



Faithful + Gould

Wrexham Delivery Office, Wrexham

Remediation Strategy

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

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1 INTRODUCTION

RemedX Limited (RemedX) was contracted by Faithful + Gould (F+G) to complete a Remediation Strategy (RS) for the identified contamination at the Wrexham Delivery Office site, Wrexham, Wales. The RS has been completed based on the previous site investigation works that have been completed for the site to date.

1.1 Objective

The purpose of this RS is to assess and identify the most viable remedial approach for the site and its specific remedial objectives. This will be assessed based on multiple criteria, including cost, time, practicality, technicality, waste and sustainability. It will also include an outline remediation process plan.

1.2 Location and description of the site

The Wrexham Delivery Office site is located on Regent Street, Wrexham, approximately 1 km northwest of Wrexham city centre. To the south of the site is mixed commercial and residential housing, with additional residential properties to the north. To the east and west of the site lie commercial properties. A site plan with red line site boundary is presented in Figure 1.

1.3 History of the site

Limited site history has been supplied for review; however a study of available historical maps has been undertaken for the site to provide some context.

The earliest maps available for the site date back to 1874, showing the site area occupied by agricultural land. This appears to remain the case until mapping dated 1937-1939 shows a building marked "works" occupying the broad location of the current day delivery office. By 1960, the site buildings resemble the current site layout, with mapping in 1963 specifically referring to a sorting office to the west of the site area. The site does not undergo significant change to the current day.

1.4 Summary of previous investigation

It is understood that a single phase of site investigation has been undertaken at the site, comprising the advancement of three boreholes, MW1, MW2 and MW3, draft logs for which along with the results of groundwater gauging and sampling events conducted on 18th February 2021 for MW1 and MW2, with MW3 sampled on 25th February 2021; 4th March 2021; and 10th March 2021, have been reviewed.

1.5 Limitations

The comments given in this report and the opinions expressed are based on the information made available to RemedX in addition to the site investigation works

completed by RemedX. However, there may be conditions pertaining to the site that have not been revealed by the previous phases of investigation and therefore could not be taken into account for the completion of this RS.

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2 CONCEPTUAL SITE MODEL

This section presents the previously established conceptual site model, identifying geology, hydrogeology, sources, pathways and receptors as well as summarising complete contaminant linkages for the site.

2.1 Geology

Based upon intrusive investigations, the site geology can be generally summarised to be as follows:

- 0 – 3-4m bgl - asphalt / engineered surfaces
- 3-4 – 5.80-6m bgl – clayey sandy gravels, some clay evident at the base of MW2 at 5.80m bgl

2.2 Hydrogeology

The hydrogeological conditions are determined by the geological and tectonic structure of the region.

Groundwater gauging has shown there to be a shallow groundwater body present beneath the site in all monitoring wells. The levels appear to be relatively consistent across the site. Generally, groundwater is between 3.5 and 4.0m bgl based on previous monitoring rounds.

Primary groundwater flow direction has been inferred towards the south east. No gradient has yet been calculated and communicated to RemedX.

2.3 Sources

The following potential sources were identified:

- Potential leak from an underground storage tank or associated pipework.
- Residual contamination in soils surrounding the fuel storage and distribution infrastructure.
- Other potential historic contamination associated with the site use.
- Potential contamination from the highway run off.

2.4 Pathways

The following potential pathways were identified:

- Leaching of contaminants sorbed to soils in the unsaturated zone and migration into groundwater
- Migration of dissolved phase contaminants laterally within the groundwater
- Vapours generated from contaminants within the soil
- Vapours generated from contaminants within the groundwater

2.5 Receptors

The following potential receptors were identified:

- Aquifer within the sands and gravels below the site
- Onsite infrastructure and buildings
- Site workers

2.6 Linkages

Based on the findings of the previous site investigations and previous further assessment the following contaminant linkages are confirmed or potentially complete:

- Migration of contaminants from the source/s directly into groundwater.
- Potential lateral migration of impacted groundwater to offsite receptors to the SE.

3 REMEDIATION OPTIONS APPRAISAL

A remediation options appraisal has been undertaken by RemedX to enable the selection of the most feasible remedial options for the residual impacted soils and groundwater at the site. The appraisal takes into consideration multiple criteria including cost, time, practicality, technical, waste and sustainability of the given remediation techniques.

3.1 Remediation objectives

The specific remediation objectives for the site are as follows:

- Removal of primary and secondary sources of contamination
- Protection of off-site receptors to the south and south east of site
- Reduction of dissolved phase concentrations on site to acceptable levels

3.2 Remediation target zones

Throughout redevelopment and remediation works, it is understood that the site will continue to be operated as a Royal Mail delivery office, with vehicular access required to the northern part of the site comprising the vehicle parking and loading area.

Whilst this will restrict access for the site as well as access to the residual contamination and potential plume spread, the remedial works will be designed in such a way as to integrate into the site development and minimise impact to both site operations and remediation programme.

The zone of remedial works is shown on Figure 2 of Appendix A.

3.3 Initial remediation technique selection

Below in Table 1 is a full matrix of remediation techniques that could be utilised. The matrix gives a generalised summary of applicable implantation, target phase, geology and contaminants for each technology. The techniques viable for this site are then selected to be taken forward for detailed assessment.

Table 1: Remediation technology matrix

Remediation technology	Implementatio n		Target phase				Geology							Contaminants		
	In-situ	Ex-situ	Vapour	NAPL	Aqueous	Sorbed	Gravel >2mm	Sand 0.06-2mm	Silt 2-60um	Clay <2um	Peat	Sedimentary bedrock	Crystalline bedrock	TPH	PAH	Metals
✓ = Applicable, ? = Potential / limited, ✖ = Not applicable.																
Biological breakdown																
Bioremediation	✖	✓	✖	✓	✖	✓	✓	✓	✓	?	?	✖	✖	✓	✓	✖
Monitored natural attenuation (MNA)	✓	✖	✖	✖	✓	?	✓	✓	?	?	?	?	?	✓	✓	?
Enhanced MNA	✓	✖	✖	✖	✓	✓	✓	✓	✓	?	?	?	?	✓	✓	?
Bio venting	✓	✓	✖	✖	✖	✓	✓	✓	?	?	✖	✖	✖	✖	✖	✖
Bio sparging	✓	✖	✖	✖	✓	✓	✓	✓	?	✖	✖	✖	✖	✓	✖	✖
Phytoremediation	✓	✖	✖	✖	✓	✓	✓	✓	✓	✓	✓	✖	✖	✓	✓	✓
Chemical breakdown																
Chemical oxidation	✓	✓	✖	✖	✓	✓	✓	✓	✓	✓	✖	?	?	✖	✖	✖
Chemical reduction	✓	✓	✖	✖	✓	✓	✓	✓	✓	✓	✖	?	?	✓	✓	?
Soil flushing / desorption	✓	✓	✖	✓	?	✓	✓	✓	?	?	✖	?	?	✓	✓	✓
Physical extraction																
LNAPL recovery	✓	✖	✖	✓	✖	✖	✓	✓	✓	?	✖	?	?	✓	✓	✖
Total fluids recovery	✓	✖	✖	✓	✓	?	✓	✓	✓	?	✖	✓	✓	✓	✓	?
Soil vapour extraction (SVE)	✓	✓	✓	✖	✖	✓	✓	✓	?	?	✖	?	?	✓	?	✖
Air sparge SVE	✓	✖	✓	✖	✓	✓	✓	✓	?	✖	✖	✖	✖	✓	?	✖
Dual / multi-phase extraction (DPE / MPE)	✓	✖	✓	✓	✓	✓	✓	✓	?	?	✖	✓	✓	✓	✓	?

Remediation technology	Implementation		Target phase				Geology							Contaminants		
	In-situ	Ex-situ	Vapour	NAPL	Aqueous	Sorbed	Gravel >2mm	Sand 0.06-2mm	Silt 2-60um	Clay <2um	Peat	Sedimentary bedrock	Crystalline bedrock	TPH	PAH	Metals
✓ = Applicable, ? = Potential / limited, ✖ = Not applicable.																
Thermally enhanced extraction	✓	✖	✖	✓	✓	✓	✓	✓	?	?	?	✓	✓	✓	✓	✖
Thermal desorption – low temperature	✖	✓	✖	✖	✖	✓	✖	✓	✓	?	?	✖	✖	✓	✓	?
Soil washing	✖	✓	✖	✖	✖	✓	✓	✓	?	?	?	✖	✖	✓	✓	✓
Excavation – disposal	✖	✓	✖	✖	✖	✓	?	✓	✓	✓	✓	?	?	✓	✓	✓
Thermal destruction																
Thermal conductive heating	✓	✖	✖	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✖
Thermal desorption – high temperature	✖	✓	✖	✖	✖	✓	✖	✓	✓	?	?	✖	✖	✓	✓	?
Containment																
Solidification / stabilisation	✓	✓	✖	✖	✖	✓	✓	✓	✓	✓	✖	✖	✖	✓	?	✓
Cover systems	✓	✓	✖	✖	✖	✓	✓	✓	✓	✓	✓	✖	✖	✓	✓	✓
Sub surface barriers	✓	✖	✖	✓	✓	✖	✓	✓	✓	✓	✓	✖	✖	✓	✓	✓
Permeable reactive barrier (PRB)	✓	✖	✖	✖	✓	✖	✓	✓	?	?	?	?	?	✓	✓	✓

Upon consideration of the site's specific characteristics, taking into account cost and sustainability, the following potentially viable options have been selected and taken forward for a detailed assessment:

- Monitored Natural Attenuation (MNA),
- Total Fluids Recovery and
- Dual Phase Extraction (DPE) / Multi Phase Extraction (MPE).

3.4 Discussion of options

The selected remediation techniques from the initial selection are presented below.

3.4.1 Monitored natural attenuation (MNA)

Technology			
Monitored natural attenuation (MNA)			
Applicable Implementation			
In-situ		Ex-situ	
✓		✗	
Applicable Target Phases			
Vapour	NAPL	Aqueous	Sorbed
✗	✗	✓	?
Applicable Geology			
Gravel >2mm	Sand 0.06-2mm	Silt 2-60um	Clay <2um
✓	✓	?	?
Peat	Sedimentary Bedrock	Crystalline Bedrock	
?	?	?	
Applicable Contaminants			
TPH	PAH	Metals	
✓	✓	?	
Description			
Monitored natural attenuation (MNA) consists of a range of naturally occurring in situ physical, chemical, and biological processes that attenuate contaminant concentrations in groundwater to achieve remedial goals within a reasonable timeframe and protect human health and the environment. MNA relies on groundwater data to develop contaminant trends and to evaluate reductions in contaminant concentrations brought about by naturally-occurring destructive mechanisms (e.g., biodegradation and/or chemical/abiotic degradation) and non-destructive mechanisms (e.g., advection, dispersion, dilution via recharge, sorption, and volatilization). While non-destructive mechanisms decrease contaminant concentrations spatially through redistribution (scattering) of the contaminant mass, destructive mechanisms reduce contaminant concentrations through degradation/alteration of the contaminants' chemical composition. Biodegradation is often the predominant (destructive) mechanism to reduce the mass of the contaminants at a site. However, it is noted that the impacts of chemical degradation (or abiotic degradation) mechanisms are becoming better understood and are recognized to contribute more significantly to MNA, under certain site-specific conditions.			

Advantages	Limitations
• Less generation or transfer of remediation waste; • Less intrusive as few surface structures are required; • Can be used in conjunction with, or after other remediation methods; • Overall cost likely to be lower than many active remediation technologies.	• Requires extensive site investigation; • Requires a long term commitment to monitoring and a contingency plan (and funds) if the contaminants or groundwater do not behave as predicted; • Requires significant depth of understanding of local geology and hydrogeology; • Subsurface conditions may change over time and may result in renewed mobility of previously stabilised contaminants.
Site Specific Application	
This could be a potentially viable option should excavation remove suitable mass of contamination. However, any presence of Light Non Aqueous Phase Liquids (LNAPL) will likely hinder the feasibility of applying MNA. In addition, if off site migration continues to occur an assessment on whether suitable attenuation is occurring to avoid the need of actively controlling groundwater. It is possible the removal of the primary source and bulk of the contaminant mass via the previous excavation works may mean that contaminant levels are reduced across the site to the point that MNA and natural degradation of the residual contamination is sufficient to protect off site receptors. Site appears to have reasonable hydraulic flux in the sub surface and as such there is likely to be high potential for continued aerobic degradation. The high hydraulic flux could also mean the contamination is mobilised off site towards receptors before being degraded, however. Likely to be required in all situations to demonstrate compliance with remediation objectives.	

3.4.2 Total fluids recovery

Technology			
Total fluids recovery			
Applicable Implementation			
In-situ		Ex-situ	
✓		✗	
Applicable Target Phases			
Vapour	NAPL	Aqueous	Sorbed
✗	✓	✓	?
Applicable Geologies			
Gravel >2mm	Sand 0.06-2mm	Silt 2-60um	Clay <2um
✓	✓	✓	?
Peat	Sedimentary Bedrock	Crystalline Bedrock	
✗	✓	✓	
Applicable Contaminants			
TPH	PAH	Metals	
✓	✓	?	
Description			
Total fluids recovery is performed using one or more pumps in a well or trench to recover LNAPL and groundwater. A pump is placed at a specified depth beneath the groundwater/LNAPL interface. A pumping rate is set sufficiently high to create a groundwater cone of depression, which provides a gradient to induce the flow of LNAPL into the well or trench. The pump can be used to recover LNAPL and groundwater in a single stream, or a second pump can be placed at a shallow interval to recover LNAPL (and some water). Total fluids recovery systems generate a large volume of water that must be treated and disposed at the surface. However, the greater driving force creates a localized depression in the water table that can result in a greater volume of LNAPL recovered in a shorter period. Above ground treatment can take the following forms; • Air stripping: VOCs in groundwater are transferred from the dissolved phase to the vapour phase by air bubbles. The contaminated air rises to the water surface where vapours are drawn off and treated; • Carbon adsorption: adsorption of dissolved organic contaminants on to granular activated carbon (GAC); • Filters: mechanical separation based on removing particulate material from water; • Membrane filtration: filtration using semi-permeable membrane on the basis of different molecular size. Can be used to treat inorganic and organic compounds; • Ion exchange: contaminant ions are removed from water as they are exchanged with non-contaminant ions in the exchange resin; • Reverse osmosis: low concentrations of inorganic contaminants may be removed through this separation mechanism; • Chemical oxidation: ozone, hydrogen peroxide and ultraviolet light may be used to degrade contaminants by oxidation;			

Technology	
Total fluids recovery	
• Precipitation: dissolved contaminants are transformed into insoluble compounds which may be less toxic, or easier to treat or remove; • Neutralisation: chemical reaction to amend the pH of a solution; • Biodegradation: sand/gravel filters are colonised with microorganisms to promote biodegradation of organic compounds in water; Total fluids recovery systems generally are used when substantial LNAPL remains at a site. They also are used when it is desirable to prevent migration of the LNAPL or the associated dissolved phase plume since the cone of depression also creates a groundwater capture zone. Groundwater modelling using site-specific data should be performed to determine the extraction flowrate needed to establish the desired capture zone and to design an appropriate number and spacing of recovery wells.	
Advantages	Limitations
• Removal of contaminants and the risk they pose from the site; • Able to also gain hydraulic control of an area; • Can be inexpensive depending on the surface treatment required.	• Limited by the structure of the soil, degree of saturation, pore connectivity and porosity; • Effectiveness can be hindered by a strong water table for in-situ; • Recovery with drawdown can smear contamination across less contaminated zones; • Susceptible to contaminant rebound after pumping stops.
Site Specific Application	
This approach would achieve targeting of any LNAPL and dissolved phase organic contamination across the target areas. Based on the theoretical hydrogeological conditions, it would be able to achieve a cone of depression with drawdown which would be used for hydraulic containment of contamination and prevent further migration off site. this approach is a relatively low maintenance active approach. Extracted liquids would require processing on site. Impacted soils in the subsurface would not be targeted. However, it is a robust proven technique. Logistically it would have to be installed and operated to ensure there were no issues associated with harsh weather conditions.	

3.4.3 Dual / multi-phase extraction (DPE/MPE)

Technology			
Dual / multi-phase extraction (DPE/MPE)			
Applicable Implementation			
In-situ		Ex-situ	
✓		✕	
Applicable Target Phases			
Vapour	NAPL	Aqueous	Sorbed
✓	✓	✓	✓
Applicable Geology			
Gravel >2mm	Sand 0.06-2mm	Silt 2-60um	Clay <2um
✓	✓	?	?
Peat	Sedimentary Bedrock	Crystalline Bedrock	
✕	✓	✓	
Applicable Contaminants			
TPH	PAH	Metals	
✓	✓	?	
Description			
DPE/MPE are two very similar techniques that combine the effects of a liquid extraction system with a SVE system. With DPE, pump and treat is used to dewater a target smear zone and once exposed a vacuum is then applied to the newly exposed unsaturated zone to further remove contamination in the vapour phase. MPE is similar to DPE, except both waste streams are extracted together from 1 extraction lance using a vacuum. This dewateres the target smear zone and once exposed the vacuum is then applied to the newly exposed unsaturated zone to further remove contamination in the vapour phase, as well as stripping vapours from the groundwater. The waste streams are then treated separately for both DPE and MPE. MPE initially requires the liquid and vapour streams to be separated using knockout vessel. Then in both methods via sand and carbon for liquids and via a carbon filter for vapours. There are many other liquid treatment stages that can be added to a water treatment plant depending on the contaminants. The advantages of DPE is that it is better for handling LNAPL as it reduces hazards associated with process safety that occur with LNAPL and MPE. DPE is also better suited if there is higher hydraulic conductivity and more water to process. The value of DPE decreases with reduced requirement for liquid recovery. DPE is a more complex and involved installation with additional pumps installed and associated pipework runs. MPE is a simpler system with less installation requirements and is more suited to tighter geologies, however, struggles with increasing depths below 10m.			

Advantages	Limitations
• Can be cost effective; • Can treat many organic compounds across all phases, including LNAPL (DPE); • MPE has simpler installation requirements; • Minimal site disturbance for in-situ.	• Limited by the structure of the soil, degree of saturation, pore connectivity and porosity for in-situ; • Neither are simple to operate; • Effectiveness can be hindered by high hydraulic conductivity for in-situ; • Verification of treatment can be difficult; • Not applicable to inorganic compounds due to their low volatility; • MPE has limited depth due to vacuum capacity.
Site Specific Application	
Most involved system being a combination of total fluids removal and SVE. But would effectively target LNAPL and dissolved phase contamination across the area and be suited to the geology and contamination. Also gives the benefit of hydraulic control. However it has the same drawbacks of total fluid recovery of potential issues with sub zero temperatures and freezing of extracted water during treatment at certain times of the year. Very effective solution which could see duration of operation reduced, but also most costly and complex to install and operate. Would also require network of extraction wells installed. MPE would be best suited for to the geology and hydrogeology and contamination profile observed.	

3.5 Conclusions from options appraisal

Based on the remedial options appraisal assessment the most feasible technique for achieving the remedial objectives for the site is considered to be DPE/MPE. This is a robust system that will actively treat soils and groundwater providing more assurance in achieving the remedial targets set out for the site. It is well suited to the geology and hydrogeology which has demonstrated itself to not have as high hydraulic conductivity as first expected, likely associated with higher fines content in the moraine sand geology.

The MPE is used to lower the water table and expose the smear zone to airflow and vacuum hence increasing hydrocarbon mass transfer and removal in the vapour phase. The system should be robust enough to handle fluctuating water levels based on seasons and effectively sustain hydraulic control and dewatering. The system, once installed, will be able to operate without any disruption to existing site operations.

Based on the above, there are merits in considering simpler alternatives to achieve the MPE effect without the need of installing and operating a full scale MPE system. RemedX considers the LNAPL and contaminant mass recovery utilising vacuum tankers or mobile vacuum units through Vacuum Extraction Removal (VER) events could therefore be considered. It is much simpler to instigate, however it will likely have limitations in terms of radius of influence and rate that mass is removed thus limiting the ability to reach remedial targets or prolonging the timescales to achieve objectives.

MNA has been discounted largely on the basis of the very limited site investigation, though additional investigation, data assessment and refinement of the remedial model would likely reduce the overall requirement for and scope of remediation works, albeit at additional cost. These costs however, are likely to offset against the overall cost of any remedial scheme implemented at the site.

Whilst dig and dump presents programme benefits in terms of removing the majority of contaminated soil and mass from the site via excavation and removal to landfill quickly, the potential for expansive excavation to interfere with site operations, cost implications from landfill tax and uncertainties regarding extent and nature of contamination given the limited site investigation data have discounted this option.

4 PROPOSED REMEDIATION STRATEGY

Based on the remediation options appraisal assessment, MPE is presenting as the most technically viable methodology for the site at this current stage.

4.1 Overview

The system will require the network of wells and trenches install for the extraction pipework. Being MPE, waste streams of liquids and vapour are both extracted via vacuum down the same line and there is no requirement for air supply with MPE which makes the installation simpler. These will feed into the extraction and treatment plant which will require positioning on site somewhere suitable to not interfere with ongoing site use. It will be ideally located close to a potential discharge location (combined/foul sewer).

The active remediation works to be undertaken at the site can be broadly split into 3 phases of works, designed to progress construction at the site, which are outlined below. This strategy presents these three phases as:

- Phase 1: Removal of existing underground storage tanks and removal of any grossly impacted soils
- Phase 2: Installation and operation of DPE/MPE system
- Phase 3: Post remediation monitoring and validation

4.2 Site constraints

Prior to commencing the works a site visit will be required to confirm any site constraints specifically relevant to the remedial methodology and proposed field works. Currently the following site constraints have been noted for this site:

- The site is still an operational delivery and sorting office. The designation and segregation of target work locations will have to be carefully considered and executed to ensure no incidents occur in relation to site use, public access and critical use areas within the site.
- It is assumed that a suitable power supply to run the system will be made available for these works. If one is not available there will be the requirement to source a new connection or run the system using generators for the duration of the works. This however is not recommended given the associated costs, carbon footprint and operational issues.
- Future works will have to minimise disruption to ongoing site activities. Wells and trenching will need to be installed in such a way to minimise the impact on ongoing site operations.
- It is unknown if a water supply is available on site. Water supply will be required to commission the water treatment plant system when installed.
- Discharge location. It is unknown if there is a suitable discharge location for the extracted liquids to be discharged to post treatment. This will be essential for this

works to be able to proceed. It has been assumed a suitable discharge location with sufficient capacity is available.

4.3 Installation requirements

The specific number and spacing of remediation wells would be best determined by pilot testing works but for the purposes of this proposal a total of 8 installations for the MPE system have been assumed based on a radius of 4m per extraction well. It should be noted that this provisional design could be changed based upon the results of any agreed pilot testing works. Figure 2 shows the proposed well installation layouts.

New remediation wells should be installed in 110mm diameter PVC or HDPE pipes, screened from 1.5m to 6m bgl, targeting the residual smear zone.

All wells will be installed within manhole chambers to allow for connection with below ground pipework and installation of extraction lances. All of the extraction and distribution pipework will be installed in trenches so as not to impact upon the ongoing operation of the site.

The existing monitoring wells on site will be utilised for ongoing groundwater monitoring.

4.4 Full scale equipment

The Equipment required for these works are as follows:

- Basic hand tools for conducting maintenance and connections
- Photo Ionisation Detector (PID) for monitoring VOCs
- Interface probe for measuring water levels / LNAPL in wells
- Anemometers for measuring air velocity
- Thermometer for measuring temperature
- Vacuum gauges for measuring vacuum at well heads and system
- Data loggers for monitoring groundwater levels inside wells
- Vapour sampling pumps and kit
- Water sample bottles
- MPE container comprising:
 - 2 x vacuum pumps
 - Knock out separation vessel
 - System control panel
 - Safety controls
 - Dilution control
- 10m³/hr Water treatment plant (WTP) comprising:
 - Oil/water separator
 - Buffer tank with forwarding pump
 - Sand filter unit (BI50)

- Aqueous phase carbon vessel units (2 x BI50)
- LNAPL storage tank
- Vapour phase carbon vessel units (2 x BI25)
- Pipework infrastructure and manifold

4.5 Remedial works methodology

The key tasks involved in the remediation works for this site are highlighted in this section.

4.5.1 HAZOP

A HAZOP will be completed during design stage to assess process safety and identify all safety devices and measures required for the safe operation of the system

4.5.2 Installation of new wells for systems

The new wells will need to be installed in the target remediation zones. This will be done using the most suitable drilling method for the geology present. Installations will be profiled with a PID to allow for targeted removal during the extraction works. Arisings will be collected up and arranged for disposal to a suitable licensed facility. Wells will need to be installed in chambers with surface cover access due to the existing site use. Wells will be suitably developed once installed, ready for use.

4.5.3 Baseline groundwater sampling and gauging

The baseline GW sampling round will be collected from all wells installed to the groundwater, new and old, once they have been installed and have had a chance to settle. A selection of wells providing suitable coverage of the site has been assumed for these works. Sampling will be completed using a bladder pump (or similar) and low flow cell due to the depth of the groundwater. Samples will be analysed for TPH CWG (to include BTEX), PAH and metals in line with existing testing. This will inform the baseline conditions for the remediation works.

4.5.4 Installation and commissioning of systems

This phase of the work will involve delivery of the plant to site prior to setting it up in position, building the bund, connecting all plant, testing and commissioning before finally starting the system operation.

4.5.5 System operation and maintenance

The operation and maintenance will take place initially on a weekly basis and will be split into two types of visit. They are as follows:

- Operation and optimisation visits – this will involve a day visit to conduct basic system checks of the plant and wells, check lance inlets and record system and well data which will then allow for re-optimisation of the system if required. These will be initially completed on a weekly basis then moved to fortnight visits.
- Maintenance and service visits – this will involve a two day visit to conduct all that would be completed on a normal operation visit, but also additional plant servicing

and maintenance which requires more involved tools and knowledge. This visit will be conducted on a monthly basis.

4.5.6 Quarterly remediation groundwater sampling

Groundwater sampling of applicable wells to be decided based on baseline conditions will be completed on a quarterly basis during operation of the plant. The groundwater abstraction plant be switched off and groundwater levels allowed to settle prior to completing the sampling. Sampling will be completed using a peristaltic pump and low flow cell due to the depth of the groundwater. These samples should be analysed for TPH CWG. The data will then be used to help further direct extraction and optimisation of the system.

4.5.7 Decommissioning of plant

For this part of the works the equipment will be turned off and isolated to allow for it to be dismantled, cleaned and packed up ready for transport off site back. Wastes media and sludges will be removed from site and transported to a suitable disposal facility.

4.5.8 Post remediation groundwater sampling

Groundwater sampling of applicable wells will be completed on a quarterly basis post remediation works. Sampling will be completing using a bladder pump and low flow cell due to the depth of the groundwater. These samples should be analysed for TPH CWG (to include BTEX). The data will then be used to help further delineate residual contamination and demonstrate continued attenuation of concentrations and meeting of remediation targets.

4.6 Groundwater monitoring and sampling

The groundwater sampling analysis will be used to assess the progress of the job throughout the works and inform areas to target for the DPE extraction system as well as inform on duration to run the system for. It is recommended that a full groundwater sampling round is completed prior to works commencing to create a baseline data set. For the purposes of this scoping, it has been assumed to include 4 wells, and will be made up of a cross section of the new and existing installations to give good coverage of the site.

Allowance should also be made for monthly monitoring of wells post completion of remediation works. This is to allow for validation of the remediation targets.

The sampling should be completed using low flow sampling methods with a peristaltic style pump and assessed for water quality parameters (pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, temperature) via a suitable water multi parameter probe.

The water samples should be sent to an accredited laboratory for the following analysis:

- TPH CWG (to include BTEX), PAH and metals.

4.7 Regulatory Context

MPE would require a mobile treatment plant license as well as a discharge consent for processing and discharge the water to foul sewer. The system should not need an abstraction license for pumping the water from the ground.

Waste would have to be handled by appropriate handlers, spent carbon etc is considered a hazardous waste substance.

Wastes should be disposed of to a suitably licensed facility.

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5 ADDITIONAL WORKS

In addition to the proposed active remediation works, it should be noted that all stakeholders acknowledge that, despite the conclusions drawn in earlier sections of this report, the conceptual site model for the site concerning groundwater in particular to be limited in terms of available data.

It is therefore proposed that as the active remediation works progress that in order to further inform the design and implementation of the proposed DPE/MPE system, supplementary site investigation is undertaken

5.1 Phase 1a: Supplementary intrusive site investigation

It is proposed that a supplementary intrusive site investigation is undertaken to better delineate the remaining contamination across the site by installing additional monitoring wells. The scope of the works will include the following:

- 6 shallow boreholes will be installed to a provisional final depth of approximately 6 metre below ground level (m bgl). Figure 3 shows the proposed shallow borehole locations.
- 1 deeper borehole will be installed to confirm the depth to the aquitard and establish the extent, or lack of, vertical migration of contamination. Figure 3 shows the proposed deeper borehole location.
- Groundwater sampling will be collected from the 7 new monitoring wells once they have been installed and have had a chance to settle; and the 3 existing monitoring wells already established on the site. Sampling will be completed using a bladder pump (or similar) and low flow cell due to the depth of the groundwater. Samples will be analysed for TPH CWG (to include BTEX), PAH and metals in line with existing testing.
- Three rounds of groundwater sampling will be completed over a period of three months at the 10 monitoring wells.

5.2 Data analysis and refinement of conceptual site model

Following receipt of each round of groundwater analysis, it is proposed that a data review be undertaken to further inform both the conceptual site model and refine the proposed remedial approach to better target the residual groundwater contamination identified at the site, together with any additionally identified sources.

At each stage of the process, consultation with the regulatory authorities will be undertaken to ensure compliance with the approved RS and planning conditions.

FIGURES

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