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BY Email

Dear Andy

FORMER MANOX SITE – MILES PLATTING SUPPLEMENTARY SITE INVESTIGATION REQUIREMENTS

1. BACKGROUND

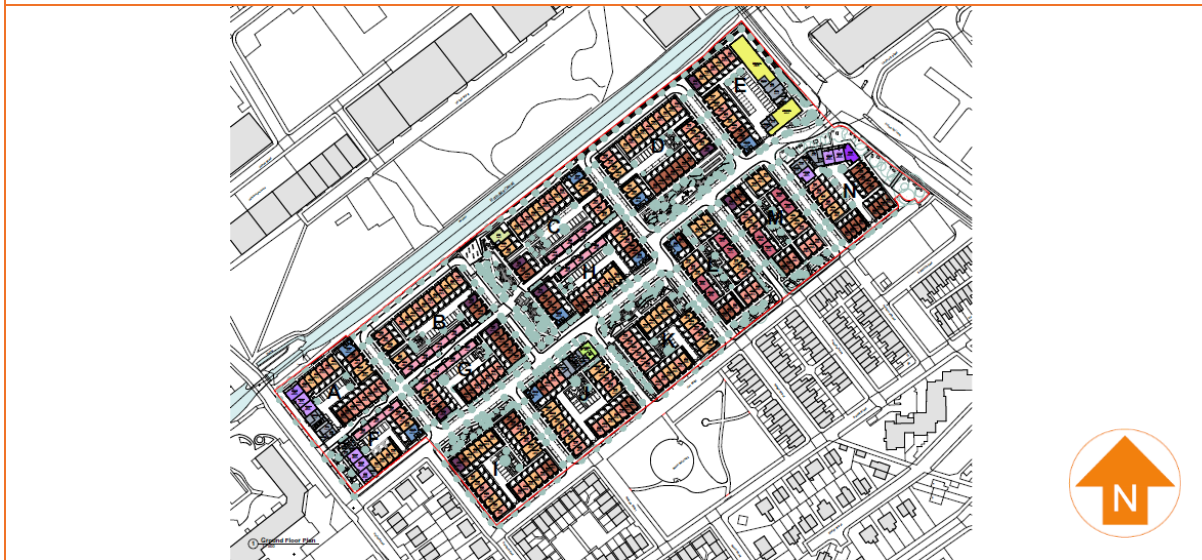
E3P are appointed by Landcare (East Manchester) to provide professional consultancy services as part of the regeneration of the subject site for a low rise residential end use. The purpose of this letter report is to identify the areas of the site requiring supplementary ground investigation and specify the proposed works to do so in order to accurately assess the site and increase the robustness of the conceptual site model.

In the Manchester Core Strategy 2012 – 2027, Miles Platting and the Manox site is allocated as one of Manchester's strategic housing locations. According to the core strategy the Manox site has the potential to accommodate regeneration objectives and create sustainable communities by delivering increased housing numbers to underpin local services and facilities. The Manox site plays a key role in the regeneration aspirations for the wider Miles Platting area, accordingly the site is already designated for 'higher density residential including family housing' in MCC's Eastland's Regeneration Planning Framework.

It is intended to construct a residential development comprising 410 low rise residential dwellings with associated gardens, public open space, estate roads and infrastructure. An extract of the proposed development layout is indicated in Figure 1.1 (overleaf) and enclosed as Drawing 13-887-002.



FIGURE 1.1 SNAPSHOT OF PROPOSED DEVELOPMENT



This letter addresses Condition 56 from planning application 125596/FO/2019.

"Prior to the commencement of development and where necessary additional ground investigations (based on the information already provided, the outline remediation scheme and the remediation phasing plan) to address information gaps, are identified for each phase of the development so as to provide sufficient information for a detailed assessment of risks to human and environmental receptors for each phase as identified in the remediation phase plan, shall be submitted to and approved in writing by the City Council as local planning authority. The development shall be implemented in full accordance with the details so approved."

Reason – to gather sufficient information on each phase of the development to ensure that all possible risks to human and environmental receptors are known and be addressed in detail to facilitate further work on the development site, pursuant policies EN17 and EN18 of the Manchester Core Strategy."

2. INTRUSIVE GROUND INVESTIGATION WORKS

2.1. SCOPE OF INTRUSIVE GROUND INVESTIGATION

A Ground Investigation has been designed based on the findings of the ground investigations carried out by URS (2006), ERM (2009) and RSK / Westlakes (2019) and site characterisation by E3P in 2020.

2.2. SUMMARY OF PREVIOUS GROUND INVESTIGATION WORKS - MANOX

Several Phases of ground investigation (GI) have been completed at the site previously. It is noted in the E3P Site Characterisation Report (Ref: 13-887-R4, dated August 2020) that the works were sufficient to enable a general site characterisation and conceptual site model.

URS (2004-2006)

The investigation works by URS targeted several key areas in the Manox section of site through advancing a total of 19 boreholes in the Phase 2 works and 18 boreholes and 16 trial pits in the Phase 3 works. The locations investigated included the tar channel, chemical storage areas, VAT farm, oil storage area, blue stores, blue making section and the general ground conditions in the southern area of site. This is summarised in Table 2.1.



The investigation works confirmed the location of the Tar Channel transecting east west located to the north of sub-station running westwards to the acid storage area. URS located the Tar Channel in their exploratory positions TP6, TP7, TP9 and TP10.

The Tar Channel is identified as a Brick Structure no more than 2.00 m in width, however no formal basal level could be identified, it is therefore inferred that this structure is 'keyed' into the underlying glacial till.

A salt glazed feeder pipe is identified at URS TP5, it is thought that this feeder pipe lead to the footbridge where the pipe crossed from the chemical works to the north of the Rochdale Canal.

The Tar Channel is recorded to have been filled with gravels that are coated / saturated in separate Phase hydrocarbon compounds (Tar), this situation is believed to remain to the present day.

Separate phase hydrocarbon impact (Tar) intermixed with the infill gravels is understood to be present at depths from circa 1.10 m bgl to 2.20 m extending to a depth in excess of 3.00 m in TP7.

In URS location TP4 and TP8, separate phase hydrocarbon product (Tar) is identified.

URS report visual and olfactory evidence of TPH impact across the site, with shallow near surface made ground recorded as being stained in many locations.

Extensive discolouration with blue and green staining within the near surface Made Ground is report by URS. It is considered this represents spillage from chemicals utilised in the process and the finished pigment products.

The reports note the critical receptors as being future site users, neighbouring site users, the underlying aquifer, Shooters Brook and the Rochdale Canal. The aquifer is considered as a receptor at this stage in time as the full extent of overlying drift geology had not been identified, therefore, the confining thickness of the low permeability clay was unknown. The reports denote that the location and nature of Shooters Brook is not confirmed, including the confirmation of its hydraulic continuity with the site. Therefore, a complete pollutant linkage must be assumed during any assessment at the site, to ensure a worst-case scenario approach is taken.

The soil Tier 1 assessment confirmed the presence of elevated total petroleum hydrocarbons, BTEX compounds, toluene, cyanide, thiocyanates, phenol, polycyclic aromatic hydrocarbons (PAHs) and sulphur with a strong focus on lead and cyanide in the recommendations sector.

URS analysed 60 samples for Volatile Organic Compounds (VOC), only two of which identified results above the Tier 1 assessment criteria utilised within their assessment.

Generally, phenolic compounds were reported to be relatively low from this investigation phase.

However, it is noted that the extent of the contamination was not collated into a drawing to give a clearer picture of the extent and, during the time that the assessment was carried out, many of the contaminants do not have a GAC value to compare against.

After cyanide is highlighted as an issue in the soils assessment it is not considered within the controlled waters risk assessment. The highlighted contaminants of concern are ammonium, chloride and sulphate in the water. The assessment concluded that Shooters Brook, if a receptor of the site, would see a diluted amount of the highlighted contaminants of concern and, given that it is culverted, it is not likely to be in hydraulic continuity with the site. Further monitoring is recommended upstream, at the site and downstream to obtain a sufficient data set to quantify the risk at the site.

ERM (2009)

ERM advanced 22 trial pits along the northern boundary of the site whilst analysing ten groundwater samples and six soil samples taken from within the pits. Surface soil samples were also taken from the adjacent towpath to confirm whether contamination from Manox was impacting the offsite area.



Temporary groundwater wells were installed within TP403, TP405, TP406, TP408, TP413 and TP416 and data pertaining to the encountered depth of water and a chemical sample was taken from these locations.

In several trial pits (e.g. TP401, TP402, TP405, TP406, TP407, TP408, TP419 and TP421), a second concrete or brick obstruction was encountered, potentially from a former below-ground structure or former foundation, suggesting there are remaining constraints at the site, below which has not been investigated.

A full wall survey was conducted and confirmed the visual note of leaking contamination from the Manox site. A full log of the inspection is available within this report. Chemical analysis confirms the presence of TPH and cyanide within several samples but SS401 recorded the highest concentrations.

The main contamination sources at the Manox site are identified as:

- ✿ Residual impacts contained within brickwork and trapped between brick layers in the perimeter wall;
- ✿ Minor residual impacts in the demolition rubble placed on the site surface, adjacent to the northern perimeter wall;
- ✿ Minor dissolved phase impacts in the perched water encountered within demolition rubble (pooling in hollows and depressions at the interface of the hardstanding beneath the demolition rubble);
- ✿ Shallow soil impacts in Made Ground deposits;
- ✿ Groundwater impacts resulting from historical processes on-site;
- ✿ Residual impacts associated with the footprint (concrete hard standing) of historical structures on-site including:
 - ✿ The processing plant;
 - ✿ Easisperse, mill;
 - ✿ Chemical storage such as VAT storage areas;
 - ✿ The tar channel; and
 - ✿ Drainage network.

The Tier 1 human health risk assessment confirmed a marginal exceedance of Benzo(a)pyrene (TP405) in soils on site when comparing to ERM derived chemical thresholds. The report states that this is only an exceedance because the limit of detection was raised during analysis. It is not clear why this was the case. No exceedances were reported within samples from the towpath.

The Tier 1 controlled waters risk assessment considered both groundwater within Made Ground deposits on-site and standing water on the canal towpath and states that the aquifer is not considered a critical receptor.

The Tier 1 controlled waters risk assessment indicated that a potential risk to surface waters (both Rochdale Canal and Shooters Brook) may be present from several constituents, including PAH compounds, metals, cyanide and ammoniacal nitrogen from on-site perched waters. ERM also concluded that the canal is a potential receptor of the contaminated soils leaching contaminants and groundwater laterally migrating from the Manox site and note that the water level in the canal is between approximately 0.50 m to 1.00 m below site level.



RSK – Westlakes (2019)

RSK attended site in November 2019 and installed 11 groundwater wells, 5 cable percussive boreholes, six window samples probe holes and 22 trial pits. Additionally, the sampling of several on site demolition waste stockpiles was carried out.

TP610, TP611, TP612 and TP620 were advanced to delineate the tar channel. Constraints identified include surface water flooding, shallow perched water, reinforced slabs, substructures, utility services, dense mature vegetation and stockpiles of rubble and fly tipping.

Two rounds of groundwater monitoring were completed in September and October 2019 from groundwater wells installed during the RSK works and upstream and downstream samples were also taken from the Rochdale Canal.

The human health risk assessment compares chemical data to human health targets for a residential end use with plant uptake. Made Ground samples recorded elevated concentrations of arsenic, lead, cyanide, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, naphthalene, phenanthrene. Elevated semi-volatile organic compounds (SVOC) with no GAC values available for comparison include dibenzofuran, carbazole, 2,4-dichlorophenol, 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2-methylnaphthalene, pentachlorophenol, n-dibutylphthalate, perylene.

All carbon disulphide results were below the ATRISK SSV of 0.839 mg/kg for a SOM of 6%. TP606 identified elevated aromatic hydrocarbon fraction from C8-C21.

Asbestos was identified within three samples of Made Ground at concentrations of 0.02% (TP607 – chrysotile, loose fibres), 0.038% (TP613 – amosite, loose fibres) and 0.802% (TP615 – amosite, loose insulation). Asbestos was not detected in the stockpiles tested at the site.

The controlled waters risk assessment compares chemical data to Environmental Quality Standards (EQS) values as the identified receptors are in line with the former assessments and conclude that the surface water receptors are critical, not the bedrock aquifer. It concludes that Elevated concentrations of leachable contaminants were detected in samples of Made Ground (metals, cyanide, PAHs, SVOCs, VOCs and TPHs), elevations have also been detected in groundwater both within the perched groundwater in the Made Ground (metals, cyanide, PAHs, SVOCs, TPHs and benzene) and groundwater in the Glacial Till (metals, cyanide, PAHs and TPHs), compared to GAC. A sample of natural ground also recorded arsenic above the human health GAC so there may be some leaching of contamination into the underlying Glacial Till. The risks to the adjacent Canal and Shooters Brook were moderate at this stage and should be considered further including consultation with the EA and MCC.

Sampling of the canal at the site confirmed chemical exceedances for copper, cyanide and zinc within both upstream and downstream samples. Chromium was identified as marginally exceeding in the downstream sample.

2.3. SUMMARY OF PREVIOUS GROUND INVESTIGATION WORKS – ZONE 5 AND 7

Zone 5 and 7 – Parsons Brinckerhoff (2007)

Seven intrusive locations consisting of two trial pits, taken to 2.00 m bgl and 2.60 m bgl, two hand auger pits, taken to 1.00 m bgl, two deep cable percussive boreholes, taken to 10.00 m bgl and 15.00 m bgl and one rotary borehole, advanced to 50.00 m bgl, were completed. The rotary borehole confirmed bedrock (MUDSTONE with siltstone bands) at 26.50 m bgl.

E3P have not been provided the chemical data from this assessment so cannot perform an updated risk assessment. The conclusions from the report denoting chemical exceedances have been stated below.



Screening of contaminant concentrations against residential and leisure end use (targets applicable from 2007) highlighted PAH's, TPH and arsenic as a site wide problem. An outlier of BTEX contamination was identified at location WS607 at 0.50 m bgl.

Additional outliers were identified for residential end use for zinc and thiocyanate at locations TP5W01, TP5W02 and HA601. Chrysotile asbestos was identified in BH602 at 1.00 m bgl. The perched groundwater within the Made Ground of Zones 5 and 6 (Zone 7) was less contaminated than within Zones 2 and 4 (Manox Zone) with only a few results greater than the screening criteria. The contaminants that exceeded include cyanide, cresol and sulphate.

Parsons Brinkerhoff include a summary from a former report from 2006 written by Scot Wilson which is that visual and olfactory evidence of contamination was encountered i.e. blue discolouration, black ash and various odours. Some determinants had concentrations that were significantly elevated compared to laboratory detection limits i.e. arsenic, lead, copper, sulphate, toluene, cyanide, PAH's and sulphur. Groundwater samples identified no significantly elevated concentrations of determinants.

Zone 5 – RSK and Westlakes (2019)

The GI was undertaken between 02/09/2019 and 05/09/2019 by RSK Ltd with supervision by Westlakes Environmental. The GI comprised four cable percussive boreholes drilled to 10.00 m below ground level (bgl), five window sample boreholes to 5.45 m bgl, and seven trial pits excavated to depths between 2.50 m and 3.20 m bgl. Combined gas and groundwater monitoring wells were installed in all CP and WS boreholes.

To assist with quantifying geotechnical ground properties, in-situ Standard Penetration Tests (SPTs) were also undertaken in all boreholes and selected samples have been scheduled for geotechnical laboratory testing. All exploratory locations were screened with a Photoionization Detector (PID) during the GI. Chemical analysis of 14 soil samples and 4 groundwater samples was completed.

Zone 7 – RSK and Westlakes (2019)

The GI was undertaken between 04/09/2019 and 10/09/2019 by RSK Ltd with supervision by Westlakes Environmental. The GI comprised 3 cable percussive boreholes drilled to between 10m and 12.45m below ground level (bgl), 6 window sample boreholes to between 4.0m and 5.45m bgl, and 10 trial pits excavated to depths between 3.0m and 3.6m bgl. 11 trial trenches were excavated to locate a former coal shaft. Combined gas and groundwater monitoring wells were installed in all CP and WS boreholes.

To assist with quantifying geotechnical ground properties, in-situ Standard Penetration Tests (SPTs) were undertaken in all boreholes and samples were scheduled for geotechnical laboratory testing. All exploratory locations were screened with a Photoionization Detector (PID) during the GI. Chemical analysis of 22 soil samples and 4 groundwater samples has been completed

2.4. CURRENT CONCEPTUAL SITE MODEL

As part of the development of the CSM, a review of the prior Ground Investigation works has been completed to compare the identified sources of potential pollution to the investigative locations to highlight data gaps and uncertainties within the model. This is presented in Table 2.1 and 2.2.

TABLE 2.1 SOURCE AREAS TARGETED BY INTRUSIVE INVESTIGATION AT MANOX WORKS

	URS 2004-2006	ERM 2009	RSK 2019
Oil Storage Area	✓	✓	✓
VAT Farm	✓	✓	✓
Tank Storage	✓	-	✓
Cyanide Storage	-	✓	✓
Acid Storage	✓	✓	✓
Blue Stores	✓	✓	✓



	URS 2004-2006	ERM 2009	RSK 2019
Blue Mill	✓	✓	✓
YPS Plant	✓	-	-
Tar Channel	✓	-	-
Brass Works	✓	✓	✓
Effluent Treatment	-	✓	✓
Ducie Mill	✓	✓	-

TABLE 2.2 CONTAMINANTS TESTED DURING INTRUSIVE INVESTIGATION AT MANOX WORKS

	URS 2004-2006	ERM 2009	RSK 2019
SOILS			
Heavy Metals	✓	✓	✓
Cyanide	✓	✓	✓
Hexavalent Chromium	-	-	-
Phenol	-	-	✓
PAHs	✓	Within SVOC	✓
SVOC	Limited	✓	✓
VOC	Limited	-	✓
Asbestos	Limited	-	✓
BTEX	✓	-	-
TPH Aliphatic	✓	✓	✓
TPH Aromatic	✓	✓	✓
Carbon Disulphide	✓	-	✓
GROUNDWATER			
Heavy Metals	✓	✓	✓
Cyanide	✓	✓	✓
Hexavalent Chromium	-	-	-
Phenol	-	✓	-
PAHs	✓	Within SVOC	✓
SVOC	✓	✓	✓
VOC	✓	-	✓
BTEX	-	-	✓
TPH Aliphatic	✓	Within SVOC	✓
TPH Aromatic	✓	✓	✓
Carbon Disulphide	-	-	-

2.4.1. SUMMARY OF UNIDENTIFIED RISK

A review of the historical ground investigations has identified several gaps in knowledge at the site. These include:

- ✳ the extent of the former tar channel and its contents and chemical makeup;
- ✳ the chemical classification of soils denoted as 'blue / green stained' within exploratory hole logs, inferring cyanide salt presence, and areas chemically confirmed to exceed thresholds for cyanide, arsenic and lead;

3. PROPOSED AREAS OF INVESTIGATION

3.1. TRIAL PITTING

Trial pitting will be undertaken on the Manox site only by the use of a mechanical excavator (JCB 3CX or similar) over a period of three working days to investigate the supplementary locations.



It is proposed to excavate 20 trial pits to a depth of between 3.00 m to 4.00 m bgl and six trenches to delineate the tar channel feature. The works will include the breaking out of surface structures. The final number of trial pits would depend upon the ground conditions encountered together with the nature of any subsurface obstructions encountered.

No allowance would be made for reinstatement of the trial pits other than backfilling with arisings and nominal compaction with the excavator backhoe bucket. If a greater specification for reinstatement were required, E3P would be pleased to supply costs to achieve this.

Environmental chemical and bulk samples are required for the McAuliffe, the remediation subcontractor, treatment trials for the stabilisation remediation of impacted soils at the site. Chemical samples will also be taken to quantify levels of impact noted at previous locations, where chemical analysis was not scheduled. This will help to inform the data set and reduce the knowledge gaps at the site, thus reducing the potential for any not-yet identified gross contamination at the site.

3.2. TESTING

Samples taken from the Made Ground and natural soils encountered within the exploratory holes will be analysed for a suite of contaminants of concern and utilised by the remediation subcontractor for use within treatment trials for impacted soils.

3.2.1. SOIL

- ✳ pH
- ✳ CLEA suite to include:
 - total cyanide, sulphate, sulphide, phenols, arsenic, barium, beryllium, boron, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium, vanadium and zinc
- ✳ Asbestos
 - ID and quantification if the ID is positive
- ✳ Total Organic Carbon
- ✳ SVOC (including PAH) & VOC Screen;
- ✳ Total Petroleum Hydrocarbon (TPH)
- ✳ TPH Criteria Working Group (TPH CWG)
 - Aliphatic TPH Fractions (C5-C35), Aromatic TPH Fractions C5-C35)
 - Benzene, toluene, ethylbenzene, M & P-Xylene, O-xylene and MTBE

3.2.2. LEACHATE ANALYSIS

- ✳ CLEA suite to include:
 - total cyanide, phenols, arsenic, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium and zinc
- ✳ SVOC & VOC Screen; and,
- ✳ TPH CWG



- Aliphatic TPH Fractions (C5-C35), Aromatic TPH Fractions C5-C35)
- Benzene, toluene, ethylbenzene, M & P-Xylene, O-xylene and MTBE

3.3. REPORTING

E3P will issue a report that includes the following:

- ✿ Factual information on the work undertaken, including:
 - Desk study information,
 - Sampling location plan,
 - Borehole and trial pit logs,
 - A Conceptual Site Model (CSM) in accordance with Environment Agency, Land Contamination: Risk Management (LCRM) (2019).and BSI 10175 (*Code of Practice for Investigation of Potentially Contaminated Land*).
- ✿ Interpretative information relating to the site investigation, including:
 - A Tier 1 (qualitative) risk assessment to inform a revised CSM in accordance with Land Contamination: Risk Management (LCRM) (2019).
- ✿ Detailed Remediation and Enabling Works Strategy

Table 3.1 below proposes trial holes to investigate several areas of the site.

TABLE 3.1 SUPPLEMENTARY INVESTIGATION SPECIFICATION

FEATURE TO INVESTIGATE	AIM	CHEMICAL TESTING REQUIRED
Tar Channel	Delineate extent of feature, visual and olfactory contamination, chemical classification of soil, obtain samples for treatment trials	TPH, BTEX, SVOC, VOC PID Readings
Blue or Green Staining	Investigate soils beneath former structures highlighted within exploratory hole logs for cyanide chemical contamination, obtain samples for treatment trials and updated chemical analysis	Heavy Metals and Inorganic Salts
Dissolved phase and free phase product	To obtain samples for treatment trials and updated chemical analysis	TPH, BTEX, SVOC, VOC PID Readings
Historical cyanide, arsenic and lead exceedances	To obtain samples for treatment trials	Heavy Metals

Drawings 13-887-038 and 039 denote the proposed supplementary investigation locations.

As part of the supplementary Ground Investigation, samples will also be collected for analysis by the specialist Remediation Contractor (McAuliffe Geo-Stream). These samples will be subject to extensive bench testing as part of the 'pilot study' to determine the optimal methodology for treatment by stabilisation and solidification. The specification for the Pilot Study will be prepared by McAuliffe Geo-Stream for consideration by the Local Authority (MCC) and the EA for approval.

I trust this information is satisfactory to your requirements, and should I be able to be of any further assistance, please do not hesitate to contact me.



Yours sincerely,

For and on behalf of E3P Ltd

Olivia Jackson
Geoenvironmental Consultant

Martin Dyer
Director

Enclosed:

Proposed Further Investigation Plan
Visual and Olfactory Contamination Plan
McAuliffe Propose Treatment Scope





Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Blue Staining
- HC Odour
- Oily/sheen
- PID reading high
- TAR / LNAPL / DNAPL

Notes:

Data for Manox site only					
P1	R3	13.11.2020	REVISION	LM	OJ
P1	R2	10.11.2020	REVISION	LM	OJ
P1	R1	04.08.2020	REVISION	HM	OJ
P1	-	20.07.2020	DRAFT	LM	MD
Phase	Revision	Date	Issue	Drawn	Checked

Client:

Engie	
Manox	

Job No:

13-887	13.11.2020
Drawing No:	Scale:
021	NTS
Drawing Title:	
Visual Olfactory Contamination Plan - Manox Area	



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Manox Site – Stabilisation/solidification (S/S) Treatment

S/S treatment Process

In the UK S/S techniques are well established for ground treatment of multiple contaminants. The process is an enhanced approach that has been applied to a broad range of contaminated soils, dredged materials and other media, contaminated with a wide variety of hazardous substances.

At its simplest, the process involves mixing chemicals, reagents and binding agents into the contaminated media in order to change and immobilise the contaminants within the material. The resulting chemical reactions and physical changes chemically fix the contaminants, so removing the risks to human health and the wider environment.

The ability to treat multiple contaminant types within the same media is a key benefit of the S/S process, as it means it can be used in complex contamination situations such as are found when treating heavy industrial, chemical/manufacturing, coke and town gas sites. Experience has shown that chemical and physical test results from laboratory-scale studies provide a good indication of the expected performance in the full-scale works.

Treatability Study

Bulk soil samples of contaminated soils are taken from trial pits excavated at the site for use in the trials. Due to the potential for relatively high localised variability of contamination impacts and concentrations to be present across a site, composite samples are generally produced. However, highly impacted hotspot areas, which exhibit different chemical composition and make-up, can be treated as a separate source. In this instance it is proposed that three material types are used for the trial: -

1. heavily impacted chemical waste
2. more general residual impacted material
3. tar from the identified tar channel

Total concentration and baseline batch leachate analyses are carried out on the untreated composite/source materials for the main contaminants of concern (CoC). Batch leachate testing is carried out using BS EN12457 Part 2, with a liquid to solids ratio of 10:1, as this represents worst case environmental stress scenarios in the field. However, tanks tests, in accordance with EA NEN 7375:2004, will also be progressed for two of the preferred mix designs.

Treatment mixes are initially based on those that have been successful in targeting similar contaminants and soil types on previous projects. A total of 10 different preliminary mix designs will be used for material sources 1&2, with three for the tar, incorporating various combinations of binders and additives. Some particle size reduction is undertaken on the source soils, with material greater than 15mm being removed. This is to ensure that the materials are comparable with the various sample moulds used.

Composite/single source impacted materials are mixed with the various admixtures to form a homogenous mix, then placed into sample moulds and left to cure/hydrate in a high humidity environment until required for testing, at 28-42 days. Batch and tank leachate testing is then be carried out.

Calcium-alumina-silicate based fixation and encapsulation additives have been used successfully for many years for the immobilisation of contaminants, particularly within soils and sludges. Most of this success is based on results of treatability studies in developing suitable treatment mix designs, which are usually conducted over short time periods, typically from 28 to 42 days after treatment.

The main concern regarding the long-term behaviour of S/S treated material, is the environmental impact that may occur should a treated material 'fail'. Failure will be related to the dominant deterioration mechanisms prevailing at the service location and the variation in pH conditions of the system.

The environmental impact, due to the deterioration of the material could be in the form of vapour, or particulate emissions and/or leachates. The degree of impact will depend on the pathway and receptor. Therefore, treatment specifications for S/S material are now generally based on probabilistic risk assessments.

It is vital to identify and understand the potentially destructive mechanisms that could affect the long-term performance of the S/S material at a site. 'Intrinsic' actions are as a result of poor workmanship, poor design, reactions between waste components and binders and reactions between different waste components. 'Extrinsic' actions, which include physical and chemical weathering, mechanical damage, biological attack and attack by aggressive water, are as a result of the final environmental exposure conditions. It is a widely held view that the presence of organic contaminants can have a detrimental impact on the hydration of Portland cement. However, provided such effects can be controlled to acceptable limits, the fact that contaminants are immobilised by various mechanisms as the materials undergo hydration and their leaching potential is reduced, can most often provide the required degree of treatment for the final service environment.

In addition to the above mechanisms, macro-encapsulation of contaminants will also occur. This is where contaminants are physically entrapped in the discontinuous pores within the larger structural matrix of the solidified material. This aspect of the immobilisation is mainly dependent on the physical integrity of the S/S material. Studies involving tank leachate testing of monolithic samples have generally demonstrated up to a two order of magnitude reduction in leachable concentrations, as compared to standard batch tests on similar samples (Kogbara et al., 2013). However, it is always prudent that that likely performance is assessed on the results of batch testing, as there is then an additional factor of safety built into potential performance at full-scale.

Treatability studies, using the contaminated source materials from the site, although conducted over a relatively short time scale, are enough to understand the behaviour of the mixes and eliminate the potential for failures following full-scale treatment works. A fundamental aspect of the testing regime is that worst-case leachate testing is undertaken on the treated materials, as the sample preparation involves a reduction in the particle size/structure of the S/S samples, thus eliminating the macro-encapsulation aspect of the treatment and so relying solely on chemical fixation processes at the micro-encapsulation level. This is beneficial in understanding potential longer-term behaviour should extreme weathering effects impact on the materials in the near surface ground. Particle reduction seeks to simulate more extreme effects of mechanisms, such as carbonation, sulphate attack and freeze-thaw, which might reduce the physical integrity of the material depending on severity and the mix design constituents. This, therefore, provides an understanding of the effects of worst-case leaching potential. As data from most on-site studies is only available for a maximum of 20 to 30 years, reliance is placed on the results of modelling in order to provide confidence in the much longer-term performance. Further information on the results of such studies is provided in the references listed in Appendix A.

This study should demonstrate there to be enough reduction in the leachability of the CoC present within the source soils, to be able to confirm several suitable designs can be used to achieve significant leachability performance. It should also be noted that the study will confirm that use of the technique will improve the visual and olfactory nature of the most impacted materials, such as tar likely to be present at the site.

APPENDIX A References

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