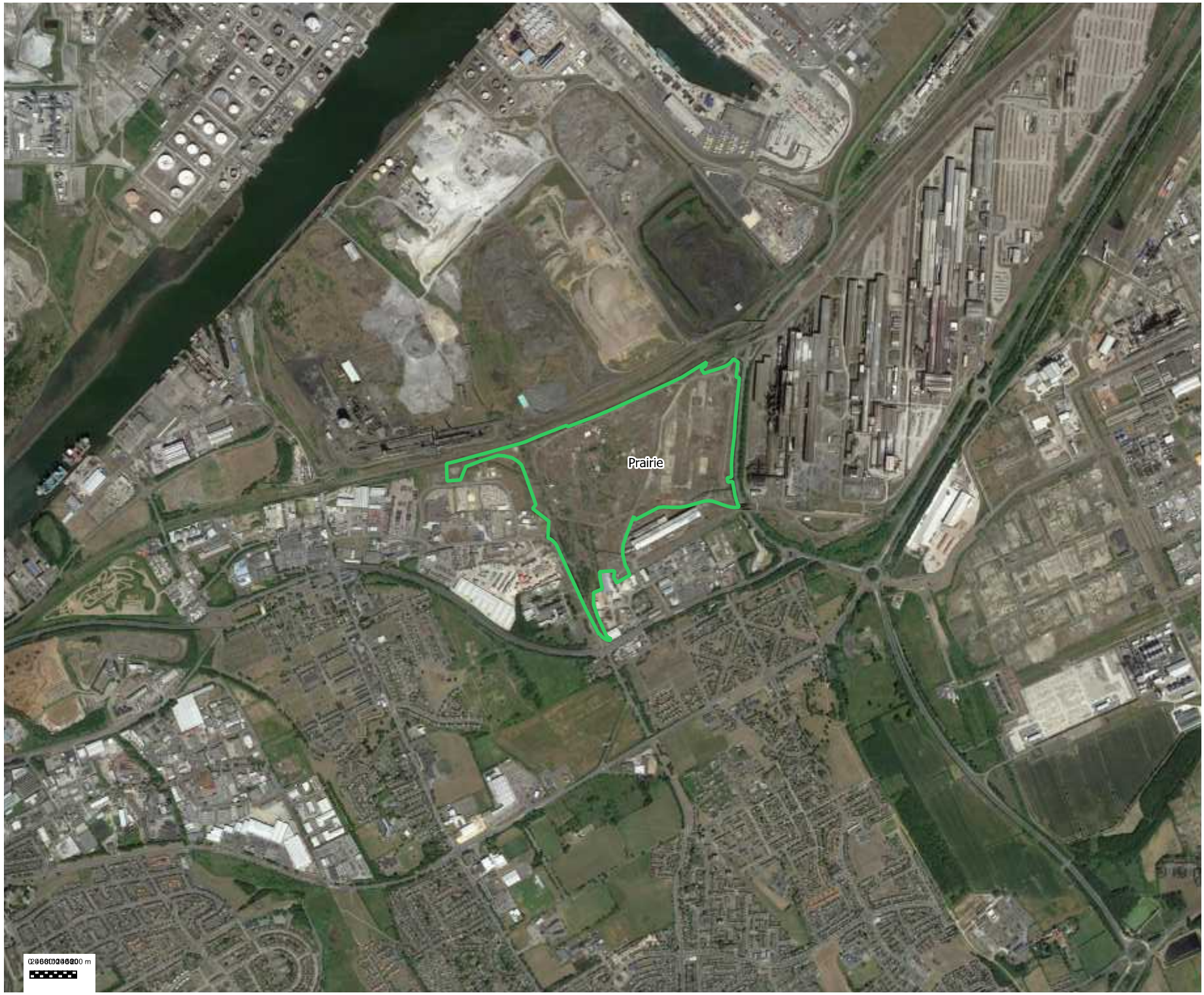
8.3.4 Materials Audit Trail Records & Environmental Monitoring

The results of the monitoring and testing set out in the EMP, including details of any spills or emergency response measures employed, will be included together with evidence to demonstrate that:

- Re-used material has been deposited in the correct location in compliance with the materials management plan;
- Waste materials have been properly quantified and have been accepted by an appropriately licenced facility include completed waste transfer documentation; and that
- Imported materials are of correct quality and volume for use on site and free of asbestos.

APPENDIX A

Figures



Legend

Site Boundary

Prairie

Notes:

CONTACT ARCADIS IN CASE OF ANY QUERIES.

N

Title: Prairie - Site Location Plan

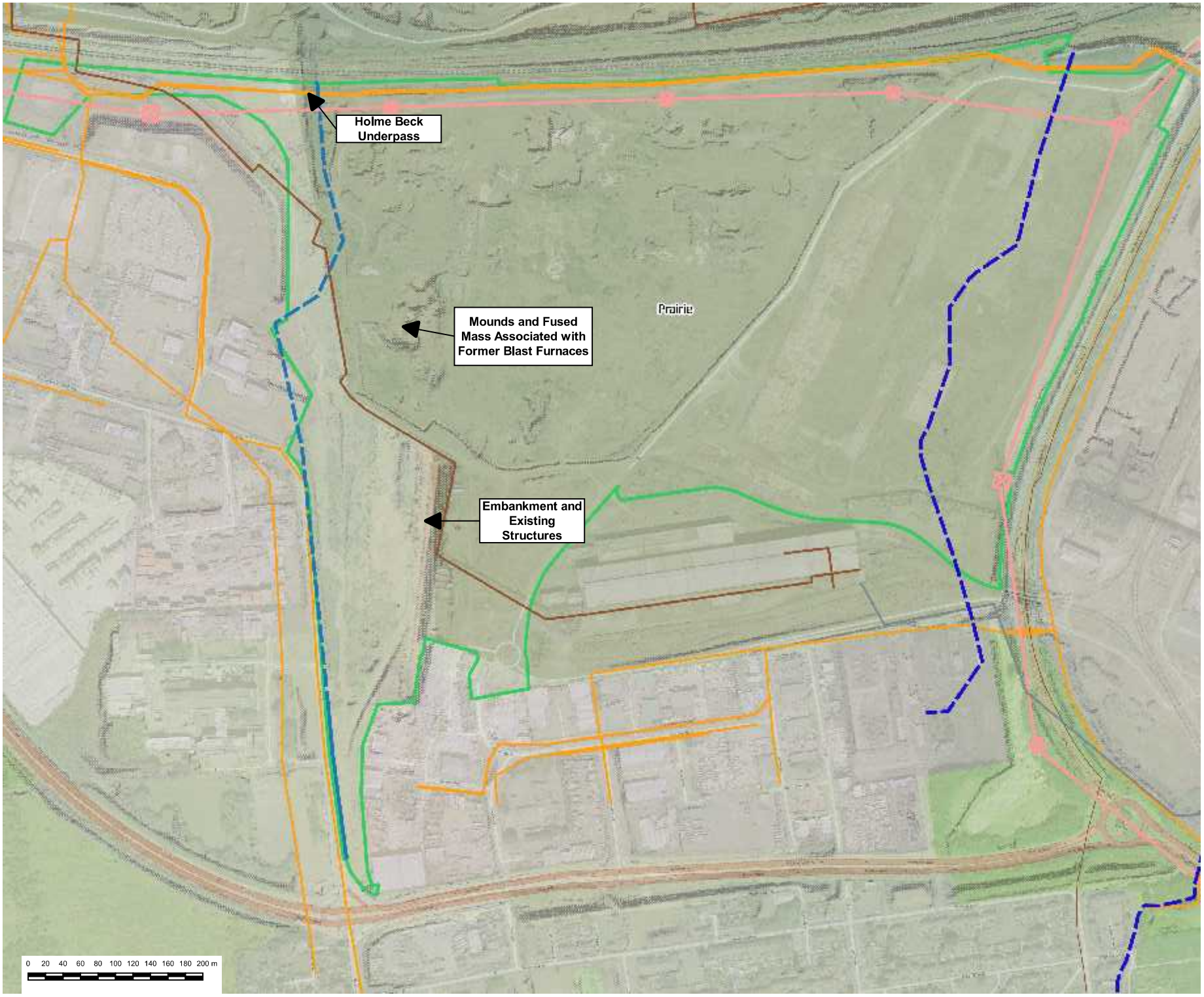
Site: Redcar Steelworks (Prairie)

Client:
South Tees Developement Corporation

Project: 10035117	**Figure 1**

Date: 05/06/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0063-01-Prarie_SLP

ARCADIS Design & Consultancy for natural and built assets



Legend

STDC Shapefiles

- Knitting Wife Beck

STDC data

Holme Beck

- Holme Beck
- Holme Beck Culvert
- Sewers
- Layer_MGT 275KV Cable
- Layer_Existing National Grid Elec
- Layer__CokeOvenGasUnderground
- Layer__CokeOvenGasAboveGround

Site Plans

Redline

- Prairie

Notes:

CONTACT ARCADIS IN CASE OF ANY QUERIES.

The accuracy of non-Arcadis data has not been verified.

Holme Beck route added by Arcadis based on historical site plans, accuracy has not been confirmed.

N

Title:
Prairie - Site Setting and Layout

Site: Redcar Steelworks - Prairie

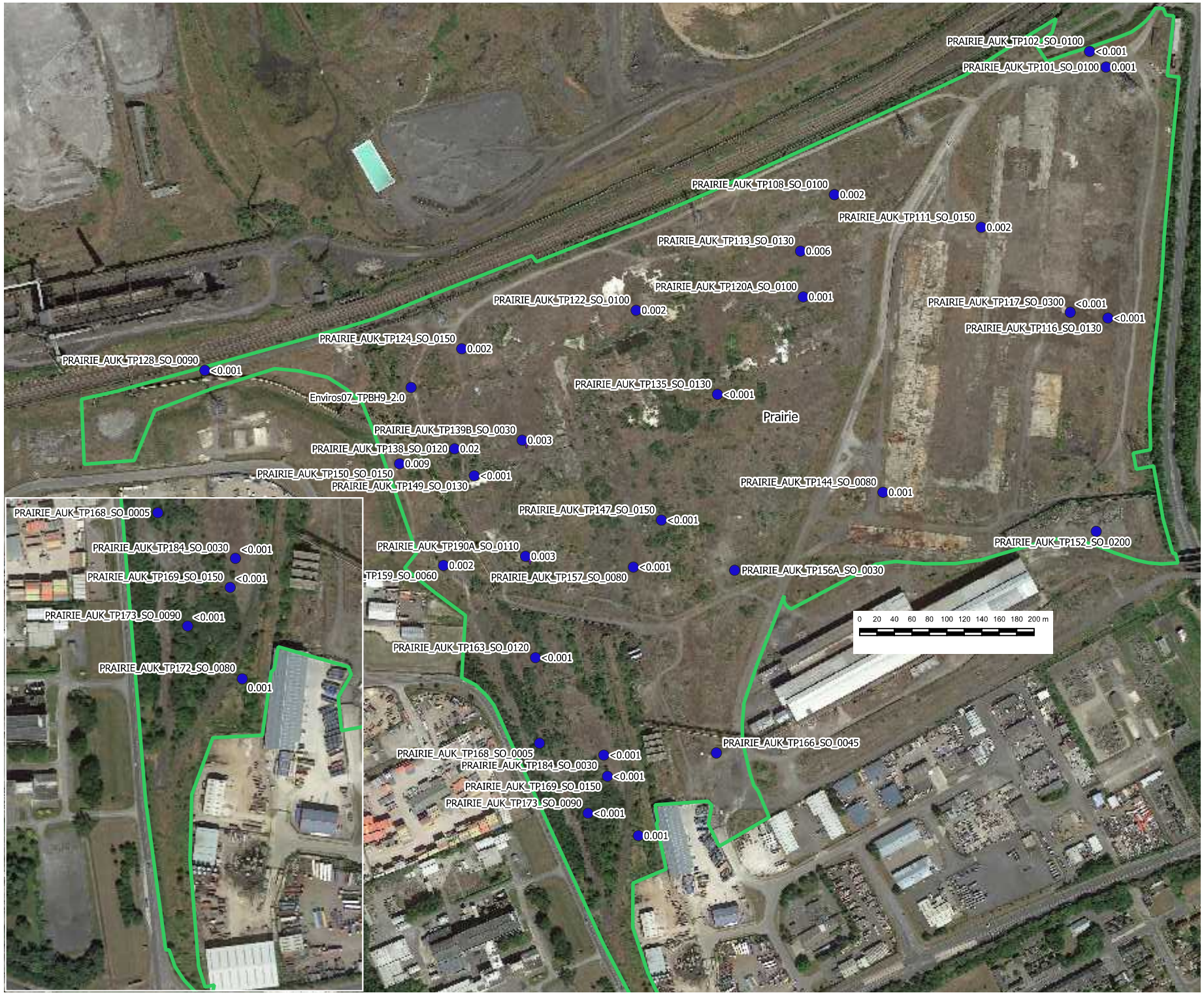
Client:
South Tees Developement Corporation

Project:
10035117

Figure 2

Date: 15/05/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0065-01-Prairie_Sett

ARCADIS



Legend

Asbestos Detected

- Yes

Site Boundary

- Prairie

Notes:

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CONTACT ARCADIS IN CASE OF ANY QUERIES.

Label: SampleID and Percentage Quantification

Title: Prairie - Asbestos Testing Results (Presence and Quantification)

Site: Redcar Steelworks - Prairie

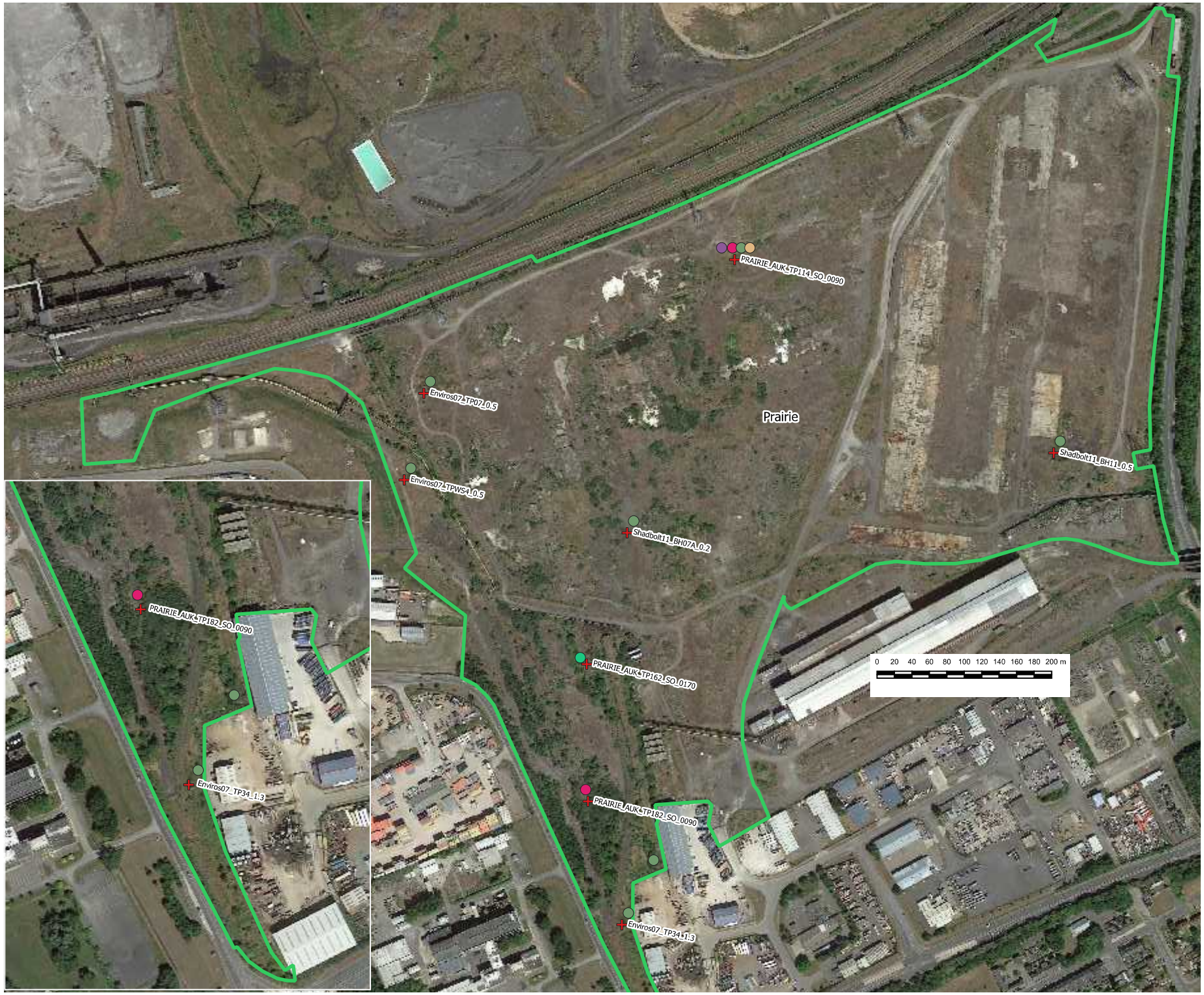
Client:
South Tees Developement Corporation

Project:
10035117

Figure 3

Date: 04/06/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0080-01-Prairie_Asbestos

ARCADIS



Legend

Contaminant

- Naphthalene
- PAH (ex. Naphthalene)
- 2-Naphthalene
- Dibenzofuran
- Arsenic

Location Centre Point

- Sample ID and Depth

Site Boundary

- Prairie

Notes:

CONTACT ARCADIS IN CASE OF ANY QUERIES.

Arcadis cannot warrent the accuracy of 3rd Party data

Title: Prairie - Exceedences of Soil Screening Criteria (Human Health)

Site: Redcar Steelworks - Prairie

Client:
South Tees Developement Corporation

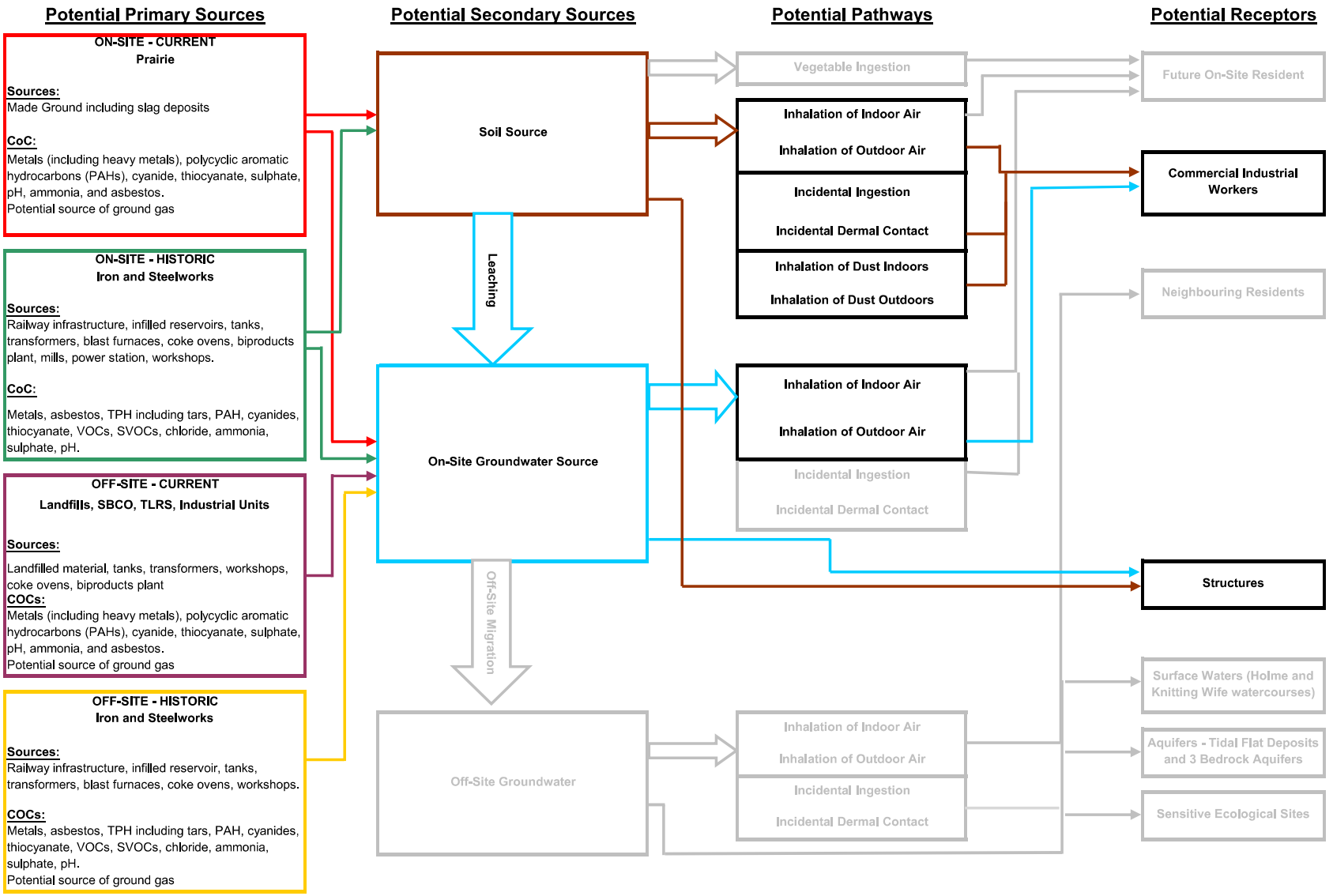
Project:
10035117

Figure 4

Date: 19/05/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0078-01-Prairie_Soil_Exceed

ARCADIS

Figure 5
Conceptual Site Model - Commercial Industrial End Use



Key: Pollutant linkage not considered to present a significant level of risk

ARCADIS Design & Consultancy for natural and built assets

Legend

Remedial Excavations
- Up to 1.5m bgl
- Up to 2.5m bgl
- Up to 4mbgl
- Up to 5mbgl

Holm Beck (Assumed Route)
- Holme Beck
- Holme Beck Culvert

Site Boundary
- Prairie

Notes:

Works to daylight Holm Beck to be confirmed.
Route of Holm beck taken from STDC dtawing PX90320

CONTACT ARCADIS IN CASE OF ANY QUERIES.

N

Title: Prairie - Estimated Dig Depths - Prairie Site

Site: Redcar Steelworks - Prairie

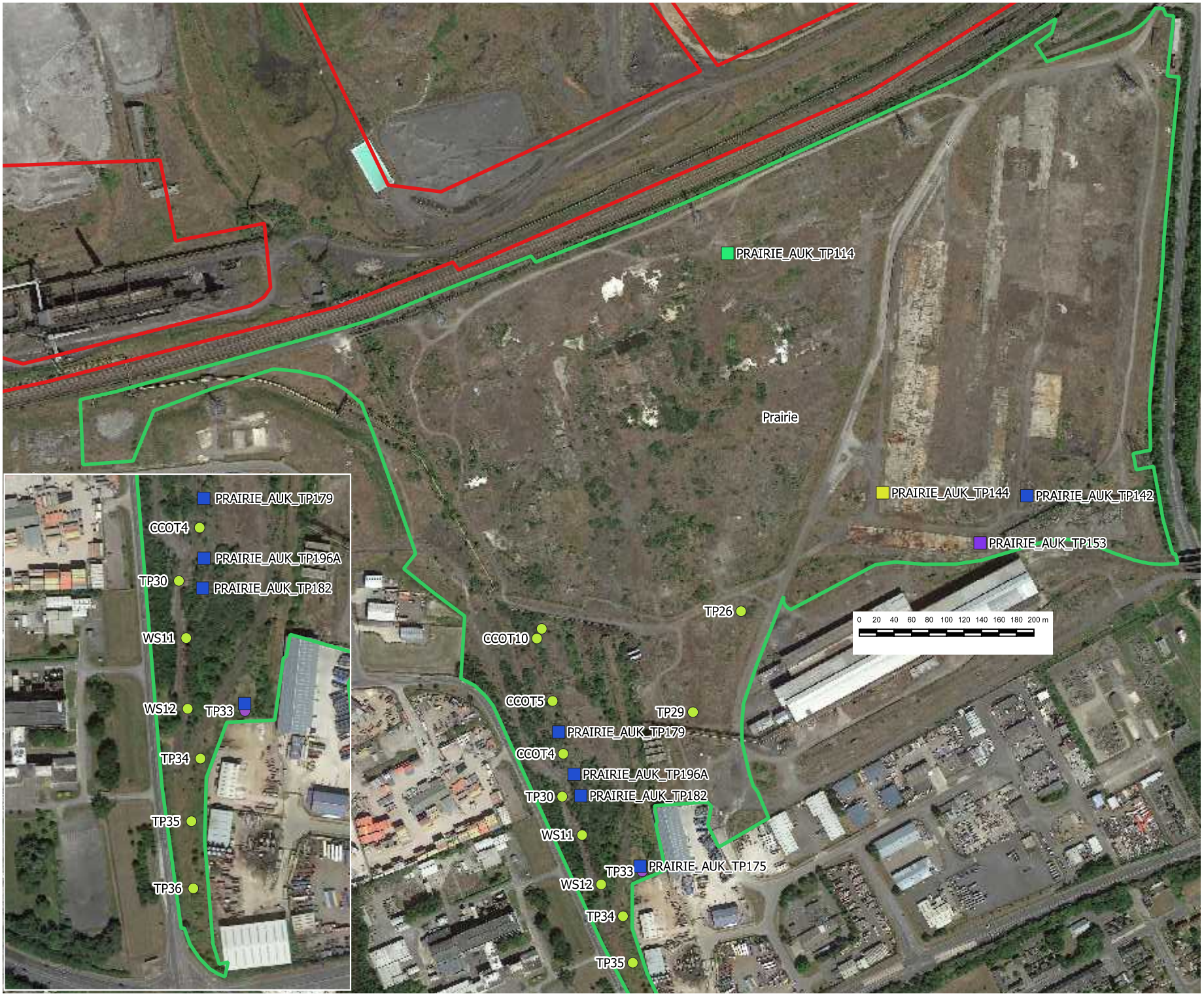
Client:
South Tees Developement Corperation

Project:
10035117

Figure 6

Date: 21/05/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0075-02-Prairie_Rem_Ex

ARCADIS



Legend

Arcadis Investigations

- NAPL
- Sheen / Seepage
- Sheen
- Tar

Historic Locations

- NAPL
- NAPL / Tar

Redline

- Prairie

Notes:

CONTACT ARCADIS IN CASE OF ANY QUERIES.

NAPL: Non-aqueous Phase Liquid

Arcadis cannot warrent the accuracy of third party data.

Title: Prairie - Locations Where NAPL Identified

Site: Redcar Steelworks - Prairie

Client:
South Tees Developement Corporation

Project:
10035117

Figure 7

Date: 03/10/2020
Drawn By: JALM
DRG No: 10035117-AUK-XX-XX-DR-ZZ-0079-01-Prairie_NAPL

ARCADIS

APPENDIX B

Study Limitations

IMPORTANT: This section should be read before reliance is placed on any of the information, opinions, advice, recommendations or conclusions contained in this report.

1. This report has been prepared by Arcadis UK Ltd (Arcadis), with all reasonable skill, care and diligence within the terms of the Appointment and with the resources and manpower agreed with **STDC** (the 'Client'). Arcadis does not accept responsibility for any matters outside the agreed scope.

2. This report has been prepared for the sole benefit of the Client unless agreed otherwise in writing.

3. Unless stated otherwise, no consultations with authorities or funders or other interested third parties have been carried out. Arcadis are unable to give categorical assurance that the findings will be accepted by these third parties as such bodies may have unpublished, more stringent objectives. Further work may be required by these parties.

4. All work carried out in preparing this report has used, and is based on, Arcadis' professional knowledge and understanding of current relevant legislation. Changes in legislation or regulatory guidance may cause the opinion or advice contained in this report to become inappropriate or incorrect. In giving opinions and advice, pending changes in legislation, of which Arcadis is aware, have been considered. Following delivery of the report, Arcadis have no obligation to advise the Client or any other party of such changes or their repercussions.

5. This report is only valid when used in its entirety. Any information or advice included in the report should not be relied upon until considered in the context of the whole report.

6. Whilst this report and the opinions made are correct to the best of Arcadis' belief, Arcadis cannot guarantee the accuracy or completeness of any information provided by third parties.

7. This report has been prepared based on the information reasonably available during the project programme. All information relevant to the scope may not have been received.

8. This report refers, within the limitations stated, to the condition of the Site at the time of the inspections. No warranty is given as to the possibility of changes in the condition of the Site since the time of the investigation.

9. The content of this report represents the professional opinion of experienced environmental consultants. Arcadis does not provide specialist legal or other professional advice. The advice of other professionals may be required.

10. Where intrusive investigation techniques have been employed they have been designed to provide a reasonable level of assurance on the conditions. Given the discrete nature of sampling, no investigation technique is capable of identifying all conditions present in all areas. In some cases the investigation is further limited by site operations, underground obstructions and above ground structures. Unless otherwise stated, areas beyond the boundary of the site have not been investigated.

11. If below ground intrusive investigations have been conducted as part of the scope, service tracing for safe location of exploratory holes has been carried out. The location of underground services shown on any drawing in this report has been determined by visual observations and electromagnetic techniques. No guarantee can be given that all services have been identified. Additional services, structures or other below ground obstructions, not indicated on the drawing, may be present on Site.

12. Unless otherwise stated the report provides no comment on the nature of building materials, operational integrity of the facility or on any regulatory compliance issue

APPENDIX C

Remediation Option Appraisal Tables

Table 1
Remediation Technology Selection
Contaminants of Concern (CoC) in Soil
Industrial End Use Scenario

Technology	Biological Techniques		Chemical Techniques			Physical Techniques				Ex Situ Techniques						Score	Weighted Coefficient	
	Source Zone Depletion (SZD)	Bioventing	Chemical Oxidation or Reduction *via In Situ* Soil Mixing	*In Situ* Chemical Oxidation (ISCO)	*In Situ* Stabilisation / Solidification	Soil Vapour Extraction with potential low thermal enhancement	*In-Situ* Thermal Desorption via Conductive Heating	In-Situ Thermal Treatment (Enhanced Physical Recovery)	Capping Layer to break Source Pathway Receptor Linkage	Excavation & Off Site Disposal / Treatment	Ex Situ Bioremediation Amended Biopiles / windrows	Ex Situ Physical Treatment (Soil Vapour Extraction)	Ex Situ Chemical Treatment (Stabilisation / Oxidation)	Ex Situ Soil Washing	Ex Situ Thermal Treatment (Thermopile or StarX)			
Technical Parameters																		
Contaminant Properties	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	6 SPR linkage breakage would address primary remediation drivers associated with Human Health exceedances but not mass of NAPL containing materials	9 Proven technology used widely to treat CoC	6 Proven technology used widely to treat CoC - Concentrations of heavy end hydrocarbons indicative of NAPL could be slow to treat	6 Proven technology used widely to treat CoC - Concentrations of heavy end hydrocarbons indicative of NAPL could be slow to treat	6 Proven technology used widely to treat CoC - contaminants are not degraded or broken down but locked up to prevent contact or exposure	6 Proven technology used widely in the UK to treat CoC• Contaminants are concentrated into finer fractions that would require further treatment or disposal	9 Proven technology used widely in the UK to treat CoC	0 - Technology not suitable 1 - Technology may work (50%) 2 - Technology will probably work (70%) 3 - Technology very suitable (90% +)	x 3	1 - Less Important 2 - Important 3 - Very Important
Extent of Contamination (concentration, distribution and plume dimensions)									9 Technology can be applied over large treatment zones	9 Off Site Treatment Facilities routinely accept waste types	9 Technology can be applied to large treatment zones of highly contaminated materials	9 Technology can be applied to large treatment zones of highly contaminated materials	9 Technology can be applied to large treatment zones of highly contaminated materials	9 Technology can be applied to large treatment zones of highly contaminated materials	9 Technology can be applied to large treatment zones of highly contaminated materials	0 - Technology not suitable 1 - Technology may work (50%) 2 - Technology will probably work (70%) 3 - Technology very suitable (90% +)	x 3	1 - Less Important 2 - Important 3 - Very Important
Geology / Hydrogeology Suitable									6 Processing of materials beneath the capping layer would require to be complete before installation	9 No processing of materials required	6 Made ground materials would require physical screening and crushing to facilitate treatment	6 Made ground materials would require physical screening and crushing to facilitate treatment	6 Made ground materials would require physical screening and crushing to facilitate treatment	6 Made ground materials would require physical screening and crushing to facilitate treatment	6 Made ground materials would require physical screening and crushing to facilitate treatment	0 -Technology not suitable 1 - Technology may work (50%) 2 - Technology will probably work (70%) 3 - Technology very suitable (90% +)	x 3	1 - Less Important 2 - Important 3 - Very Important
Technical Score									21	27	21	21	21	21	24			
Technical Ranking									2	1	2	2	2	2	#N/A			
Operational Parameters																		
Operational Implementation	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	6 Technology requires capping layer (>0.5m thickness) to be installed over treatment areas	2 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works including off site.	4 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works	4 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works	4 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works	4 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works	4 Access to all contaminated materials may not be possible due to site utilities remaining in situ. Excavation area closed off and increase traffic movements during excavation works	0 - Impacts on site operation not acceptable 1 - High impact on working operation of site 2 - Minor impacts on working operation of site 3 - Minimal impacts on working operation of site	x 2	1 - Less Important 2 - Important 3 - Very Important
Long Term Operational Demands									6 May cause some restrictions on future land development to avoid damage to the capping material or require cap to be reinstated if damaged	9 Post remediation groundwater monitoring anticipated.	9 Post remediation groundwater monitoring anticipated.	9 Post remediation groundwater monitoring anticipated.	9 Post remediation groundwater monitoring anticipated.	9 Post remediation groundwater monitoring anticipated.	9 Post remediation groundwater monitoring anticipated.	0 - Impacts on site operation not acceptable 1 - High impact on working operation of site 2 - Minor impacts on working operation of site 3 - Minimal impacts on working operation of site	x 3	1 - Less Important 2 - Important 3 - Very Important
Operational Requirements									9 Technology only requires monitoring wells as remediation infrastructure	6 Treatment area would need to be cleared (above and below ground) prior to implementation, plant required for excavation and disposal during works additional areas required for implementing ex situ treatment.	6 Treatment area would need to be cleared (above and below ground) prior to implementation, plant required for excavation during works additional areas required for implementing ex situ treatment.	6 Treatment area would need to be cleared (above and below ground) prior to implementation, plant required for excavation during works additional areas required for implementing ex situ treatment.	6 Treatment area would need to be cleared (above and below ground) prior to implementation, plant required for excavation during works additional areas required for implementing ex situ treatment.	3 Significant water and plant requirements to implement technology in addition to ex situ remediation works	3 Significant power requirements to implement thermal technology in addition to ex situ remediation works	1 - Substantial operational requirement (e.g. power and large plant required) 2 - Relatively large operational requirement (e.g. power and portable plant) 3 - Very minor operational requirement (e.g. monitoring only)	x 3	1 - Less Important 2 - Important 3 - Very Important
Health & Safety / Nuisance									9 Excavation and placement of shallow engineered material required	3 Dust, noise, traffic and other nuisance would need to be managed, Significant increased traffic on wider site.	6 Dust, noise, traffic and other nuisance would need to be managed	6 Dust, noise, traffic and other nuisance would need to be managed	3 Use of oxidants and other reagents requires specialist H&S planning. Dust, noise, traffic and other nuisance would need to be managed	3 Specialist plant and machinery requires specialist H&S planning and monitoring• Dust, noise, traffic and other nuisance would need to be managed	3 Specialist plant and machinery requires specialist H&S planning and monitoring• Dust, noise, traffic and other nuisance would need to be managed	1 - Higher risk remediation activity / Higher potential for nuisance 2 - Lower risk remediation activity / lower potential for nuisance 3 - Minimal risk remediation activity / Minimal potential for nuisance	x 3	1 - Less Important 2 - Important 3 - Very Important
Track Record / Development Status									6 Commonly applied and proven technology	6 Commonly applied and proven technology	6 Commonly applied and proven technology	6 Commonly applied and proven technology	4 Limited application of this technology , trials recommended to confirm design.	4 Limited application of this technology , trials recommended to confirm design.	4 Limited application of this technology , trials recommended to confirm design.	1 - Remediation approach has had limited application at full scale 2 - Remediation approach been applied with successful case studies 3 - Remediation approach has been used extensively	x 2	1 - Less Important 2 - Important 3 - Very Important
Operational Score									36	26	31	31	26	23	23			
Operational Ranking									1	4	2	2	4	6	6			
Commercial Parameters																		
Residual Liability	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	0 In-situ technologies discounted during pre-screening	3 Mass is not depleted, pathways to receptors on and off site need to be decontaminated to be controlled / broken.	6 Removal of contaminant mass from site	6 Contaminant type, mass and nature of geology means moderate mass removal most likely scenario	6 Contaminant type, mass and nature of geology means moderate mass removal most likely scenario	6 Contaminant type, mass and nature of geology means moderate mass removal most likely scenario	9 Extent / high level of contaminant mass and nature of geology means significant mass removal (81 - 85%) most likely scenario	9 Extent / high level of contaminant mass and nature of geology means significant mass removal (81 - 85%) most likely scenario	0 - Technology as stand alone not suitable to achieve remediation objective 1 - Technology may achieve remediation objective (50% possibility) 2 - Technology would achieve remediation objective (70% possibility) 3 - Technology would achieve remediation objective (90% possibility)	x 3	1 - Less Important 2 - Important 3 - Very Important
Commercial Availability									3 Equipment required is readily available	3 Equipment required is readily available	3 Equipment required for bioremediation is readily available	3 Equipment required for SVE is readily available	3 Readily available equipment and reagents would be required	1 Specialist equipment and contractor would be required	1 Highly Specialist equipment and contractor would be required	1 - Equipment not readily available 2 - Equipment available 3 - Equipment readily available	x 1	1 - Less Important 2 - Important 3 - Very Important
Implementation Timescale									3 Technology could be applied reasonably quickly	3 Technology could be applied reasonably quickly	2 Technology anticipated to take 1 - 3 years to implement	2 Technology anticipated to take 1 - 3 years to implement	2 Technology anticipated to take 1 - 3 years to implement	3 Technology could be applied reasonably quickly	3 Technology could be applied reasonably quickly	1 - Slow >3 years 2 - Moderate 1-3 years 3 - Fast <1 year	x 1	1 - Less Important 2 - Important 3 - Very Important
Remediation Timescale									1 No active remediation but long term (>10 year) monitoring programme required	3 Technology could be applied reasonably quickly	2 Technology anticipated to take 1 - 3 years to implement	2 Technology anticipated to take 1 - 3 years to implement	2 Technology anticipated to take 1 - 3 years to implement	3 Technology could be applied reasonably quickly	3 Technology could be applied reasonably quickly	1 - Slow >10 years 2 - Moderate 5-10 years 3 - Fast <5 years	x 1	1 - Less Important 2 - Important 3 - Very Important
Capital Cost									9 Application of cap is relatively inexpensive combined with initial cost of monitoring plus decommissioning and installing replacement monitoring wells.	3 Cost of disposal is high	9 Costs to be incurred in setting up bunded treatment areas and excavating material into windrows.	9 Costs to be incurred in setting up bunded treatment areas, active extraction systems and excavating material into Bio piles	6 Costs to be incurred in setting up bunded treatment areas and treating with chemical reagents.	3 Cost of applying soil washing and associated processes is relatively high	3 Cost of applying thermal is high	1 - High 2 - Medium 3 - Low	x 3	1 - Less Important 2 - Important 3 - Very Important
Sustainability									6 Reuse of mudstone from Sirius site.	3 large volume to landfill unsustainable solution, high carbon footprint including haulage	9 Sustainable reuse of soils using low energy intensive technology	6 Sustainable reuse of soils using medium energy intensive technology	6 Sustainable reuse of soils using medium energy intensive technology	6 Sustainable reuse of soils using medium energy intensive technology. Potential significant water use.	6 Sustainable reuse of soils using medium energy intensive technology. Possibly high depending on thermal technology adopted.	1 - Low 2 - Medium 3 - High	x 3	
Operation & Maintenance Cost									6 Long Term monitoring costs will accumulate with time	3 Enabling works, excavation safety controls, some dewatering and nuisance controls required as well as large plant and backfill material during active works	6 Enabling works, excavation safety controls, some dewatering and nuisance controls required as well as large plant	6 Enabling works, excavation safety controls, some dewatering and nuisance controls required as well as large plant	3 Enabling works, excavation safety controls, some dewatering and nuisance controls required as well as large plant	3 System will require daily / weekly checks and continued water and energy demand.	3 System will require daily / weekly checks and continued high power demand.	1 - High 2 - Medium 3 - Low	x 3	1 - Less Important 2 - Important 3 - Very Important
Commercial Score									31	24	34	34	28	28	28			
Commercial Ranking									3	6	1	1	4	4	4			
Overall Summary																		
Overall Score									88	77	86	86	75	72	75			
Overall Ranking									1	4	2	2	5	6	5			

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