PHASE I GEO-ENVIRONMENTAL SITE ASSESSMENT

Land off Congleton Road
Biddulph
Staffordshire

E3P Report: 10-047r3
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Prepared for

RENEW LAND DEVELOPMENTS LIMITED

ARJ ASSOCIATES

QUALITY ASSURANCE

Remarks	Final
Date	September 2014
Prepared by	A Edgar
Qualifications	BSc, MSc, AIEMA, MIEnvSc, CEnv
Signature	
Checked by	S Towers
Qualifications	BSc, FGS, AIEMA
Signature	
Authorised by	M Dyer
Qualifications	BSc, AIEMA, MIEnvSc, CEnv
Signature	
Project number	10-047

E3P
City Airport Business Park,
Eccles,
Manchester,
M30 7RU
UK

www.e3p.co.uk

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APPENDICES

1.0 INTRODUCTION

1.1 Background

E3P has been commissioned by ARJ Associates on behalf of Renew Land Developments Ltd to provide an updated a Phase I Geo-Environmental Site Assessment of the former Lea Forge Mill Colour Works, Congleton Road, Biddulph, Staffordshire.

This report is required to support a Planning Submission for a residential development.

It should be noted that the Phase I report cannot address all the data gaps and that a phase of additional intrusive investigation will be required.

1.2 Proposed Development

The client intends to redevelop the site for a residential end use, comprising 19 low rise properties with associated gardens, drive ways and road.

1.3 Objectives

The objectives of the Geo-Environmental Site Assessment are to:

- Undertake a site inspection to identify any current areas of potential environmental concern;
- Review historical plans, geology, hydrogeology, site sensitivity, flood-plain issues, mining records and any local authority information available in order to complete a Desk Study in line with Environment Agency (EA) document Model Procedures for the Management of Contaminated Land (Contaminated Land Report 11 (CLR11));
- Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors;
- Provide a factual and interpretative report relating to the desk study and provide preliminary recommendations on any potential development issues;
- Assess feasible remediation options; and,
- Outline the likely scope of works required to address data gaps.

1.4 Sources of Information

Background information was sought from the following sources:

- Groundsure Database Search;
- Historical mapping dated 1878 to 2012. A selection of historical maps are reproduced in Appendix III;
- Biddulph and District Genealogy and Historical Society publication entitled ‘The History of Lea Forge Colour Works’ by C E Ellerton;
- On-line planning records held by SMDC;
- Consultations with representatives of the SMDC;
- Environment Agency Groundwater Vulnerability Map (www.environment-agency.gov.uk/wiyby);
- Radon: Guidance on protective measures for new buildings (BRE Document BR 211, 2007);
- British Geological Survey Mapping; and,

- Department for the Environment Industry Profile. Chemical Works. Coating (Paints and Printing Inks) Manufacturing Works.

1.6 Limitations of the Study

The limitations of this report are presented in Appendix I.

2.0 SITE SETTING

2.1 Site Details

Site Address	Land off Congleton Road, Biddulph, Staffordshire
National Grid Reference	E388824 N359818
Site Area	1.64 Ha

A site location map is presented in Appendix II as Drawing No 10074p1/001.

2.2 Current Site Use

Site Description

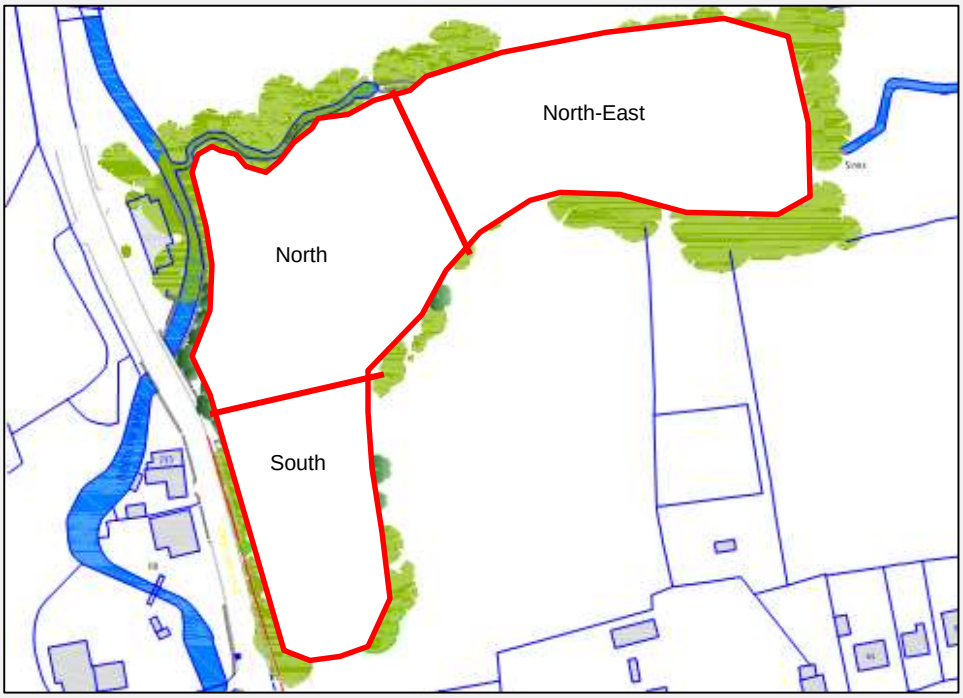
Occupancy/ use

The site is currently unoccupied.

For the purpose of this report and to aid understanding the site has been split into three sectors:

- Northern Sector
- Southern Sector
- North-eastern Sector

These sectors are presented in the Figure below:



Structures

There are a number of low walls and slabs across the northern and southern sectors of the site indicating the presence of historical structures.

A series of concrete chambers are present along the northern boundary adjacent to the watercourse [Plate 1]. These are considered to represent historical effluent treatment chambers. A number of the chambers appear to have been in-filled as they are flush with the surface. Where they do not appear to have been in-filled, pipework is evident running east and siphons are present to the north indicating where these might have once discharged to the adjacent brook [Plate 2].

All of the previous buildings have been demolished but distinct colouration was observed at the surface which is presumed to mark the location of previous trial pits.

Access	Site access is gained via Congleton Road to the west.
Slope	The site falls from east to west and there is a steep slope along the northern edge of the site, where a small watercourse forms the boundary. The North Eastern sector of the site has a relatively steep slope along its northern edge and there is evidence that this is area has been undermined by burrowing animals [Plate 4].
Retaining structures	A low wall that appears to be acting as a retaining structure is present in the central sector of the site.

Surface Cover (%)

Sector	Northern	Southern	North-Eastern
Buildings:	0	0	0
Hardstand:	30	70	0
Soft cover:	70	30	100

Trees	Mature and semi-mature tees form the northern and western site boundary and the whole of the north-eastern sector is wooded.
Hazardous Material Storage	No hazardous materials are currently stored at the site.
Asbestos Containing Material (ACM)	No structures are present that may contain ACM. However cement sheets have identified in the north of the site [Plate 5] and are suspected to be ACM.
PCBs	No equipment that may potentially contain PCBs was observed at the site.
Waste Storage	No potentially hazardous waste streams are generated at the property.
Drainage	▪ A formal drainage survey has not been completed but a culverted watercourse is stated as being present across the North-Eastern sector of the site. The exact position and construction of the culvert is not known but a bricked up chamber was noted in the north of the site adjacent to an outfall for the adjacent watercourse [Plate 6]. While only a slow flow was noted from the bricked up chamber, blue staining was noted on the brickwork and an orange ochre was present on the water. This was in contrast to the relatively clear water coming from the adjacent outfall, which was clear [Plate 7]. ▪ At the east of the site where the adjacent brook approaches the site, there are a series a pipes and chambers which indicates that water to the culvert and the effluent system was probably pumped to the site [Plate 8]. There is no connection now between the culvert and the adjacent watercourse at the upstream side of the site. This suggests that water within the culvert and discharging to the brook is likely to be due to the culvert acting as a sump for storm water infiltration. The fact that the culvert is now blocked may also provide an explanation as to why the eastern area is waterlogged [Plate 9] and why water was observed to be springing from the base of the slope between the North Eastern and Northern areas. A slight sheen was noted on the water where is was at the surface. ▪ As discussed above, there are a number of concrete chambers along the northern site boundary and these are considered to be part of the former dye works effluent treatment system. Historical research (see below) suggests that these were associated with discharges of the treated effluent to the adjacent brook and the pumping of sludge to a lagoon in the north-east.

2.3 Surrounding Area

The surrounding land uses are summarised below:

Direction	Land Use
North	Small watercourse with open-land beyond.
East	Open land.
South	Pond with residential properties beyond.
West	Biddulph Brook and Congleton Road with residential properties beyond.

3.0 SITE HISTORY

3.1 On-Site Historical Development

A review of historical maps pertinent to the site is summarised in Table 3.1 below.

Table 3.1 Summary of Potentially Contaminative Historical Land Uses

Map Edition	Historical Land Use		
	North	South	North-East
1879	The site is recorded as Leamill Forge with a number of buildings located principally along the western site boundary and a single structure at the eastern boundary. The boundaries in the sector are all marked by surface watercourses. The north-east of this sector is shown as open land. Markings on map indicate an increase in elevation at the rear of the southern-most building.	The entire sector is recorded as a pond.	The sector is recorded as woodland that is crossed east to west by two parallel streams.
1899	The site is recorded as Leamill Forge and a well is recorded at the western boundary.	There are no significant changes when compared with the previous map but marking indicate that the pond is elevated above Congleton Road.	There are no significant changes when compared with the previous map.
1925	The site is recorded as Forge Colour Works. Additional linear structures are recorded along the northern boundary with an above ground tank marked in the centre. The well is no longer shown. Additional buildings have been constructed in the northeast of this sector with markings suggesting a pond may have been formed in this area also.	There are no significant changes when compared with the previous map.	There are no significant changes when compared with the previous map.
1954	The buildings in the west have been expanded with above ground tanks now recorded in the centre and east and potentially along the southern elevation of the southern-	There are no significant changes when compared with the previous map.	A Sludge Bed has been constructed which appears to be fed by the northern-most watercourse from the east. The southern-most

Map Edition	Historical Land Use		
	North	South	North-East
	most building. A building has been constructed in the north (with weighbridge) with marking indicating a fall in height to the linear features along the northern boundary.		watercourse is now marked as a reservoir and appears to drain in a southern direction beneath the southern site sector.
1971	The linear structures in the north are marked as tanks. Additional cylindrical tanks are also recorded in the north with a rectangular tank structure also marked in the south of this sector. A number of buildings have also been constructed along the east of this sector.	The pond has been entirely backfilled with a building marked at its former northern edge.	There are no significant changes when compared with the previous map.
1989	The majority of the buildings in this sector have been demolished with only the southern-most works buildings and a single structure in the northeast remaining.	No significant change in this sector of the site when compared with the previous map.	The Sludge Beds and reservoir are no longer recorded.
2002	No structures are recorded.	No structures are recorded.	No structures are recorded.
2012	No structures are recorded.	No structures are recorded.	No structures are recorded.

3.2 Off-Site Historical Development

A review of potentially contaminative uses identified on historical Ordnance Survey maps within 250m radius of the site is summarised below in Table 3.2.

Table 3.2 Summary of Potentially Contaminative Off-Site Historical Land Uses

Surrounding Feature	Distance	Dates	Direction
Timber Yard	25m	Pre 1954 to Pre 2012	West
Biddulph Valley Branch Railway Then disused	100m	Pre 1878 to Pre 1971 Pre 1971 to Present	West
Garage	210m	Pre 1989 to Pre 2012	North

3.3 Historical Research

E3P has obtained a copy of a publication prepared by the Biddulph and District Genealogy and Historical Society publication entitled 'The History of Lea Forge Colour Works' by C E Ellerton.

A review of this document provides the following environmentally pertinent information:

- The site was originally an iron forge that than manufactured pick and shovels;
- The site was converted to a dye works in 1917 and manufactured pigment colours blue, reds, yellows, green, black for use in printing ink and paint and more recently for PVC and plastics industry. It is considered by E3P that the manufacture of pigments does not involve a coating process and as such is unlikely to have utilised significant volume of solvent carrier solutions. Rather the pigment formation process is likely to have used acid and alkali reaction to ensure solution/precipitation;
- The site produced its own electricity from a gas producer engine;
- A programme of expansion commenced in the 1920s with features reporting to include:
  - A coal fired boiler;
  - Laboratory;
  - Garage;
  - Weighbridge; and,
  - A larger building for colour production in which were large wooden vats that connected to water and steam pipes and run-off pipes smaller dissolving vats and mixing vats, filter presses, drying stoves and grinding mills. It should be noted that the production process is described in detail in Section H of the report;
- The vats of colour were allowed to settle over-night and the clear liquid at the top of the vats was siphoned off to the site's effluent treatment plant for pre-treatment prior to discharge into Biddulph Brook;
- The effluent plant is described as comprising five brick lined tanks outside, in open air, by the side of the brook. This suggests the linear features in the north were the effluent tanks. The liquor form the tanks were reportedly acid and therefore dosed with alkali in the form of caustic soda. Once neutralised the effluent was allowed to settle and the clear liquid at the top discharged to the brook via a coke and gravel filled filter. The remaining slurry in the settling tanks was then said to be pumped into the storage lagoon (Sludge Beds) for dissipation into the ground;
- While the nature of the clear liquid or remaining slurry cannot be determined from the CE Ellerton study, information contained in The DoE Industry Profile for Chemical Works Coatings (Paints and Printing Inks) Manufacturing Works indicates the effluent treatment areas can be a source of metal / metalloids, inorganics and acids/bases;
- Chemical deliveries were reported to be made by road tankers to sealed storage vessels and the report states chemicals sodium cyanide (for the colour Prussian blue), hydrochloric acid and caustic soda were accepted;
- Waste products from the site were reported to be seeped via the ground in the sludge beds. This took place between 1917 and 1980. The original pool adjacent to Congleton Road is reported to have been filled with rubble, old colour and chemical waste; and,
- Finished products were bagged or placed in drums for distribution by road.

4.0 ENVIRONMENTAL SETTING

4.1 Geology & Hydrogeology

The British Geological Survey (BGS) map for the site indicates that the site is underlain by the following geological sequence:

Geological Unit	Classification	Description	Aquifer Classification	Sensitivity
Drift	Glacial Till	Largely clay with variable sand, silt and gravel to cobble sized fragments	Unproductive	Low
Solid	Pennine Lower Coal Measures	Mudstone, Siltstone and Sandstone	Secondary A	Low/Medium

A review of the geological maps indicates that Alluvium may be present along the western site boundary which is marked by Biddulph Brook.

Environmental data indicates that there is a spring fed catch-pit located approximately 550m to the west of the site and a groundwater abstraction approximately 720m to the east. The catch pits are reported as general use whereas the groundwater abstraction is reported to be for potable water supply. Neither abstraction is associated with a currently defined groundwater source protection zone and as the shallow groundwater beneath the site is not considered likely to be in continuity with the abstractions these are not considered to be sensitive receptors.

Based on the local topography and location of surface watercourses it is considered likely that shallow groundwater will flow in a north-westerly direction toward Biddulph Brook and stream to the north. More locally, groundwater flow may be controlled by the depth and shape of the underlying Glacial Till stratum.

4.2 Geotechnical Data

Geotechnical Data presented within the Envirocheck report identifies the following ground conditions:

Hazard	Designation
Collapsible Ground	Very Low
Compressible Ground	Low
Landslide	Null – Negligable
Running Sand	Moderate
Shrinking Swelling Clay	Very Low

4.3 Hydrology

Surface water features in the vicinity of the subject site are as follows:

Surface Water Feature	Quality*	Distance (m)	Direction
Biddulph Brook	Chemical – Good Ecological - Moderate	Adjacent	West
Culvert	Unclassified	On-site	Centre of Site

*Chemical water quality as classified under the EA's River Basin Management Plan

4.5 Industrial Land Uses

No significant industrial activities have been identified within the surrounding area.

4.6 Sensitive Land Uses

The closest residential properties are located adjacent to the subject site. No other environmentally sensitive land uses have been identified within close proximity to the subject site.

4.7 Site Sensitivity Assessment

The site is considered to be located within a moderate sensitivity setting due to the following reasons:

- A Grade B classified watercourse forms the western site boundary and culvert crosses the central sector of the site;
- Residential properties are located in close proximity;
- Perceived low permeability drift is present beneath the majority of the site;
- The underlying solid strata comprise Coal Measures which are known to have been mined historically;
- Groundwater abstractions and spring fed catch-pits are not considered to be in hydraulic continuity with the site; and,
- The site is not located within a Groundwater Source Protection Zone.

5.0 CONSULTATIONS

5.1 Contaminated Land Officer

Daniel McCrory has been involved in the site and has provided a number of responses to information requests. This report provides additional assessment and information based on these responses.

5.2 Landfill Sites and Waste Treatment Sites

No historical or current landfill or waste treatment sites have been identified within a 250m radius of the subject site.

5.3 Regulatory Database

The following information has been obtained from a commercially available environmental database. The summary table only includes records not otherwise detailed in the report.

Table 5.1 Summary of Data

Entry	Number within 250m	Details
Contaminated Land Register Entries and Notices	0	None Identified
Authorised industrial processes (IPC/IPPC/LAPPC).	0	None Identified
Fuel Stations Entries	1	A Texaco branded filling station is identified approximately 75m east
Licensed radioactive substances	0	None identified
Enforcements, prohibitions or prosecutions	0	None identified
Discharge Consents	4	All the consents relate to sewage discharges to Biddulph Brook.
Pollution Incidents	1	One Category 3 –Minor Incident has been identified approximately 16m from the site. The incident is reported to have involved chemicals but the source is not specified.
Consents issued under the Planning (Hazardous Substances) Act 1990	0	None identified
Control of Major Accident Hazard (COMAH) sites	0	None identified

6.0 PREVIOUS REPORTS

E3P has been provided with copies of the following reports:

- The Forge Colour Works, Congleton Road, Biddulph, Staffordshire, Derbyshire. Site Investigation. Completed by the Woodford Group, October 2003, Ref 392;
- Former Forge Colour Works. Prepared by Sladen Associates on behalf of DEP Architects. June 2011; and,
- Phase II Ground Investigation, the Forge Works, Biddulph. Prepared by Chandos Remediation on behalf of ARJ Associates November 2012. Ref.323.03.
- Phase I Geo-Environmental Site Assessment, The Forge Works, Biddulph. Prepared by REC Ltd on behalf of Renew Land Developments Ltd c/o ARJ Associates September 2013.

To assist in developing a more robust Conceptual Site Model for the site, E3P has completed a re-evaluation of the Sladen, Chandos data within the context of the historical development and site setting. A full copy of the Woodford report is not available as such it has not been possible to include an assessment of their data but where appropriate comments and discussion has been included.

For ease of discussion, the data and supporting information has been split into three areas, reflecting the three distinct sectors of the site identified in the historical map search, See Section 2.0:

1. Northern Sector – Chemical Storage, Production & Effluent Treatment
2. Southern Sector – Pond & Backfill
3. North-Eastern Sector – Sludge Bed

Controlled waters are discussed on a whole site basis.

The main exploratory hole locations relevant to each area are summarised in Table 6.1.

Table 6.1 Summary of Previous Exploration Locations

Site Sector	Woodford	Sladen	Chandos
Northern	WS1A, WS03, WS04, WS05, WS06, BH01, BH02, R01, R02	TP2, TP3, TP4	WS04, WS05, WS06, TP303, TP304, TP306, TP307, TP308, TP309
Southern	WS07, WS08, WS09, WS10, BH03, R03	TP1	TP301, TP302, TP311, TP312. WS301, WS302, WS303
North-Eastern	WS02	TP5	TP310

6.1 Northern Sector – Production Area

6.1.1 Ground Conditions

Made Ground is largely absent from the south-eastern part of this sector. This is in keeping with historical map research which did not indicate significant development in this area.

Made Ground is excess of 3.0m have been recorded (Chandos TP304 and Sladen TP4). This may reflect how the site was constructed at the foot of a relatively steep valley. The Made Ground in this sector is highly variable with logs recording fragments of concrete, metal, wood, cloth, asbestos and ash. All reports of possible asbestos were limited to the northern sector. Woodford refer to the presence of colour variations within the Made Ground including blue dyes in WS1 (north) which they state as being former filter beds. Woodford also describe the

thickest Made Ground 6.4mbgl being present in Borehole 2 in the west of the Northern sector.

The Chandos TP310 logs record the presence of vibrant colouration in TP305, TP309 and TP310, with TP306 recording a thin discontinuous black lens of ash with a weathered hydrocarbon (oil) odour.

Natural strata in the northern sector are described as comprising both cohesive and granular types. In general it appears that natural strata are predominantly clayey in the west with sandy strata in the east and north. Woodford describe pigmentation in the sand strata though without the logs it is not possible to determine if this was in all locations or localised occurrences and to what depth.

6.1.2 Chemical Testing

Chemical analysis completed by Chandos is inconsistent and does not readily allow for comparison of data or the establishment patterns. Additionally, Woodford report elevated strontium concentrations in this area but without the relevant appendices this cannot be further assessed. However what can be established from the limited data available is that the main constituents of concerns are:

Determinand	Units	GAC	MC	Loc. of Ex	Pathway
Chromium	mg/kg	4.3	1850	TP304-1.0	1
Chromium IV	mg/kg		<1	TP304-1.0	1
Lead	mg/kg	82	1840 1300 287 230	TP304-1.0 TP309-0.4 TP305-1.0 TP305-0.3	1
Cyanide	mg/kg	791	>10000	TP305-0.3	1

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples, MC = Maximum Concentration; Loc of Ex = Location of Exceedance
GAC based on human health criteria
Pb – CL:AIRE C4SL derived value
CN – CLEA 1.06 Derived Value

The data indicates that there is no correlation between Chromium IV and Total Chromium suggesting that if chromium was used as a pigment that is most likely comprised chromium III, further assessment would be required to confirm this. The elevated cyanide concentration recorded in TP305 and the blue correlation does strongly suggest the presence of Prussian Blue, which is known to have been manufactured at the site.

Where tested, (Chandos TP305 and Sladen TP2 and TP3) no significant concentrations of organic determinands were recorded. However, the soils from TP306 where hydrocarbon odours were noted were not tested.

Woodford state that WS1 and WS1A within the former filter beds appears to be a source of cyanide, lead, strontium and copper as well as chromium. It was stated by Woodford that these areas are conjectured to be representative of filter beds as a whole. However, additional testing by Chandos in this area suggests that impact may be more localised.

6.2 Southern Sector – Backfilled Pond

6.2.1 Ground Conditions

Made Ground has been recorded in all the exploratory locations in this sector, which is keeping with historical research that indicated the backfilling of a large pond. As with the northern

sector, the thickest Made Ground deposits are recorded in western (Chandos WS02). Mapping suggests that this boundary may have been 'made up' to allow for the construction of the pond.

Made Ground is variable across the southern sector with logs noting the presence of ash, slag, concrete, timber, coke, brick, metal and a drum (TP302). As with the northern sector, vibrant colouration is recorded within the Made Ground with red/blue pigmentation in TP302, red tinting - TP311, red/blue - TP312 and vibrant blue - WS02. Woodford report that that blue dye was present in WS8.

Natural Clay strata in the southern sector are principally recorded as cohesive silty and sandy which possibly explains why water could be ponded in this area. There are no reports that the pigmentation has extended into the underlying cohesive strata.

6.2.2 Chemical Testing

Samples tested from the southern sector are limited but the main constituents of concern are:

Determinand	Units	GAC	MC	Loc. of Ex	Pathway
Chromium	mg/kg	4.3	11500 4770	WS02-0.9 TP302-0.5	1
Chromium IV	mg/kg		<1	-	1
Lead	mg/kg	82	2150 545	TP2-0.7 TP311-0.6	1
Cyanide	mg/kg	791	>10000 9100 1000	WS02-0.5 WS02-0.9 TP302-0.5	1

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples, MC = Maximum Concentration; Loc of Ex = Location of Exceedance
GAC based on human health criteria
Pb – CL:AIRE C4SL derived value
CN – CLEA 1.06 Derived Value

The sampling has been focussed toward the visual evidence of pigmentation and in common with the north, the impact would appear to be associated with the use of cyanide (Prussian blue), chrome and lead.

A single elevated concentration of strontium was recorded by Chandos (8250mg/kg in TP302-0.5m). Research conducted by REC and presented with their initial Phase I report suggested that strontium is a biologically inert element that is used in dyes for plastic food packaging as it does not dissolve in water. Historically research has indicated that in its later years, the facility did produce PVC dyes and pigments. There has been no assessment as to whether the strontium is radioactive.

No significantly elevated concentrations of organic determinands were recorded in the two samples tested.

Samples of the underlying natural strata were only tested at one location (WS02-3.70m) and for the determinands tested, no significantly elevated concentrations were recorded.

6.3 North-Eastern Sector – Sludge Beds

6.3.1 Ground Conditions

The two exploratory positions advanced in this area (Chandos - TP310 and Sladen-TP5) both encountered Made Ground at depths ranging from 0.45m bgl to 0.80m bgl. The Made Ground is described as sandy clay and clayey sand and both record blue staining that appears to extend into the underlying natural strata (sandy Clay). This corroborates historical records that the effluent liquors were pumped to the sludge beds to dissipate into the ground. However, in both locations the blue staining is reported to decrease with depth with Chandos reporting the staining to stop after 1.0m (1.8m bgl). Woodford also report that a blue and red dye was present in the WS2.

6.3.2 Chemical Analysis

A review of the chemical analysis indicates that the following constituents of concern are present:

Determinand	Units	GAC	MC	Loc. of Ex	Pathway
Chromium	mg/kg	4.3	6230 856 5400	TP310-0.6 TP310-2.0 TP5-0.5	1
Chromium IV	mg/kg		61	TP5-0.5	1
Lead	mg/kg	82	330 326	TP5-0.5 TP310-0.6	1
Cyanide	mg/kg	791	19000	TP5-0.5	1

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples, MC = Maximum Concentration; Loc of Ex = Location of Exceedance
GAC based on human health criteria
Pb – CL:AIRE C4SL derived value
CN – CLEA 1.06 Derived Value

The available chemical analysis from the North-Eastern sector identifies a common theme with the other sectors with respect to the constituents of concern that have been identified. Significantly however, TP5 from the Sladen investigation identified an elevated concentration of hexavalent chrome.

Analysis of a deeper sample from TP5 did not identify any significantly elevated concentrations of either organic or inorganic determinands.

6.4 Controlled Waters Analysis

Only the Woodford investigation contained actual groundwater analysis with the Sladen investigation including leachate testing that was not consistent across all three sectors. The method of sample collection is not stated within the Woodford report. A summary of the Woodford analysis is presented below.

Determinand	Units	EQS Freshwater	Concentration	Loc. of Ex
Ammonium (NH4)	µg/l	25[1]	57000 18000 66000 400 800 200	BH1 BH2 WS2 WS4 WS8 WS10

Chromium	µg/l	10[2]	42 35 221	WS2 WS8 WS10
Nickel	µg/l	50[3]	72	WS10

Notes
1 Council Directive on the quality of fresh waters needing protection or improvement in order to support fish life (Freshwater Fish Directive)
2 Council Directive on the quality required of shellfish waters (Shellfish Waters Directive), repealed by the codified Directive on the quality required of shellfish waters
3 Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances

In addition to the determinands detected and summarised above, Woodford also recorded concentrations of strontium within all of monitoring wells tested apart from BH1. However, a Tier I assessment of the risk to controlled water associated with strontium is not possible as there is no UK Tier I guideline value. What is evident from the analysis completed by Woodford is that significantly elevated concentrations of Ammonium are present within the shallow groundwater beneath the site. In order to assess whether this is likely to be a significant risk to surface water it will be necessary to determine the relative properties of Ammonium and Ammonia (NH3), which is more toxic to aquatic life.

Chandos undertook analysis of three surface water samples, comprising two upstream and one downstream sample. The results indicated that surface water is generally hard being within the 50 to 200mg/l $CaCO_3$ range. However, no patterns indicating that the identified constituents of concern are impacting surface water, which is particularly significant for cyanide as leachate tests indicate this may be mobile.

6.5 Ground Gas

Monitoring has been completed as part of the previous work and this has not identified any significantly elevated concentrations.

Sources of ground gas at the site are considered to be the presence of deep areas of Made Ground and the possible presence of a coal mine entries in the North Eastern sector (35m from the closest proposed dwelling). Shallow mine working may also be present but if they had represented a significant gas risk then it is likely continuous elevated methane and carbon dioxide would have been recorded during the previous monitoring. The presence of coal mine shafts either on-site or within the surrounding area may represent a vertical migration pathway for gas migration but as they often vent directly to atmosphere they do not necessarily represent a lateral migration risk unless blocked or capped inappropriately.

It is likely that the presence of shallow mine workings and/or mine shafts will need to be established from a stability perspective in addition to any ground gas issues. Stabilisation and treatment of any such features will appropriately manage any gas risk by sealing and breaking the migration pathway.

6.0 CONCEPTUAL SITE MODEL (CSM)

6.1 Initial CSM

In accordance with Environment Agency, CLR 11 (2004) and BSI 10175 (Code of Practice for Investigation of Potentially Contaminated Land), EP3 have developed an initial CSM to identify potential contamination sources, migration pathways and receptors within the study area. This CSM is presented pictorially as Drawing 003 in Appendix II.

Table 6.1 Initial Conceptual Site Model

Source	Exposure Pathways	Potential Receptors
Human Health		
[1] Metal Compounds – Cr, As, CN, Pb, Sr	Dermal Contact Ingestion	Residential End Users - Gardens
Discussion Elevated metal compounds have been recorded throughout the Made Ground, typically associated with vibrant pigmentation that is considered to have arisen through historical spillages and site practices. The metal compounds identified as part of previous investigations typically pose a risk to human health through dermal contact and ingestion such as would occur if impacted soils were encountered while gardening etc.		
[2] Asbestos Containing Material (ACM)	Dust Inhalation	Residential End Users - Gardens
Discussion Chrysotile sheets have been identified within the north of the site and further fibres may be present within the Made Ground though fibre testing on the Made Ground has not taken place to date. Asbestos fibres pose a risk to human health through the inhalation of microscopic crystals that become airborne as a result of mechanical disturbance. Such disturbance could occur in a residential scenario through digging in dry soil that is impacted with ACM.		
[3] Petroleum Hydrocarbons	Leaching through plastic potable water pipework	Residential End Users
Discussion Significant petroleum hydrocarbon impact has not been identified at the site to date, though there are some data gaps in the previous investigation data. Where impacted soils or groundwater are present protector-line pipework may be needed.		
[4] Metal Compounds & Asbestos	Dermal Contact Ingestion Inhalation	Construction Workers
Discussion The development of the site is likely to require significant earthworks which may expose impacted soils at the surface. If impacted soils are exposed then there is a risk to the health of construction workers through dermal contact with impacted soils, ingestion of impacted soils through poor site hygiene and inhalation of dust and/or chemical vapours from stockpiles or open excavations.		
[5] Ground Gas/ Chemical Vapour Emissions	Indoor Air Inhalation	Residential End Users
Discussion Ground gas monitoring undertaken as part of the previous ground investigations has not identified any significantly elevated concentrations though monitoring to date would not necessarily comply with the requirements of CIRIA 665 to enable a detailed assessment. Sources of ground gas may include from Made Ground or from coal mine workings or shafts that have been recorded in and in close proximity to the site. The shafts are likely to represent a predominantly vertical preferential pathway for gas. Furthermore, the chemical analysis has identified the presence of certain compounds such as CN which under certain, low likelihood, conditions could generate potentially hazardous vapours. Gases and chemical vapours could migrate through permeable strata or service entries and accumulate within sub-floor voids or wall cavities and pose a risk to future occupiers through inhalation.		
[6] Metal Compounds – Cr, As, CN, Pb	Dermal Contact Ingestion	Residential End Users – Eco Area
Discussion Part of the scheme in the North East comprises a proposed Eco-Area that will be landscaped or left 'wild' to encourage wildlife and enhance biodiversity. This area is known to have historically comprised a sludge bed and while there has been only limited investigation, elevated concentrations and vibrant pigmentation has been identified during previous ground investigation. As the area will be adjacent to a residential development, it is feasible that the area will be utilised by residents who may come into contact with exposed impacted soils or dust or ponded water.		

Source	Exposure Pathways	Potential Receptors
Controlled Water / Ecology		
[7] Metal Compounds– Cr, As, CN, Pb Ammonium (NH4)	Lateral migration via culvert	Adjacent Brook
Discussion The site inspection completed by E3P has identified what is considered to be the bricked up outfall to the culvert. The brickwork is stained blue and the small discharge noted, tainted by an ochrous coloration. The colouration of the stream is evident to the point where the adjacent brook converges with Biddulph Brook. Previous testing has taken place which does not indicate any significant impact but the sample points are not known.		
[8] Metal Compounds– Cr, Ni, Ammonia (NH4)	Lateral migration via permeable Made Ground & permeable natural strata	Adjacent Brook / Biddulph Brook
Discussion Testing of the shallow perched groundwater has identified elevated concentrations of ammonia, chromium and nickel. These may pose a risk the adjacent watercourses through lateral migration within permeable strata. The likelihood of lateral migration may be limited by the fact that the sand horizons within the Glacial Till are confined by low permeable Clay horizons. However consideration as the effect that below ground structures may have on the local groundwater will need to be considered, particularly if these are to be removed as part of the proposed development, in-particular the former effluent chambers along the northern boundary. Shallow groundwater analysis has identified significantly elevated concentrations of ammonium (NH4). Ammonia comprises two principal forms: the ionised ammonium ion (NH4+) and un-ionised ammonia (NH3). The toxicity of Ammonia to fish is attributable mainly to the un-ionised NH3 molecule. Therefore, based on the results to date ammonia may not present as significant a risk as it first appears but further work will be required to confirm this.		
[9] Metal Compounds– Cr, Ni, Ammonia (NH4)	Vertical Migration	Secondary A Aquifer
Discussion Testing of the shallow perched groundwater has identified elevated concentrations of ammonia, chromium and nickel. Assessment of the underlying Clay stratum as part of previous ground investigations suggests that vertical migration has not taken place.		

7.0 OUTLINE REMEDIATION STRATEGY

Based on the CSM outlined in Section 6.0, E3P has established an outline worst case remediation that can technically deliver a platform suitable for a residential development while also preventing short-term and long term risk to human health and controlled waters.

This strategy will need to be confirmed through additional ground investigation and risk assessment, the scope of which is outlined in Section 8.0.

This strategy is summarised within Table 7.1 below.

Table 7.1 Outline Remediation Strategy

Source	Exposure Pathways	Potential Receptors
Human Health		
[1] Metal Compounds – Cr, As, CN, Pb, Sr	Dermal Contact Ingestion	Residential End Users - Gardens
[2] Asbestos Containing Material (ACM)	Dust Inhalation	Residential End Users - Gardens
[6] Metal Compounds – Cr, As, CN, Pb	Dermal Contact Ingestion	Residential End Users – Eco Area
Remediation Option The majority of the compounds identified in the previous phases of work have dermal contact and ingestion pathways and this can be broken by the provision of a suitable cover system to areas of landscaping and gardens. The cover system utilised at this site will need to conform to the requirements of BRE 465 and be subject to appropriate validation if adopted. Should the site be stabilised (see controlled waters below) then a cover system may not be required.		
[3] Petroleum Hydrocarbons	Leaching through plastic potable water pipework	Residential End Users
Remediation Option It will be necessary to complete a UK WIR risk assessment to determine what type of pipework will be required for the proposed residential development but it is likely that Protector Line will be required throughout the site and this will prevent tainting of water supplies to the properties.		
[4] Metal Compounds & Asbestos	Dermal Contact Ingestion Inhalation	Construction Workers
Remediation Option Prior to completing any construction and/or remediation works it will be necessary to complete detailed Health and Safety Risk Assessments and Method Statements to determine how to most appropriately manage on-site risks. For the majority of the compounds identified the risks can be managed through the adoption of PPE (gloves, overalls, dust masks) and if appropriate dust suppression techniques. In addition, it is worthy of note to remember that the exposure period of any works is likely to be short so there are unlikely to be chronic health risk provided that appropriate mitigation is put in place for construction workers.		
[5] Ground Gas/ Chemical Vapour Emissions	Indoor Air Inhalation	Residential End Users
Remediation Option Depending on the finding of any ground gas and chemical risk assessment, appropriate gas and chemical vapour protection systems are available in order to prevent fugitive gas and vapour accumulation within indoor spaces. These systems are well documented and will provide a high level of protection provided they are installed correctly by qualified specialists. Treatment of the mine shaft (if located) will typically include sealing of the shaft and ventilation to atmosphere of ground gas beneath the cap, thus breaking the pathway while maintaining a vertical migration pathway and preventing accumulation and/or subsequent lateral migration.		

Controlled Water		
[7] Metal Compounds– Cr, As, CN, Pb Ammonia (NH4)	Lateral migration via culvert	Adjacent Brook
[8] Metal Compounds– Cr, Ni, Ammonia (NH4)	Lateral migration via permeable Made Ground & permeable natural strata	Adjacent Brook / Biddulph Brook
Remediation Option Based on the findings of the previous investigation and from site observations by E3P, the culvert does not appear to form part of the wider drainage system. Therefore, it is considered likely the culvert could be entirely grubbed out with detriment to wider drainage but with significant benefit to water quality. However as impact may still present a risk to controlled water through lateral migration within permeable strata, E3P considered the most appropriate and economic remediation technique to comprise a phase of in-situ stabilisation works across all three areas of the site. Documents explaining how these are installed are provided by CL:AIRE and from discussions with the EA, E3P has been informed that that have been successfully implemented on sites with inorganic contamination, where the main risk it to controlled waters. The in-situ stabilisation works are likely to involve excavation and/or in-situ batching of shallow Made Ground with concrete or proprietary engineered clay. Once stabilised the contaminants can no longer migrate. This process would need to be agreed with the Environment Agency and is likely to be subject to a period of post remediation monitoring.		
[9] Metal Compounds– Cr, Ni, Ammonia (NH4)	Vertical Migration	Secondary A Aquifer
N/A		

Based on the above it is E3Ps considered opinion that the site:

- Can be remediated without significantly impacting the surrounding environment or adjacent properties;
- Can be remediated for a future residential end use, subject to the development of a detailed remediation scheme that will be determined through additional assessment in consultation with the Local Authority Environmental Health Department and Environment Agency;
- Will present significantly less risk to the environment once the works have been completed compared with at present; and,
- Will result in the site being of greater benefit to the surrounding neighbourhood.

8.0 RECOMMENDATIONS PRIOR TO DEVELOPMENT

In order to confirm the findings of the initial Conceptual Site Model a detailed ground investigation will be required to fill in the data gaps and ensure that the latest requirements in contaminated land assessment are followed.

The methods of investigation will ultimately depend on the requirements of the site and the presence of obstructions etc. However, as a minimum any future investigation will need to be capable of providing:

- Details of the underlying strata and vertical and lateral delineation of any impact;
- Monitoring infrastructure for shallow groundwater and ground gas;
- Monitoring infrastructure for deeper groundwater; and,
- Consistent surface water sampling points.

Testing

As a minimum any additional testing completed at the site should comprise the following:

Soil

- Inorganic suite comprising CLEA metals, Chromium (IV), Chromium (III) and Strontium;
- Asbestos;
- Total Organic Carbon;
- Semi Volatile Organic Compounds (SVOC);
- Volatile Organic Compounds (VOC);
- Aliphatic / Aromatic Total Petroleum Hydrocarbon (TPH);
- Total Organic Carbon (TOC); and,
- pH and Sulphate.

Groundwater

- Inorganics (as above);
- VOC;
- SVOC;
- Aliphatic / Aromatic Hydrocarbons;
- Ammonia/Ammonium; and,
- pH and Sulphate.

Surface Water

- Inorganics (as above);
- Hardness;
- VOC;
- SVOC;
- Aliphatic / Aromatic Hydrocarbons; and,
- Ammonia/Ammonium.

It may be possible to reduce the testing suite for any post completion monitoring depending on the initial site investigation and risk assessment results.

Monitoring

On-Site Monitoring

During the site investigation on-site radionuclide detection will be required to determine if the strontium identified within the shallow Made Ground is in an active or inert form.

Ground Gas

Guidance provided in CIRIA 665 indicates that nine monitoring visits should be undertaken over a three month period to allow for the measurement of ground gas concentrations, flow rates and groundwater levels. This is based on a low gas generation potential for a high sensitivity residential end use. Previous monitoring has not identified any significant ground gas issues but in addition to methane, carbon dioxide and oxygen addition analysis will be completed for:

- Hydrogen Cyanide; and,
- Petroleum Hydrocarbon Vapours.

Groundwater

Groundwater samples for chemical analysis will be collected during the first monitoring visit and will be undertaken a minimum of five working days after the completion of the drilling operations, to allow for the re-establishment of ground conditions. All samples should be recovered by a low flow sampling technique that is designed to minimise the amount of suspended solid in the sample matrix. Slow flow techniques require the collection of in-situ determinands such as Redox, pH and conductivity.

END OF REPORT

APPENDIX I - LIMITATIONS

1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between E3P and the Client as indicated in Section 1.2.

2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.

3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.

4. During the site walkover reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not be made known or accessible.

5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.

6. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.

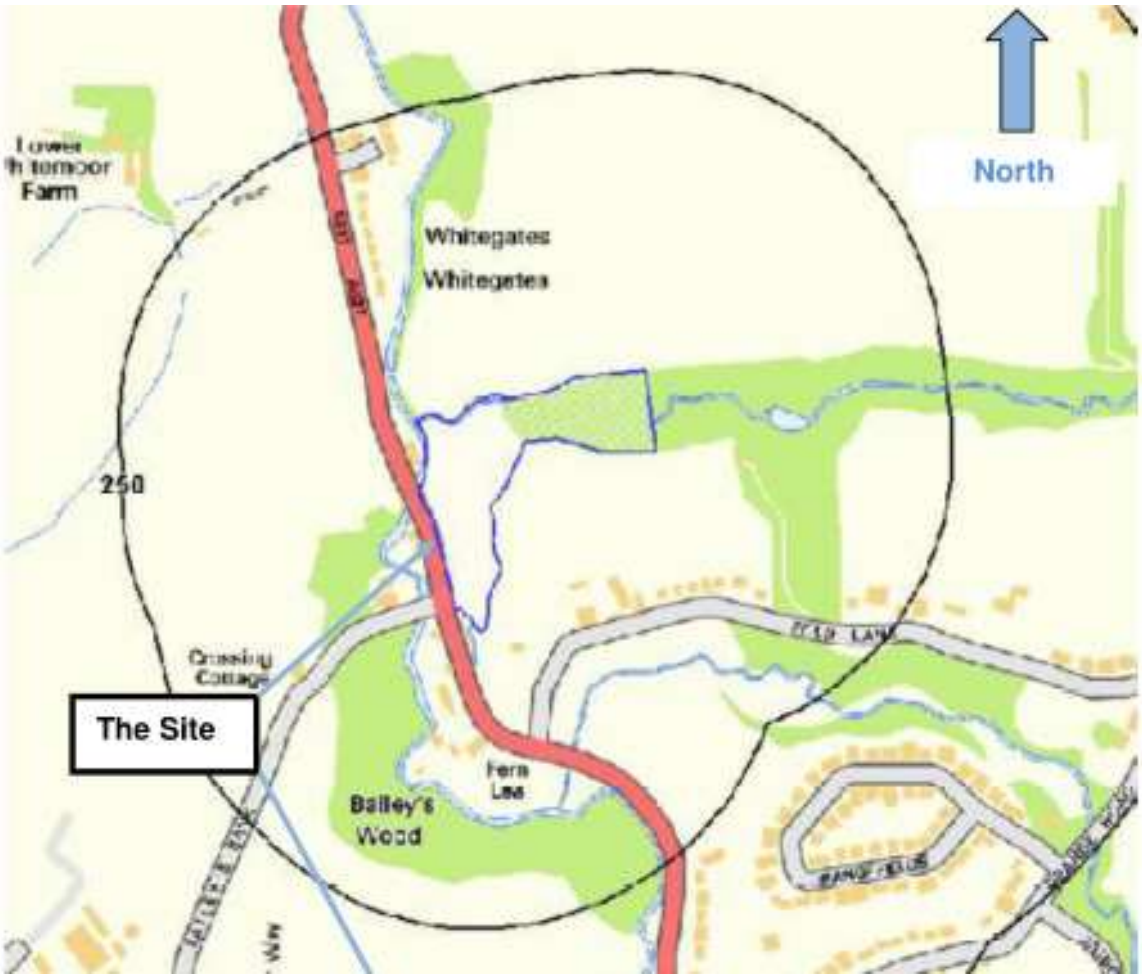
7. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials this is for indicative purposes only and do not constitute or replace full and proper surveys.

8. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.

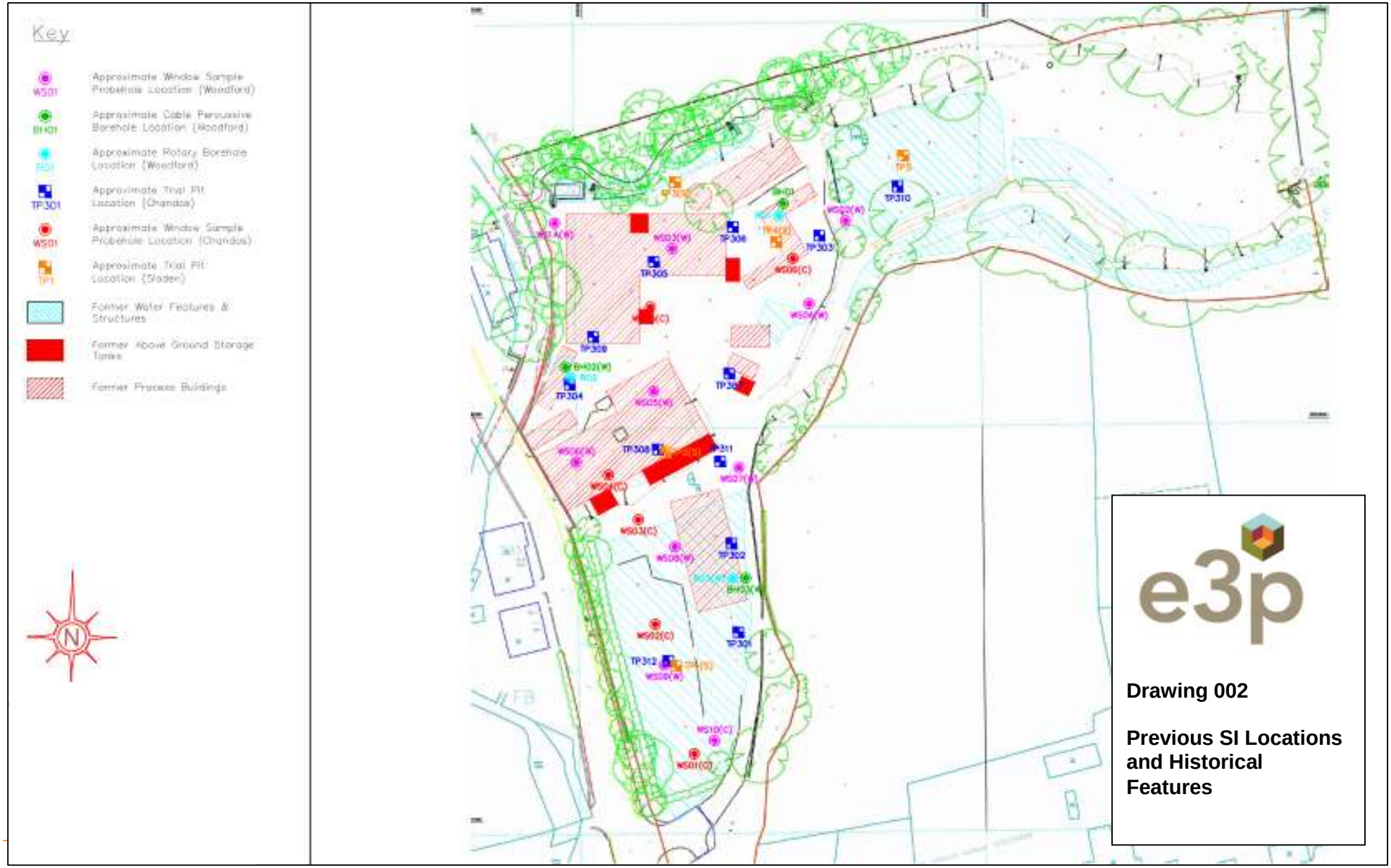
9. E3P cannot be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by E3P is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by E3P in this connection without their explicit written agreement there to by E3P.

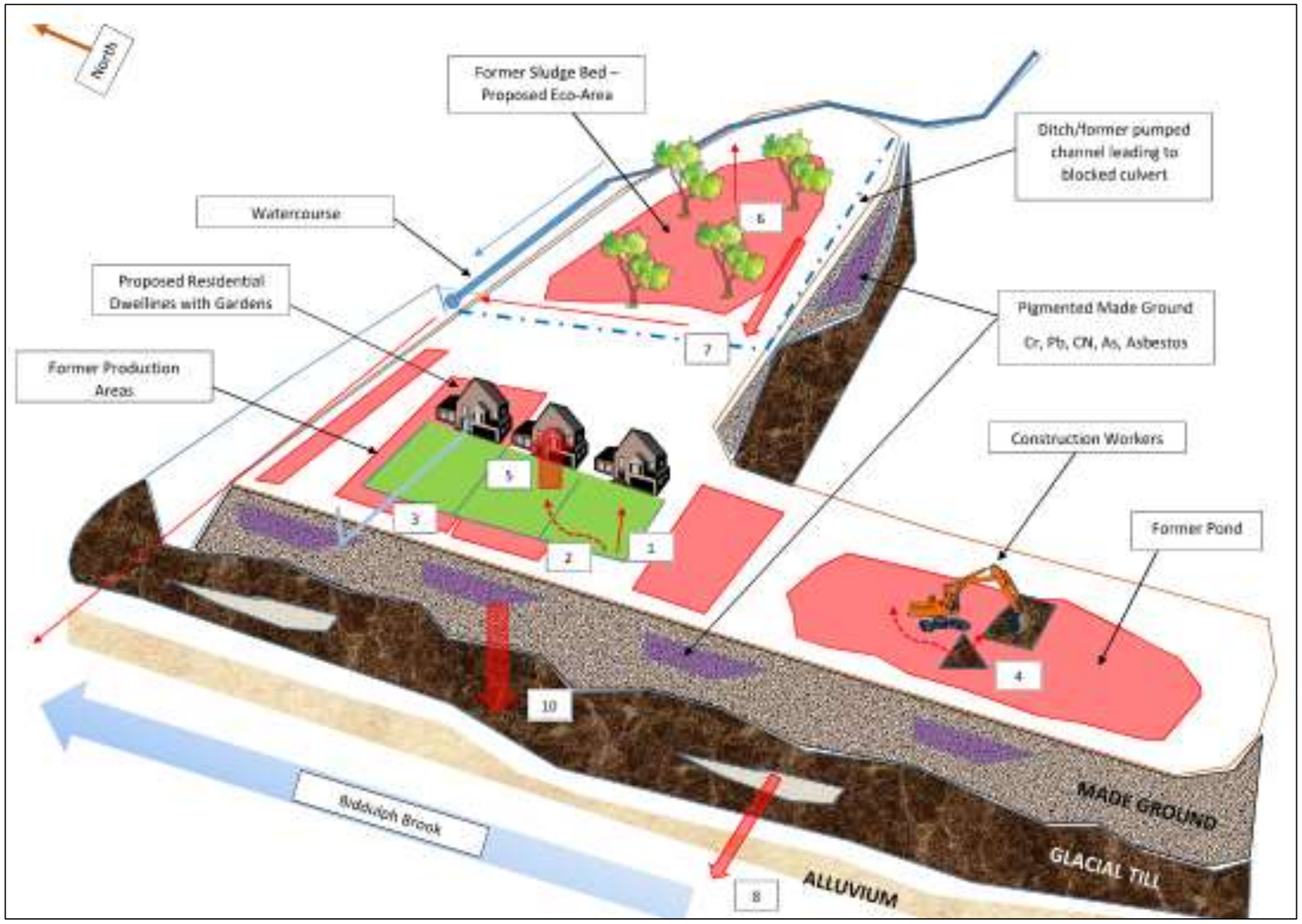
10. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

APPENDIX II - DRAWINGS



Drawing 001
Site Location Map


Key
WS01
Approximate Window Sample Probehole Location (Woodford)
BH01
Approximate Cable Percussive Borehole Location (Woodford)
RC01
Approximate Rotary Borehole Location (Woodford)
TP301
Approximate Trial Pit Location (Chandos)
WS01
Approximate Window Sample Probehole Location (Chandos)
TP1
Approximate Trial Pit Location (Sladen)
Former Water Features & Structures
Former Above Ground Storage Tanks
Former Process Buildings
N
e3p
Drawing 002
Previous SI Locations and Historical Features



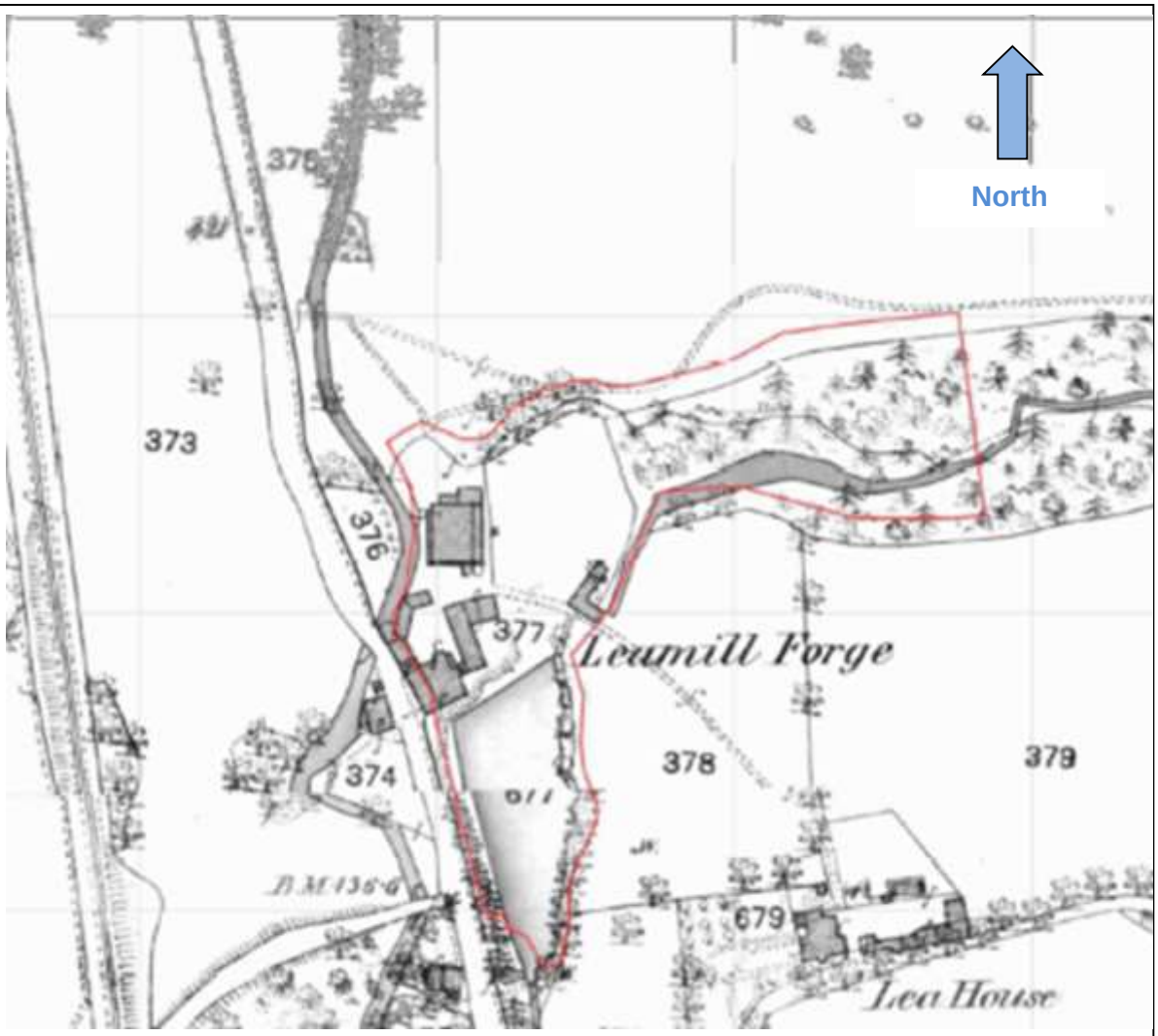
e3p

Drawing 003
Initial Conceptual Site Model

Source	Exposure Pathways	Potential Receptors
Human Health		
[1] Metal Compounds – Cr, As, CN, Pb, Sr	Dermal Contact Ingestion	Residential End Users - Gardens
Discussion Elevated metal compounds have been recorded throughout the Made Ground, typically associated with vibrant pigmentation that is considered to have arisen through historical spillages and site practices. The metal compounds identified as part of previous investigations typically pose a risk to human health through dermal contact and ingestion such as would occur if impacted soils were encountered while gardening etc.		
[2] Asbestos Containing Material (ACM)	Dust Inhalation	Residential End Users - Gardens
Discussion Chrysotile sheets have been identified within the north of the site and further fibres may be present within the Made Ground though fibre testing on the Made Ground has not taken place to date. Asbestos fibres pose a risk to human health through the inhalation of microscopic crystals that become airborne as a result of mechanical disturbance. Such disturbance could occur in a residential scenario through digging in dry soil that is impacted with ACM.		
[3] Petroleum Hydrocarbons	Leaching through plastic potable water pipework	Residential End Users
Discussion Significant petroleum hydrocarbon impact has not been identified at the site to date, though there are some data gaps in the previous investigation data. Where impacted soils or groundwater are present protector-line pipework may be needed.		
[4] Metal Compounds & Asbestos	Dermal Contact Ingestion Inhalation	Construction Workers
Discussion The development of the site is likely to require significant earthworks which may expose impacted soils at the surface. If impacted soils are exposed then there is a risk to the health of construction workers through dermal contact with impacted soils, ingestion of impacted soils through poor site hygiene and inhalation of dust and/or chemical vapours from stockpiles or open excavations.		
[5] Ground Gas/ Chemical Vapour Emissions	Indoor Air Inhalation	Residential End Users
Discussion Ground gas monitoring undertaken as part of the previous ground investigations has not identified any significantly elevated concentrations though monitoring to date would not necessarily comply with the requirements of CIRIA 665 to enable a detailed assessment. Furthermore, the chemical analysis has identified the presence of certain compounds such as CN which under certain, low likelihood, conditions could generate potentially hazardous vapours. Gases and chemical vapours could migrate through permeable strata or service entries and accumulate within sub-floor voids or wall cavities and pose a risk to future occupiers through inhalation.		
[6] Metal Compounds – Cr, As, CN, Pb	Dermal Contact Ingestion	Residential End Users – Eco Area
Discussion Part of the scheme in the North East comprises a proposed Eco-Area that will be landscaped or left 'wild' to encourage wildlife and enhance biodiversity. This area is known to have historically comprised a sludge bed and while there has been only limited investigation, elevated concentrations and vibrant pigmentation has been identified during previous ground investigation. As the area will be adjacent to a residential development, it is feasible that the area will be utilised by residents who may come into contact with exposed impacted soils or dust or ponded water.		
Controlled Water / Ecology		
[7] Metal Compounds– Cr, As, CN, Pb Ammonia (NH4)	Lateral migration via culvert	Adjacent Brook
Discussion The site inspection completed by E3P has identified what is considered to be the bricked up outfall to the culvert. The brickwork is stained blue and the small discharge noted, tainted by an ochrous coloration. The colouration of the stream is evident to the point where the adjacent brook converges with Biddulph Brook. Previous testing has taken place which does not indicate any significant impact but the sample points are not known.		
[8] Metal Compounds– Cr, Ni, Ammonia (NH4)	Lateral migration via permeable Made Ground & permeable natural strata	Adjacent Brook / Biddulph Brook
Discussion Testing of the shallow perched groundwater has identified elevated concentrations of ammonia, chromium and nickel. These may pose a risk the adjacent watercourses through lateral migration within permeable strata. The likelihood of lateral migration may be limited by the fact that the sand horizons within the Glacial Till are confined by low permeable Clay horizons. However consideration as the effect that below ground structures may have on the local groundwater will need to be considered, particularly if these are to be removed as part of the proposed development, in-particular the former effluent chambers along the northern boundary. Shallow groundwater analysis has identified significantly elevated concentrations of ammonium (NH4). Ammonia comprises two principal forms: the ionised ammonium ion (NH4+) and un-ionised ammonia (NH3). The toxicity of ammonia to fish is attributable mainly to the un-ionised NH3 molecule. Therefore, based on the results to date ammonia may not present as significant a risk as it first appears but further work will be required to confirm this.		
[9] Metal Compounds– Cr, Ni, Ammonia (NH4)	Vertical Migration	Secondary A Aquifer
Discussion Testing of the shallow perched groundwater has identified elevated concentrations of ammonia, chromium and nickel. Assessment of the underlying Clay stratum as part of previous ground investigations suggests that vertical migration has not taken place.		

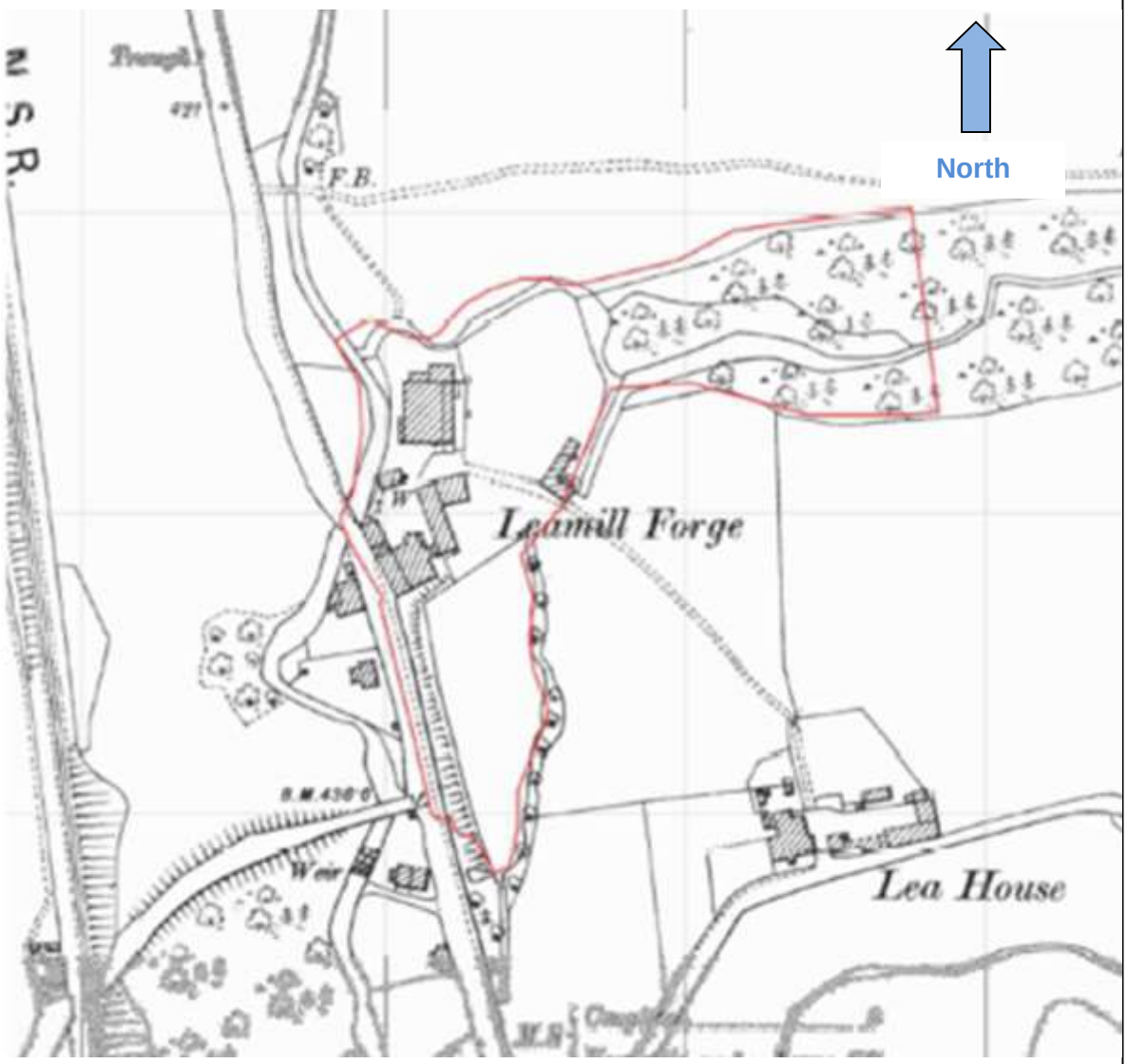
Drawing 004
Proposed Layout

APPENDIX III - HISTORICAL MAPS



Historical Map

Dated: 1882



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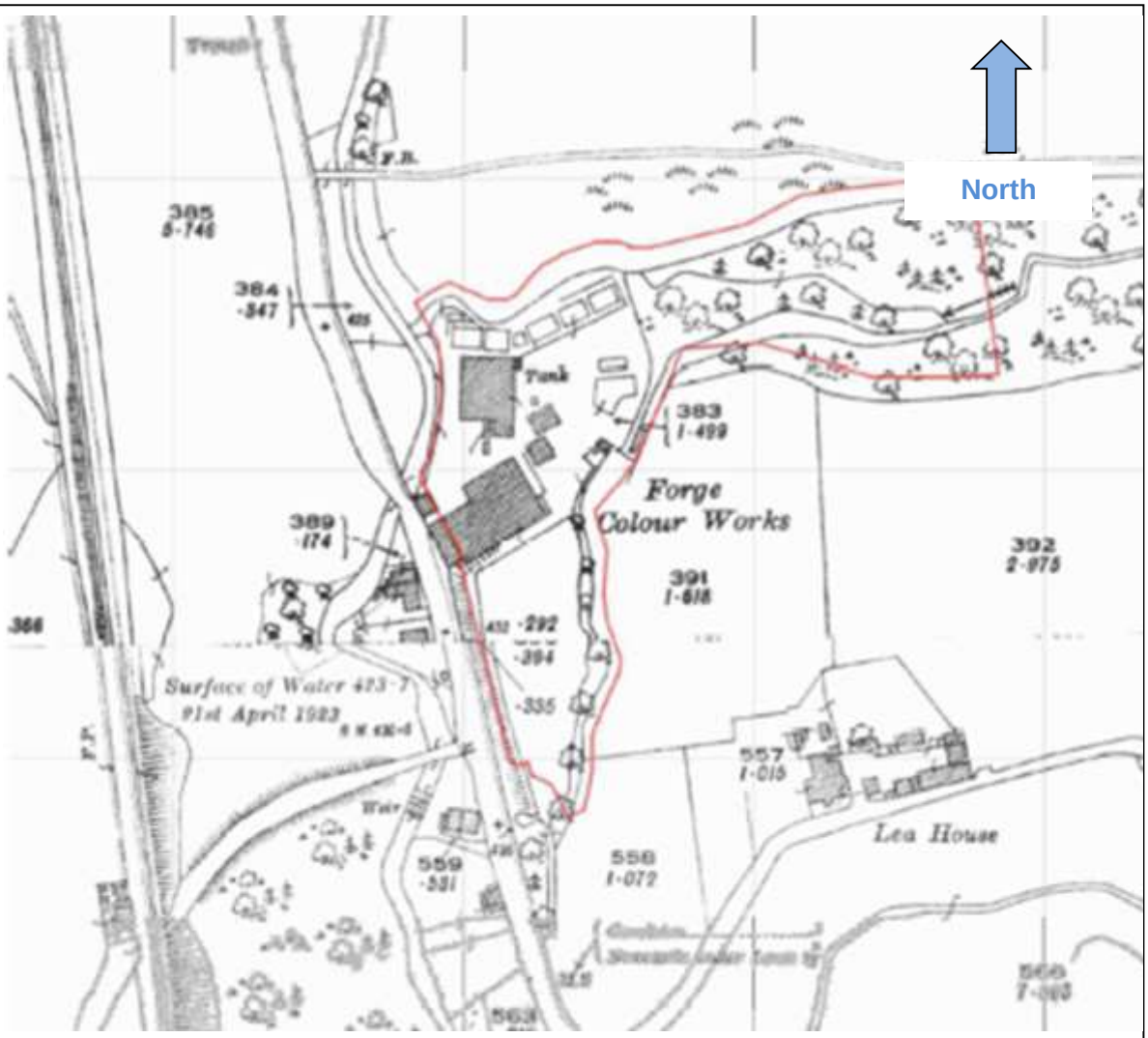

Historical Map

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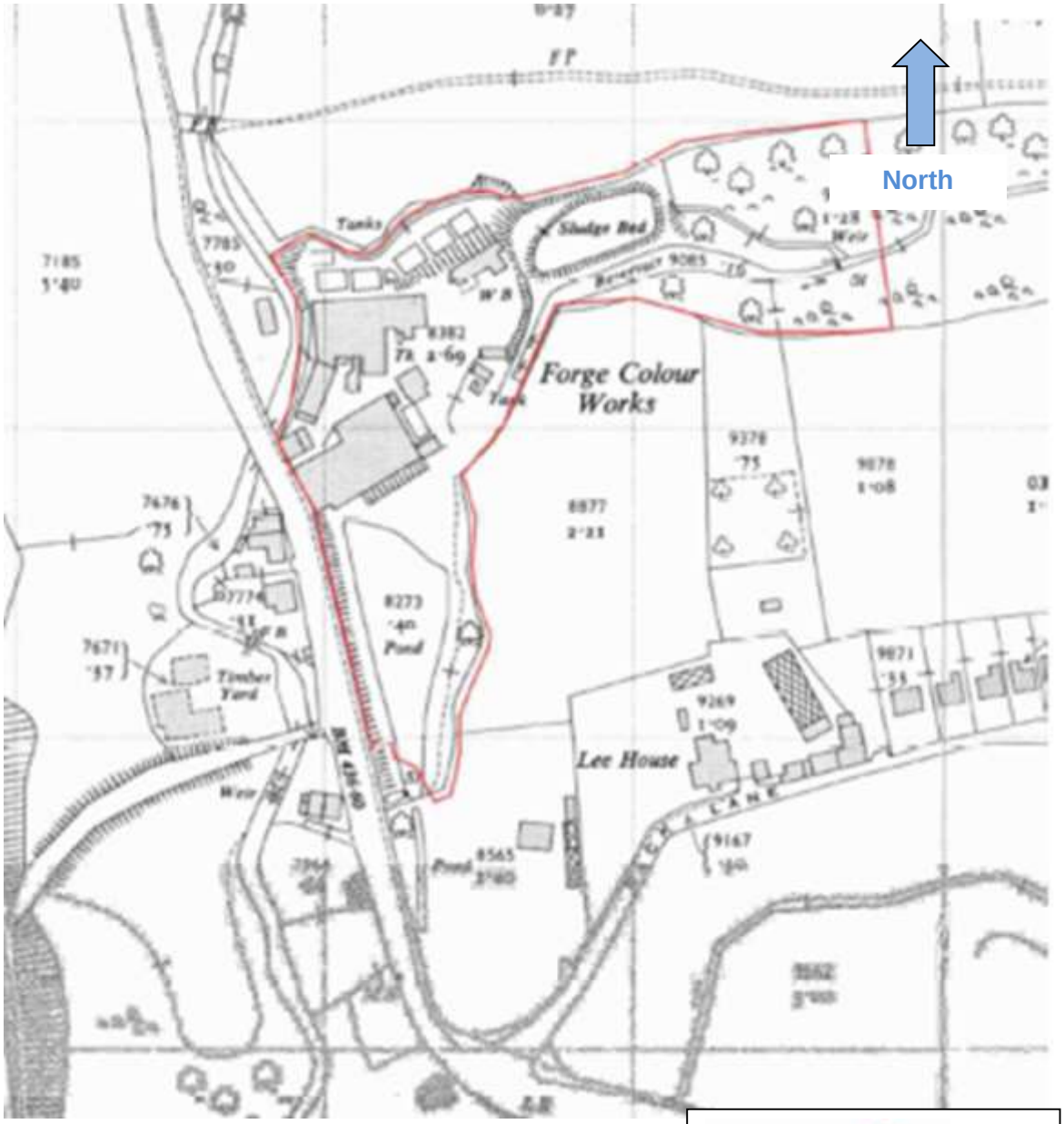

Historical Map

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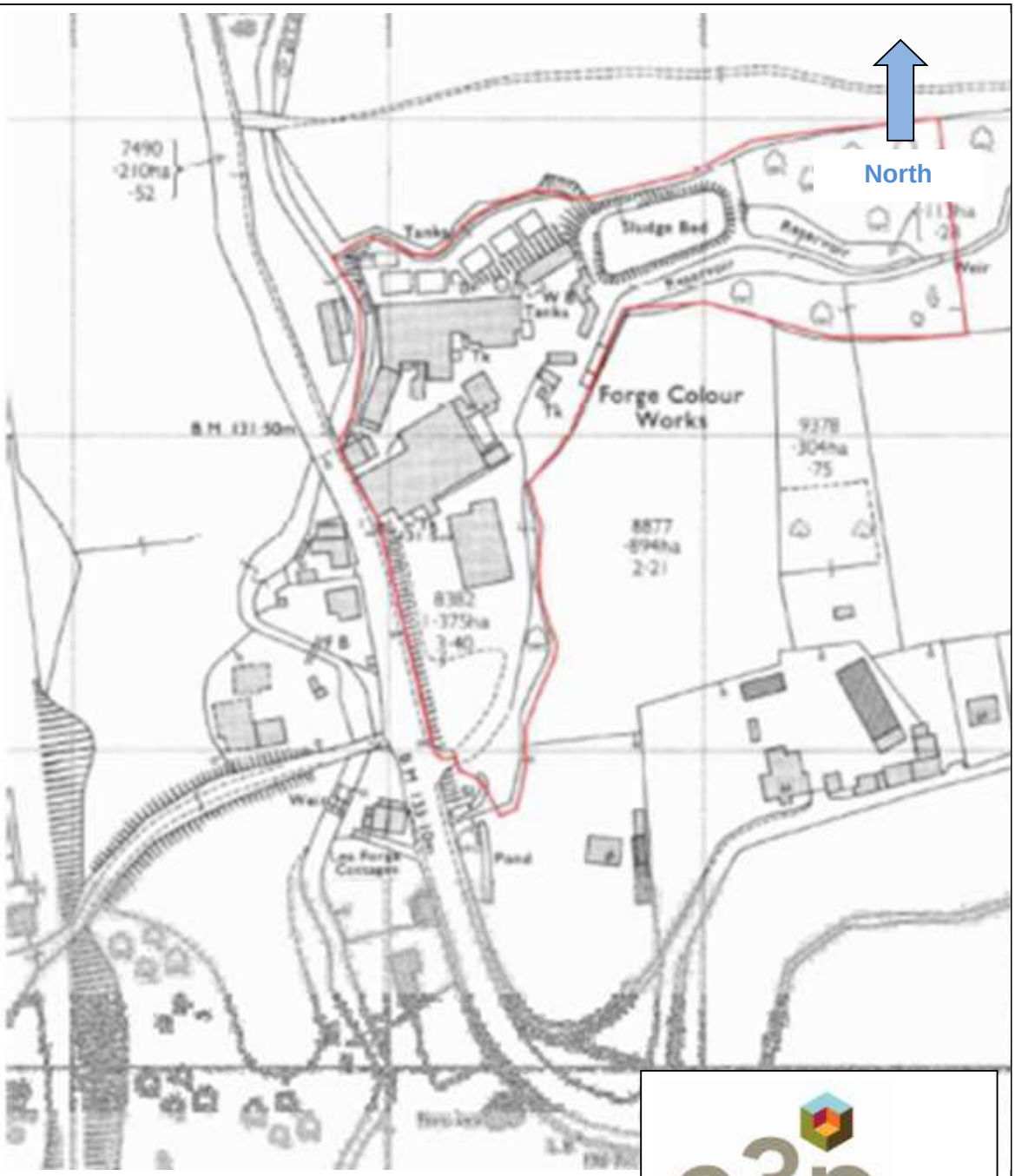

Historical Map

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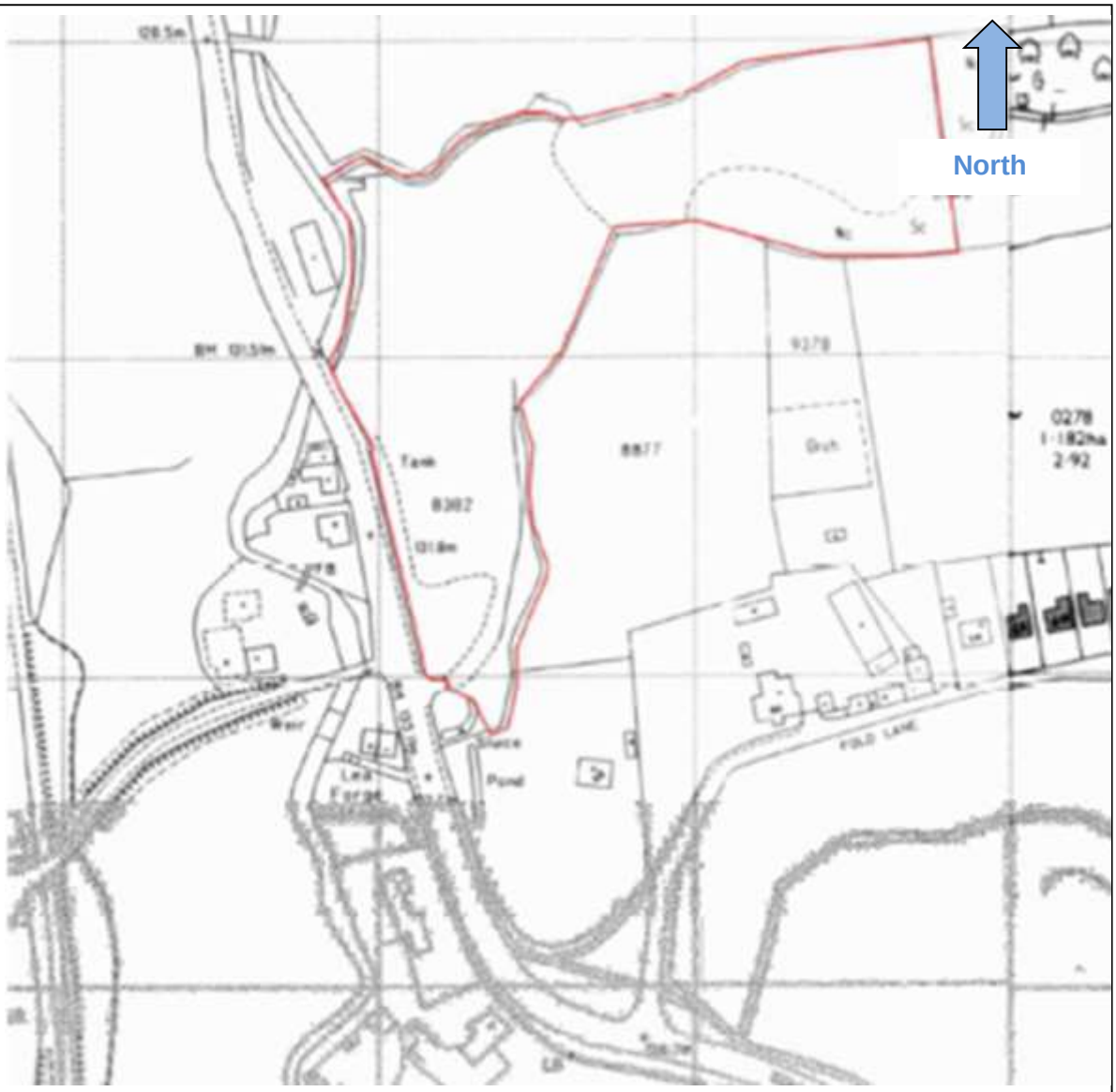

Historical Map

Dated: 1993

APPENDIX IV - PHOTOGRAPHS

Plate 1 – Concrete Chambers At Northern Boundary

Plate 2 – Infilled Concrete Chambers with view of Siphon Down To Adjcaent Brook

Plate 3 – Blue Staining At Surface

Plate 4 – Slope Along North Of Former Sludge Bed

Plate 5 – ACM Sheets In North of Site

Plate 6 – Presumed Bricked Up Culvert Outfall

Plate 7 – Ocre From Culvert And Clear Water From Main Outfall

Plate 8 – Former Sumps and Presumed Pumps To Former Reservoir and Culvert

Plate 9 – Water Logged Ground In North East Sector – Presumed Former Reservoir Or Poorly Drained Land