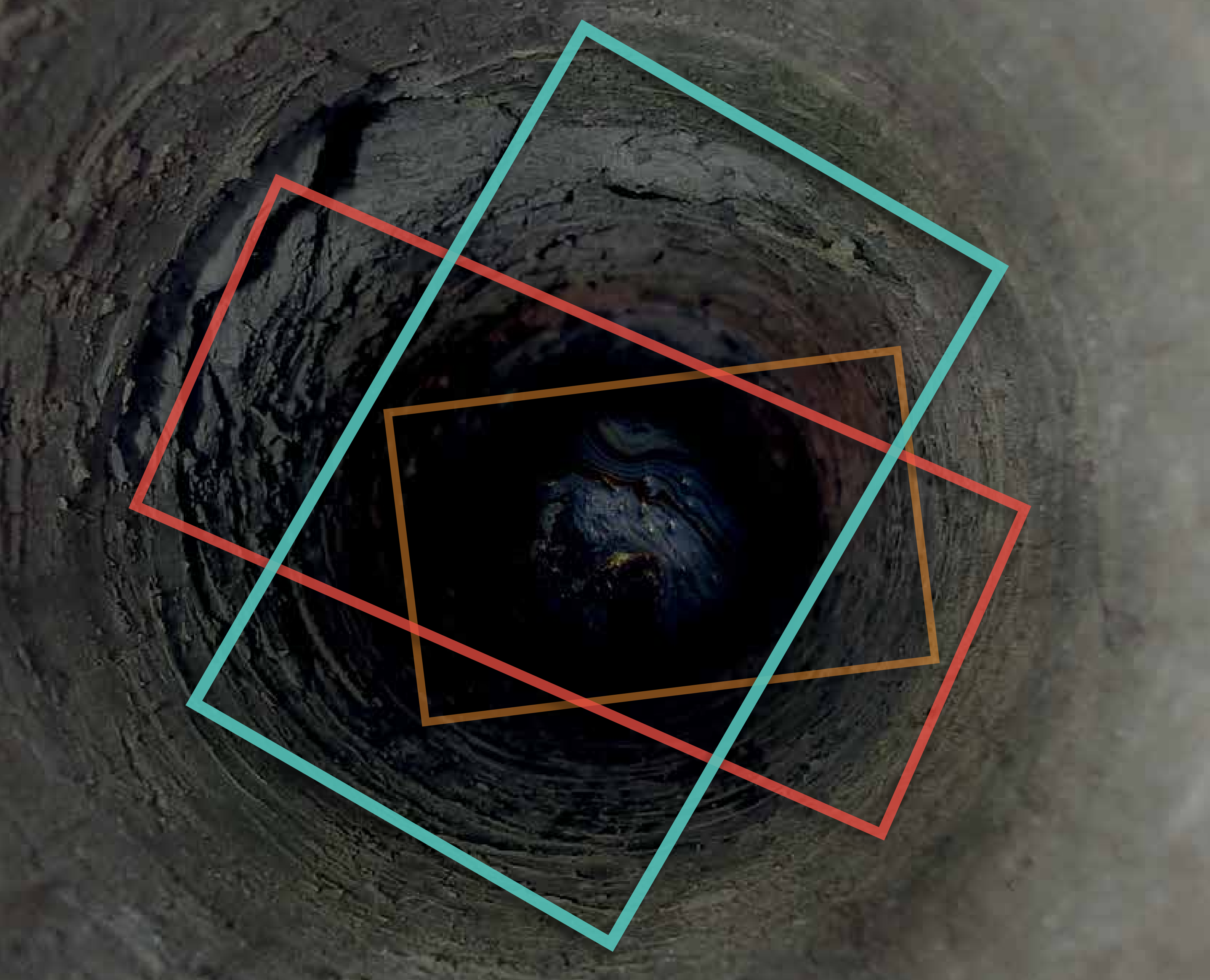
environmental SCIENTIST

February 2018
Journal of the Institution of Environmental Sciences

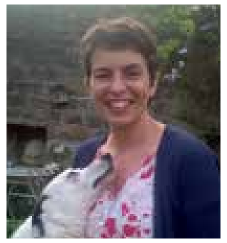
JUST BORING?



CHALLENGING PERCEPTIONS IN LAND CONDITION

EDITORIAL

Working together to unlock the potential of brownfield sites



In the early years of my career, I remember innocently thinking that work in the assessment and remediation of contaminated land would be finite and in a few years' time, the workload for this sector would drop off; we would have tackled the worst polluting problem sites, and we would be moving onto the next burning environmental issue. I was a little naïve.

With increasing pressure on the built and natural environment, the need for a sustainable approach to the use and management of land is more important than ever. Last year, the Government introduced the requirement for each English council to produce a register of brownfield sites in their areas. The register is designed to help identify derelict or previously developed sites that are potentially suitable for residential development. While it has been suggested that this would improve the planning process and reduce the potential need to develop greenfield sites, sound science and robust assessment by suitably qualified professionals of the environmental constraints linked with developing contaminated land remains fundamental, to ensure that any development is appropriate and safe.

Being able to draw from a diverse range of skill sets is an important requirement when dealing with the issues associated with contaminated land. Support is needed from a pool of expertise including, amongst others, geologists, chemists, geotechnical engineers, environmental scientists, hydrogeologists, hydrologists, ecologists and archaeologists. There will almost always be something unusual, unique or challenging when dealing with individual sites, and practitioners gain a great deal of knowledge and practical experience from working within these cross-disciplinary teams.

Reading this edition of the environmental SCIENTIST, I am reminded of the challenges facing the land condition sector, but also the opportunities in finding sustainable solutions where remediation strategies are necessary to manage unacceptable risks to people or the environment. The land remediation case studies presented here each describe different remediation options which have been designed with consideration to sustainability. Whether you are already working or studying within this sector or not, I trust you will find this edition of interest.

At the Institution of Environmental Sciences, we strive to provide a platform for the sharing of knowledge and best practice across the environmental professions. By highlighting some key issues in land condition, be it the legal framework, best practice considerations or whether the introduction of brownfield registers will indeed help unlock land for much needed new homes, we hope to spark these conversations. I look forward to continuing our work to build and support the community of land condition specialists at the IES and engaging with experts from across our diverse membership.

Linsey Cottrell works as a Principal Environmental Consultant at Sweco UK, in Leeds. She has worked on contaminated land projects over the last 20 years for the public and private sector, she is a Chartered Environmentalist, a Specialist in Land Condition (SiLC), a member of the IES Council and is registered as a Suitably Qualified Person under the National Quality Mark Scheme.

Cover Design by Design Science and IES
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CONTENTS


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environmental SCIENTIST
The Journal of the Institution of Environmental Sciences

Volume 27 No 1
ISSN: 0966 8411 | Established 1971

The environmental SCIENTIST examines major topics within the field of environmental sciences, providing a forum for experts, professionals and stakeholders to discuss key issues.

Views expressed in the journal are those of the authors and do not necessarily reflect IES views or policy.

Published by
The Institution of Environmental Sciences
3rd Floor
140 London Wall,
London, EC2Y 5DN

Tel 020 7601 1920
Email info@the-ies.org
Web www.the-ies.org
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Guest editors Linsey Cottrell, Charlie Knox, Joanna Wilding
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Designer Kate Saker katesaker.com
Printers Lavenham Press Ltd.

This journal is printed on paper produced by a Programme for the Endorsement of Forest Certification (PEFC) certified supplier.

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INTRODUCTION

Contaminated land management: Do legislation and industry practice work hand-in-hand?

Charlie Knox reflects on the relationship between legislators, regulators, researchers and industry experts on the management of contaminated land in the UK.

Land condition can be defined as the state of the environment or actual resources, such as air, land, water and ecology. In response to the effects of human activities including industry, energy use, agriculture and population growth on land condition, a 'community' of environmental specialists now exists within the UK to protect and restore the environment, and mitigate future risks to ecosystems or individuals within areas of a degraded condition. Such areas may be those considered as land that has, in some way, been changed by the introduction of man-made materials. This could include, for example, land contaminated by military activities, such as World War II bombing raids and the historical manufacture of ammunitions, or contamination by point or diffuse sources associated with manufacturing processes. Additionally, excavations may have been filled with chemical or physical waste without controls in place to prevent contamination of the wider environment.

Owing to its long industrial legacy dating back to the start of the Industrial Revolution in the 18th century, the UK is now estimated to have some "400,000 hectares of contaminated land"[1]. In an attempt to monitor the availability of brownfield sites (developed land) that is suitable for residential development, and unlock land for much needed housing, the Town and Country Planning (Brownfield Land Register) Regulations 2017 now require local authorities to provide a Brownfield Land Register.

"The registers will provide up-to-date information on sites that meet the criteria set out by the Regulations so planning authorities will be able to trigger permission in principle for residential development"[2].

The registers are intended to be publicly available to help housebuilders identify suitable development sites. Whether these measures will resolve the so-called 'housing crisis' in the UK remains to be seen. However, at the very least, redevelopment of this type of land offers protection to greenfield or other environmentally sensitive areas, and brings vacant or derelict sites that may have once brought blight upon an area, such as closed landfill sites, back into use. The contaminated land industry exists to facilitate this process.

Broadly speaking, since the Control of Pollution Act 1974 was enacted to address environmental issues associated with waste, land, water, atmospheric, noise pollution and abandoned mines, the contaminated land industry began in earnest. This industry is now made up of multidisciplinary environmental consultancies offering services ranging from due diligence advice to environmental engineering design. There are contractors and technicians implementing site investigations, and complex remediation techniques. Companies now exist to provide specialist equipment and technology to collect robust data and remediate pollution.

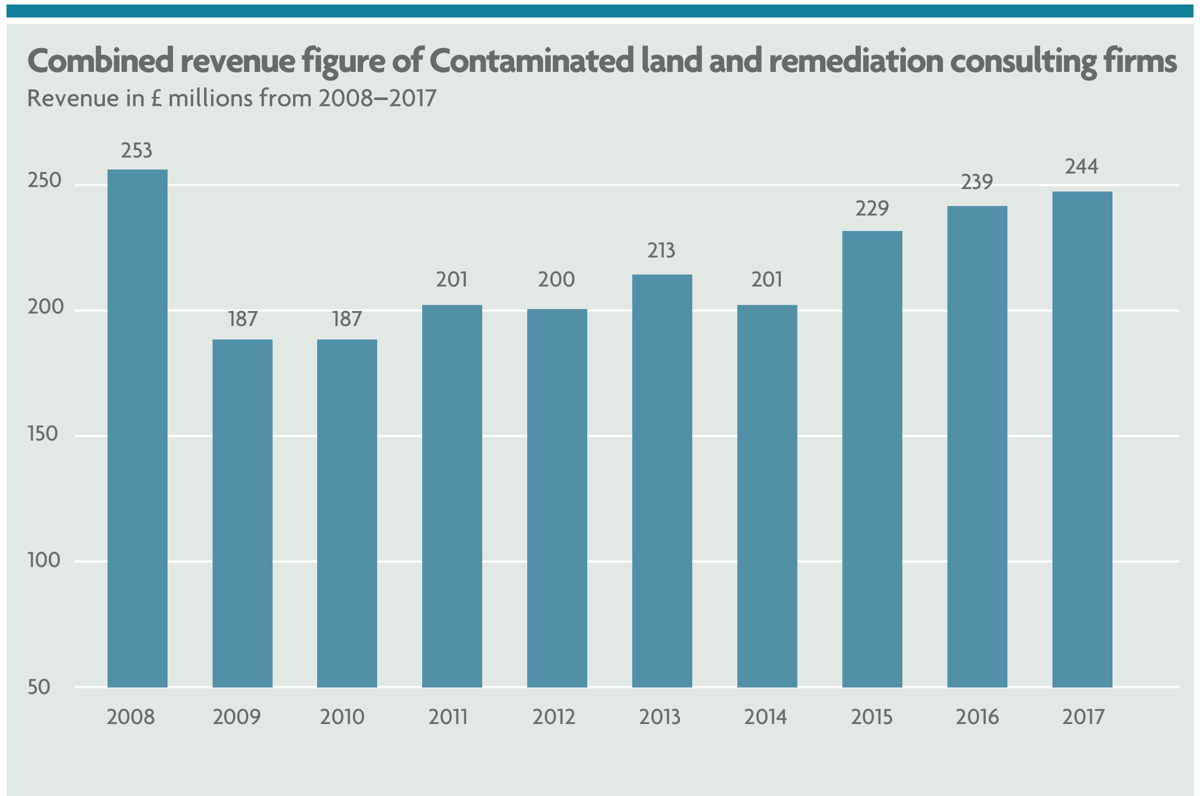
Additionally, the industry could not exist without expert legal and financial services, as well as regulators and academics, who continue to deliver research and strive to improve standards and quality.

According to 2017 figures presented by Environment Analyst (see **Figure 1**), "Contaminated land/remediation consulting revenues were estimated to be around £244 million in the UK. This does not quite reach the levels of revenue reported for 2008 of £253 million"[3]. However, the significant improvement seen since the economic down-turn possibly demonstrates the resilience and necessity of this niche industry. Since the recession, there has been significant dissolution, devolution and restructuring of environmental organisations, budget cuts, and the withdrawal and revision of guidance and planning documents that were integral to the industry. However, one pillar of the industry that remains fundamentally unchanged is Part 2A of the Environmental Protection Act (EPA) 1990.

REGULATION

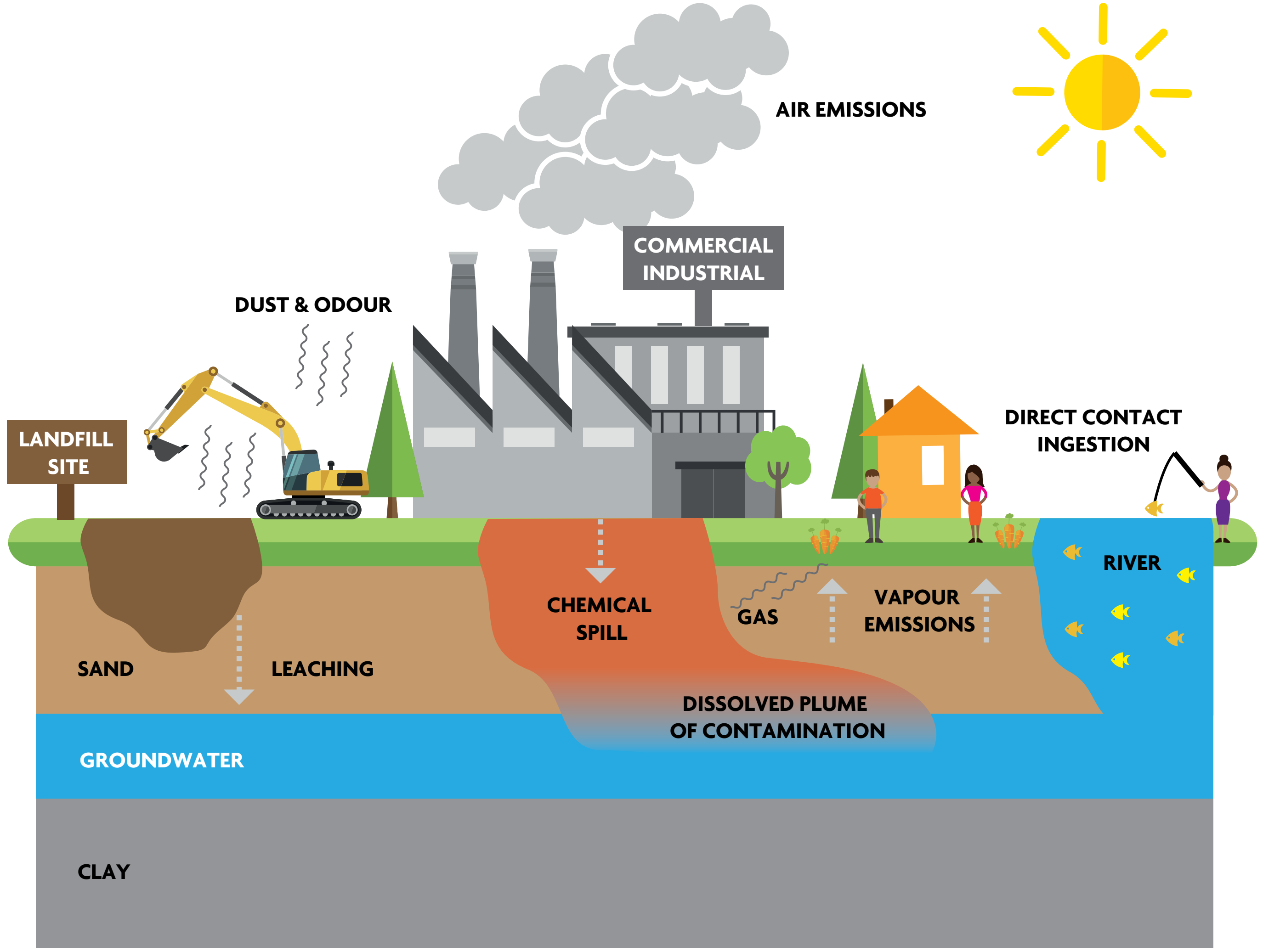
Part 2A of the EPA 1990 is the principal legal framework, which is available to deal with the legacy of contaminated land in the UK. Whether or not you believe our forthcoming withdrawal from the European Union (EU) will present risks or opportunities for the environmental industry, changes to this piece of core domestic statute legislation are unlikely. Regardless of the deal that will be eventually struck. Of course, there are many other regulations and policies with their roots in European law, such as climate change regulation, waste management and disposal, environmental impact assessments and wildlife and habitat protection, which will need to be reviewed. Potentially, therein lie opportunities for new rules and standards to be created that are more relevant to conditions in the UK with input from our own specialists, politicians and academics. The contaminated land sector is no stranger to this; industry professionals have, over some five decades, contributed to or developed a range of essential design and practice guides including:

- Various British Standards on soil quality, site investigation and sustainable remediation;
- Guides to understanding and managing risks from asbestos in soil and made ground (areas of land that are man-made), ground gases and volatile organic compounds;
- Engineering guides for the remediation of closed landfill sites;
- Guidance for the assessment and management of unexploded ordnance; and
- Industry practice for the reuse of materials.



▲ **Figure 1. Environmental Analyst market analysis of revenue for consulting firms working in Land Condition (adapted from Environmental Analyst[3]).**

INTRODUCTION



▲ **Figure 2. Mechanisms of contamination.**

Additionally, in 2017, a group of private and public sector organisations launched the National Quality Mark Scheme (NQMS). This scheme is intended to help drive improvements in the standard of work that is submitted to regulators relating to the redevelopment of brownfield land, which has attracted land quality planning conditions. NQMS provides a means of identifying whether documents have been quality checked by a 'Suitably Qualified Person' the criteria for whom is determined by the 'Specialist in Land Condition' (SiLC) registration body. Such standards of regulation are required to ensure that land which has been affected by contamination is transformed back into use in a robust manner that ensures the upmost standards of environmental and human health protection.

CONTAMINATED LAND RISK ASSESSMENT

Contaminated land assessment is a process by which professional judgement, experience, knowledge, and both qualitative and quantitative data are compiled to form a ground model, or 'conceptual site model' (CSM), similar to that shown in **Figure 2**, in order to establish whether substances have the potential to cause harm to:

- Human health via inhalation of dust and gases or contact with contaminated soils and consumption of food grown within it.
- The water environment (Controlled Waters) via direct release of liquid pollutants and from the leaching of contamination from soils.
- Building materials and structures from corrosive or explosive contaminants.
- Flora and fauna from contaminated materials bioaccumulating within the environment.

All local authorities have a duty to identify sites that would meet the legal definition of contaminated land; regulation is supplemented by the Environment Agency's (EA) role as the statutory consultee on Controlled Waters.

Solicitors have a responsibility to advise on the potential liabilities associated with contaminated sites. Site or land owners have a responsibility to ensure that they are appropriately managing environmental risks that may arise from their property. It is the role of those in industry to help establish the potential for harm from viable pollutant pathways, as set out in the CSM, and recommend ways to mitigate risk.

The way in which contamination risks are assessed has changed a great deal over time. Following the use of the Dutch Target and Intervention Values and the Interdepartmental Committee on the Redevelopment of Contaminated Land trigger concentrations, the Department for Environment, Food and Rural Affairs (Defra) and EA published a limited number of 'Soil Guideline Values' (SGVs) in 2002, together with toxicology data that was later withdrawn and replaced in 2008/2009. A new suite of SGVs and toxicology reports were then released and were derived to provide scientifically-based trigger levels, above which there may be a possibility of harm to human health. The SGVs were derived using the *Contaminated Land Exposure Assessment (CLEA)* tool, which uses toxicological data of the contaminants and generic assumptions about the site and people using it. The latest iteration of the CLEA model was released in 2015, when it was updated to include datasets from Defra's *SP1010 Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination*.

These screening criteria were originally derived from a general misuse of SGVs, and other industry derived 'generic assessment criteria', as 'clean-up' standards despite being very conservative. The C4SL derivation was also intended to help local authorities recognise sites that do not present a 'Significant Possibility of Significant Harm' (see **Box 1**).

BOX 1: POSSIBILITY OF SIGNIFICANT HARM

'Significant Possibility of Significant Harm', or SPOSH, is a term set out in Part 2A of the Environmental Protection Act 1990 for determining whether land can be legally defined as contaminated land.

The Act sets out that contaminated land is any land which appears to be in such a condition, by reason of substances in, on or under the land and that significant harm is being caused or there is a significant possibility of such harm being caused to human health or controlled waters. It goes on to state that 'harm' refers to harm to health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property.

The 'Category 4 Screening Levels', or C4SLs, were produced in conjunction with revised statutory guidance for local authorities in order to help them determine what presents as SPOSH under a new four category system; Category 4 is where the risk is acceptably low and Category 1 is where the risk is unacceptable.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INTRODUCTION


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The initial C4SLs were published in 2014 for arsenic, benzene, cadmium, chromium VI, lead and benzo(a) pyrene and consisted of pragmatic, but precautionary estimates of contaminant concentrations in soil that are considered to present an acceptable level of risk[4]. Following a consultative process that chose the contaminants considered to be most useful to the industry, a second phase of work commenced in November 2017. This will continue with the development of a further 20 C4SLs for the range of contaminants that have been selected; the project is aiming to complete in two years[5]. At this point, in the advent of the UK leaving the EU and the release of the latest tranche of industry-led screening levels for contaminated land, it will be interesting to see what new developments and innovations unfold for the industry as it enters a sixth decade. ES

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CASE STUDY

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How risk-based remediation enabled the safe and sustainable reuse of 350,000 tonnes of contaminated material

Anna Hitchmough, Felipe Couto and **Lucy Thomas** describe their successful application of a windrow turning and cover system in the remediation of colliery spoil.

Grassmoor comprises of a series of 15 lagoons within a country park near Chesterfield, UK, covering approximately 14 ha and on land covered with colliery spoil. The lagoons were previously used for the treatment of ammonia and tar impacted waste from two adjacent coking works, much of which was also contaminated with various hydrocarbon compounds. Although the lagoons were fenced, the site posed a risk both to people and animals, as well as potentially impacting subsurface groundwater and Grassmoor Brook. RemedX Limited (the contracting part of the RSK Group) was tasked with designing and implementing a sustainable remedial solution to allow the site to be safely restored to use within the wider country park.

The site had already been subject to a number of historic site investigations, and after an analysis of data gaps, RSK Group (RSK) carried out a site investigation to collect missing data and reduce uncertainty in the conceptual site model. Site works included measuring the relevant properties of soil and groundwater at the site, including bioacessability, as well as measuring the current quality of the adjacent stream and other surface water near to the site.

RISK ASSESSMENT

A conceptual site model, based on site investigation data, was developed to describe the potential pollutant linkages at the site. In addition to this, RSK implemented a scheme of extensive stakeholder engagement where 100 questionnaires were completed by the community, and site surveys were undertaken to identify how the rest of the country park was used. This data allowed RSK to quantify who was at risk, how often, and in what manner they were likely to use the site. This resulted in the production of a set of soil concentrations via quantitative risk assessment, which would specifically be protective of people using the site. RSK continued to engage with stakeholders by regularly updating a website dedicated to describing the scheme and detailing progress as the scheme was implemented. They also manned a telephone enquiry line which allowed local residents, and other interested parties, to ask questions and discuss concerns.

Risks to groundwater and surface water were assessed by detailed quantitative risk assessment (**Box 1**). This process resulted in a complimentary set of soil and groundwater concentrations which were protective of controlled waters. By combining the concentrations

▼ **Table 1. Remedial targets.**

Compound	Remedial target (mg/kg)	Driver
benzene	204	Human health
aromatic C › 12–16	6,500	Grassmoor Brook
aromatic C › 16–21	5,000	Grassmoor Brook
naphthalene	2,100	Grassmoor Brook

protective of people with those protective of water, a set of remedial targets were produced, which when achieved, would allow the site to be restored to use. An interactive modelling process was employed, with continued dialogue between remediation contracting experts (RemedX) and the RSK risk assessment team, to assess and consider all relevant site-specific parameters; allowing achievable targets to be set and agreed with all regulatory bodies. Key remedial targets (**Table 1**) were set for benzene, naphthalene and aromatic hydrocarbons of the range [C > 12–16] and [C > 16–21] because they were identified as the compounds which represented the highest levels of risk to flora, fauna and water.

OPTIONS APPRAISAL

The project was publicly funded with a fixed financial cap. Therefore, it was important to find a solution that was sustainable in terms of impact to society as well as economically, while still achieving the remedial targets. In line with the Model Procedures for the Management of Land Contamination (CLR 11)[1] process (see **Box 1**), an options appraisal was undertaken to identify feasible remediation treatment techniques. Once the most sustainable solution was found using the principles of the Sustainable Remediation Forum (SuRF-UK) Framework[2] for assessing the sustainability of soil and groundwater remediation, a remediation strategy was developed.

A total of 12 options were considered which included traditional thermal desorption, excavation and disposal at landfill, and a bioremediation scheme. The thermal desorption method was eliminated early in the options appraisal due to energy consumption, vehicle movements, economic cost, and on the basis that bench-scale test trials confirmed that bioremediation could achieve a good result with a cost and energy saving of around half, compared to thermal desorption, which translates to a saving of the order of £20 million.

CASE STUDY

▼ **Table 2. Sustainability scores for shortlisted remedial techniques.**

Criteria	Excavation and disposal	Windrow turning (active bioremediation) combined with a capping system
Costs	1	6
Benefits	4	6
Weaknesses	5	3
Sustainability	2	3
Total	**12**	**18**

Following the initial options appraisal, a number of studies were reviewed: assessment of pre-existing pilot trials of bioremediation; a bench-scale study of aerobic degradation; consideration of a CL:AIRE[3] demonstration project on hydraulic binders; an Odournet Group odour assessment for excavation and windrowing activities; and a risk assessment of site post-remediation using windrowing.

A shortlist of two remediation methodologies were selected for the sustainability assessment:

1. excavation and disposal; and
2. bio-remediation combined with a cover system.

SUSTAINABILITY ASSESSMENT

The two options were ranked in light of economic cost, benefits, weaknesses and sustainability; the latter being based on a number of environmental, social and economic criteria, aimed to strike a balance in protecting human health and the environment in a proportionate and risk-based manner. Each of these four main categories were ranked from 1 to 7, with 1 being the least suitable and 7 being the most effective or suitable solution (it should be noted that the indicators now documented within the SuRF-UK Framework were not published at the time). The scores for each category were then totalled and the scheme with the highest score was considered to be the most cost effective, practical and sustainable solution (as shown in **Table 2**).

The most sustainable solution was found to be bioremediation combined with a cover system (required for all options). Monitoring of groundwater, surface water and air quality while excavating the sludge material, and stabilising it with burnt shale (sourced on site), was also required. The mixture was bioremediated in a series of windrows on site. The bioremediated material was shaped to form two small hills and a valley that led to a wetland. A shale and subsoil mix was used to provide a covering layer as it was assessed as a substrate suitable for landscaping a public open space. The remediated site will become part of the Grassmoor Country Park once the landscape planting and grasslands are fully established in 2018.

BOX 1: DEFINITIONS

Quantitative Risk Assessment

In the context of contaminated land, a detailed quantitative risk assessment is used to define an acceptable level of risk to human and environmental receptors. The assessment simulates pollutant linkages through a numerical conceptual site model, modified according to site-specific properties.

CLR 11

Published by the Environment Agency, the Model Procedures for the Management of Land Contamination (CLR 11) provides a best practice framework, helping businesses and organisations to carry out a quantitative risk assessment to plan, instigate and validate remediation at contaminated sites.

Pollution Linkage

A pollutant linkage is the process of contaminant movement from its **source** to a **pathway** (via dispersion or ingestion, for example) and then to a **receptor** like a dog walker, a river or groundwater.

Bioremediation

In this case, bioremediation was carried out by mechanically turning materal to allow oxygenation, and leaving it in long lines of heaped material (linear windrows) for a period of a few weeks. During that time, degradation of chemical compounds takes place.

SuRF-UK

The UK's Sustainable Remediation Forum (SuRF-UK) developed a framework based on sustainability assessments, to identify the optimum remedial solution and compliance with the following six key principles:

1. protection of human health and the wider environment;
2. safe working practices;
3. consistent, clear and reproducible evidence-based decision making;
4. record keeping and transparent reporting;
5. good governance and stakeholder involvement; and
6. sound science.

While excavation and disposal of the material would have been the quickest option and produced the highest certainty of breaking the pollutant linkages (**Box 1**), it would have been prohibitively expensive. In addition, the impact to the local, relatively rural, community from multiple daily shipments of material away from the site (over 15,000 lorry movements) on local roads that are not designed for such a high volume of traffic, would have been significant. In contrast, as part of the bioremediation scheme (see **Box 1**), the only material to be disposed of off-site was just 272 t of cyanide (15 lorry movements).

As well as the significant cost savings from the bioremediation option, the impact on local roads was significantly reduced and the risks associated with uncontrolled vapour and particulate release was well controlled within the site boundary by the careful selection of working methods. The cover system of a depth of at least 300 mm of site worn shale materials made it suitable for grassland planting and was designed to provide a robust and long lasting practical solution to keep treated material out of the reach of future site users.

THE FUTURE

If such a sustainability appraisal was repeated today, it would be appropriate to follow the entire SuRF-UK Framework which was subsequently published in 2010 (see **Box 1**). This is so that the two options could be ranked using a selection of the indicators. Nevertheless, it is expected that the same outcome would be reached since the principles of this assessment were the same. The selection of the most sustainable solution encouraged regulatory confidence in an effective solution at the same time as providing good public value for money, and providing an attractive and safe public amenity. ES

Anna Hitchmough is a Principal Consultant at RSK Group Limited where she is Technical Lead for Non Aqueous Phase Liquids and specialises in detailed quantitative risk assessment. Anna is a Chartered Geologist, an accredited risk assessor under the Society of Brownfield Risk Assessor's scheme and is currently a committee member of the Geological Society of London Contaminated Land Specialist Group.

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Brownfield Registers and Permission in Principle

Ann Barker and **Michael Eaglestone** explore the newly introduced Brownfield Registers and assess the implications for the redevelopment of potentially contaminated sites.

In England, Local Authority Planning Departments, also known as the Local Planning Authorities (LPA), regulate the development of land. The most important component of the planning system is the 'Local Plan' prepared by each LPA. The National Planning Policy Framework (NPPF)[1] is also a material consideration, but by law, planning applications must be determined in accordance with the Local Plan unless valid material considerations (established through case law) indicate otherwise. The approach to dealing with land contamination through the planning system is outlined in the UK government's Planning Policy Guidance[2]:

"If there is a reason to believe contamination could be an issue, developers should provide proportionate but sufficient site investigation information (a risk assessment) to determine the existence or otherwise of contamination, its nature and extent, the risks it may pose and to whom/what (the 'receptors') so that these risks can be assessed and satisfactorily reduced to an acceptable level".

"Even if a development is acceptable and receives planning permission, it will not go ahead unless its delivery is viable"

The main types of planning permission relevant to this discussion are 'outline' and 'full'. Outline permission is based on basic feasibility information about the proposed land use and it essentially provides 'Permission in Principle' (PiP). Key aspects of the development are then controlled by planning conditions and planning obligations. Conditions can be attached where it is necessary and reasonable to do so. Full planning permission requires submission of more detailed information to demonstrate how the development will be delivered.

The type of information which must be submitted with planning applications depends on site and development characteristics, and must demonstrate that the proposed scheme is acceptable in terms of land use planning principles and environmental matters, such as land quality. Even if a development is acceptable and receives planning permission, it will not go ahead unless its delivery is viable, that is, the value of the development sufficiently outweighs the costs of developing the site.

For potentially contaminated sites, the minimum information required for planning permission is a Phase 1 Desk Study which summarises available information, such as land use history, pollution incidents, mining history, geology, groundwater vulnerability, controlled waters etc. This is then used within a risk assessment, to develop a conceptual site model and identify uncertainties.

A Phase 2 Site investigation is used to examine those uncertainties and involves intrusive investigation into the ground using trial pits and boreholes, and the extraction and analysis of samples of soil, groundwater and gas. A risk assessment will determine what, if any, remediation will be required. When remediation is complete, a verification report must be produced to demonstrate that the site will then be suitable for use.

Submission of these land quality reports may be required with the planning application or by condition on the decision notice. The principles for the investigation and assessment of land contamination are defined within CLR11[3]. The Yorkshire and Lincolnshire Pollution Advisory Group's [4] flow chart in **Figure 1** illustrates the mechanics of the phased investigation of land affected by contamination.

BROWNFIELD REGISTERS

The planning system has been under attack from those who accuse it of being too slow and cumbersome, and at fault for the persistent national under-delivery of new housing. In 2016, the Government began a consultation on changes to make the planning system more responsive and efficient[5], including the introduction of 'Brownfield Registers' and an expansion of the system for granting 'PiP'. While existing outline permissions allow developers to seek approval in principle for the development of land, the new 'PiP' procedure, brought in through Section 150 of the Housing and Planning Act 2016, now enables LPAs to proactively grant PiP for sites.

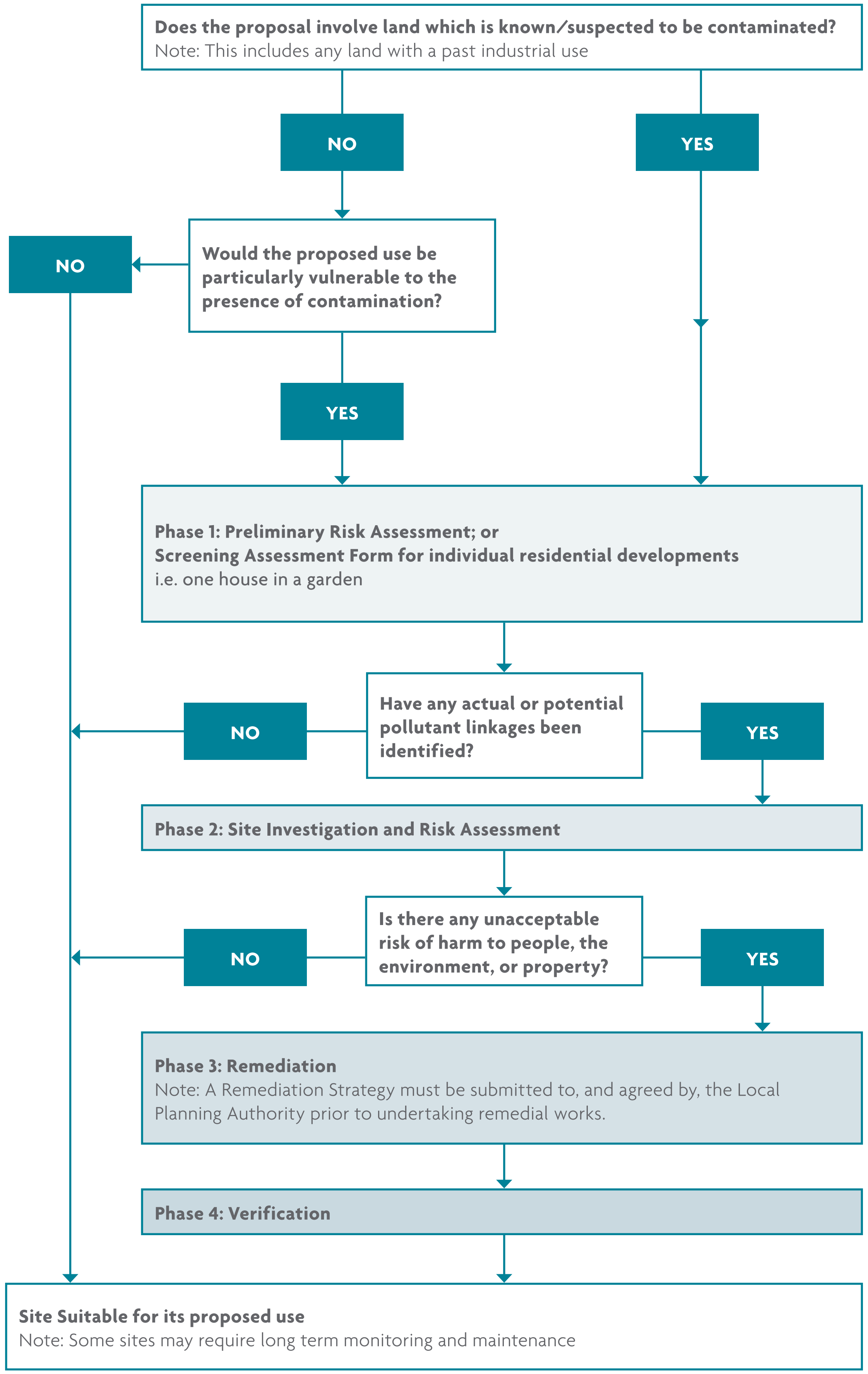
In association with PiP, legislation was published in April 2017 requiring LPAs to prepare and maintain registers of brownfield land which were identified as suitable for housing[6,7]. The purpose of Brownfield Registers is to encourage the reuse of land, stimulate regeneration and promote housing delivery.

There are two parts to the Brownfield Registers: Part 1 is a list of brownfield sites based on existing information, such as Strategic Housing Land Availability Assessments[8]; and Part 2 will be a subset of Part 1 and will comprise the land for which the LPA grants 'PiP'. The developer can then apply for 'Technical Details Consent' (TDC) to bring forward the site for development. TDC should "Particularise all matters necessary to enable planning permission to be granted without any reservations". From a land quality point of view, TDC should include land contamination reports which are not already available including, for example, a Phase 2 site investigation report and remediation strategy.

ANALYSIS OF BROWNFIELD REGISTERS: ENGLISH CITIES

For the purposes of this article, data have been collated and analysed from relevant Brownfield Registers. Given that brownfield land is likely to be concentrated in major cities and that development pressures are also likely to be greatest in these cities, it was decided to take data from the Brownfield Registers of the 13 largest cities in England, excluding London and Coventry. London was excluded because it is subdivided into multiple different planning authorities, each responsible for producing their own Brownfield Registers, and Coventry was the only city which does not appear to have published a Brownfield Register online.

▼ **Figure 1. Flow chart for the phased investigation of land affected by contamination[4].**



The collated data is presented in **Table 1** and includes averaged data for the 13 cities assessed. The findings confirm that there is no early interest in including land on Part 2 of the register. The amount of land identified on Brownfield Registers generally correlates to some degree with the population of the relevant city council (see **Figure 2**); however, certain anomalies are readily discernible, such as the disproportionately large amount of land identified by Leeds City Council and the disproportionally small amount of land identified by Liverpool City Council. Further research is warranted into the reasons behind these anomalies. They are likely to relate to both geographical factors which affect the number and size of brownfield sites located in a particular city and differences in approach, in terms of the method used to identify and sift sites for the purposes of producing a Brownfield Register.

The collated information also shows that the average brownfield site area for the 13 cities was 1.23 ha, with an average estimated minimum dwelling yield per site of 70. However, the relevant Brownfield Registers generally included a large proportion of small sites, with a smaller number of very large sites. Therefore, the majority of sites identified on all of the assessed Brownfield Registers were significantly smaller than this mean average.

In addition to the number and area of sites, and dwelling yield, the proportion of sites which have already achieved either full or outline planning permission, were also identified. On average, 57 per cent of the sites placed upon Brownfield Registers already benefit from planning permission for residential development. A couple of statistical outliers were found, for example, Liverpool chose to only place sites which had already achieved planning permission on their Brownfield Register; however, for the majority of cities, between 40 per cent and 60 per cent of sites on their Brownfield Register had already benefited from planning permission.

▼ **Table 1. Brownfield register statistics for the 13 largest city unitary authorities (excluding London and Coventry) with published Brownfield Registers.**

City Unitary authority	2016 Population (ONS Estimate)	Number of Part 1 Sites	Average Estimated Minimum Dwelling Yield	Total Estimated Minimum Dwelling Yield	Average Size of Site (ha)	Total Area of Sites (ha)	Proportion of Sites with Planning Permission	Number of Part 2 Sites
Birmingham	1,124,600	384	61	23,249	1.04	400.48	41%	0
Leeds	781,700	361	78	28,198	2.17	784.49	55%	0
Sheffield	575,400	300	74	22,243	1.04	311.58	51%	0
Manchester	541,300	326	134	43,589	1.10	358.04	48%	0
Bradford	534,300	216	53	11,465	0.84	181.94	37%	0
Liverpool	484,600	89	95	8,431	0.84	75.19	100%	0
Bristol	454,200	221	30	6,642	0.47	102.90	88%	0
Leicester	348,300	66	75	4,927	0.59	39.15	85%	0
Wakefield	336,800	144	65	9,307	1.72	247.04	38%	0
Nottingham	325,300	198	51	10,124	1.49	294.71	58%	0
Newcastle	296,500	101	72	7,307	1.43	144.21	49%	0
Brighton & Hove	289,200	172	47	8,158	0.46	78.74	35%	0
Sunderland	278,000	61	76	4,633	2.79	170.29	52%	0
Collective Average	**490,015**	**203**	**70**	**14,483**	**1.23**	**245.29**	**57%**	**0**

BOX 1: QUOTE FROM GAVIN BARWELL MP

Former Housing and Planning Minister Gavin Barwell said:

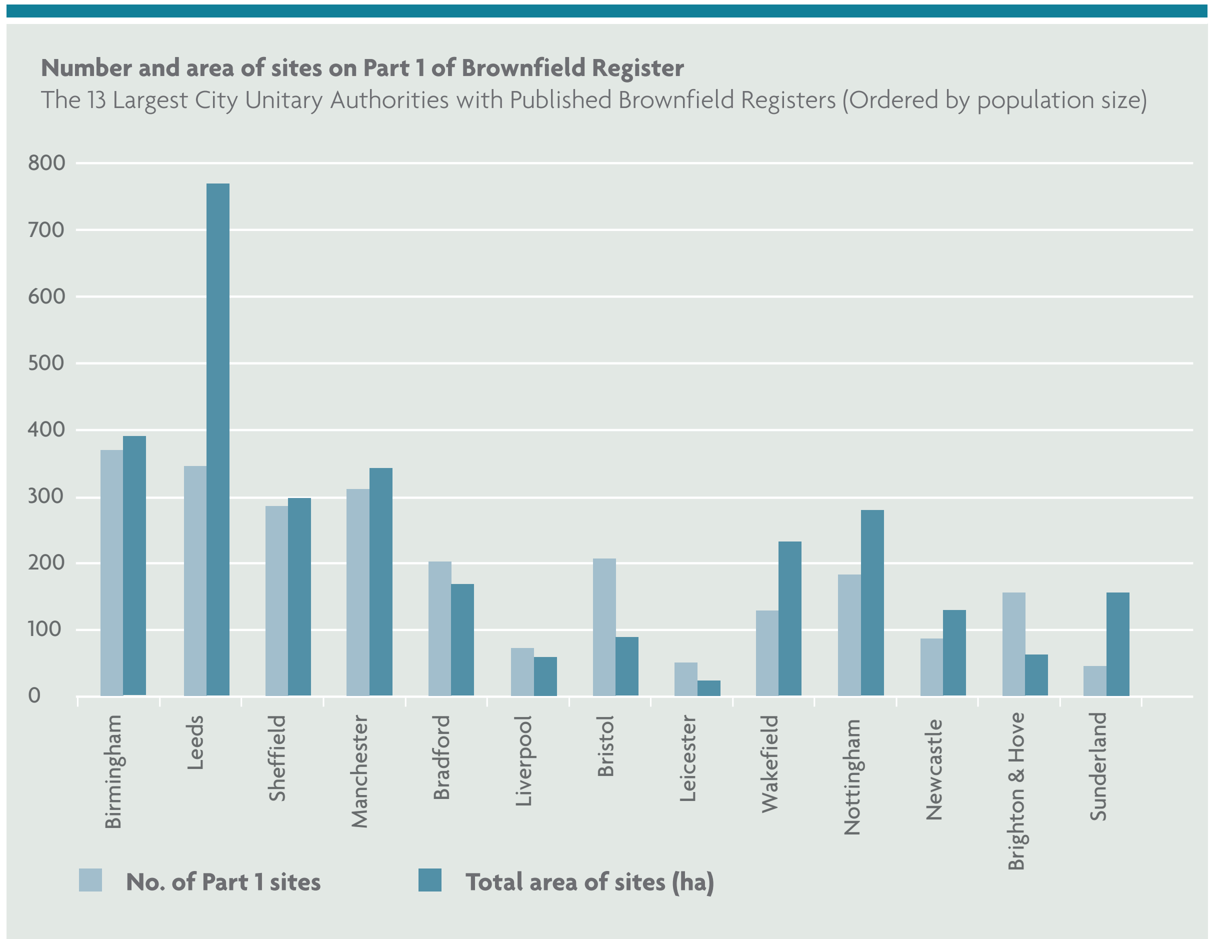
"We need to build more homes in this country, so making sure that we reuse brownfield land is crucial. We want to bring life back to abandoned sites, create thousands more homes and help protect our valued countryside. These new registers will give local authorities and developers the tools to do this"[9].

WHAT DOES THIS MEAN FOR BROWNFIELD REGISTERS?

It is very early to draw any firm conclusions from the information presented in **Table 1**, as local authorities were under a relatively tight timescale to produce their first Brownfield Register with little time allowed to fully consider any opportunities to grant PiP for the sites (by placing them on Part 2 of the register). However, this early indication suggests that use of Part 2 of the register is likely to be very limited, with wholesale granting of PiP seemingly unlikely.

Nonetheless, this research has shown the usefulness of Brownfield Registers in bringing together large amounts of data. The registers also provide a very important tool for developers and policy makers to understand the potential capacity of brownfield sites in a given area, and apply strategies to allow this land to be brought forward for development in an effective, strategic and coordinated way. The statistics presented in **Table 1** also effectively illustrate the massive potential of brownfield sites to help meet housing pressures, with the 13 cities collectively identifying brownfield sites estimated to deliver a minimum of 188,273 new homes.

It is also interesting to note that, given the increasing pressure on greenfield sites, the statistics show that a large proportion of brownfield land already has Permission in Principle, by virtue of having been granted either outline or full planning permission. The failure of housing delivery on the majority of brownfield sites is therefore clearly not due to difficulties in obtaining planning consent and instead other inhibiting factors



▲ **Figure 2. Number and total area of sites on Part 1 of the Brownfield Register for the 13 largest city unitary authorities (excluding London and Coventry).**

ANALYSIS

BOX 2: BROWNFIELD REGISTER & PERMISSION IN PRINCIPLE

Local Government Development Orders give effect to the permission in principle legislation. The Town and Country Planning (Permission in Principle) Order 2017[6] grants permission in principle for all land allocated on Part 2 of a 'Brownfield Land Register', that is, Part 2 of the brownfield land register will be a 'qualifying document' for the purposes of permission in principle.

The Town and Country Planning (Brownfield Land Register) Regulations 2017[7] specify the procedure for compiling the Brownfield Land Register and what land should go onto the register.

must be in play such as, development viability or land banking. Thus the argument that the Planning system is the main factor holding up housing delivery does not seem to be supported by this evidence.

In order for a site to be placed upon Part 2 of the Brownfield Register, the same principles should apply as they would for an outline planning application. That is to say, the contamination and geotechnical risks associated with a site should be sufficiently understood to identify the scope of remediation likely to be required to make the site suitable for the intended development. Land contamination reports are also essential to demonstrate to insurers and financiers that a development project is feasible. Verification reports must be publicly available to confirm that remediation has been completed and disruption during property transactions avoided.

A key challenge in progressing with placing sites on Part 2 of the Brownfield Register will be the ability of local authorities to gather sufficient information to be confident that sites are deliverable in terms of land quality issues and other matters. Where sites have already gained recent planning consent the challenge may be less; however, the benefits of placing sites which already have planning consent upon Part 2 of the register are debatable. Until further guidance is available about who will be expected to provide the relevant report to demonstrate the feasibility of a project, it is difficult to assess whether the changes will have a positive impact on the delivery of a housing development.

If the LPA is expected to produce or commission the necessary land quality and other assessment reports (for example, a Phase 1 desk study, a flood risk assessment, a highways and transport assessment, stability/geotechnical assessment, air quality assessment etc.), there is a massive staff resource issue which could impact on other experts such as contaminated land officers. Also of concern is the inference that TDC is to be issued 'without any reservations'. This could involve a significant pre-application expense for a developer if they are going to produce all the required land quality reports. Additionally, the TDC system does not detail whether the LPA can include conditions to require verification of remediation after the development is completed. On the positive side, there is a potential opportunity for local authorities to identify sites in their own portfolios for which they could carry out the necessary preliminary studies and bring those forward for PiP.

WHAT DOES THE FUTURE HOLD?

To be considered successful, Brownfield Registers and PiP would have to help to deliver the government's stated objective of speeding up the delivery of housing. PiP and Brownfield Registers represent two complementary new tools which should both allow developers to readily identify brownfield land with potential for development, and policy makers to better understand the strengths and opportunities offered by the brownfield land portfolios in their areas. However, the extent to which LPAs possess the resources which would enable them to make best use of PiP is uncertain. In any event, neither Brownfield Registers nor PiP address the fundamental challenges associated with the development of brownfield land, which is the capability of local authorities and the development industry to deliver housing on brownfield sites with challenging viability. **ES**

Please note that the views expressed in this article are those of the authors and do not represent the views of the City of Bradford Metropolitan District Council.

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CASE STUDY

Sunshine on the Tyne: Sustainable hydrocarbon remediation at Redheugh Gasworks

Emma King, Tim Vickers and **Neil Whalley** show how sustainability principles can be incorporated into the remediation of hydrocarbon contaminated land.

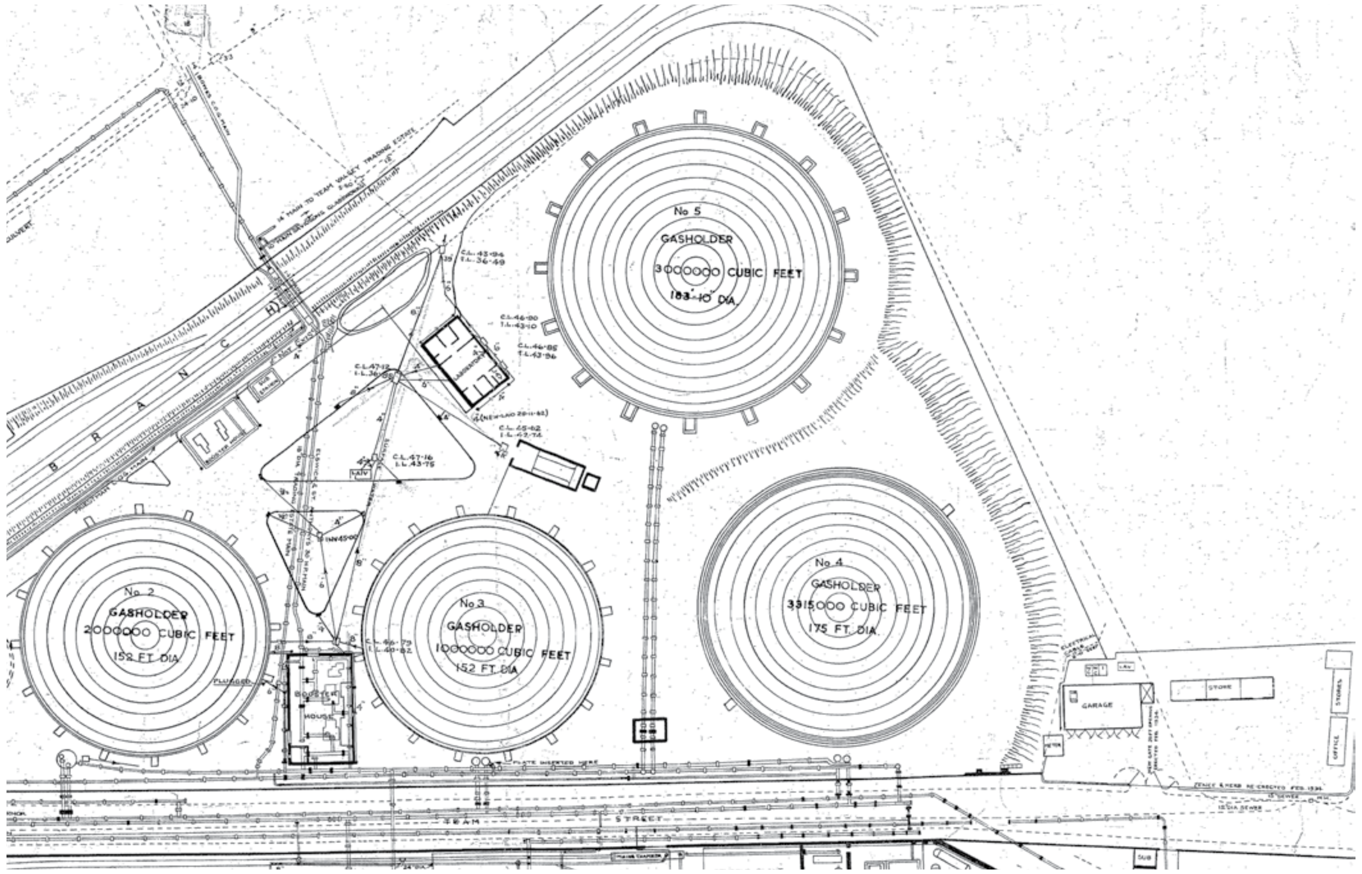
Northern Gas Networks (NGN) delivers natural gas to 2.7 million homes and businesses in North East England, northern Cumbria and much of Yorkshire through a network of approximately 37,000 km of underground pipes and 2,750 above ground asset sites covering approximately 25,000 km^2.

Prior to the introduction of natural gas and the national network of transmission and distribution in the 1960s and 1970s, gas was typically manufactured from coal and distributed on a local scale, with the result that gasworks and gas holders were common to most towns and cities. The contamination potential of former town gas production and storage sites is well established, for example in the Department of the Environment Industry Profile for Gas works[1]. As a result of this heritage, a small number of NGN's asset sites are constructed on the footprint of former town gas sites and have the potential for historical land contamination associated with this former usage.

▲ **Figure 1. Photograph taken in 1939 showing the former Redheugh Gasworks: The four gas holders on the NGN site are in the front right of the photograph[2] (© Newcastle Libraries | Flickr).**

THE PROBLEM

NGN own and operate a gas holder station at Redheugh, Gateshead ('the Site'). The Site contains three decommissioned gas holders (all three of which began demolition in 2017 and are set to complete in 2018). The Site has been a gas holder station since the 1890s and was remote from the gas production works which was formerly located off-site to the north beyond Team Street (**Figure 1**). The Site originally contained four water sealed gas holders, each comprising a telescopic metal tank set within an outer circular masonry tank, which was constructed below ground level (**Figure 2**). Gas Holder No.3, in the centre of the Site and the subject of this project, was demolished and the tank infilled during the late 1980s/early 1990s with the result that the structure is no longer visible.



▲ **Figure 2. Extract from 1936 site layout plan showing the location of the four gas holders on-site: Gas Holder No.3 is the middle of the four gas holders shown (Courtesy of National Gas Archive).**

The Site has been subject to several phases of land quality assessment since 2000, most recently in 2014 as part of NGN's land contamination management programme, which is operated to ensure that NGN's sites pose no significant risk to environmental receptors from historical land contamination. Previous investigations identified significant hydrocarbon contamination (dissolved and non-aqueous phases) in the infilled in-ground tank of former Gas Holder No. 3. Ground investigation confirmed that the in-ground gas holder tank structure has a diameter of approximately 48 m with a masonry wall and base. The base of the tank is approximately 5.7 metres below ground level (mbgl) in the centre and 9.5 mbgl in the annulus (immediately inside the tank wall). Fill materials within the holder tank typically comprised clayey gravel and gravelly clay with some tarmacadam, plastic, wood, glass and metal. The in-ground tank contained water resting at between 0.2 mbgl and 0.5 mbgl. Monitoring wells installed into the gas holder tank identified that dense non-aqueous phase liquid (DNAPL), in the form of creosote, was present within the base of the tank.

Assessment of the site investigation records identified that the DNAPL was substantially contained by the former tank structure and was considered to be hydraulically isolated from the water within the surrounding ground. As such, the contamination within the gas holder tank was not considered to pose a significant risk to environmental receptors under current site conditions and usage. However, this assessment could change in the event of degradation of the in-ground former gas holder tank wall.

The Site contains regionally important gas distribution equipment which will remain following demolition of the gas holders, with the consequence that the Site will be in NGN ownership for the foreseeable future. In recognition of the presence of DNAPL within the former holder tank and the potential for it to leak in the future, NGN commissioned a short remediation pilot trial in 2016 which lasted three weeks. The objectives of the pilot trial were to collect DNAPL samples for characterisation, provide an initial estimate of potential DNAPL volume present, and test possible *in situ* techniques for DNAPL recovery.

The remediation pilot trial confirmed the presence of significant quantities of DNAPL, which could be freely recovered from monitoring wells installed within the former holder tank by *in situ* pumping techniques. Following this successful trial, NGN commissioned an extended DNAPL recovery trial over an initial

six-month period to further characterise the volume of DNAPL present and assess the proportion which might be recoverable via *in situ* techniques. The overall objective for NGN at the Site was to achieve environmental betterment by reducing the quantity of DNAPL present and the associated risks posed to environmental receptors.

There were several key constraints at the Site which influenced the design of a suitable remediation solution:

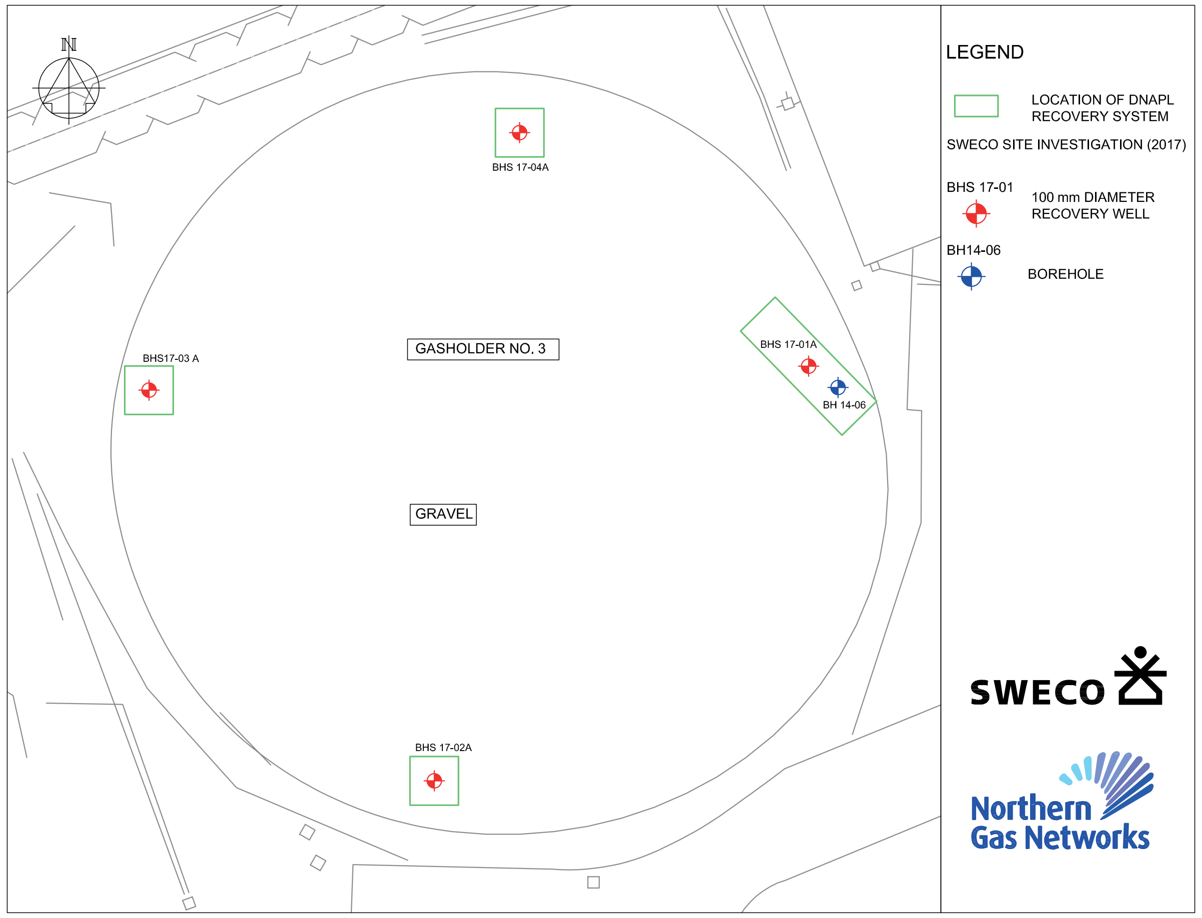
- The extended DNAPL recovery works were required to be undertaken concurrent with the large-scale demolition project underway across the wider site, meaning there was limited space available for remediation equipment;
- There was no readily accessible electrical supply within the works area on-site, and limited access to drainage.
- Telemetry could not be used to remotely monitor remediation equipment due to NGN safety restrictions regarding mobile phone usage on 'live' gas sites; and
- The Site has restricted vehicle access and is set within a wider mixed residential and industrial setting which is sensitive to vehicle movements, noise, dust and odours.

THE SOLUTION

NGN appointed Sweco to undertake the extended DNAPL recovery trial. Sweco is one of Europe's leading engineering, environmental and design consultancies. With experience gained from investigating and remediating similar former gasworks sites, Sweco designed supplementary site investigation works to delineate the extent of DNAPL within the gas holder tank and installed large diameter (100 mm) recovery wells to facilitate *in situ* remediation. Baseline monitoring and pumping tests prior to commencing DNAPL recovery confirmed the presence of DNAPL in all of the wells within the holder tank, with thicknesses ranging between 0.12 m and 1.8 m.

Sweco appointed the specialist remediation contractor, Geo2 Remediation Limited, to design, install and operate a bespoke remediation system at the Site. Bottom loading pneumatic pumps were installed in four new 100 mm diameter recovery wells and in an existing 50 mm diameter groundwater monitoring well (**Figure 3**).

An individual remediation system covering approximately 12 m² was established around each recovery well within a fenced compound.



▲ **Figure 3. Remediation system layout plan showing the location of the recovery and groundwater monitoring wells (BHS17-01A, BH17-02A, BHS17-03A, BHS17-04A and BH14-06).**

Table 1. Summary of sustainability benefits of the DNAPL remediation system used at Redheugh Holder Station.

Remediation system feature	Environmental benefit	Social benefit	Economic benefit
Use of entirely renewable energy source	Carbon savings and air quality benefits compared to use of electricity from mains or on-site generators. Use of four individual petrol powered generators, to enable the same operation, would have generated approximately 18 t of CO_2. This is equivalent to driving an average car non-stop for 29 days[3].	Minimal impact for site neighbours. Quiet system compared to use of on-site generators. No air quality impacts from emissions from generators or equipment.	No ongoing operational energy costs. Use of four individual petrol powered generators, to enable the same operation, would have cost approximately £5800 more in equipment and fuel than the solar powered solution used.
In situ remediation targeting DNAPL	Waste generation minimised. Vehicle movements associated with waste disposal minimised thereby limiting carbon and air quality emissions.	No significant odours, noise or dust during operation. Vehicle movements associated with waste disposal minimised, and thereby associated nuisance and vehicle emissions minimised.	Waste disposal costs optimised.
Remote operation with minimal maintenance requirements	Monthly maintenance visits required only, thereby limiting carbon and air quality emissions from vehicles.	Vehicle movements associated with maintenance visits minimised, and thereby associated nuisance and vehicle emissions minimised.	Minimal maintenance costs.

Figure 4. Remediation pumping system for well BHS17-04A (© Tim Vickers).

The remediation systems comprised of a pneumatic pump which recovered DNAPL and contaminated water into intermediate bulk containers (two per system) stored within constructed bunded areas. Each system was fitted with a high level cut off switch to prevent over filling of the storage vessels. The need for a small operational footprint was a key design condition due to the space requirements for the ongoing gas holder demolition works across the wider site. **Figure 4** shows the pumping system at well BHS17-04A.

Each pneumatic pump was powered by an individual receiver compressor connected to a battery and a timer/controller unit. The battery was charged via a 100 W photoelectric solar panel; this was an important aspect of the design as there was no readily accessible electrical supply on the Site and it also delivered a renewable energy source. Examples of similar solar powered remediation systems in the UK are rare.

Each pumping system could be set at user defined intervals to suit the recovery characteristics of each well and the volume of DNAPL being recovered at that location, while also balancing the power requirements from the battery. During the six months of operation, pumping intervals within the wells ranged between 3 s/hr and 30 s/50 hrs, with the interval within each well being reviewed during each maintenance visit.

Monthly site visits were undertaken by Sweco and Geo2 to monitor the DNAPL thickness, undertake maintenance works and adjust the system to optimise DNAPL recovery rates. The system was designed to be both robust and durable, with only minimal moving parts allowing for easy maintenance and also confidence that it could operate remotely with no requirement for full time supervision.

Over the six months of operation (June to December 2017), the system proved to be very successful with the removal of a total of approximately 4,370 l of DNAPL. This was periodically removed from site by a specialist and licensed waste disposal contractor, via a vacuum tanker, to their treatment facility in Middlesbrough.

The durability of the system has allowed for continued operation with only minimal maintenance required. The solar panels continued to maintain power to allow optimum operation of each system during the shorter daylight hours of the winter months.

A SUSTAINABLE SOLUTION

NGN are developing a new Environment Strategy taking them to 2050 which has been influenced by the United Nations Sustainable Development Goals. This strategy includes five main focus areas targeted at reducing NGN's environmental impact, with the remediation of historical land contamination at its asset sites such as Redheugh Holder Station, forming a strategic element. The remedial solution utilised at Redheugh Holder Station featured many sustainability benefits which are summarised in **Table 1.**

Operation of the remediation system at Redheugh Holder Station was successful in the removal of DNAPL during the six months of operation, utilising only solar energy while having no significant impact on wider site activities or site neighbours. While the operational interval of the remediation equipment had to be balanced against power generation from the solar panels, this project demonstrated this to be a successful approach to deploy on sites where the physical characteristics of DNAPL being removed require a slow sustained rate of recovery, and where there are no specific remediation time constraints such as in a development programme. Following this successful outcome, NGN are continuing remediation works at the Site for a further 6 months. ES

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Tim Vickers is a Chartered Environmentalist and Principal Consultant at Sweco, with 17 years' experience in contaminated land investigation, assessment and remediation.

Neil Whalley is a Chartered Geologist and Environment Strategy Manager at NGN and has 14 years' experience in land contamination management.

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TECHNICAL

Sustainable remediation: It's not what you do, it's the way that you do it!

C. Paul Nathanail discusses why we should all be moving towards sustainable remediation.

Safe as houses is only true if the condition of the land the houses are built on has been competently investigated, the risks assessed, and, if necessary, reduced. The past use of a site or its natural geology can result in contamination of the ground that future residents could be harmed by. Residents could be exposed to such soil contaminants by eating the soil or home grown produce, inhaling dusts and vapours or by skin contamination. Remediation is the process of dealing with the risks of such exposure safely and in a timely manner. The UK has been at the forefront of reusing land since the 1970s and robust policies, rigorous regulation and competent practitioners have delivered thousands of hectares of safe land for developers to build our homes on.

WHAT CHANGED?

In the past decade or so there has been a worldwide realisation that the process of remediation can have social, environmental and economic impacts. The way remediation was carried out was in need of a review, as well as the technical aspect of managing the risk. Beginning in the US in 2007, a series of sustainable remediation fora, such as the UK Sustainable Remediation Forum, developed to share information and raise awareness of the new concept of 'sustainable remediation'.

In July 2017, the International Standards Organisation published the first standard on sustainable remediation. It was soon adopted as a British Standard: BS ISO 18504:2017[1]. Sustainable remediation, according to the standard, is the "Elimination and/or control of unacceptable risks in a safe and timely manner while optimizing the environmental, social, and economic value of the work"[1].

Risk based land management uses risk assessments, followed if necessary, by risk reduction. Risk assessments conclude with evaluation, at a specific site and within a specific legal context, of whether or not the level of risk posed by contaminants to human health requires intervention. Intervention can be in the form of changing the land use to a less sensitive one, to prohibit certain activities or to actively break the link between the contaminant and people, that is, to remediate. It is at this point, once remediation has been deemed necessary, that BS ISO 18504 comes into its own; the risk assessment is used to decide whether to remediate and sustainable remediation is about how to do so.

Long standing government guidance, the *Model Procedures for the Management of Land Contamination* (CLR 11)[2], provides a technical framework for applying a risk management process when dealing with land affected by contamination. CLR 11 uses a process of 'remediation options appraisal' to select a suitable remediation strategy which comprises of one or more technologies that can be used to deal with the contaminant or prevent it from coming into contact with people. This process ensures the selected remediation strategy can do the job of risk reduction given the site-specific constraints and project specific objectives.

Site-specific constraints may include: the space available for equipment; the nature of the soil or anthropogenic material (formerly known as made ground); the nature of the contaminants; and the presence of occupied buildings. Project specific objectives may include: the time within which remediation needs to be completed to allow redevelopment; budget limits which may favour slow (but cheap) options over faster (but costly) options; avoidance of nuisance to neighbours; and the nature of the eventual land use.

FINDING THE MOST SUSTAINABLE REMEDIATION STRATEGY

BS ISO 18504:2017 introduces a new criterion. Once a short list of, for instance, three or four feasible remediation strategies has been identified and compared, rather than choosing the quickest or cheapest strategy, the one that delivers the optimal environmental, social, and economic value is chosen (the most sustainable remediation strategy).

Five indicator category sets are identified for each of the environmental, social, and economic aspects of the remediation. From these categories, individual indicators are chosen that can differentiate the shortlisted strategies. For example, the emissions of greenhouse gases, likely impact on local traffic levels or cost of stop-loss insurance may be used as environmental, social, and economic indicators respectively. Specific indicators can be measured in different ways and there can be no fixed list indicators[3]. A general principle though is to use the smallest number of indicators needed to identify the most sustainable strategy, and to combine those indicators in the simplest way possible. This helps minimise the time and cost of the process of identifying the most sustainable of the shortlisted remediation strategies. This method leads to a qualitative or semi-quantitative approach, rather than full blown quantitative form such as life cycle analysis. Such an approach is compatible with the principles of parsimony and Occam's razor (see **Box 1**); it is better to be comprehensive in the coverage of all relevant indicators than to be sophisticated in the quantification of a few.

BOX 1: OCCAM'S RAZOR

Occam's Razor is a philosophical principle dictating that, when given multiple options, the option with the fewest assumptions should be taken. Therefore, when you have two competing theories to solve the same problem, the simpler theory is better.

BS ISO 18504:2017 emphasises a strong preference for simple comparisons of feasible remediation strategies, once the indicators have been selected. Such comparisons could be simple rankings – which is the best option from an environmental, a social, and an economic perspective; these rankings can then be used to create a 'medal table'. Only rarely, if ever, are thorough life cycle analyses required.

QUESTIONS, QUESTIONS

Delegates at commercial exhibitions or conferences will come across claims from technology vendors or consultants that their products or services are sustainable or even constitute sustainable remediation. What these claims usually mean is the products have been developed to reduce energy consumption, greenhouse gas emissions or some other aspect of the environmental performance of a technology. ES

Readers of this article are encouraged to read BS ISO 18504:2017 and are welcome to contact the author with their thoughts, findings or questions.

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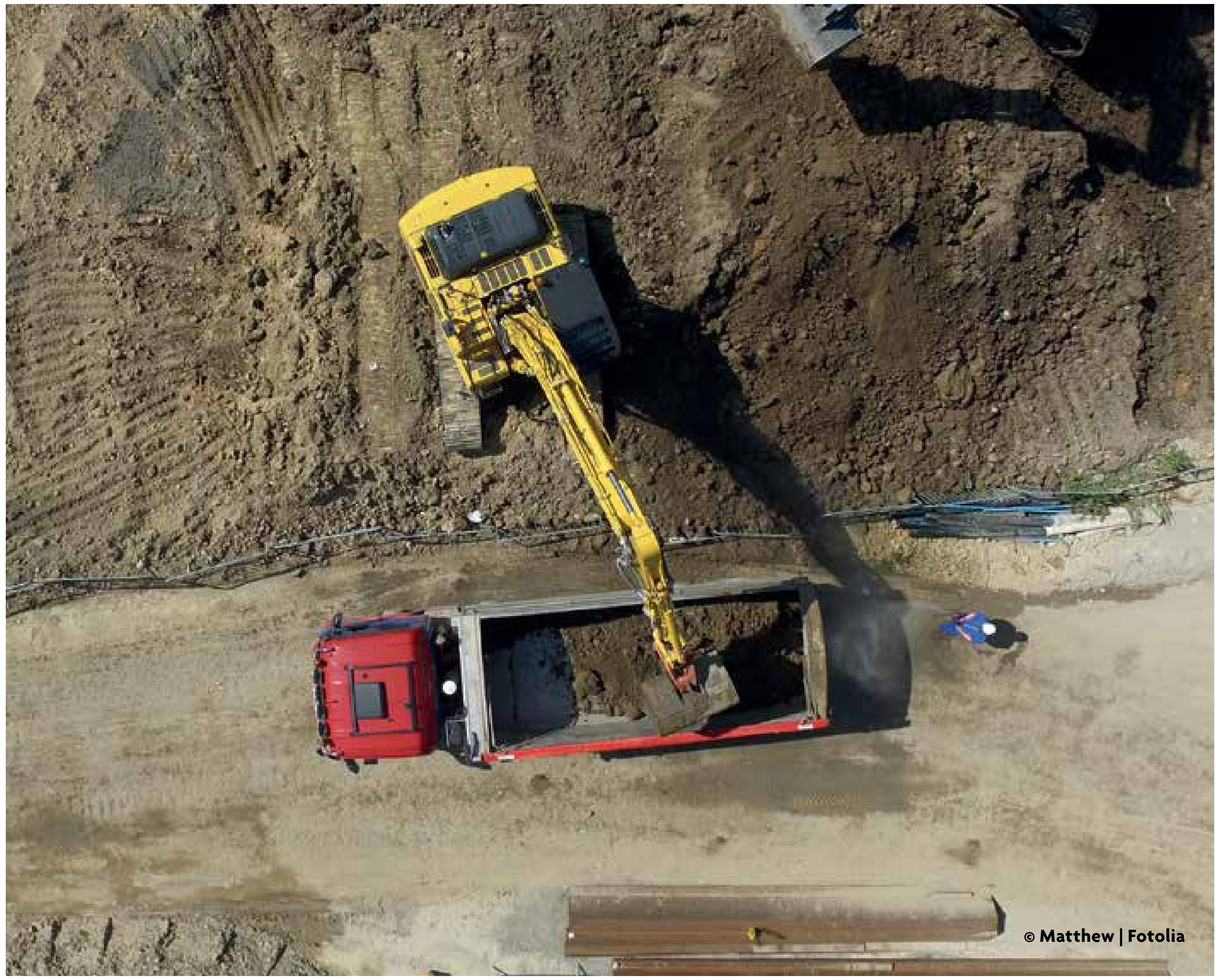
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Incorporating sustainability into land condition assessments

Vivien Dent describes how sustainability considerations can be incorporated into land condition assessments by using risk-based assessments, sustainable remedial solutions and by considering sustainable management practices.

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FEATURE

When managing risk at sites affected by land contamination, the Model Procedures for the Management of Land Contamination (CLR11)[1] provides the key framework. There are three main components to the risk management process in CLR11: risk assessment, including ground investigation; options appraisal; and implementation of the remediation strategy. All three components have the capacity for sustainability considerations to be incorporated, this can be achieved by:

- Ensuring an appropriate scope of investigation and testing, and deriving risk-based remedial targets (typically site-specific target chemical concentrations in soil or water) at the risk assessment stage that are achievable and reasonable;
- Undertaking a sustainability assessment at the options appraisal stage to determine the social, economic and environmental benefits or impacts of relevant remedial options, taking into account the relative costs, the environmental impact and the resources required to achieve the risk-based target concentrations; and
- Executing the sustainable solutions at the implementation stage that were identified during the remedial options appraisal and by using sustainable management practices, for example, energy consumption, working hours and mode of travel.

These stages, if followed, ultimately result in the use of a sustainable remedial solution to break the identified site-specific source-pathway-receptor linkages.

CLR11 states that with respect to historic contamination: "Technical obstacles as well as potentially large costs mean that it is often neither feasible nor realistic to think in terms of total clean-up of past damage. Instead, the goal is to find solutions that identify and deal with risks from contamination in a sustainable way", and that "At several stages of the risk management process, judgements have to be made about the relative costs and benefits of particular courses of action or decisions. This 'cost-benefit analysis' is an inherent part of the management of environmental risks in a sustainable way, and is a formal component of particular stages of regulatory regimes".

The Environment Agency's approach to groundwater protection[2] supports the UK government's objectives to deliver sustainable development (see the UK National Planning Policy Framework[3] for further details) and states that one approach used to address existing land contamination is by "collaborating with others to develop a framework, tools and guidance that help identify and sustainably deal with land contamination set out in Model procedures for the management of land contamination (CLR11)". Furthermore, the Environment Agency approach to groundwater protection states that "Sustainable remediation seeks to manage unacceptable

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Table 1. Examples of sustainable management practices in site investigations.

Sustainable management practice	Benefit/Impact		
	Social	Economic	Environment
Use local labour.	People away from home less.	Generates local employment. Lower travel costs.	Reduced emission levels.
Hold a toolbox talk at the commencement of works specifying the work, the mitigation measures, the sensitive receptors and health and safety requirements. For example, what to do in the event of a spill.	Certainty about what is required. An opportunity to clarify uncertainties.	Work more likely to be conducted correctly.	Informed response to any spills on-site.
Turn equipment off when not in use.	Better air quality.	Lower fuel costs.	Reduced emission levels.
Separate made ground arisings from natural soil and reinstate soil from where it was excavated.		Materials do not become mixed therefore, a potential reduction in disposal costs.	Contaminated horizons do not become mixed with 'clean' soil.
Consider using reusable sampling equipment.		Lower purchase and waste disposal costs.	Less waste production.
Consider the use of real-time monitoring equipment.	Fewer vehicle movements. Truer reflection of conditions being monitored and thus more certainty in decision making.	Lower travel costs.	Reduced emission levels. More data obtained and therefore, increased certainty.

risks to human health and the environment (including groundwater), whilst optimising the environmental, economic and social benefits", and references the SuRF-UK framework[4].

BS ISO 18504:2017[5] defines sustainable remediation as the "Elimination and/or control of unacceptable risks in a safe and timely manner whilst optimising the environmental, social and economic value of the work". The various stages of sustainability assessment are briefly introduced over the following sections using a range of examples.

SUSTAINABLE MANAGEMENT PRACTICES

Sustainable management practices can be incorporated into every stage of the risk management process, where technically appropriate for the specific project. A comprehensive list of sustainable management practices can be viewed on the SuRF-UK website[6].

Table 1 gives some examples of the sustainable management practices that could be incorporated at the site investigation stage.

When relatively simple sustainable management practices are implemented and recorded on a project, social, economic and environmental benefits can easily be achieved and measured.

RISK ASSESSMENT

An investigation conducted on a depot site showed that the underlying geology comprised of interbedded mudstone, siltstone and sandstone. These strata formed an aquifer beneath the site that the Environment Agency classified as a 'Secondary A Aquifer' (permeable layers capable of supporting water supplies at a local rather than a strategic scale and, in some cases, forming an important source of base flow to rivers). Groundwater beneath the site was shown to be flowing towards a surface water receptor: a river approximately 150 m from the site.

On-site groundwater quality monitoring identified the presence of dissolved-phase petroleum hydrocarbons and non-aqueous phase liquids. A consequent detailed quantitative groundwater risk assessment to controlled waters concluded that on-site sources presented an unacceptable risk to groundwater and a nearby river, from the dissolved-phase petroleum hydrocarbons. Achievable site-specific remedial target concentrations were derived for soil and groundwater using the Environment Agency's 'Remedial Targets Methodology'[7].

During this phase of the assessment, further ground investigations and more detailed risk assessments can be conducted to reduce uncertainty, if it is considered that there is insufficient data to assess the contamination status of the site adequately.

OPTIONS APPRAISAL & SUSTAINABILITY ASSESSMENTS

A remedial options appraisal for the same depot identified two possible solutions that were likely to be the most effective for the site to achieve the remedial targets:

- option A – dual-phase extraction alone; and
- option B – *in situ* thermal technologies (i.e., steam injection) in conjunction with either pump and treat or dual-phase extraction.

A sustainability assessment was undertaken to identify the optimum remedial solution. This can take the form of either a qualitative, semi-quantitative or quantitative assessment, but each requires detailed information. The assessment should be undertaken at the lowest level that will enable robust decision making.

The SuRF-UK framework[4], for assessing sustainable remediation, states that a sustainability assessment should aim to comply with six key principles:

a. protection of human health and the wider environment;
b. safe working practices;
c. consistent, clear and reproducible evidence-based decision making;
d. record keeping and transparent reporting;
e. good governance and stakeholder involvement; and
f. sound science.

The SuRF-UK indicator set[8] identifies 18 sustainability indicator categories in the social, environmental and economic pillars of sustainability to be used in the assessment of remediation options. Indicators in these pillars include items, such as health and safety, soil and ground conditions, and direct economic costs and benefits. Within these 18 indicators, parameters, such as vehicle movements, improvements in water quality, waste disposal distances and economic cost of active remediation with land value increase, are also evaluated. Decisions include identifying the relevant stakeholders, the boundaries within which the assessment is to be undertaken (i.e. the criteria to be evaluated), the indicators used and the sensitivity of any scoring used.

Table 2. Sustainability assessment results for the semi-quantitative assessment.

Sustainability pillar	No further action	Option A	Option B
Environment	5	3	3
Economic	-3	-21	-23
Social	-6	-21	-7
Total	**-4**	**-39**	**-27**

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The key stakeholders identified for the depot site were the property owner and the regulators (the local authority and the Environment Agency, respectively), given that the contaminant linkage for which any remediation would be driven pertained to the water environment.

The assessment boundaries considered were:

- energy use;
- waste generation, for example, wastewater treatment;
- contamination within the site boundary only; and
- timescales of < 1 year, 1–10 years and > 10 years.

Areas of uncertainty were considered and documented. Two key uncertainties were identified: recontamination of the site by off-site sources that might cause longer timescales for remediation (these may have unknown financial and liability implications and result in uncertainty in gaining approval from regulators); and no pilot trials on the possible remedial options.

QUALITATIVE SUSTAINABILITY ASSESSMENT

A qualitative sustainability assessment does not include any metrics. A qualitative assessment was undertaken for the depot using the descriptors of equal, better and worse. There was found to be a greater appearance of 'better' descriptors for option A, so this option seemed to be the more sustainable option.

SEMI-QUANTITATIVE SUSTAINABILITY ASSESSMENT

A simple in-house semi-quantitative assessment, involving ranking the sustainability pillars and scoring the indicators, was undertaken for the depot site.

Scores ranging from +1 to +9 for positive impacts and from -1 to -9 for negative impacts, were given. Impacts not considered relevant were excluded (by ranking these as 0).

▼ **Table 3. Total carbon dioxide emissions compared with total hydrocarbon mass removed.**

	Option A	Option B
Travel kg CO_2/month	176	176
Plant (fuel) kg CO_2/month	26,800	10,720
Shipping kg CO_2/month	118	118
Lorry movements kg CO_2/month	536	536
Total/month kg CO_2/month	27,630	11,550
Number of months	9	24
Total carbon dioxide emissions (kg)	248,677	277,219
Potential total hydrocarbon mass removal (kg)	20,210	5,052
Cost (£)	250,000	310,000
Carbon dioxide emissions/kg of hydrocarbon removed	12.3	54.86
Cost/kg of hydrocarbon removed (£)	12.37	61.35

The ranking and scoring of the pillars resulted in a total score for each sustainability pillar of between +90 and -90 and the results are given in **Table 2**. A positive score meant a net benefit from intervening, a negative score meant a net negative impact from intervening, and a score of zero meant that the solution was neutral. Option A and B both had positive scores for the environmental pillar owing to the overall potential improvement to controlled water pollutant linkages.

In terms of the economic pillar, each remediation option scored negatively overall mainly because of the costs associated with implementing, running and maintaining the remedial systems and the emphasis given to economic cost (given the remediation would be undertaken voluntarily and funded by the client). For the social pillar, taking no action would have meant a marginal negative impact owing to the uncertainty in the data, and the fact that the regulators had not been consulted regarding remedial options.

Both active technologies would have had, overall, a negative impact due to short or medium term site staff safety issues associated with operating the equipment. There would have also been short or medium term negative impacts on local residents and businesses, and uncertainties regarding the effectiveness of the remediation technologies. The assessment indicated that none of the remedial options were sustainable overall.

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▼ **Table 4. Costs and other key factors associated with remediating the aquifer.**

Item	Anticipated remedial costs ranked in order of environmental benefit		
	Monitored natural attenuation	Groundwater treatment using chemical oxidation	Excavation of soil to groundwater level
Value of aquifer (£)	3,285–32,850	3,285–32,850	3,285–32,850
Anticipated total cost (£)	15,641.18	1,824,000–1,760,010	1,146,000–3,756,000
Operation time (years)	2	2	1
Probability of success	High to moderate	High to moderate	High to moderate
Environmental benefit	2	2	-8

QUANTITATIVE ASSESSMENT: COST-BENEFIT ANALYSIS

Quantitative assessment, if undertaken, is unlikely to be conducted for all indicators. For the depot site, cost-benefit analysis was undertaken to assess the carbon dioxide emissions against the total hydrocarbon mass removed by the two remedial options. The mass of petroleum hydrocarbons in the source areas was conservatively estimated to be some 43,800 kg. The total hydrocarbon mass removed was estimated using experience of the remedial options on other sites (see **Table 3**).

The results indicated that on a carbon footprint basis, option A was better than option B, which confirmed that the remedial solutions identified for removing petroleum hydrocarbons from soil beneath the site were energy intensive.

In a second example, cost-benefit analysis was used to determine whether the cost of remediation outweighed the resource potential of the aquifer being remediated. The aquifer in question was considered of low resource potential for several reasons. **Table 4** summarises the estimated resource value of the aquifer, the costs for each remedial technique (including operation time), the probability of success and the environmental benefit calculated in a semi-quantitative assessment.

The assessment demonstrated that the cost of remediation was disproportionate to the value of the aquifer, so it was agreed with the stakeholders (the Environment Agency in this case), that remediation was not required. ES

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Approaching asbestos: Remediation and reuse

Simon Eden and **Patricia Gill** describe successful techniques used to remediate asbestos contaminated soil at two city centre sites in Leeds.

© Simon Eden

CASE STUDY

The mention of asbestos often strikes fear in the thoughts of many people, including professionals in the construction industry, their clients, and members of the general public. Considering there were approximately 5,500 asbestos related deaths in the UK during 2014[1], those fears are not without basis. Every fibre inhaled into the lungs increases the potential for asbestos related illnesses to develop, typically many years to decades later. That risk is reflected in Part 2, 11(1) of The Control of Asbestos Regulations (CAR) 2012 which state an employer must:

"Prevent the exposure to asbestos of any employee employed by that employer so far as is reasonably practicable; and where it is not reasonably practicable to prevent such exposure, to take the measures necessary to reduce exposure to asbestos of any such employee to the lowest level reasonably practicable"[2].

What many people are unaware of is that asbestos fibres are present in the air that we breathe in every day, with concentrations normally higher in urban settings than in rural environments.

The construction and demolition industries have progressively been improving standards. Various bans on the use of asbestos products have culminated in the Asbestos (Prohibitions) Regulations 1999. In contrast, going back to the last century, reports in the geo-environmental industry, particularly prior to the 1990s, often did not feature asbestos as a possible contaminant. Even as asbestos started to be included in the analysis of soil as a potential contaminant, there was little industry consensus on what level of risk asbestos in soil posed. For example, what level of asbestos in soil is acceptable in residential garden topsoil and would a regulator agree? Since 2014, that situation has dramatically altered and those changes are currently changing industry practice.

While the *CAR 2012 Approved Code of Practice*[2] kept its focus on the construction and demolition industries, it was initially the CIRIA (2014) *Asbestos in Soil and Made Ground: A Guide to Understanding and Managing Risks*[3] and then the CL:AIRE (2016) *CAR-SOIL*[4] that led to a much greater understanding of the approach to assessing and managing asbestos in soil. Asbestos in soil has gone from being a forgotten aspect, to a feared and misunderstood contaminant, to one that is much better understood and can be properly assessed.

CASE STUDIES

There are four categories that work with asbestos falls into:

- licenced work;
- notifiable non-licenced work;
- non-licenced work (not notifiable); and
- outside of CAR 2012.

CASE STUDY

▲ **Figure 1. Quarry Hill site during remediation (© Simon Eden).**

WYG's Geo-environmental team recently managed the remediation of two sites in Leeds (at Leeds Arts University and at Quarry Hill) where asbestos was the key contaminant of concern, and sustainability of the remediation was a major driver in the cost and programme of both projects. The licenced remediation project at Leeds Arts University won a Brownfield Briefing Award in 2017 for best reuse of materials. Quarry Hill, in central Leeds, was a remediation project in which the asbestos works were non-licenced.

CASE STUDY 1: LICENSED REMEDIATION

Leeds Arts University is located close to Leeds city centre, opposite the main entrance to Leeds University. The 0.27 ha constrained site comprised of a car park where planning permission had been granted for the construction of a new teaching block.

The Phase I geo-environmental desk study identified that a former school had been present on the site which was built in 1896 and demolished by 1978. Architectural records showed the former school to have had two basements, the lower of which included a swimming pool, a boiler room and heating ducts. What was not immediately obvious was that:

- the boilers were of a type that had sprayed asbestos insulation;
- the heating pipework through the ducts was covered by lagging, which had degraded to spread loose asbestos fibres through the ducts;
- the swimming pool was surrounded with asbestos insulation board which had degraded through decades of being left underground; and
- material containing asbestos including degraded asbestos insulation board had become mixed through the subterranean demolition rubble.

Any one of these aspects was sufficient to classify works that disturbed these features as being licenced work, but this site had all the worst forms of asbestos containing materials (ACMs) combined.

Enabling works were required to remove the sub-surface structures, voids, and the uncompacted made ground. The area was backfilled to an engineering specification using site-won material to provide a suitable founding stratum for the new building, which was to be piled with a suspended ground floor slab.

The remediation specification for the works was being developed as *CAR-SOIL 2016*[4] was being released, so it was important that the remediation contract adhered to the new guidance. Few earthworks and remediation contractors hold an asbestos licence, so even leading remediation contractors had to partner with other companies in order to be considered for the work. Sanctus Limited, a remediation contractor with an asbestos licence, was appointed to undertake the works.

The site was located adjacent to one of the main routes into Leeds city centre with no potential for heavy goods vehicles (HGVs) to turn on-site. Therefore, bringing HGVs onto site to remove material for disposal or off-site treatment would have resulted in traffic management difficulties. Waste disposal of soils containing ACMs classifies them as hazardous waste[5], and would have been prohibitively expensive. The only feasible option was therefore to treat the soils, demolition materials and excavated underground structures on-site. This involved hand picking out any ACMs from the rubble, and licenced works to remove the lagged pipework and associated ducts, and the boilers and boiler house.

Materials were then screened, crushed and processed on-site enabling:

- the re-use of soils and crushed materials in the earthworks to meet the engineering specification for the slab;
- the reduction of risk to the piling contractors should they decide to use piling methods which generated arisings instead of driven piles; and
- the upper one meter of soil to have a complete absence of ACMs and asbestos fibres where the piling mat, piling caps, landscaped areas, service trenches, movable soil access ramps, and the lift shaft base were to be constructed.

At the end of the works, approximately 10 t of asbestos had been removed from the ground in a city centre environment adjacent to housing, offices, and a main road. The works had included a 9 m deep excavation adjacent to the road on one side of the site and a 4–5 m retaining wall up to the houses on the other side.

Only 0.1 per cent of soils were disposed of to landfill (10 m^3) because the soils had been in direct contact with degraded lagging, so it was considered safer to dispose of them (despite no visual ACMs and the laboratory sample recording asbestos below the level of detection). Excluding asbestos waste which was disposed of, 97.4 per cent of all processed material was reused on-site and 99.9 per cent was reused or recycled in total.

The maximisation of reuse of material on-site saved some 1,850 lorry movements against a disposal and import option; it also saved costs and was a sustainable remediation approach. A critical reason this was

CASE STUDY

▲ **Figure 2. Quarry Hill site post remediation (© Simon Eden).**

achieved was because the risk from asbestos had been understood in light of *CIRIA C733*[3], and the remediation specification was innovatively written, agreed with the regulator and amended to reflect the progress of the works in conjunction with the contractor and with the client's agreement, in order to maximise reuse of materials. Both Sanctus's and WYG's teams were highly committed to the sustainability of the scheme, in recovering the asbestos, and maximising reuse which allowed them to adhere to the programme and avoid financial implications from any delays to the construction programme.

CASE STUDY 2: NON-LICENCED REMEDIATION

Quarry Hill flats previously housed around 3,000 people close to Leeds city centre, but were also demolished in 1978 before asbestos demolition surveys were industry practice, and before asbestos was stripped out of buildings prior to demolition.

Demolition rubble had been left for decades on this development site where many mature trees had grown. To develop the site for an 11-storey new college, 17,600 m^3 of material needed to be removed from the site in order to access the development platform. That material largely comprised of the demolition rubble, in which the ground investigation by WYG had identified the presence of ACMs. The condition of these materials classified the earthworks as non-notifiable non-licenced remediation works.

Historically, it would have been possible for a contractor to have simply taken all the material to landfill. However, given the landfill tax escalator and WM3's guidance[5] on classification of soils as hazardous waste, landfill was not a financially feasible option. Off-site treatment, without the programme constraints of the site, enabled reuse of the material such that the majority was reused elsewhere.

The removal of all the ACMs was critical in the minimisation of the generation of hazardous waste since a very small presence of ACMs can classify a waste material as hazardous according to WM3[5]. Therefore, hand picking techniques to remove the ACMs can be very cost effective. This was undertaken off-site in accordance with the CL:AIRE *Definition of Waste: Development Industry Code of Practice*[6] to allow re-use of the material elsewhere. The absence of ACMs in a waste stream can be confirmed via undertaking just Stage 2 of the 'Quantification Test', where a soil sample is spread out on a tray and visually inspected for the presence of ACMs and fibre bundles (offering a time and cost saving compared to undertaking the phase contrast optical microscopy (PCOM) Stage 3 test.

WYG wrote the specification for the remediation works using a re-measurable contract, in conjunction with a materials management plan, such that the remediation contractor, Keltbray, was required to minimise the waste and the associated costs via processing the material into seven different disposal, waste treatment, and recycling streams.

The volume of hazardous waste was reduced by 97 per cent to 576 m^3 by processing the soils off-site. Keltbray worked with Biogenie at the soil treatment facility at Skelton Grange, Leeds to process soils. Allied Plant in West Yorkshire, were also involved in producing a 6F2 material for re-use. ES

Simon Eden is part of the WYG Leeds Geo-environmental team. He was designer & consultant for both projects and teaches about asbestos in soils for CIRIA.

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Changing landscapes and unlocking land

Paddy Fowler talks to **Paul Sheehan** about the current state of the land condition sector and what the future may hold.

Paul Sheehan is a Board Director at Ecologia and is the most recent former Chairman of the Land Forum, working towards progress in issues affecting brownfield development and sustainability. He has more than 18 years experience in environmental consultancy, regulation and contracting with a specialism in undertaking contaminated land assessments and remediation.

OPINION

We spoke to Paul about his thoughts on how the land condition sector has developed, what role it has to play in the current climate, and where the future lies for land condition.

The last environmental SCIENTIST journal that focused on land condition was published in August 2012. How has the sector changed since then?

For me it has changed in a number of way. We have developed a real focus on competency and skills, with a drive towards self-regulation. Being able to show that the right people have the competency and skills to deliver, without the necessary need for intense regulation, is important.

Development is moving fast and we are having to build very quickly, so we are seeing increasing reports of investigation and remediation problems arising on development sites. We need to promote a renewed climate of social responsibility amongst those in the industry. Therefore, we have to continue to focus on building those competencies and skills in the sector.

There are, and always have been, sites in the UK that have been subject to poor assessment and remediation. This has resulted in poor outcomes for the future owners, occupiers or users of the site. Some of this is due to ignorance, cost cutting, poor practice or lack of quality. It is naïve to think that all site assessments and remediation contracts will be without defect or will be following best practice, but we must strive to minimise this. If we don't, it may be that we are creating problems for the future, with contaminated land related issues on our development sites. Additionally, due to the cost cutting and austerity agenda of the last few years, there is a need to prioritise the deployment of scarce public resources.

> **"We are a cog in a much bigger land stewardship wheel"**

There are still some brilliant regulators out there with fantastic knowledge of contamination, but overall there is less knowledge out there than before. In some cases this is leading to a reduction in pragmatic decision-making. That is why schemes like the National Quality Mark Scheme (NQMS) are important. This initiative has two important aims: firstly, to improve standards, and secondly, to help regulators prioritise the deployment of scarce public resources whilst, reassuring the public that land contamination risks have been adequately addressed. I do appreciate there are differing schools of thought across the industry on this, but to me, such schemes are not there to replace regulation - they are there to drive improved standards and help regulators focus resources in the right areas, as and when they are needed.

With respect to skills, there is an excellent availability of graduate labour in the market. This is having a really positive impact on the industry as they are starting to fill some of the skills gaps that were left after the 2008 crash and the reduction in labour supply with 5 to 10 years of experience. We are seeing them bring passion and enthusiasm, whilst they learn to stand on their own two feet, be bold, and make their own decisions which is key. It is brilliant that we have a talent pool with a diverse set of skills from a wide range of universities to choose from, all with a great commitment and enthusiasm for the industry which is refreshing after the crash.

We have also seen a real focus on high quality ground investigation, characterisation, understanding contaminants, visualising those contaminants, and driving the risk assessment elements of the investigation. We are no longer doing risk assessments based solely on limited data, we are really getting into the nitty gritty of characterising and understanding those contaminants, including their fate and transport, therefore adding real value to providing remediation solutions.

Potential concerns tend to be associated with the presence of emerging contaminants, most notably per-fluorinated and poly-fluorinated substances. I think that these emerging contaminants are going to drive innovation. The characterisation and solution provision for these emerging contaminants is where the industry is driving towards. Wehave got a really good handle on how we characterise, how we remediate, and how we understand the fate and transport of those known contaminants. It is now about how we move it forward and come up with pragmatic solutions for those that are emerging both in terms of their assessment and ultimately their remediation.

What part do land condition professionals have to play in achieving the housing targets set out to tackle the current crisis?

We play a key role, but it is clear that we are not alone. We are a cog in a much bigger land stewardship wheel and we have a huge part to play in thinking about development viability, providing solutions to make difficult sites viable, and ultimately unlocking those sites. However, we have to also understand that just by unlocking a particular piece of land it is not the be all and end all of the process. We have to unlock the right types of land and we have to be big enough to understand that sometimes, whilst the brownfield first agenda is correct, it should not be a brownfield only agenda. There are other parts to this wonderful land condition industry that we need to interact with to do this and ensure we are using land sustainably.

We also have to really understand the impacts of our industry. People may look at what we do as moving mud around and testing soils, but if you actually boil it down, we are at the heart of solving some of society's largest challenges. We, as a society, want green infrastructure, we want homes built on land that is safer for us and our children, we want to live close to work so that we don't have to commute so far, plus we need food and clean water.

"People may look at what we do as moving mud around and testing soils, but if you actually boil it down, we are at the heart of solving some of society's largest challenges."

For us to achieve all of this together at the same site is a challenge, but we as land condition professionals are part of that solution! So, for me, what we do and how we can play our part in achieving that is actually really important to society.

What effect do you think the introduction and ratification of the Sustainable Development Goals (SDGs) in 2015 has had on land condition?

I think it comes back to what I said before: land condition is just one part of land stewardship. If you look at land as a whole, rather than just somewhere to place houses, you can start to look at it in terms of the community, the effects of and impacts on climate change, the ability to grow food, and our access to uncontaminated water. We are but one part of the land stewardship process: developing the right land, in the right place, in the right way; that is what is key. But it is more than just geotechnics and ground contamination, it is part of the bigger picture. That is why the SDGs (see **Box 1**) and land condition go together.

Members of the IES work in a wide variety of roles across the environmental sector, and have a diversity of different disciplinary and inter-disciplinary backgrounds. Does land condition have many ties with other disciplines?

For me, there is a real appreciation starting to develop in the industry that we can't work in isolation. We need to be considering the sustainable use of land as part of a bigger picture, whether that is driven by Europe historically or by the SDGs. More recently still, it is being driven by the Government's 25 year environment plan that, to my interpretation, is seeking to pull together the different strands of work to promote long term improvements to the environment. We have always done it through the production of Environmental Statements (ES), but we are now seeing more collaboration than ever. I do remember times when I would go and do a ground investigation, write a chapter of an ES, and then someone doing water management, agricultural land classification, or minerals, for example, would take on some of that information for their chapters and it would be worked through one by one. What we are seeing now is that we are actually sitting down together and pulling that together at the beginning.

BOX 1: THE SUSTAINABLE DEVELOPMENT GOALS

The Sustainable Development Goals comprise of 17 goals, 169 targets and 232 indicators that were developed over two years of public consultation that aim to represent both the most vulnerable and the major stakeholders equally. The aim is to eradicate poverty through the use of sustainable development with a universal and non-political common ground.

When there is below-ground knowledge needed by more than one discipline, such as agricultural land classification; minerals; drainage; or highways design, we now tend to sit down at the beginning with all parties and work out how we are going to do the ground investigation to make sure we all benefit and get the information we need. It is not just us and I think the clients are starting to also realise that if you combine all of these aspects together at the start, not only are you quicker, but you are actually driving costs down. It may not always work but we do try! Hopefully this again links into what Defra are trying to do and to what land stewardship across the world is trying to progress.

One theme we have picked up on throughout this edition of the journal is how contaminated land remediation often focuses on relics of the industrial era and industrial contaminants. This has been the past and present of remediation, where do you think the future of land condition lies?

I think the key is that the past is there. We are cleaning up a lot of the past and we have a lot of legislation in place at present to minimise impact. But we still, occasionally, have industrial incidents that lead to contamination of the ground. More importantly still, we are looking to build on sites that were not potentially viable before because we can think of new ways to tackle the problems that the industrial era has left behind. Alternatively, we are finding new contaminants and further information about known contaminants that were not considered such a risk before. But with new information they are coming back as a potential risk, so we are always going to be learning as our knowledge grows.

Technically, I suppose for me it is about continuing to drive innovation on those new emerging contaminants but not forgetting what we have learnt from the past. It is still important to use this information, so we can be quicker at coming up with future solutions as these situations arise. It is also about controlling all the data and the data flow. We can be a lot quicker and a lot more efficient, and by working together across the environmental sciences industry, we are likely to come up with better solutions for managing our data quicker than doing it in isolation.

Ultimately, yes, you are going to get to a point where we have unlocked or developed a majority of sites and the supply for land versus the need equalises. That is where land stewardship comes in. If you are going to build on a gasworks, the first thing you are going to think about historically is: what is in the ground, how are you going to take down the infrastructure and how are you going to make it developable? But does it have to be built on or is there a wider value to the land?

Going forward, the mass of large contaminant sites will either have been dealt with, or have been parked as unviable. We have now got the opportunity to unlock those but not necessarily just for development. With the wider consideration for sustainable development of land and land stewardship, we can consider value in a more rounded way. We are seeing recognition of additional benefits in terms of natural and social capital and why these are important considerations during decision making. Land condition is and always will be part of this.

So a message to the future? Remember what we do in land condition is not just looking at soil or water - we are part of something much bigger! Whether it be a desk study or remediation, it is part of a bigger picture and we are part of something that is helping society and the greater community. That is why I love my job. ES

Paddy Fowler is the Publications Officer at the Institution of Environmental Sciences. Previous to joining the IES team in October 2017, he studied for an MSc in Science Communication after completing a BSc (Hons) in Pharmacology. Paddy has a keen interest in aquatic conservation and an enthusiasm for communicating interesting sustainability innovations across the environmental sciences.

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