China UK partnership for contaminated land management

Land contamination and brownfield management policy development in China: learning from the UK experience

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Executive Summary

Over the last 30 years, China's fast urbanisation along with huge expansion of its manufacturing industry has led to the emergence of significant soil and water contamination problems across China. In the meantime, a number of policies and regulatory agencies for the protection of the environment have been implemented to stop deliberate pollution and more recently to address pollution prevention at source on a wider scale.

Soil protection and management have been featured in policy discussions since the late 1950s in China. However, the topic has recently been of greatly expanded interest in the development of emerging policies, particularly with regards to the role of soil as a resource, independent of the functions that it carries out. Soil provides multiple important functions such as provision of food and raw materials, a platform for urban development and human wellbeing and a filtering and transforming media for water, nutrients, and carbon.

However as pointed out by Yuan Si, Deputy Director of the Environmental Protection and Resources Conservation Committee of the National People Congress (China Daily, 11 March 2016), the move toward integrated management that has been driving policies for air and water has proven to be a challenge for soil management, mainly due to the multiple functions that soils provide. This is also true internationally and explained by several drivers for soil protection including among others soil contamination, construction, agriculture and amenity value.

China is starting to release details of its 13th Five-Year Plan and of particular relevance to soil management, land contamination was highlighted as an immediate priority. Under the current 12th Five-Year Plan, the Ministry of Environmental Protection has earmarked 30 billion RMB from central finances to support national land remediation projects and it is expected that the environmental industry sector will grow by 15% annually, generating a turnover of 4.5 billion RMB. In the meantime, China's first nationwide soil quality survey released by the Environmental Protection and Land Resources Ministries in 2014 highlighted the significant challenges to maintain and restore soil function and quality. China's government has just begun to lay the foundation for market growth which will bring a wide variety of opportunities for business. However, soil protection and remediation are still in the early stages of development in China. Also Chinese agencies recognize there is still need for support to develop and enforce a comprehensive legislative framework and funding systems (Coulon et al., 2016). Thus, in common with other emerging land contamination markets, China stands to benefit from comprehensive and systematic planning for risk based land management, encompassing both contaminated soil and groundwater.

The last 40 years of 'environmental revolution' in the UK has helped to establish comprehensive frameworks built around preventing pollution and risk-based management. After various lessons learnt, the UK has now a set of mature policy frameworks and successful track records of sustainable integrated remediation strategies. The risk-based approach of the UK's contaminated land legislative regimes has further allowed more innovative cost effective approaches to be applied than elsewhere in the world. China can therefore benefit greatly by adapting best practices as now established in the UK after many decades of effort. By doing so, it will lever existing knowledge and know-how, and boost the timeline for effective policy and regulatory development, and reduce the cost of this effort. Further to this, China will need to support its initiative on land contamination management by developing comprehensive risk and sustainability assessment systems and processes to support:

1. risk management decision making,
2. verification of remediation outcomes,
3. systems for record keeping and preservation and integration of contamination issues into land use planning, along with procedures for ensuring effective health and safety considerations during remediation projects, and
4. effective evaluation of costs versus benefits and overall sustainability, both for remediation and in the broader brownfields regeneration context.

The following key conclusions can be drawn from this report:

- There is a need for shared experience of practical deployment of remediation technologies in China, analogous to the situation before the establishment of the independent, non-profit organisation CL:AIRE (Contaminated Land: Applications In Real Environments) in 1999 in the UK.
- A shared endeavour is also needed to promote the development of technically and scientifically sound land management and soil protection to improve the sustainability of the rapid urbanisation in China.
- It is important to recognise that soil remediation needs more than technological innovation and risk management, as it depends highly on business models that help translate scientific/technological findings into real world solutions. Thus, drawing on the experience of the UK and other countries, China needs to establish sustainable, non-prescriptive and pragmatic funding mechanisms for land remediation and regeneration.
- Future collaboration on land contamination management and policy between China and the UK should be sustained, as the UK has developed mature market and management systems for land contamination.
- Furthermore, it is suggested that the existing Sino-UK Technical Cooperation in Soil Remediation Under the Background of Fast Urbanization be extended and perhaps converted to a “Innovation and demonstration platform” that will coordinate and support demonstration and innovation projects, enhance international collaboration in the management and sustainable development of contaminated land and therefore help achieve policy compatibility, joint action, and provide international training to meet the urgent need of the opened market of land remediation and management in China.

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
BREEAM	Building Research Establishment Environmental Assessment Methodology
CEEQAL	Civil Engineering Environmental Quality Assessment
CL:AIRE	Contaminated Land: Applications In Real Environments
CLEA	Contaminated Land Exposure Assessment
CLR 11	Contaminated Land Report 11, the Model Procedures for the Management of Land Contamination
DDT	Dichlorodiphenyltrichloroethane
DoWCOP	Definition of Waste: Development Industry Code of Practice
EB	Eligible Body
EDC	Endocrine Disruptive Compound
ELD	Environmental Liability Directive
ELI	Environmental Liability Insurance
ERA	Ecological Risk Assessment
EPR	Environmental Permitting Regulations
ERDF	European Regional Development Fund
GDP	Growth Domestic Product
HCA	Homes and Communities Agency
HCH	β-hexachlorocyclohexane
ISO	International Standards Organization
LCF	Landfill Communities Fund
LEP	Local Enterprise Partnerships
LEZ	Local Enterprise Zones
MEP	Ministry of Environmental Protection
MLR	Ministry of Land and Resources
MSW	municipal solid waste
MWR	Ministry of Water Resources
NHBC	National House Building Council
NPPF	UK National Planning Policy Framework
PAE	phthalate esters
TDS	total dissolved solids
SURF-UK	Sustainable Remediation Framework UK
UNCED	United Nations Conference on Environment and Development

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1 Overview

China's rapid urbanisation along with a remarkable expansion of its industrialization over the past three decades have contributed to significant environmental issues due to prolonged poor practices in environmental and waste management strategies. As cities continue to expand rapidly, industrial facilities along the edge of or within the city boundaries are being closed or relocated to designated industrial parks. Soil and groundwater conditions within and adjacent to industrial facilities have been affected. At the same time, the continuous outward shift of urban boundaries and the expansion of territorial jurisdictions of cities, primarily through the expropriation of surrounding rural land and its integration into urban areas, means that land use patterns have changed over the last few decades. Another major regional problem is the diffuse pollution of large areas of agricultural land caused by fertiliser use, industrial mining and refinery activities.

The latest national soil survey published in April 2014 by the Environmental Protection and Land and Resources Ministries of China revealed the significant challenges China is facing to maintain and restore soil functions and quality. Extrapolation of the soil survey indicates that the total area of arable land polluted with heavy metals has reached 20 million hectares, accounting for approximately 16% of the total arable land in China. Most significantly, there are substantial areas (36%) within the vicinity of industrially contaminated sites being potentially contaminated.

Recent publication of a series of technical guidelines and policies dealing with land contamination has fuelled the emergence of Chinese enterprises in soil remediation market. However these guidelines have been mainly derived from the American Society for Testing and Materials (ASTM) international standards without contextualisation to China's settings, such as the lack of a risk management framework and a different legal system to the US.

Also with out-dated site investigation technology and inappropriate remediation technology choices at many site restoration projects, these have resulted either in secondary pollution or incomplete outcomes. This has largely been attributed to the absence of an integrated framework of guidance and experience to support remediation decision making in China. Therefore technical collaboration in the development of risk based approaches to contaminated land characterisation, assessment and remediation will lead to substantial benefits for China. At the urban planning stage, China needs support to develop comprehensive and systematic planning in soil protection and risk management. This needs to be further supported by a comprehensive risk assessment system, including post-restoration monitoring and safety and human health assessment and a system of recording site ownership and land quality.

The UK has had an active programme of land rehabilitation for over 50 years. In the late 1970s, the UK was the first country to develop detailed guidance for contaminated land management, including land quality thresholds. In parallel, the UK has developed, elaborated and evolved a large body of research and guidance related to risk based land management, in particular the Model Procedures for the management of land contamination, known as the Contaminated Land Report CLR 11 published in 2004.

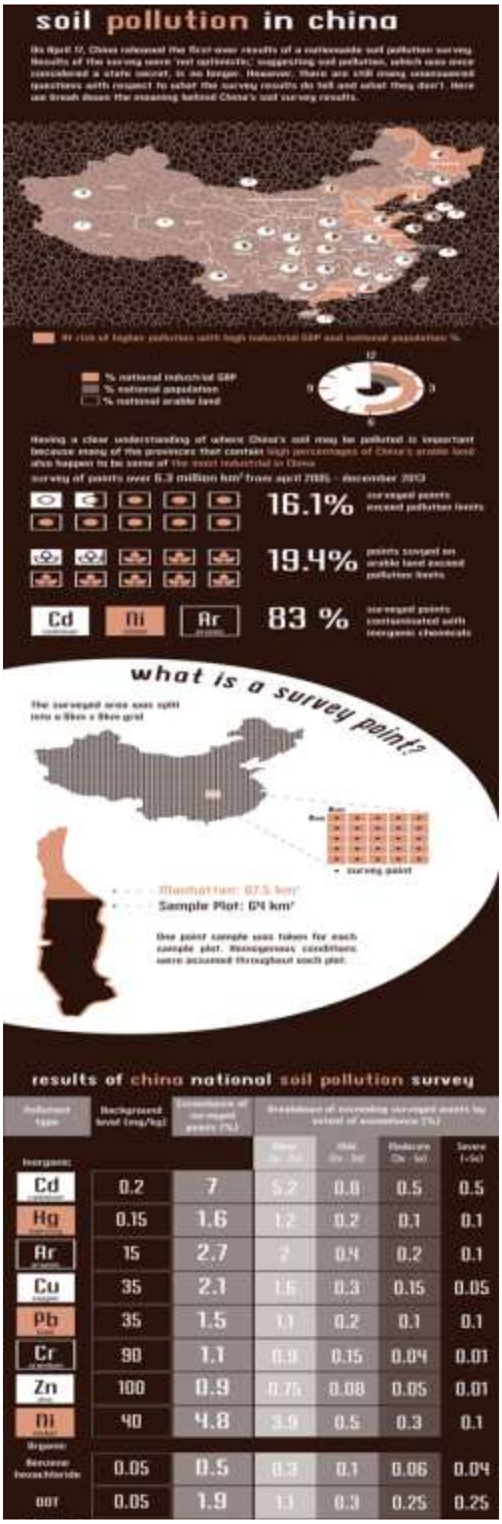
The UK has also established a central organisation for the sharing of contaminated land research, technology and demonstration information in the late 1990s. This organisation, known as CL:AIRE, has had a major benefit in developing contaminated land management practice in the UK, ensuring a rapid proliferation of good practice in the UK, and the availability of verifiable technology performance information.

The UK has now established mature and comprehensive risk-based management solutions with a wide range of remediation technologies for soil and groundwater. The UK has accumulated valuable practical experience of large-scale soil integrated remediation work.

Being one of the pioneers in soil and water environment protection, the UK has a well-established and successful commercial mode and remediation experience for China to refer to. A collaborative effort would allow the use of UK model systems modified as necessary by shared research and dialogue for adjustment and optimization based on China's own national conditions. It should not be overlooked that the commercial mode, legislation, management system, technical methods and case experience developed by China's soil remediation industry will also provide other developing countries with a good example.

2 Current Land Status Affected By Contamination in China: Challenges and Ambitions

According to the National Soil Pollution Survey conducted under the auspices of the Environmental Protection and Land and Resources Ministries in 2014, up to 16% of the total survey sites failed to meet the environment quality standards for soil. Further to this, the percentage of cultivated soils exceeding the soil quality standards reached 19%, among which 14% were slightly polluted, 2.8% were lightly polluted, 1.8% moderately polluted and 1.1% were heavily polluted.



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Major pollutants were cadmium, nickel, copper, arsenic, mercury and lead, and HCH, DDT and other traditional persistent pesticides. PAHs, PCBs and dioxin-like chemicals were also identified as chemical of concern in farmland. Further to this, the survey reported the presence of new pollutants, such as rare earth metals, phthalate esters (PAEs), antibiotics, endocrine disruptive compounds (EDCs) hormones, radionuclides and pathogenic bacteria, which all pose a threat to the soil and water quality standards and safety. Besides the serious impact on the quality of the soil and water environment, the pollution of farmland soil constitutes an immediate danger to food safety, human health and ecological safety. This is further exacerbated due to the influence on the foreign trade of domestic agricultural products and the interests of environmental diplomacy.

Meanwhile the pollution of urban industrial sites is complicated and serious and hindering land redevelopment. Again the National Soil Pollution Survey published in 2014 reported that more than 20% of the former industrial sites, including industrial estates, solid waste disposal sites and oilfield extraction sites were exceeding the environmental quality standards in China's in terms of heavy metals and various organic pollutants, including mainly pesticides, BTEX, halogenated hydrocarbons, PAHs and derived petroleum products. In addition to this, the pollution identified on the industrial sites surveyed highlighted that pollution and/or contaminant plumes are often deep underground leading to groundwater contamination as well.

Across China there are about 80,000 state-owned mining enterprises and 200,000 collectively owned mines. Approximately 4000 mining areas are located in the southern regions of the country such as Guangxi, Hunan, Yunnan, Guangdong provinces, which all have rich mineral resources. The contamination of heavy metals comes from wastewater discharges, soil erosion, runoff, infiltration and leaching of stockpiled mining waste, landfilling, and waste burning. Without suitable pollution prevention programmes, these activities have resulted in impaired environmental conditions within and downgradient from the mining sites.

Severe groundwater pollution by heavy metals has been reported. Based on the Report on the State of Environment in China 2014, of the 4,896 monitoring wells 45% were reported as poor water quality, and 16% with extremely poor water quality. Key parameters measured included total hardness, total dissolved solids (TDS), iron, manganese, nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, fluoride and sulphate. Further to this, some monitoring wells were found with excessive level of heavy metals. It was worth noting that the quality of groundwater of the northern areas of China is on the decline. Groundwater contamination has been identified as a very serious and diffuse issue in China.

2.1 Developing Soil Environmental Protection, Pollution Control and Environmental Management in China

Soil protection in China has made progress in the last 3 years, in capital investment, environmental management and supervision, and aspects of technical research. Although the government is continuing to enhance its environmental protection management system, with the rapid development and the growing population of Chinese society and economy, the existing soil pollution control laws and regulations, standards and technologies cannot meet the rapid increasing soil environmental works' needs. Soil pollution has been identified as major issue in China to prioritise in the next 10 years with southern areas being more heavily contaminated than northern areas and causing significant concerns in regards to soil, water and food quality and safety and human and environmental health. Soil environmental protection, pollution control and management is now one of the top priorities for the Chinese government.

Since 1949, environmental protection can be roughly divided into the following three stages (Figure 1).

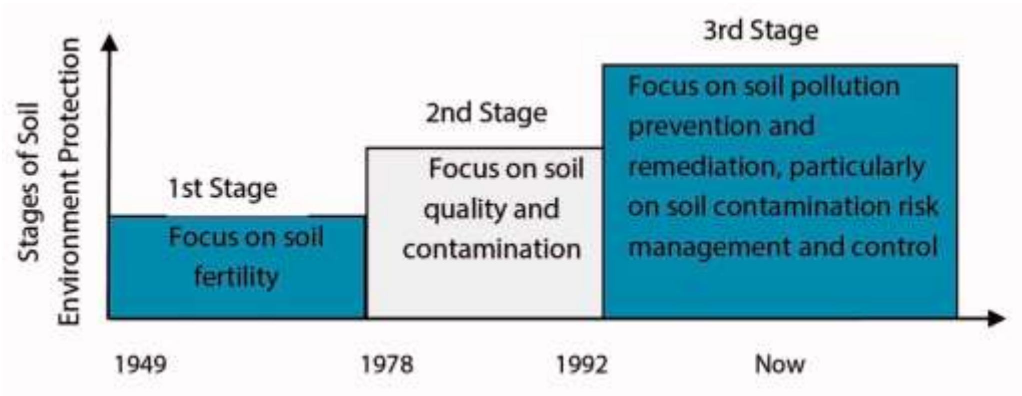

Figure 1: Overview of the Soil Environmental Protection and Pollution Control development stages in China

- **The first stage (1949 - 1970s)** focused on the increasing of fertility and food production that led to severe challenges caused by population growth. From 1960, organochlorine pesticides and chemical fertilizers were widely used in China and people began to have concerns about soil environmental problems in the early 1970's. In the first National Conference of Environmental Protection in 1973, the conference environmental issues in China began to be discussed for the first time. After that, the Chinese government gradually developed a series of pilot activities, such as a national survey of key regional pollution sources, environmental quality evaluation and pollution control, to understand the extent of the environmental issues.

- **The second stage "reform and opening" (~1970 – 1990)**. Following the government reform and pilot activities that started at the end of the 1970's, the issue of soil protection received public attention, along with the rapid development of economy and society, and it entered to a new innovation period. The environmental protection policies and legal system were developed at the same time. Several milestone laws were issued, including the first legislation relating to the protection of soil (People's Republic of China Environmental Protection Law (Trial), 1979), the Constitution (People's Republic of China Constitution, 1986), the specified law in land management (People's Republic of China Land Management Law, 1986), and the law which clearly defines the relevant provisions of soil pollution prevention (People's Republic of China Environmental Protection Law, 1989).

- **The third stage (1992 – onwards)** was after the United Nations Conference on Environment and Development (UNCED) held in 1992, when sustainable development strategies came to the fore. China's State Council issued the "Decision of the State Council on Several Issues Concerning Environmental Protection" in 1996. The guideline provided the direction for China's soil environment protection and pollution control to sustainable development. The State Council then issued the "Decision of the State Council on Implementing Scientific Viewpoint of Development and Strengthening Environmental Protection" in 2005 which emphasised that soil protection should focus on pollution prevention and remediation, especially strengthening rural environmental protection. In 2006, the Environmental

Protection (MEP) and the Land and Resources (MLR) ministries jointly launched a National Soil Survey and pollution prevention projects. This was the largest of its kind in China, which helped to produce an nationwide overview of soil pollutant status. Since 2008, the Chinese State Council and MEP successively published guidelines to enhance soil pollution prevention and control in urban and rural environments.

To assess the state of soil environmental quality of China and implement effective prevention and control measures, the Chinese government has carried out a series of nationwide surveys over the last 10 years, such as

- the National Soil Environmental Background Values Survey,
- the soil environmental quality in Non-Staple Food Supplies,
- Main Pollution Sewage Irrigation Survey, and
- the National Survey of Soil Pollution.

These fundamental investigations helped to develop a series of standards and technical specifications, such as "Soil Environmental Quality Standards" and "Soil Environmental Monitoring Technical Specifications", which are helpful to control soil pollution of farmland and industrial contaminated sites (i.e. brownfields). The Chinese government is also strengthening pollution control, especially on point source pollution control, and actively looking into developing regional soil environmental quality assessments, risk management of soil pollution and contaminated site remediation strategies.

2.2 Planning

China is starting to release details of its 13th Five-Year Plan, where a number of environmental challenges are addressed, including contaminated land which has again been highlighted as an immediate priority. The Plan also places a greater responsibility on companies to manage their environmental impacts and creates a much greater awareness within industry of its responsibilities. The Plan mainly focused on the following key aspects:

- improving investigation and assessment standards for soil and groundwater pollution;
- prioritising the areas where soil and groundwater will be protected and remediated;
- in-depth research of the soil and groundwater remediation management model;
- monitoring of typical soil and groundwater contamination sources, and
- finally controlling the soil and groundwater contamination at source;
- promoting the soil and groundwater remediation demonstration projects of farmland, industrial sites and mining area, and
- developing a number of soil and groundwater remediation technologies.

Further to the key aspects mentioned above, a series of tasks have been defined including:

- **Task 1: Enhancing soil and groundwater protection legislation and probing into the soil and groundwater regulatory system**

This task is focused on advancing special legislation for soil and groundwater protection, enacting relevant rules and systems and formulating an integrated legal system for soil and groundwater contamination prevention. By doing so, it will strengthen the monitoring of major pollution sources such as sewage irrigation areas, industrial estates, landfills, hazardous waste disposal sites, petrol stations and mining areas. It will further support the joint efforts between the Ministry of Environmental Protection (MEP), the Ministry of Water Resources (MWR) and the Ministry of Land Resources (MLR) and contribute to the establishment of a unified soil and groundwater remediation regulatory system.

- **Task 2: Conducting research on soil and groundwater environmental criteria and developing a complete system of soil and groundwater evaluation.**

This task will contribute in developing model databases, methodologies for soil and groundwater risk assessment through site investigation and research. It will establish a technical framework for soil and groundwater risk assessment using a risk-based standards approach for soil and groundwater pollution prevention. It will further combine the existing soil and groundwater quality criteria and background values into the development of national and regional environmental criteria.

- **Task 3: Conducting soil and groundwater environmental surveys to assess the status quo of contamination.**

There is still a need for further investigation of soil to assess the status quo and extent of contamination of arable soil, farmland, urban industrial sites, mining areas, groundwater recharge areas, to get a clearer picture of soil and groundwater contamination across China. There is also a need to establish environmental quality backgrounds of soil and groundwater.

- **Task 4: Defining soil and groundwater pollution prevention and control standard levels, and implementing regional protection standards**

This task will rely on the existing standards for soil and groundwater contamination prevention, and will need to explore further how regional protection standards can be developed and be fit for purpose with regard to land use (e.g. farmlands, urban industrial sites and mining area). It is important to promote the division of national soil and groundwater protection zones, and implement hierarchical and zonal management.

- **Task 5: Identifying the major contamination sources, and gradually controlling and preventing soil and groundwater contamination at the source**

This task will involve conducting a comprehensive monitoring in priority areas of concern, and identification of the best management approach to control and mitigate the negative effects of contamination and to reduce the pollutants emission to soil and groundwater pollution at source.

- **Task 6: Strengthening the prevention and remediation of soil and groundwater in farmlands, industrial sites and mining area**

Two cities in the southern part of the country have been chosen (Liuzhou, Guangxi province and Chenzhou, Hunan province) as representative cities. They will be used as pilot demonstration cities to carry out comprehensive risk assessment systems, develop structures to support risk management decision making, processes for verification of remediation outcome, systems for record keeping and preservation and integration of contamination issues into land use planning, along with procedures for ensuring effective health and safety considerations during remediation projects, and effective evaluation of costs versus benefits and overall sustainability. There will be also a focus on moderately and lightly polluted farmlands where research and development remediation projects for heavy metals could be promoted and then applied on a large scale. In the meantime, typical groundwater contamination sites in North China and Northwest and Southwest China will be selected to carry out a range of demonstration projects for remediating contaminated groundwater under different hydrogeological conditions

- **Task 7: Intensifying the environmental protection of drinking water sources and improving the local groundwater quality**

This task is focused on looking for and promoting sustainable water management and developing standards for water resources treatment facilities. It will also help to identify and delineate centralised drinking water source protection zones, coordinate the prevention and control of soil and groundwater contamination and strengthen the monitoring and protection of recharge areas and their upstream pollution sources. All the proposed actions within this task will ensure the quality of groundwater of the protected areas is not affected. There is also need for chemical investigation programme to evaluate and control entry of new pollutants and gradually improve the groundwater quality, which in turn will guarantee drinking water quality and safety.

- **Task 8: Strengthening the building of a talents team for soil and groundwater environmental protection and upgrading the management capacity**

This task aims to develop innovative talents who possess professional technologies and managerial capabilities to lead the land remediation industry of China toward innovation and breakthrough in both technology and equipment, to promote effective management of contaminated land, so as to form a set of remediation technologies and management modes catering for the pollution status and national conditions of China. This would draw on international perspectives, ultimately contributing to the economic and social development of China.

2.3 Financing

Currently there are no formalised funding mechanisms to support soil and groundwater remediation programmes in China. It is also very difficult to implement the “polluters pay principle” in China as land ownership is controlled by the government. In addition frequent land uses and industrial activities have complicated the ways of identifying responsible parties that cause or are responsible for contamination. To date, many potential contaminated sites are left unsolved and it is not clear who should be responsible for the cost of remediation. There is also a lack of commercial drivers and government incentives for contaminated land management, which means that most of the large scale remediation programmes conducted to date were funded by central and local governments. However this trend is unlikely to continue, as it is economically not sustainable or affordable for the government.

Recently several site remediation works have been undertaken, mostly because state-owned environmental remediation companies invested in them, on the promise that if remediation was successful the companies will be paid back. However such funding mechanisms expose the state-owned environmental remediation companies to significant financial risks and similarly can lead to a single market where small remediation companies will not be able to engage. Public-Private-Partnership (PPP) models such as used for the wastewater treatment industry are also being actively discussed to fund site remediation, but to date there is not yet any PPP scheme being applied for site remediation in China.

The formulation of effective funding mechanisms will take time and will require support from and benefits to a broad range of stakeholders, including problem holders, land developers, insurers and bankers, regulators and the government.

2.4 Environmental Protection Law

The Constitution of the People's Republic of China stipulates, ‘the state protects and improves the living environment and the ecological environment, and prevents and remedies pollution and other public hazards'’ and ‘the state ensures the rational use of natural resources and protects rare animals and plants. The appropriation or damage of natural resources by any organization or individual by whatever means is prohibited’.

The Environmental Protection Law of the People's Republic of China is the primary law for environmental protection in China. The law has established the basic principle for coordinated development between economic construction, social progress and environmental protection, and defined the rights and duties of governments at all levels, all units and individuals as regards environmental protection.

China has enacted and promulgated many special laws on environmental protection, as well as laws on natural resources related to environmental protection. They include, among others, the Law on the Prevention and Control of Water Pollution, Law on the Prevention and Control of Air Pollution, Law on the Prevention and Control of Environmental Pollution by Solid Wastes, Circular Economy Promotion Law, Cleaner Production Promotion Law, Marine Environment Protection Law, Forestry Law, Grassland Law, Fisheries Law, Mineral Resources Law, Land Administration Law, Water Resources Law, Law on Water and Soil Conservation, and Agriculture Law. The various elements of the environment have been basically covered, and there are basic laws relative to the main areas of environmental protection (Table 1).

Table 1: Relevant policies and standards for soil and groundwater in China

Type	Content
Laws& Regulations	Environmental Protection Law of the People's Republic of China (2015-01-01)
	Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (2005-04-01)
	Regulations on Safe Management of Hazardous Chemicals (Decree 591)
Politics	Notice on environmental pollution prevention and control in the process of enterprise relocation (MEP No.47, 2004)
	Opinions on strengthening the prevention and control of soil pollution (MEP No.48, 2008)
	Notice on environmental safety protection of industrial sites reuse (MEP No.140, 2012)
	Notice on strengthening the environmental pollution prevention and control of industrial enterprises relocation and redevelopment (MEP No.66, 2014)
Standards	Environmental quality standard for soils (GB 15618-1995)
	Quality standard for groundwater (GB/T 14848-93)
	Environmental quality standards for surface water (GB 3838-2002)
	Standards for drinking water quality (GB 5749-2006)
	Standard for engineering classification of soil (GB/T 50145-2007)
	Standard for soil test method (GB/T 50123-1999)
	Standard for stage observation (GB/T 50138-2010)
	Standards of classification for groundwater resources (GB 15218-94)
	Standard for hydrogeological investigation of water-supply (GB 50027-2001)
	Code for investigation of geotechnical engineering （GB 50021-2001）
Specifications &Technical Guidelines	Synthetical survey code for regional hydrogeology engineering geology and environmental geology (1:50000) (GB/T 14158-93)
	The Technical Specification for soil Environmental monitoring (HJ/T 166-2004)
	The Technical Specification for groundwater Environmental monitoring (HJ/T 164-2004)
	Technical guidelines for environmental site investigation (HJ 25.1-2014)
	Technical guidelines for environmental site monitoring (HJ 25.2-2014)
	Technical guidelines for risk assessment of contamination sites (HJ 25.3-2014)
	Technical guidelines for site soil remediation (HJ 25.4-2014)
	Technical guidelines for environmental groundwater investigation (Trial, 2014)
	Technical guidelines for simulation and prediction of groundwater (Trial, 2014)
	Technical guidelines for risk assessment of groundwater (Trial, 2014)
	Technical guidelines for groundwater remediation (Trial, 2014)
	Technical Guidelines for Environmental Impact Assessment Groundwater Environment (HJ 610-2011)
	Risk screening guidelines for soil contamination of development land (Manuscript, 2015)
	Soil environmental quality standard for agricultural land (Manuscript, 2015)
	Environmental investigation and remediation of industrial sites (Trial, 2014)

- **The Constitution of the People's Republic of China and Environmental Protection Law of the People's Republic of China**

These prescribe the responsibility and the obligation of the government, entities and individuals to prevent and control solid waste pollution, and make clear that the prevention and control of solid waste pollution not only involves prevention and control of industrial and domestic solid waste, but also has a close relation with clean production, circular economy and hazardous chemicals pollution.

- **Law on Prevention and Control of Environmental Pollution by Solid Wastes, Circular Economy Promotion Law, Cleaner Production Promotion Law and other slip laws**

These laws are the major legal basis of the prevention and control of solid waste pollution. The *Law on Prevention and Control of Environmental Pollution by Solid Wastes* gives a systemic prescription of the duties of governmental departments on the prevention and control of solid waste pollution, and has special regulations on the prevention and control of pollution by industrial solid waste, urban domestic waste and hazardous waste. The Law prescribes the basic regulations such as the solid waste pollution prevention plan, solid waste pollution monitoring, environmental impact assessment and 'three simultaneously' of solid waste projects, restricted import solid wastes, and also provides the specialized regulations of industrial solid waste registration and garbage recycling. For hazardous waste management, the Law prescribes the hazardous waste list, hazardous waste labels, business license and application for registration, hazardous waste transfer manifest, and emergency response plans and related regulations for hazardous waste pollution accidents.

Aside from general laws and relevant slip laws, administrative rules, regulations and other normative legal documents also provide special regulations on certain specific works concerning the prevention and control of solid waste pollution, and ensure the enforcement of the legal documents by drafting relevant technical specifications. Administrative specifications include mainly a hazardous waste list, a transfer manifest system, safety management of hazardous chemicals, prevention and control of hazardous chemicals pollution, recycling and pollution prevention of waste electric and electronic equipment, management of import and export of solid waste, recycling of renewable resources, medical waste management, pollution prevention of tailings, and domestic waste treatment etc. Technical specifications include technical criteria on hazardous waste identification, hazard assessment of chemical substances, industrial solid waste sampling, medical waste treatment, utilization and disposal of waste electrical and electronic equipment, and environmental protection standards on imported waste, industrial solid waste, solid waste incineration and agricultural waste disposal.

2.5 Waste Legislation

The rapid social and economic development of China is also accompanied by solid waste pollution and management issues. Frequently reported illegal environmental events such as the burial of hazardous waste in Jingjiang (Taizhou) or the contamination of drinking water in Lanzhou have raised serious concerns in regards to solid waste management and hazardous waste.

China produces around 300 million tons of waste a year, the large majority of which comes from cities. Currently, urban waste management services generally collect unsorted municipal solid waste (MSW) to be disposed of in landfills or waste incinerators around the periphery of the city or further out into the countryside. Even if separate bins are available for recyclable and non-recyclable waste, government waste services do not currently have the capacity to operate a recycling system. The composition and quantity of Chinese urban waste creates many problems for landfills and waste incineration. Chinese landfills are similar to other landfills around the world in that organic matter does not decompose properly in the landfill's anaerobic conditions. This results in the release of methane, a potent greenhouse gas.

Since most of the solid urban waste stream consists of organic waste, the urban waste stream is an inefficient fuel for incineration. Even if proper management systems for composting, recycling, and further landfill waste reduction were put in place, a societal shift is still necessary for urban residents to change their consumption and waste disposal behaviors for waste management systems to be effective. Of course this is similar to the experiences and social transitions of many other countries.

To date, there are still large amounts of solid waste being buried on land without any pollution prevention and control measures in place. Urbanization, population growth and industrialization are the three key reasons behind the large magnitude of China's increase in total waste generation. China still has a long way to go in the management of solid waste with respect to solid waste recycling, treatment technology and management strategy and will have to undergo great reform in order to achieve improvement in MSW collection, recycling and disposal.

2.6 Gaps in the Environmental Protection

As already noted, China's first environmental legislation was passed in 1979. The first statute was the *Environmental Protection Law (Trial)*, which was formulated as a landmark symbol for China's environmental legislation. In the intervening thirty years, China's environmental legislation has developed from a blank space into one of the most active legal fields, as well as has been playing an important role in the Chinese legal system. Until the end of August 2014, the Standing Committee of the National People's Congress had approved thirty laws about environmental protection and resources conservation.

However there are still several deficiencies that need to be addressed in China's environmental legislation. The environmental management system and policy implementation are still far from being effective and efficient. Environmental policies have often been declarative and unrealistic. Their low effectiveness has been also influenced by a lack of coherence among environmental regulations, conflicting interests at different levels of the administration, and insufficient technical capacity and resources available to environmental institutions to carry out their duties. The general policy framework favouring development over the environment compromises the work of enforcement bodies at the subnational level and results in widespread non-compliance with environmental requirements. These problems are further magnified by slow progress in engaging sectoral agencies and the public at large in addressing environmental problems. Some of the specific obstacles to better environmental policy implementation include:

(1) The system needs to be more systemic, effective and operable

There are currently too many environmental laws, they are scattered and often the system design for these laws is inappropriate. The concept of sustainable development has not yet been fully implemented in China's environmental legislation. Also the principle of "Prevention priority, combining prevention with source control" should be emphasised with "prevention in the first place" and "treatment as the last option". However, the existing legal system is more often confined to "treatment at the end", meaning the pollutant emission control at the end of pipe, rather than to the "control at the source".

Also the institutional and financial subordination of Environmental Protection Bureaus (EPBs) to provincial and local governments and their low ranking in the government hierarchy implies that the actions of EPBs are directed more by those governments than by MEP, such that local governments tend to favour economic development over environmental considerations. In addition, the performance of local government leaders has been evaluated using criteria that emphasise GDP growth, with little, if any, consideration of environmental performance.

Although the Law on Prevention and Control of Environmental Pollution by Solid Wastes provides the framework for the reuse of solid waste and waste reclamation and minimisation, the Circular Economy Promotion Law and the Cleaner Production Promotion Law are mainly promotive regulations, featuring incentives but only few obligatory and compulsory measures. The relevant stipulations of the Law on Prevention and Control of Environmental Pollution by Solid Wastes are more like principles and therefore have little effect on the ground.

(2) The System needs coordination between environmental laws and regulations.

There are still many gaps in China's environmental legislation, and the non-coordination phenomenon between laws and regulations stands out. Many legislative gaps exist at a number of important environmental protection areas. For example, there are still no specific laws in the fields of soil pollution control, toxic chemicals management, nuclear safety, bio-security, nature conservation, environmental damage compensation, and some environmental technical specifications and standards are also lacking. Especially in regard to soil pollution, it has been one of the most severe environmental problems in China, but, unfortunately, it is still not well addressed by current laws and regulations. Furthermore, some laws are often difficult to be implemented because many specific relevant regulations required by the laws were not finished in a timely manner. Many supporting rules and regulations are completed too slowly after the law enforcement which is obviously not conducive to its functioning.

Also the system is hampered by the fragmented and overlapping structure of environmental governance in China. At present, the environmental law system is overseen by several agencies, including the Ministry of Environmental Protection, the Ministries of Water Resources, Land and Resources, and Agriculture, the Ministry of Housing and Urban-Rural Development and the Ministry of Health which is often not conducive of concerted and joint actions.

(3) Technical specifications are hard to meet practical demands.

Present technical specifications on the prevention and control of solid waste pollution mainly cover sampling preparation, pollutants identification, hazard assessment, disposal technology and environmental standards for disposal. However, these specifications are not well detailed and comprehensive and do not provide a harmonised technical specifications framework. This hinders the efficacy of the prevention and control of solid waste pollution law. Also, the existing technical specifications are often not fit for purpose to tackle new pollution problems and therefore will need to be revised swiftly.

(4) The investigation into the responsibilities of polluting enterprises is not adequate.

Polluter registration and environmental permitting in China are sporadic and not backed up by nationwide binding provisions and procedures. In permitting, only ambient standards are considered, and the methodological basis for their determination is weak and not coherently applied across the country. Pollution charges are still significantly lower than the cost of pollution reduction, despite the recent increases of their rates. In addition, the charge collection rate is low, estimated on average at less than 50% of the charges imposed which reduces their incentivisation effect.

2.7 Revising and Developing New Soil Standards

Since 1995, China has developed different sets of soil standards for organic and inorganic pollutants (Environmental Quality Standards for Soil (GB15618-1995, MEP, 1995). These standards were originally developed for protection of agricultural food safety and human health. They also included soil background values. However only 8 heavy metals (cadmium, mercury, arsenic, copper, lead, chromium, zinc and nickel) and two organic compounds (HCH and DDT) were covered. Although the values are still commonly applied at remediation sites, the limited number of regulated chemicals cannot meet the needs for clean-up of the contaminated sites and is not protective of contaminated farmland. It should be noted however that the national standards are currently under revision and the new standards are expected to cover urban and rural sites.

In this section, heavy metals (including metalloids) have been taken as example to discuss how soil standards can be improved for the protection of soil resources.

Heavy metals in soils are derived from both natural and anthropogenic sources. Thus assessment of soil contamination is not always straightforward. In the recent National Soil Pollution Survey, the status of soil contamination was determined by comparing the soil concentrations of heavy metals to the Environmental Quality Standard for soils issued by MEP in 1995 (Table 2).

Table 2: Chinese soil quality standards and the percentages of soil samples exceeding the Class II standards in the recent national soil contamination survey

Metals / metalloid	Class I (natural background)	pH < 6.5	Class II pH 6.5 - 7.5	pH > 7.5	Class III pH > 6.5	% exceeding the limit
Cd	0.2	0.3	0.3	0.6	1.0	7.0
As (paddy soil)	15	30	25	20	30	2.7*
As (upland)	15	40	30	25	40	-
Hg	0.15	0.3	0.5	1.0	1.5	1.6
Cu (farmland)	35	50	100	100	400	2.1*
Cu (orchard)	-	150	200	200	400	-
Pb	35	250	300	350	500	1.5
Cr (paddy soil)	90	250	300	350	400	1.1*
Cr (upland)	90	150	200	250	300	-
Zn	100	200	250	300	500	0.9
Ni	40	40	50	60	200	4.8

* The percentage exceedance is for all soil types.

- **Class I values** are considered to represent the natural background to be used in the protection of regional natural ecosystems from contamination.
- **Class II values** are set up to protect agricultural production and human health via the food chain, and can be applied to agricultural, orchard and pasture land. The class II values are dependent on soil pH and land use. In the recent MEP and MLR soil contamination survey, a soil is considered to be contaminated if a contaminant is above the class II value; the degree of contamination is designated as light, medium or severe when the concentration is 1-3, 3-5 or >5 times the benchmark value, respectively.
- **Class III values** are for the protection of crops or forests from phytotoxicity and may also be used where the natural background is elevated.

However the fitness of China's soil quality standards is still a matter of debate. For a country as large and geochemically diverse as China, natural background concentrations of heavy metals and metalloids are not a matter of single values but are likely to vary substantially across the country. Natural background levels depend on the soil parent materials and pedogenetic processes, and therefore vary among different soil types. For example, soils developed from serpentine rocks are naturally enriched with nickel and chromium. The concentrations of several heavy metals are known to correlate closely with those of iron or aluminium oxides in soils, reflecting the parallel influences of pedogenesis on these elements. A pan-European comparison revealed higher background levels of several heavy metals and metalloids in the more weathered soils of southern Europe than in the younger soils of northern Europe, with the break in concentrations coinciding with the maximum extent of the last glaciation. A national soil survey conducted in the early 1980s showed that the 90th percentile Cd concentrations in both the A and C soil horizons were markedly higher in Guizhou and Guangxi provinces in southwest China than in the other regions of China.

Furthermore, soils developed from sedimentary parent materials, particularly sedimentary limestone, tend to have higher Cd concentrations than others.

It has been suggested that Class II values maybe over-protective or under-protective. Recent studies using soil to plant transfer models suggest that the Class II Cd limit may be set too low (i.e. over-protective) for soils with near neutral to alkaline pH. Certainly, the 0.3-0.6 mg kg^{-1} soil Cd limit (Table 1) is lower than either the 1-3 mg kg^{-1} limit adopted by the EU for land applications of sewage sludge or up to 39 mg kg^{-1} in the US-EPA's rules on land applications of biosolids. The EU risk assessment on Cd has derived the predicted no effect concentrations (PNECs) of 0.6-2.3 mg kg^{-1} for the protection of human health, mammals and bird, plants and soil organisms, whilst the US-EPA recommends a screening value (ECOSSL) of 0.4-0.8 mg kg^{-1}. In highly acidic soils, however, food Cd limits may be exceeded even when soil Cd concentrations are below 0.3 mg kg^{-1}. On the other hand, there is some evidence that the Class II Pb limits may be set too high and may lead to non-compliance with the food Pb limits. The exposure pathway of soil ingestion by humans is also not considered in setting the Pb limits.

It is clear that any future revision of the soil quality standards in China should take into account evidence accumulated since the standard was issued in 1995, particularly soil risk assessment. When assessing the current status of soil contamination in China, it is important to note that the assessment is relative to the magnitude of the benchmark values in the soil quality standard. Furthermore soil standards should be developed considering the soil use, whether it is for food production or construction or other purposes. In the case of agricultural soils, food quality standards should be the baseline for revising the soils quality standards.

2.8 Main Challenges and Opportunities for China's Soil Environmental Management

Chinese soil protection, pollution prevention and control have achieved some positive results. However, compared with air and water pollution control, there are still some gaps in soil (including brownfields) environmental protection and pollution control.

2.8.1 Establishing effective regulatory framework for soil pollution prevention and control

In recent years, the Central Government of China has been paying more and more attention to the issues of soil pollution, and has taken some effective measures to strengthen the work in soil investigation, risk assessment and remediation. However, a systematic and appropriate regulatory framework for soil environmental quality management has not been established. At present, a draft of basic law for soil pollution prevention and control in China is under discussion. Parts of the regulatory tools for managing pollution of both farmland and contaminated sites have been worked out. In this process, much is needed to learn from the developed countries including UK experiences.

2.8.2 Strengthening Capacities of Environmental Administrations and Developing an Integrated Risk Management System

At present, China's soil environmental monitoring system is not integrated and there is a poor understanding of the status of land conditions due to historical pollution. Also, the types of soil pollutants (especially organic pollutants) are poorly characterised and identified to date.. More fundamentally, there is still a lack of a rigorous accepted risk assessment and management system.

2.8.3 Improving the Soil Environmental Standards System

As mentioned previously, the existing *Soil Environmental Quality Standards* (GB 15618-1995) only applies to agricultural soil environmental management, and the provision of a small number of pollutants projects, particularly the lack of a key project of organic pollutants, cannot meet the range of regional and site-specific soil contamination identified. This regulation only provides a unified national value and does not fully reflect the regional nature of the soil background and differences. In addition, the deployed soil environmental standard monitoring system of contaminated sites is still relatively weak. Comparing with European countries, the shortage of systematic, comprehensive assessment criteria related to contaminated site investigation, site restoration governance standards and technical specifications are a critical problem. Thus the existing standards cannot meet the needs of soil environment assessment and management.

The current standard monitoring and analysis methods for soil include only partly heavy metals and pesticides monitoring methods. On the other hand, standard sampling and checking would be another barrel of analysis methods. The current standard analytical methods of environmental monitoring and standard samples for soil cannot meet the requirements to carry out full soil environmental monitoring, so it is difficult to achieve the goal called "pollutants should be measurable; testing results should be accurate and precise".

2.8.4 Developing and Demonstrating Integrated Remedial Approaches

Generally speaking, the technical support system in China is still not well developed. There is a lack of shared experience of practical deployment of remediation technologies in China. Many local technology developments are at the lab-scale or pilot-scale stage without being widely tested and put into use in real site conditions. The importance of developing integrated risk management responses with combined remediation interventions (for example integrating source removal and pathway management, or for managing different Source-Pathway-Receptor linkages is not well understood in China. Often “single techniques” are implemented for complex problems with limited overall effectiveness. As combined pollution problems are commonplace in China, there is therefore an urgent need to research, develop and demonstrate integrated remedial approaches (i.e. biological, chemical and physical technology treatment trains).

2.8.5 Promoting Public Participation and Jointed Stakeholders Action

A key difference between China and countries in Europe or North America is that land ownership belongs to the state. The ownership and properties of land directly affects the contaminated land redevelopment process, and the benefits of all direct stakeholders including local governments, community residents, businesses and developers (Figure 2). Promoting public participation in environmental decision-making should continue to be one of the key objectives of the state and local environmental authorities. By enhancing environmental awareness, encouraging environmental associations and providing training, the public can become an active implementation agent. Thus achieving effective public participation, as well as establishing an harmonious relationship between stakeholders are key to China brownfield redevelopment.

Figure 2: Relationship between stakeholders of brownfield redevelopment in China

2.8.6 Developing Effective Funding Sources for Soil Remediation

Currently, the investment in site investigation and remediation generally comes from the relevant local government departments and it will soon become economically unsustainable. Thus, the funding mechanism of land remediation in China is one of the main obstacles to land redevelopment and regeneration. Learning experiences from Europe countries, including the UK, to establish a sustainable financing mechanism, is urgently needed.

3 Reuse of Brownfield Land in the UK

The UK's expertise in redeveloping brownfield land has been borne out of necessity. As the first industrialized country in the world, the UK has developed on many sites that now may have gone into disuse and require regeneration, as a legacy of its industrial revolution. Many sites have now also undergone several cycles of re-use. Before the 1970s/1980s land contamination was not widely recognized as a problem, so some contaminated sites may have a combination of legacy problems. However, brownfield sites are not necessarily contaminated. The term simply refers to land which has been previously developed and whose re-use is stalled in some way or whose re-use is somehow sub-optimal. In the UK there is a constant turnover of previously developed land, and only a small proportion of this ends up as brownfield.

3.1 Drivers for Reuse of Brownfield

In a crowded country like the UK, it is quite usual for land to cycle through different periods of use. In many cases the commercial value of land means that these transitions proceed relatively rapidly, with problems of land contamination being managed via the planning system. Brownfield land often refers to under-utilized land whose complete re-use is stalled, most often because the cost of returning it to full functionality is greater than the economic value of doing so. This often happens in areas where there has been rapid economic change, with the collapse of established primary and secondary industries. The absence of newer forms of economic activity in the area means that there is no economic incentive to redevelop the land, and the brownfield land itself becomes a blight on the local area, further disincentivising investment. Land may also become brownfield as a consequence of its former use, for example land used to extract mineral resources such as gravel may then be used for waste landfill and the nature of the landfill prevents new (built) development on the site at economic cost.

Another major part of the economic equation determining the viability of brownfield land is the availability of Greenfield land. The societal impact of the economic consequences of brownfield on local communities can also be important, particularly those affected by industrial change. These consequences may be substantial enough that a political decision is made to invest public money in land reclamation both for built re-uses (such as industrial parks) or soft re-uses (such as parkland).

So while the existence of brownfield land could be considered as a symptom of market failure i.e. an inability to attract funding and/or investment for redevelopment, in the UK, the reuse of brownfield land has a key role to play in providing sustainable development sites for a variety of purposes and to reduce the use of Greenfield sites. Brownfield redevelopment provides opportunities to improve and increase the supply of new houses and develop infrastructure and amenities that are required to develop sustainable communities.

There are a number of key drivers that have assisted the reuse of brownfield land. These are mainly:

- **Local/regional land supply**, which drives the value of land and hence the viability of brownfield regeneration in purely market terms
- **Deliberate policies** that restrict the use of greenfield sites (such as the "Green Belt" policy, which seeks to prevent uncontrolled urban sprawl), and/or encourage the reuse for brownfields (i.e. provide new space for housing)
- **Support from clear and integrated legislation and guidance**
- **Taxation policies**, for example, incentives for investment and spending on land reclamation
- **Broader infrastructure development needs**, such as the planned high speed rail connections in the UK
- **Campaigning organisations**, for example those seeking to protect the countryside or to regenerate run down urban areas
- **Accounting requirements**: Long term brownfield / contaminated land management costs have to be shown as corporate liabilities under modern accounting rules. Organizations may seek to reduce this liability to improve their financial position or as a part of merger and acquisition processes.

3.1.1 Legislation and Guidance

In recent years, legislation and government guidance has at its core, stated the importance of sustainable development. There are three dimensions to sustainable development: economic, social and environmental and all need to be addressed simultaneously for sustainable development to truly be met. The purpose of the UK planning system is to assist in achieving these principles.

The UK National Planning Policy Framework (NPPF) has identified the importance of reusing land that has been previously developed and has even stated that local authorities may wish to set a local target for the reuse of brownfield land[1]. With the guidance towards sustainable development, this has created a driver to use brownfield land providing that it is not of high environmental value.

3.1.2 Green Belt Policy

Green belt land refers to an area that is kept in reserve for an open space, most often around larger cities. The UK Government has a green belt policy with the purpose:

- to check the unrestricted sprawl of large built-up areas;
- to prevent neighbouring towns merging into one another;
- to assist in safeguarding the countryside from encroachment;
- to preserve the setting and special character of historic towns; and
- to assist in urban regeneration, by encouraging the recycling of derelict and other urban land.

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[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

The general extent and boundaries of Green Belt are fixed and have been for many years, but it is up to Local Planning Authorities to enhance the beneficial use of its Green Belt in their areas. Therefore by protecting the Green Belt also encourages the reuse of brownfield land.

3.1.3 Housing Need

With an increasing population in the UK, there is an immediate need for affordable housing. The Homes and Communities Agency (HCA)[2] are the government's housing, land and regeneration agency that are responsible for:

- increasing the number of new homes that are built in England
- improving existing affordable homes and bringing empty homes back into use as affordable housing
- increasing the supply of public land and speeding up the rate that it can be built on
- regulating social housing providers to make sure that they're well managed and financially secure, so maintaining investor confidence in the affordable housing sector and protecting homes for tenants
- helping to stimulate local economic growth by using our land and investment, and attracting private sector investment in local areas.

As part of the government's policy to build more affordable new homes, the government has identified surplus public land that has been previously developed and is classified as "brownfield land". This is seen as ideal land for development, as much of this land has existing infrastructure in place, such as transport links and utilities. By bringing this land forward for development it is taking the pressure off Green Belt land and is often seen as a more sustainable option. Government Policy has also, at times, introduced targets for housing on brownfield land, which has encouraged housing developers to develop brownfield sites preferentially in comparison to green field locations.

3.1.4 Taxation Policies

Tax incentives have been in place in the UK since 2001 to stimulate the development of derelict and brownfield sites. Both the Land Remediation Relief and Derelict Land Relief schemes offer 150% of costs spent remediating brownfield sites or developing derelict land. These savings are taken from the corporation tax paid by developers in the UK, rather than direct financial compensation.

3.2 Barriers - Past & Present

The redevelopment of brownfield sites can be perceived as harder to undertake due to lower certainty compared to a Greenfield site. For a brownfield site there may be greater

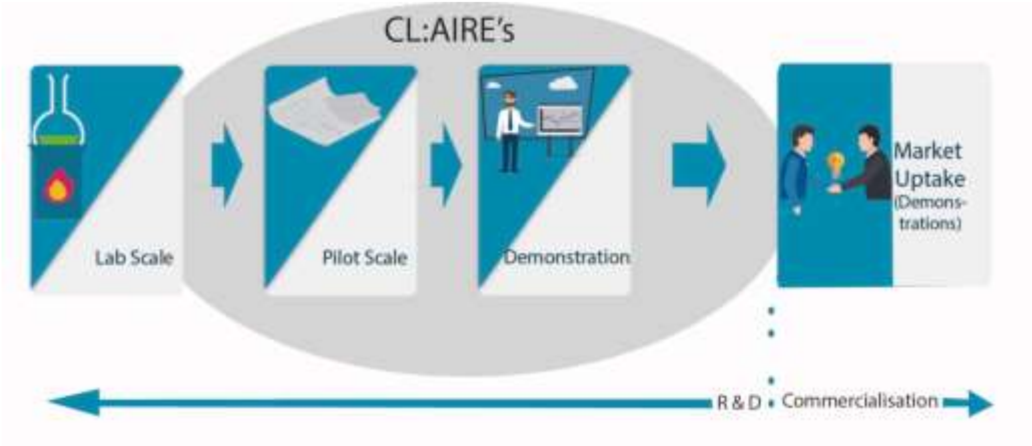
[2] www.hca.gov.uk

uncertainty in the physical nature of the site due to its former use which will affect the financial security needed to underwrite the site. These factors will be difficult to quantify, however with good planning, following good practice (see **Section 4**) and working with suitably qualified professionals the risks are manageable and greater financial returns are possible.

3.2.1 Confidence in Technologies

A major barrier to the use of remediation technologies whether *in situ* or *ex situ* in the UK was a lack of familiarity with and hence confidence in the use of technologies in the late 1990s. The development sector was using excavation and disposal on the vast majority of sites (>90%) predominantly due to economics as landfill was the cheapest option for remediating a site and confidence in using alternatives to excavation and disposal was not present. With the introduction of the European Landfill Directive and the subsequent Landfill Tax there was a step change in attitude to wanting to use alternative technologies owing to the economic driver caused by the tax. However, there was still only limited confidence or trust in using the technologies or the results across much of the sector.

To help address and build confidence, the UK government in partnership with industry and problem holders, established the independent organisation CL:AIRE in 1999. CL:AIRE's role was to build confidence and stimulate the use of alternative remediation technologies. They did this by establishing an independent technical review panel made up of applied researchers, regulators and technology developers (called the Technology and Research Group (TRG)). This panel assessed the demonstration of remediation technologies and research projects that were undertaken on real sites. The projects were written up, peer reviewed and published. Alongside the publication of technology demonstration projects, shorter case study bulletins where technologies had been used on real sites were also written up and peer reviewed by the technical review panel. In addition, other bulletins were published such as research, guidance and technical bulletins to cover areas that were also of interest but still relating to land remediation. These included information on monitoring equipment, risk communications, and more passive remediation methods all to build confidence and awareness of land remediation. Gradually as projects and bulletins got published, confidence began to grow, with greater open communication, and more specialist remediation contractors coming to the market.



For further information on CL:AIRE please visit www.claire.co.uk

3.2.2 Landfill Tax

In 1996, the UK government introduced a landfill tax alongside the implementation of the European Landfill Directive (see **Section 9** for more details) to encourage recycling, in particular of biodegradable wastes, to support target dates for compliance with Directive limits on biowaste landfilling. Initially, certain activities, including contaminated land remediation, were exempt from the tax. One of the drivers for this was a government policy aim to encourage the re-use and redevelopment of brownfield land, which was, at that time heavily reliant on landfill for the management of contaminated soil. To provide a balanced approach to both continued encouragement of brownfields re-use, and the use of more alternatives to simple excavation and disposal to landfill ("dig and dump") using *ex situ* or *in situ* remediation technologies, the UK adopted a phased approach to landfill taxation of contaminated soil. Landowners/developers/contractors that were carrying out reclamation of soil contamination to facilitate a development were permitted exemption from landfill tax to 2008. Exemption applicants qualified up until 30 November 2008 and were permitted to use these exemptions up until March 2012 (to allow for large development projects). After this date, full landfill tax was applied.

Since April 2011 the higher rate of landfill tax (soils classified as hazardous or non-hazardous waste) has increased each year from £24 per tonne in 2007 to the current rate of £82.60 per tonne in April 2015. A lower rate (that has no biodegradable material) is charged at £2.60 per tonne for less polluting (inert) soils.

The tax does mean that remediation and infrastructure construction costs have increased in the UK, which has slowed or stalled some development projects. Design works for schemes now concentrate on reducing the volume of contaminated soil produced during development. Consequently, the volume of contaminated soil generated during projects has reduced and alternative remediation options have become more cost effective to use and are being implemented more frequently.

3.3 Opportunities for Re-use

3.3.1 Built Re-uses

Typically reuse of urban brownfield sites has been a part of new development schemes. Site assessments and remediation works are incorporated within the development programmes, and regulated via the UK planning regime (see **Section 4.2**). Focus is placed from an early stage on understanding site conditions and understanding potential cost implications of remediation works, to optimize development layouts and reduce volumes of contaminated soil. Where soil is left beneath "sealed" or "hard" surfaces, lower levels of remediation are often required. Remediation design also requires integration with the selection of foundation solutions, building and pipe materials, and drainage design.

Remediation works are then usually undertaken as part of the site preparation and enabling works, linked with earthworks activities and utility (e.g. water, electricity, gas, telecommunications) installations and diversions. Remediation works then continue during building construction if ground gas protection measures, such as impermeable membranes and gas venting layers are required, and as soft landscaping is installed.

CASE STUDY 1 - DELIVERING LONDON 2012

Introduction: The London 2012 Olympic and Paralympic Games site in Stratford East London provided an opportunity to regenerate a rundown area of historical industrial development and dereliction, as well as remediate significant levels of contamination that had accumulated over 150 years. The Olympic Delivery Authority (ODA) established the enabling works project to clear the site and create the development platform on which the Olympic Park would be founded and to remediate the effects of contamination.

Figure 3: Historical Aerial Photograph of the southern part of the site now the Aquatics centre

Historical maps confirmed the Olympic Park site had over 150 years of mixed industrial land use on it with a potential for generating contamination (see Figure 3 below).

Additionally, significant importation of fill material had been carried out in several phases to reclaim the original marsh land. The initial filling was during the mid to late period of the Industrial Revolution; this was supplemented by demolition material from the clearance of damaged buildings in the London area from World War II and then material from nineteenth and twentieth century rubbish tips.

OLYMPIC LEGACY MASTERPLAN

Remediation Strategy: Two key elements of the remediation strategy were to protect against the risk to human health once construction was complete and to protect against the risk of contamination to environmental receptors such as watercourses and aquifers.

The fundamental approach to human health protection was to establish a 'separation layer' of material at the ground surface, of suitable quality for the proposed use of the site, to isolate occupants from any residual below-ground contamination.

ODA used an approach based on quantitative assessment of the risks posed by contaminants to the receptors, these being the human occupiers of the site and controlled waters – in this case, the surface water features and the Chalk aquifer. This approach targeted and removed contaminated material from below the earthworks formation level in identified 'hotspot' areas of contamination.

The project demonstrated the benefits of developing remediation technology to maximise on-site soil treatment, minimising the requirement to transport contaminated material to landfill and reduce the subsequent volume of imported clean fill material. It enabled the delivery of an Olympic Park that was safe for human use, met the prevailing planning conditions and satisfied the requirements set by both the Olympic and legacy use master plans.

The key quantities involved in the project were:

- approximately 3500 intrusive site investigations
- 140 archaeology pits
- 200 buildings demolished, including eight dismantled for reuse
- approximately 98%, or 445 000 t, of demolition arisings recycled or reused on site
- some 2 million m^3 of bulk earthworks cut and 2 million m^3 of bulk earthworks fill, with 80% reuse of arisings
- over 900 000 m^3 of soils treated for reuse, including washing of 700 000 m^3 of soil
- around 600 000 m^3 reused without treatment, with the surplus taken off site
- over 200 000 m^3 of groundwater treatment together with approximately 150 injection wells.

Lessons Learned

- *Pragmatic use of risk assessment*. Central to the design of the remediation was the use of detailed quantitative risk assessment. As further earthworks information became available, the risk assessments were reviewed and refined by the team. Throughout this process, discussions were held with the regulator on treatability requirements, contamination impacts and validation, which led to the generation of pragmatic and effective treatment solutions.

- *Soil hospitals*. In addition to the development platform earthworks, earthworks activities were undertaken by many contracts across the Olympic Park. To maximise the reuse of materials, ‘soil hospitals’ were set up to receive all soil arisings from across the park for testing, processing, treating and blending to render soils suitable for reuse. Engineering classes of material were produced from the excavated materials, thereby saving on quarry imports.

- *Appropriate long-term land use*. The remediation design allowed for games and subsequent legacy use, thereby minimising future development remediation requirements.

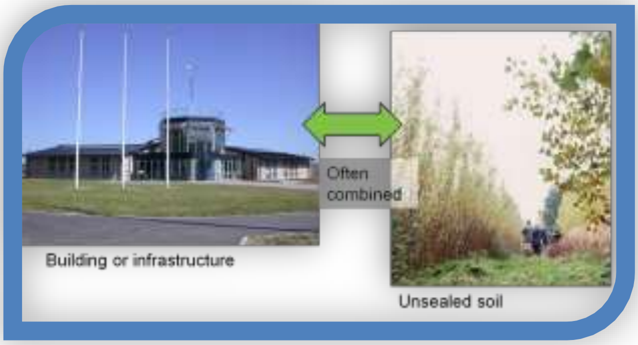
- *Follow-on projects interface*. Follow on projects needed to understand fully the ongoing requirements of maintaining a remediated site both in terms of physical works and ongoing relationships with the regulator and stakeholders.

- *Site handovers and exceedances*. Validation data was reviewed immediately on receipt to identify any exceedances that may require immediate intervention works.

Source: Proceedings of ICE Civil Engineering 164, November 2011.

3.3.2 Soft Re-uses

In comparison to 'hard' developments which describe some form of building or infrastructure, 'soft' re-use describes forms of use that do not involve substantial construction. Soft land-use is where the land remains unsealed and the soil remains in biologically productive use, for example for agriculture, habitat, forestry, amenity or landscaping. The two scenarios are not mutually exclusive.



Markham Vale Environment Centre (www.environmentcentre.co.uk)

Examples of soft re-uses include the creation of public green space. These are essentially uses where the soil is not sealed. However, significant areas of previously developed land remain under-utilized and not suitable for economic redevelopment for long periods, and indeed may never be very suitable for conventional built land-uses, for example, former landfill sites or mining areas, where installing suitable foundation structures for developments may not be cost-effective. In these areas soft re-use becomes a very important means of returning land to a productive function. Examples of soft re-uses include the creation of public green space, land area for renewable energy schemes (e.g. solar and wind power) and providing habitat and green infrastructure (particularly for urban areas). In many cases a mix of different soft re-uses may take place. The common feature of these soft reuses is essentially that the soil is not sealed and remains functional.

The situation in the UK has tended to be that the costs of rehabilitating this long term brownfield land have been a barrier to re-use, and typically, if restoration takes place, it is because it is subsidized by public funds and tax relief. The ongoing maintenance of this land remains burdensome, and is not usually subsidized. This has meant that restored land has fallen back into dereliction in some cases. It can also be difficult to demonstrate the case for soft re-use of brownfields in strictly financial terms. However, increasing evidence is showing that soft re-uses can return value for public investment in a number of ways, for instance:

- Direct financial returns for land uses connected with leisure services or renewable energy
- Uplift in surrounding property values
- Consequent improvements in local taxation bases
- Cost reductions to public services such as health and policing owing to improvements in public space
- Improvements in local environmental quality in urban areas, in particular mitigation of heat island effects and improvement of air quality
- Facilitating water management, including capacity building for flood risk management and improving sustainable urban drainage
- Community involvement, including educational and job creation opportunities (including sheltered employment)

The valuation of these wider benefits, and their sustainability, may not always be straight forward, and conventional cost benefit analyses may not always be acceptable r agreed by the variety of stakeholders who might be involved with such a project. Some of the outputs of two recent European projects, HOMBRE and Greenland, have contributed to developing a broader understanding of both the overall valuation of soft re-use of brownfields; and decision-making the use of low-input remediation technologies in effecting change. In both cases the outcomes were heavily influenced by UK thinking.

CASE STUDY 2: EU FP7 HOMBRE PROJECT: HOLISTIC MANAGEMENT OF BROWNFIELD REGENERATION (www.zerobrownfields.eu)

Valuation of soft re-use aspects: Soft re-use of brownfields describes intended temporary or final re-uses of brownfield sites which are not based on built constructions or infrastructure ('hard' re-use). Examples of soft re-uses include the creation of public green space. These are essentially uses where the soil is not sealed. Often the case for soft re-use of brownfields has not been easy to demonstrate in strictly financial terms. HOMBRE has developed a value based approach to identify and optimise services provided by the restoration of brownfields to soft re-uses, on a permanent or interim basis. A 'Brownfield Opportunity Matrix' is suggested as means of identifying and discussing soft restoration opportunities. The use of 'sustainability linkages' is suggested as a means of understanding the sustainability of the services under consideration and providing a structure for the overall valuation of restoration work, for example as part of design or option appraisal processes, or to support the solicitation of interest in a project.

Reference: Bardos, P., Jones, S., Stephenson, I., Menger, P., Beumer, V., Neonato, F., Maring, L., Ferber, U., Track, T. and Wendler, K. (2016) Optimising Value from the Soft Re-use of Brownfield Sites. *Science of the Total Environment* DOI 10.1016/j.scitotenv.2015.12.002.

CASE STUDY 3: EU FP7 GREENLAND PROJECT: GENTLE REMEDIATION OF TRACE ELEMENT CONTAMINATED LAND (www.greenland-project.eu)

Decision support: Gentle remediation options (GRO) are risk management strategies/technologies that result in a net gain (or at least no gross reduction) in soil function as well as risk management. They encompass a number of technologies which include the use of plant (phyto-), fungi (myco-) and/or bacteria-based methods, with or without chemical soil additives or amendments, for reducing contaminant transfer to local receptors by in situ stabilisation, or extraction, transformation or degradation of contaminants. Despite offering strong benefits in terms of risk management, deployment costs and sustainability for a range of site problems, the application of GRO as practical on-site remedial solutions is still in its relative infancy, particularly for metal(loid)-contaminated sites. A key barrier to wider adoption of GRO relates to general uncertainties and lack of stakeholder confidence in (and indeed knowledge of) the feasibility or reliability of GRO as practical risk management solutions.

The GREENLAND project has therefore developed a simple and transparent decision support framework for promoting the appropriate use of gentle remediation options and encouraging participation of stakeholders, supplemented by a set of specific design aids for use when GRO appear to be a viable option. The framework is presented as a three phased model or Decision Support Tool (DST), in the form of a Microsoft Excel-based workbook, designed to inform decision-making and options appraisal during the selection of remedial approaches for contaminated sites. The DST acts as a simple decision support and stakeholder engagement tool for the application of GRO, providing a context for GRO application (particularly where “soft” end-use of remediated land is envisaged), quick reference tables (including an outline economic cost calculator), and supporting information and technical guidance drawing on practical examples of effective GRO application at trace metal(loid) contaminated sites across Europe.

Reference: Cundy, A., Bardos, P., Puschenreiter, M., Witters, N., Mench, M., Bert, V., Friesl-Hanl, W., Muller, I., Weyens N., and Vangronsveld J. (2015) Developing Effective Decision Support for the Application of “Gentle” Remediation Options: The GREENLAND Project. *Remediation Journal* 25(3) 101-114

3.3.3 Endowments

The Land Trust[3] is an innovative charity that was originally established by UK Government in early 2004. It was established primarily to assist in areas of economic decline where the collapse of older industries had not been replaced by a similar level of new economic activity. The brownfield legacy was a major constraint on the recovery of many of these affected areas and was not likely to change without intervention, for example on former mining lands. Until the Land Trust, Public money was often invested in returning such land to conditions suitable for use, for example as a “country park”, and was passed back usually to local authority ownership. In the longer term the land fell back into a poor state simply because the local authorities could not afford to maintain it, especially as they already had other issues of economic deprivation to deal with. The Land Trust solution was simple - land was passed to it rather than public authorities, along with an endowment or dowry. This dowry was invested and the financial returns of this investment pay for the management of the land in the long term, which in the long run is a lower cost to the public purse. This can be an attractive land divestment route for Private Sector organizations seeking to minimize liabilities in the land asset holdings. However, the business model can be more difficult when investment income is reduced e.g. during economic downturns.

Currently The Land Trust’s portfolio is diverse and includes country parks, heritage sites, multifunctional wetlands, coastal areas, inner city parks, restored cultural attractions, community woodlands, an ecology park and a record breaking land sculpture.

[3] www.thelandtrust.org.uk

CASE STUDY 4: BEAM PARKLANDS, DAGENHAM, LONDON

The Land Trust and partners have turned this 53 ha functional flood prevention area into an innovative multi award winning space that provides significant community benefits and is helping regenerate a deprived area. The site's primary function is a flood defence; however the wider area, amongst some of the most deprived in the country, lacks quality public open space. Therefore alongside the Environment Agency's flood defence improvement works the Trust secured funding from a number of sources to enhance the space and to sustainably manage it as an attractive multi-functional community asset.

Without Land Trust ownership the project could not have happened because the key stakeholders could not agree to the liabilities and increased cost that they would incur for maintaining the upgraded site. These organisations were able to transfer their land and associated liabilities on long term lease to the Trust. In doing so they have effectively removed a financial liability from their books.

The total investment in this project has been in the region of £4 million, including the site endowment. The estimated return is £15.4M in flood prevention and public health benefits.

See more at: http://www.thelandtrust.org.uk/business/sites.html?SID=beamparklands

4 UK Regulatory Framework and Guidance

4.1 Risk Management Approach

UK government policy recognises that when dealing with past contamination, it is important to understand what risk is being caused by contamination and if that risk unacceptable. In the UK there are often technical obstacles and potentially large costs associated with dealing with contamination, therefore it is always the aim to find solutions that identify and deal with risks from contamination in a sustainable way.

The overall approach in the UK for dealing with land contamination (whether historic or recent) is one of risk management. In order for a risk to need to be addressed when related to land affected by contamination, a 'pollutant linkage' must exist.

A pollutant linkage requires the presence of:

- Contaminant **source** - A 'source' of contamination can be defined as a harmful or toxic substance present in the ground (as a solid, liquid or gas/vapour).
- **Receptor** capable of being harmed - A 'receptor' can be a person, an environmental subject (groundwater, surface water, flora or fauna) or a building/structure.
- **Pathway** capable of exposing a receptor to the contaminant - The exposure pathway can be direct (e.g. skin contact with contaminated soils) or indirect (e.g. movement of a contaminant source through air, as contaminated dust, or via water) eventually to impact the receptor.

Potential sources, pathways and receptors are identified as part of a Conceptual Site Model, developed to support site characterisation and assessment.

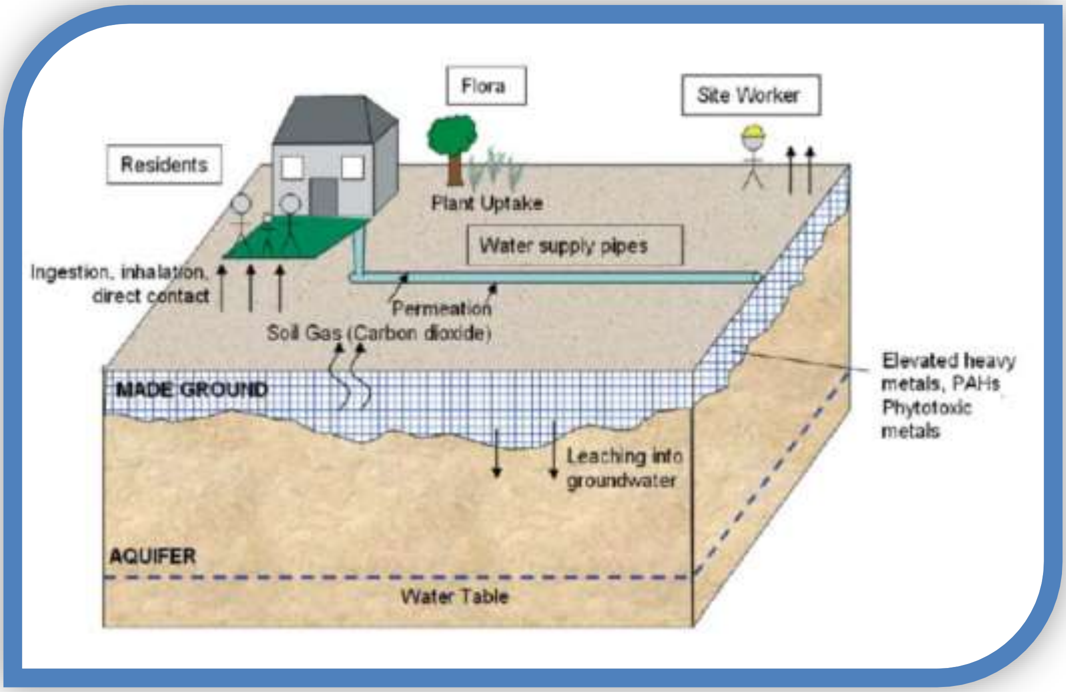


Figure 4: An example of possible pollutant linkages in a simplified "Conceptual Model" of a site (Source: Guidance for the Safe Development of Housing on Land Affected by Contamination. R & D Publication 66. 2008. NHBC & Environment Agency).

Each of these elements can exist independently, but they create a risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. It is this linked combination of source – pathway – receptor that is described as a pollutant linkage. Each pollutant linkage needs to be separately identified, understood and dealt with if appropriate. Therefore each site needs to be dealt with on an individual basis, along with the surrounding land identifying whether particular receptors and pathways are present and to the extent to which they might potentially be affected by contamination. Risk assessment allows all these factors to be considered in a structured way so that appropriate, sustainable and cost effective decisions can be taken.

Without a pollutant linkage, there is not a risk even if a contaminant is present. In the UK, even if there is a pollutant linkage, it is important to assess the level of risk to justify remediation (i.e. understand the "significance" of the pollutant linkage).

It is this risk management framework that underpins how the UK manages land contamination and is applied across a range of regulatory frameworks. The Model Procedures for the Management of Land Contamination (CLR 11) provide a technical framework for structured decision making about land contamination (see **Section 4.5.1** for details).

4.2 UK Regulatory Regimes for dealing with Land Contamination

The UK Government's policy for dealing with historic contamination focuses on taking action where there are "unacceptable risks to human health and the environment". This is in relation to the current use of the land and its environmental setting – i.e. its "suitability for use". It has developed an approach to dealing with land contamination developed around three principles).

- Ensuring that existing development and land uses are protected from existing contamination – the contaminated land regime (Part IIA)
- Ensuring new development and land uses are protected from existing contamination – through the planning system / regime or voluntary remediation (Town and Country Planning Acts and Regulations) and
- Ensuring that no new contamination is created by major industries – Environmental Permitting Regulations and Environmental Damage Regulations.

The key domestic legislation that impacts land affected by contamination in addition to the European Legislation that is set out in **Table 3**.

Table 3: Key domestic legislation that impacts land affected by contamination

Domestic Legislation	Requirements
Environmental Protection Act 1990 : Part 2A Contaminated Land Statutory Guidance 2012 Introduced as a means of dealing with the legacy of contaminated land arising from the historical use of land.	• Local Authorities are under a duty to inspect their areas to identify contaminated land causing pollution or significant harm. • Require action to make land suitable for current use using an agreed strategy. This can be voluntary or through an enforcement notice or carried out by regulators.
Town and Country Planning Acts and Regulations 1990 Planning and Development Control	• Contamination is a planning consideration and conditions can be imposed requiring assessment and remediation as part of the planning conditions. • Developers responsibility to address contamination
Environmental Permitting Regulations 2010 **Permits require the prevention of contamination and clean up to a high standard.**	• Allows regulators to set permit conditions and enforce them. • Permits can require remediation and a site may be required to be returned to a satisfactory state. • Remediation activities may need permitting. • Requires the prevention of hazardous substances being discharged to the groundwater causing pollution.
Environmental Damage Regulations 2009 **Aim to prevent environmental damage.**	• Preventing new land contamination that will damage water or health. • If damage does occur, comprehensive clean-up will be required (often to pre-incident conditions) to species, habitats, water environment and land. • Can also include for compensation.

4.2.1 Contaminated Land Regime - Part IIA of the Environmental Protection Act 1990

Only the most seriously contaminated sites are dealt with through the statutory contaminated land regime which can be found in Part IIA of the Environmental Protection Act 1990 which considers risk in relation to the current use of the land and defined receptors. “Contaminated land” is defined legally as land where significant harm is being caused or there is a significant possibility of significant harm being caused; or pollution of controlled waters (such as rivers or groundwater) is being, or likely to be caused by substances. This definition refers to contamination caused by historic uses of sites only.

Under Part 2A, liability for the remediation of contaminated land or waters broadly falls according to the "polluter pays" principle. The "polluter" is the person who "caused" or "knowingly permitted" contamination to remain on a site or to move (migrate) to other sites. A "knowing permitter" is someone who has knowledge of pollution on their land and who fails to take any action to remove or control it - the concept of knowingly permitting means subsequent owners of land can be held liable as well as the original polluter.

Under this regime, local authorities are under a duty to inspect their areas to identify contaminated land causing pollution or significant harm and to require action to make land suitable for current use using an agreed strategy. This can be voluntary or through an enforcement notice or carried out by the local regulator.

The regulators of contaminated sites are either local authorities or, in the most serious cases, the Environment Agency (in England and Wales) or SEPA (in Scotland). Different rules apply in Northern Ireland.

4.2.2 Planning Regime

The vast majority of historic contamination of soil and groundwater is dealt with through the planning regime in the UK. Planning and development control aims to ensure that there are no unacceptable risks to any receptors remaining after the site has been developed. Contamination is an issue that is considered as part of any redevelopment. Often the local authorities (regulator) will require the site developer to ensure that land contamination is considered. They will require the recognised UK risk management process to be followed (CLR 11) to identify if there are any pollutant linkages and what mitigation measures would be appropriate before development can be undertaken.

4.2.3 Voluntary Action

Site owners as part of their own corporate risk management strategy, may undertake voluntary investigation and remediation of land that is affected by contamination. This may be part of managing potential liabilities on an individual site or a portfolio of sites. Site owners would be still required to follow good practice such as CLR11.

4.3 Other UK Regulatory Regimes that Deal with Contamination

4.3.1 Environmental Permitting Regulations 2010

Environmental Permits are required to operate installations such as industrial or manufacturing facilities or waste operations, where there is a potential to pollute land, air and water with emissions. Permits require the prevention of contamination and clean up to a high standard. The Environmental Permitting regulations allow regulators to set permit conditions and enforce them. Permits can require remediation and a site may be required to be returned to a satisfactory state. Most remediation activities need permitting and require the prevention of hazardous substances being discharged to the groundwater causing pollution.

4.3.2 Environmental Damage Regulations 2009

These regulations aim to prevent the creation of new land contamination that will damage water or health. If damage does occur, comprehensive clean-up will be required (often to pre-incident conditions) to species, habitats, water environment and land. These regulations can also include for compensation.

4.3.3 UK Building Regulations 2010

Whilst not the dominant regulations in land contamination, it is also important to note that the UK Building Regulations also have requirements relating to land affected by contamination and new buildings. Approved Document C contains further guidance on appropriate investigations and assessments, and interfaces with the requirements of the planning regime.

4.4 Key European Legislation

Key European directives are those that are currently in place in England & Wales and that are used to manage land contamination and groundwater. They have been transposed into UK legislation. Key legislative changes that have occurred over the last 5 years are summarised in **Table 4,** and are discussed in more detail in **Section 9**.

Table 4: Summary of other European legislation relating to soil and groundwater and its transposition in England & Wales

Key Current European Directives	Requirements	England and Wales Transposition
Environmental Liability Directive (2004/35/EC)	Prevention and remedying of environmental damage	The Environmental Damage (Prevention and Remediation) Regulations 2009 - England
Integrated Pollution Prevention and Control Directive (2008/1/EC)	Permitting of industrial activities with a high pollution potential	The Environmental Permitting (England and Wales) Regulations 2010
Landfill Directive (99/31/EC)	Control of disposal of waste to landfill to prevent or reduce negative effects on the environment. Introduction of waste classification as inert, non-hazardous and hazardous, and requirements for the rep-treatment of waste.	Landfill (England and Wales) Regulations 2002 The Environmental Permitting (England and Wales) Regulations 2010
Waste Framework Directive (2008/98/EC)	Recovery or disposal of waste without causing danger to humans or the environment	The Environmental Permitting (England and Wales) Regulations 2010 The Hazardous Waste (England and Wales) Regulation 2005 The Waste (England and Wales) Regulations 2011
Water Framework Directive (2000/60/EC)	Prevention and control of groundwater pollution (ie preventing input of hazardous substances and limiting input of non-hazardous pollutants). Permitting of discharges and disposal of listed substances. Control of the release of listed substances to groundwater.	The Water Environment (Water Framework Directive) England and Wales) Regulations 2003 The Environmental Permitting (England and Wales) Regulations 2010 Water Resources Act 1991 and Anti-Pollution Works Regulations 1999

[1] England & Wales legislation quoted here only. Scotland and Northern Ireland have their own regulations. They are very similar but there are subtle differences.

4.5 Guidance

4.5.1 Model Procedures for the Management of Land Contamination (CLR11)

CLR11 provides a technical framework for structured decision making about land contamination. It can be used in a number of different regulatory and management contexts and be used by all those involved in managing land. CLR 11 set out the three main components of risk management – risk assessment, options appraisal and implementation of the remediation strategy (Figure 5).

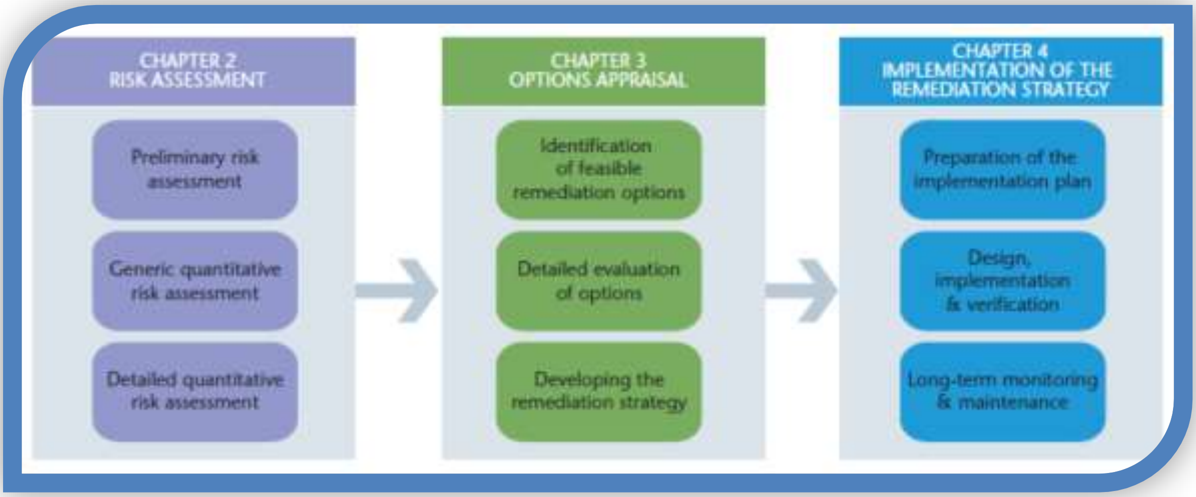


Figure 5: Main stages within CLR 11 and the key components (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297401/scho0804bibr-e-e.pdf)

4.5.2 Risk Assessment

Risk assessment is the formal process of identifying, assessing and evaluating the risks to health and the environment that may be posed by the condition of a site. If a site is contaminated, risk assessments helps decide whether contamination is or is likely to be a problem. A site investigation is sometimes required to get information to be able to do this. Understanding the risks from contamination is the first stage in the process of effectively managing it. Land contamination can affect human health, property, ecosystems and the water environment. These should all be assessed whether any of these are at risk.

A critical first step in all assessments is to define what needs to be assessed and what are the objectives. This helps to understand the purpose of the assessment and will strongly influence the following stages in the process. It is essential that at an early stage an outline conceptual model of the site is drawn up to summarise what information is available.

There are three stages of risk assessment as summarised in Table 5.

Table 5: The three stages of risk assessment

Risk Assessment stage	This involves
Stage 1: Preliminary Risk Assessment (PRA)	• Defining the project objectives • Carrying out a desk study and site visits to identify contaminant sources, pathways and receptors (pollutant linkages) • Developing an outline conceptual model
Stage 2: Generic Quantitative Risk Assessment (GQRA)	• Designing and undertaking site investigations and analysis • Undertaking risk assessment using generic assumptions • Refining the conceptual model
Stage 3: Detailed Quantitative Risk Assessment (DQRA)	• Designing and undertaking site investigations and analysis • Undertaking risk assessments using site specific data and sometimes undertaking complex numerical modelling • Refining the conceptual model

4.5.2.1 Assessing Risks to Human Health

Land contamination can affect the health of people living, working, visiting or otherwise present on a site. The risk assessment process is used to establish whether there is an unacceptable risk to humans.

In the UK, a spreadsheet based tool called CLEA (Contaminated Land Exposure Assessment) is used to estimate exposure to chemicals from soil sources by adults and children living, working or playing on land affected by contamination. CLEA model predicts human exposure to a chemical in soil by estimating the average daily exposure to a contaminant in soil via:

- Ingestion of soil, dust, and home-grown produce
- Inhalation of dust, vapour via the nose or mouth
- Absorption of the contaminant through the skin

4.5.2.2 Risks to the water environment

Land contamination can affect groundwater, freshwater and coastal waters. Groundwater is particularly vulnerable to contamination as it underlies many sites and is difficult to clean up once polluted. In the UK the Environment Agency has published a methodology to help in assessing risks to the water environment and published a tool called ConSim which is designed to provide those concerned with the management of contaminated land with a means of assessing the risk that is posed to groundwater by leaching contaminants.

4.5.2.3 Assessing risks associated with gases and vapours

Land contamination can give rise to volatile contaminants which can pose a risk of harm to human health by asphyxiation or illness if inhaled. Vapours and gases such as methane and radon may also pose a risk of fire or explosion.

4.5.2.4 Assessing risks to ecosystems

A number of regulatory regimes in the UK now require ecological risk assessment (ERA) to be carried out on sites. All these regimes are concerned with assessing the risk of significant harm to an organism, an animal or a whole ecosystem. The UK government has developed a ERA framework for industry to follow.

4.5.3 Options Appraisal

If a risk assessment demonstrates there are unacceptable risks that have to be managed, some form of risk management needs to be undertaken. Undertaking an options appraisal helps to review the options available and assists in the development of a remediation strategy. There are three main stages as summarised in Table 6.

Table 6: Options appraisal stages

Stages	This involves:
Stage 1: Identify feasible remediation options	• Reviewing and refining the conceptual model • Identifying managing the technical objectives • Defining the remediation objectives and criteria • Identifying a shortlist of feasible remediation options
Stage 2: Detailed evaluation of options	• Evaluating and analysing options individually and in combination • Deciding which of the options is/are most appropriate
Stage 3: Develop remediation strategy	• Considering the zoning and timing of remediation • Deciding how the strategy will be verified • Reviewing costs and benefits • Developing a practical strategy for the remediation

Once the general remediation strategy has been established through the options appraisal, how to implement it must be decided, show it has been successful and set in place any ongoing monitoring or maintenance.

Remediation should achieve the pre-defined objectives without harming human health or the wider environment or causing pollution.

4.5.4 Implementation of Remediation Strategy

Once the general remediation strategy has been established through the options appraisal, the decision needs to be made how it will be implemented, show it has been a success and to establish ongoing monitoring and maintenance (Table 7).

Table 7: Stages required in implementing a remediation strategy

Implementation stages	This involves:
Prepare implementation plan	• identifying management responsibilities • consulting with relevant parties (regulators, land owners, etc) • confirming what regulatory permits are needed • developing phasing and timetable
Design, implement and verify remediation	• completing pilot trials • procure contractors • obtaining any permits that may be required • producing verification plans • carrying out remediation • verify (in reports) what has been done
Long-term monitoring and maintenance	• monitoring how well remediation has worked • reviewing and adjusting monitoring programme as necessary • analysing results and reporting them • taking action if results indicate a need

4.5.5 Other Guidance

Horizontal Guidance for Environmental Permitting: Horizontal Guidance for Environmental Permitting has been prepared by the Environment Agency and is aimed to help businesses understand what measures they need to put in place to comply with their permitted operations. It has been designed to assess risks to the environment and human health when applying for a permit under the Environmental Permitting Regulations (EPR). This guidance is split into several different sections covering general guidance, energy efficiency, noise assessment and control, odour management and site condition reporting (see for further details https://www.gov.uk/government/collections/horizontal-guidance-environmental-permitting#h1-guidance).

"Green Leaves III": "Green Leaves III" is the colloquial name of an overarching piece of guidance that sets out how the UK government approaches Environmental Risk Assessment and Management. The document provides generic guidelines for the assessment and management of environmental risks. The structure of the report is developed around a framework which offers a mechanism through which the process of environmental risk assessment and management can be explained to stakeholders, and acts as a valuable tool for multidisciplinary teams conducting risk assessment. Four main components of risk assessment are identified as:

1) Formulating the problem;
2) Carrying out an assessment of the risk;
3) Identifying and appraising the management options available; and
4) Addressing the risk with the chosen risk management strategy.

For further information see: https://www.gov.uk/government/publications/guidelines-for-environmental-risk-assessment-and-management-green-leaves-iii

4.6 Lessons Learnt from the UK System

Waste legislation has had a major impact on the way the UK has approached the remediation of land contamination. One particularly challenging area has been the definition of waste. Materials are considered to be waste in accordance with European legislation if they are discarded, intended to be discarded or required to be discarded, by the holder. Once discarded, they remain a waste until fully recovered. For many years, this definition of waste led to confusion as to whether excavated soils would be considered as waste, and the position of the environmental regulators was not consistent. There were a number of waste exemptions that could be applied for, particularly if materials were to be used as construction materials, that ensured compliance with the regulations, but these were not uniformly applied.

As a result of the uncertainty, an industry initiative was co-ordinated by CL:AIRE to develop a recognised Code of Practice to provide clear guidance. The Definition of Waste: Development Industry Code of Practice (DoWCOP) is discussed in more detail in **Section 9.3**.

Another area of complexity is associated with waste classification. In accordance with the Landfill Directive, wastes are now classified as inert, non-hazardous and hazardous wastes. The assessment process for the classification of wastes is based on hazard properties, rather than risk assessment[4]. As such, excavated soils may be suitable for reuse on a site, as they meet risk assessment criteria, but could be classified as hazardous waste if sent to landfill for disposal. Interpretation and application of the two differing systems requires care and knowledge, relying on experienced specialist practitioners.

As industry matures, less guidance is produced by the regulator and government, leaving industry to develop guidance for industry if required. This allows the regulator to target its resources effectively, concentrating on those individuals and companies that do not comply with regulations, allowing those in industry who comply to experience lighter touch regulatory system.

5 Financing and Delivery of Brownfield Development in the UK

5.1 Statutory Remediation

The UK Water Resources Act 1991 allows the Environment Agency to impose remediation measures on a person causing poisonous or polluting matter to enter controlled waters.

[4] Environment Agency,

The UK Environmental Protection Act 1990 Part 2A allows the Environment Agency or local authority to impose remediation measures on a person who has caused contamination to land. The regulations also allow a waste regulation authority to impose remediation measures on a person unlawfully depositing controlled waste. The act also covers statutory nuisances such as odour, dust, noise and smoke and allows a local authority to serve an abatement notice on the person responsible.

Part 2A also stipulates that the person who caused or knowingly permitted the contamination is liable for most remediation. In their absence the present owner or occupier becomes liable. In practice, the polluter usually does not pay since most remediation funded through development (see **Section 5.2**). Identifying the polluter can be complex, and is determined in the legal courts. Attributing responsibility and financial liability one of the most complicated aspects of dealing with land contamination, and the legal precedents are often inconsistent.

The Environmental Liability Directive (ELD) now drives most of the UK regulation on environmental damage. The ELD establishes a framework for environmental liability based on the "polluter pays" principle, with a view to preventing and remedying environmental damage.

The UK Environmental Damage (Prevention and Remediation) Regulations 2009 implements the ELD in the UK, and requires operators to be proactive in dealing with imminent threats of environmental damage and remediating any damage that does occur. The Environment Agency can require operators to conduct extensive remediation.

5.2 Voluntary Remediation

There are many different funding and delivery mechanisms that have been used to redevelop brownfield land, many involve partnership working to a greater or lesser. Detailed below are the main types.

5.2.1 Partnership Working

- **Private Sector plus Public Sector**

This type of partnership working is where the private and public sector organisation enter into a joint working arrangement to deliver a project. This is often achieved via a competitive process, where a Local Authority will seek a development partner. Local Authorities will advertise the opportunities, and developers will provide development proposals, projected costs and information on their financial and technical suitability to undertake the work. The process is often phased, reducing the number of potential partners at each stage, until one preferred bidder is selected. They then work closely with the Local Authority to finalise a development agreement of contract.

In other cases, partnerships are formed where Local Authorities and private sector partners have common goals and objectives.

CASE STUDY 5: EAST MANCHESTER

In March 2010, Manchester City Council, Manchester City Football Club and New East Manchester Ltd (the former regeneration company of Manchester City Council) agreed a Memorandum of Understanding that committed each partner to work together to create a transformational plan for the area around the Etihad Stadium that would drive forward the regeneration of East Manchester. The Eastland Regeneration Framework was agreed in 2011, setting out the future vision for the Etihad Campus, the area of East Manchester surrounding the Etihad Stadium (formerly known as Sportcity). The aims of the Framework are:

- To confirm and expand the area's role as a national and international destination;
- To strengthen the area's focus on sports and recreation;
- To increase community access to sports facilities;
- To develop the area's accompanying leisure and entertainment provision;
- To provide a full range of employment opportunities;
- To build on the opportunities presented by the opening of the regional tram system, Metrolink, and its further expansion across the conurbation that will expand the local catchment area and linkages to employment;
- To strengthen the pedestrian and cycle connections of the area with the rest of the city; and
- To undertake the regeneration in a way that supports Manchester's Green City programme

The Framework recognises that the next phase of development for the Etihad Campus and its surrounding area is crucial to driving economic success for the wider East Manchester area, and provides guidance for a mix of public and private investment.

One of the first phases of redevelopment has been the construction of the Manchester City Football Academy on the site of a former chemical manufacturing facility. This 32 hectare site was a former chemical works, and has extensive organic contamination, including nitrobenzenes, anilines and tars. The coal seams beneath the site had also been mined, and there were numerous mine shafts across the site.

The site had previously been considered for a range of private development opportunities, including residential development, but had been slow to come forward due to the site constraints. The regeneration partnership with Manchester City Football Club drove forward the development, and brought the site into back into use. Remediation of the site was completed in 2013, using a combination of remediation techniques including chemical oxidation, biopiles and solidification/ stabilisation. A new state-of-the-art training academy was opened in 2015, including 16 practice pitches, youth academy facilities and a 7000 seat stadium.

- **Private Sector Partnership:**

This type of partnership is when two private companies enter into a joint working arrangement to deliver a project or a series of project.

CASE STUDY 6: ST WILLIAM

National Grid plc a land owner of former gasworks has establishment of a joint venture with a project developer The Berkeley Group Holdings plc ("Berkeley") to develop major residential and mixed-use development schemes across London and the South East in the UK. The partnership called St William, brings together access to a significant portfolio of brownfield land owned by National Grid Property in key areas of housing need with Berkeley's expertise to design, build and market new developments.

National Grid has over 20 sites in London and the South East with the potential to provide over 14,000 homes over the next 10-15 years. In its first phase, St William aims to develop more than 7,000 new homes, including over 2,000 affordable homes. Development at this scale would also deliver 5,500 jobs, 2 new schools and 22 acres of public open space, transforming 84 acres of former industrial land and contributing over £150m to local infrastructure and amenities.

The joint venture will have funds available of up to £700m, making it one of the top ten house-builders in Britain by turnover. It aims to commence development activity on its first site in 2016, with the first homes being delivered in 2017.

- **Public Sector Partnerships**

These may take many different forms including national, regional and local agencies working together to achieve common goals. These may relate to policy development and the delivery of physical projects.

CASE STUDY 7: AVENUE COKING WORKS REDEVELOPMENT, WINGERWORTH EAST MIDLANDS

Background: The former Avenue Coking Works at Wingerworth near Chesterfield is a huge 240 hectare site and is one of the most contaminated sites in Europe, and is thought to be the UK's biggest and most complex remediation project. The plant opened in 1956, and at the time was regarded as state of the art. As well as producing millions of tonnes of smokeless solid fuel through the carbonisation of coal, the plant processed by-products such as benzole, tar and sulphuric acid. It also produced town gas, which was supplied for domestic use in Chesterfield, and generated electricity for its own use, with the surplus fed into the national grid. Following its closure in 1992, the works lay disused until East Midlands Development Agency in partnership with Homes & Communities Agency and Derbyshire Council commenced the task of dismantling the plant structures and cleaning the site in 1999.

Aerial view of the site shortly following closure of the coking works

The facility included a waste tip and settlement lagoons for the disposal of hazardous solid and liquid wastes. Disposal in the lagoons was based on the 'attenuate and disperse' principle, which was an accepted technique at the time. Contamination from the site, particularly the waste tip and lagoons, is known to have polluted the River Rother that runs through the north of the site. The former plant also contaminated the underlying soils through leaks and spills from the numerous tanks, pipelines and sumps. Huge amounts of hydrocarbons, asbestos, cyanide and arsenic still contaminate the 98 ha site, the size of around 200 football pitches.

Aerial view of the site – during remediation

Remediation strategy and masterplan: The remediation involves the excavation and processing of materials using a variety of techniques. Many materials, once cleaned up, will be re-used in appropriate locations across the site. The masterplan for the site encompasses a number of end uses, including areas of native woodland, wet grassland, ponds and reed beds, parkland, sports pitches, a network of footpaths, cycleways and multi-user routes to connect the restored site to surrounding areas. An area of the site has also been allocated for a mixed-use commercial and residential development.

Proposed development plan showing the large expanses of open space.

Remediation: due to the cocktail of different chemicals present at The Avenue, no single treatment has been found to be fully effective in removing the contamination. The remediation strategy therefore comprised a number of different techniques which, when combined, means the materials will be safe for re-use. These include:

- thermal desorption
- *ex situ* bioremediation
- screening and soil washing
- concrete crushing and grading.

Key Project Aspects

The project looked to follow good practice in every aspect including:

- site-specific risk assessments to significantly reduce the volume of material requiring remediation
- on-site treatment of contaminated materials which reduced landfilling of wastes significantly
- use of an environmental management system (EMS) to effectively manage environmental risks
- a programme of consultation and engagement to address the concerns and capture the wishes of the local community
- the creation of large areas of open space, new habitats, community sports facilities, together with a large amount of new housing and some light industrial development which will be assets for the community.

For more information: www.theavenueproject.co.uk

Another example of public sector partnerships which was run with previous governments was the development of Brownfield Land Action Plans. The partnership was between local authorities, English Partnerships[5] and Regional Development Agencies (see **Section 5.2.2**) where they were taking a regional approach to tackling brownfield land on a local and sub-regional basis. The concept was to accelerate the pace of reusing brownfield land. This initiative was stopped when the Regional Development Agencies were dissolved in 2012.

- **Local Enterprise Partnerships and Enterprise Zones**

Local Enterprise Partnerships (LEP) were established in 2010 and are partnerships between businesses and local councils to come and work together on joint projects to encourage local growth, encourage business investment and promote economic development. Enterprise zones are specific geographical areas within local enterprise partnerships' boundaries where local authorities can offer a range of incentives for businesses to start up or expand, such as:

- a business rate discount worth up to £275,000 per business over a 5 year period
- simplified local authority planning
- government grants to install superfast broadband
- enhanced capital allowances in some zones - tax relief for investments in equipment.

LEP's provide strategic economic leadership for their areas, bringing public and private sector partners together around a common set of goals. Government development funding (e.g. the Local Growth Fund) are increasingly administered via the LEP's.

[5] The National Regeneration Agency – now renamed the Homes and Communities Agency

5.2.2 Funding Subsidies

In addition to the tax relief and exemption initiatives described in **Sections 3**, a number of other sources of funding subsidies are currently, or have been, used to support brownfield development in the UK.

- **Regional Development Agencies**

Eight Regional Development Agencies (RDAs) were established in April 1999 covering the eight major regions across England. The ninth RDA, the London Development Agency (LDA), was launched in July 2000. They had a wide range of responsibilities relating to developing the economic prosperity of particular regions of England. Their purpose was:

- To further economic development and regeneration in the regions
- To promote business efficiency, investment and competitiveness
- To promote employment
- To enhance development and application of skill relevant to employment
- To contribute to sustainable development

With a change of government the RDAs were abolished in June 2010 and ceased to operate by April 2012.

- **Local Enterprise Zones**

Local Enterprise Zones (LEZ) were established in 2012 after the abolition of Regional Development Agencies. They were established to assist businesses grow by attracting over £2.2 billion pounds of private sector investment, building world class business facilities and transport links and attracting 19,000 jobs. Momentum is now building across the programme and many zones are poised for substantial development in the coming months and years. Areas across England bid to create new enterprise zones. Currently there are 24 areas across England. Businesses basing themselves on Enterprise Zones can access a number of benefits:

- By receiving up to 100% business rate discount worth up to £275,000 per business over a 5 year period
- Simplified local authority planning, for example, through Local Development Orders that grant automatic planning permission for certain development (such as new industrial buildings or changing how existing buildings are used) within specified areas
- Government support to ensure that superfast broadband is rolled out throughout the zone, and, if necessary, public funding
- 100% enhanced capital allowances (tax relief) to businesses making large investments in plant and machinery on 8 Zones in Assisted Areas

- **Local Enterprise Partnerships**

Local Enterprise Partnerships (LEP) were also established to replace the Regional Development Agencies in 2010. The government invited businesses and councils to come together to form local enterprise partnerships whose geography properly reflected the natural economic areas of England. One such partnership is the South East Local Enterprise Partnership. This is a business-led, public/private body established to drive economic growth across a large area of south east England (outside of London). Part of this LEP is Thames Gateway Partnership (see Case study 8 below).

CASE STUDY 8: THAMES GATEWAY PARTNERSHIP

Thames Gateway is a large and diverse area stretching north of the Thames from Canary Wharf to Southend, and south of the Thames from Deptford to the Medway and Swale. It includes parts of nine boroughs in east London, as well as all or part of five local authority areas in South Essex and the four authorities of North Kent. The 'Outer Gateway' (North Kent and South Essex) alone is home to 1.5 million people and a workforce of over 520,000 people.

Transformation of the Thames Gateway has been underway since the 1990s - earlier if you include the Isle of Dogs - and is recognised as a long term programme of unrivalled economic potential and opportunity.

Thames Gateway Kent lies within the boundaries of the County of Kent and covers the North Kent boroughs of Dartford, Gravesham and Swale and the unitary authority of Medway.

At a wider scale, Thames Gateway Kent also forms part of the South East Local Enterprise Partnership (LEP) area which covers the counties of Kent, Essex and East Sussex, together with the unitary authorities of Medway, Thurrock and Southend-on-Sea. See Figure 6

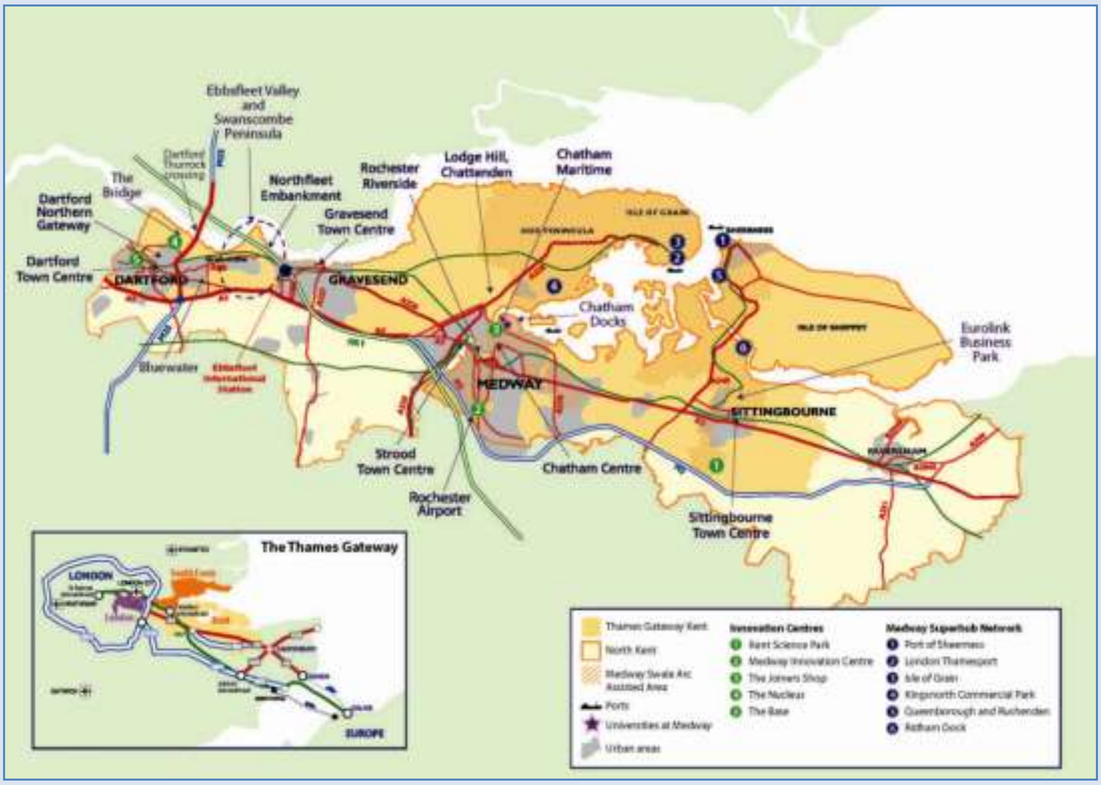


Figure 6: Thames Gateway Kent

North Kent will be recognised as an area of exciting towns and cities complemented by an outstanding natural environment, providing an exemplar of urban regeneration.

- A thriving business centre attracting leading investors and businesses through its diverse and skilled workforce, high-quality commercial sites and local services, and accessibility to transport links and strategic routes to UK and Continental markets.
- An area of strong, integrated communities with harmony between new and existing businesses and residents – where the benefits of development and investment are shared by the whole community.
- A vibrant cultural hub with a thriving social scene and civic pride – attracting a growing student population, bringing youth and vigour to the community.

The Thames Gateway partnership has set out 10 long-term economic objectives for North Kent.

- Improve the productivity of the North Kent economy. To raise Gross Value Added (GVA) per head in North Kent to the average for the south east of England, attaining at least 90% of the south east average by 2026.
- Attract and retain investment in its priority employment locations, ensuring the development of new employment sites and provision of high-quality, marketable business premises.
- Represent North Kent's interest to Government and the Local Enterprise Partnership to secure the necessary investment in transport and infrastructure, to assist connectivity and sustainable economic growth.
- Support the delivery of at least 50,000 new homes, between 2006 and 2026.
- Ensure that all new development is of the highest possible quality.
- Improve the skills of North Kent’s workforce and tackle unemployment, particularly raising the proportion of residents with higher level skills, and securing effective support to residents wanting to enter the jobs market.

- Support the creation of at least 58,000 jobs between 2006 and 2026, particularly in high value sectors.
- Attract and grow knowledge based employment in North Kent.
- Increase the rate of new business start-ups to exceed the national average, matched by better than average business survival rates.
- Maximise the economic benefits of our universities by strengthening the links with industry and retaining more graduates in North Kent.

- **Homes and Communities Agency**

HCA are the UK government's current housing, land and regeneration agency (see Section 3.13). They own public land, which is sold to housebuilders and others, to overcome barriers to development and help increase the speed of regeneration In 2014/15, HCA invested over £4 billion in building new homes across the UK, including the remediation and regeneration of derelict and contaminated sites.

- **European Regional Development Fund**

The European Regional Development Fund (ERDF) was aimed at economic regeneration projects promoted primarily by the public sector. This involves:

- government departments
- local enterprise partnerships
- local authorities
- further and higher education establishments
- other public bodies
- volunteer sector organisations

ERDF helps projects which offer substantial benefits to a programme area and its communities. These projects would not take place without a grant. The rest of the funding, known as 'match funding', comes from other sources such as local authorities, government schemes, other public bodies and the private sector.

ERDF is provided in geographically defined operational programmes that aim to support economic regeneration through projects in the areas of innovation, business support and sustaining communities. The current round of programmes started in 2007 and finished in 2013.

- **ENTRUST – The Landfill Communities Fund**

The UK Government introduced tax on landfill waste in 1996 to reduce the amount of landfilled waste and to promote more environmentally sustainable methods of waste management. The Landfill Communities Fund (LCF) is a way for Landfill Operators (LOs) and Environmental Bodies (EBs) to relive some of this tax loss through work in partnership on projects that create significant environmental benefits, jobs and which improve the lives of communities living near landfill sites.

(LCF) is an innovative tax scheme which allows operators of landfill sites to contribute money to organisations enrolled through ENTRUST (the regulator of the Landfill Communities Fund) as an eligible body (EBs). EBs carry out projects that comply with the objectives set out in The Landfill Tax Regulations 1996 (Regulations).

LOs are able to claim a credit (currently 5.7%) against their landfill tax liability. This is 90% of the contribution LOs make to EBs. They then either bear the remaining 10% themselves or can ask an independent third party (usually described as the Contributing Third Party) to make up the difference. This can be a very effective method of working with local community groups to regenerate non development community brownfield areas. For further information: www.entrust.org.uk

CASE STUDY 9: GRANTSCAPE - A LANDFILL COMMUNITIES FUND DISBURSEMENT BODY

http://grantscape.org.uk/landfill-communities-fund-lcf/

GrantScape distributes grants through the Landfill Communities Fund (LCF), formerly known as the Landfill Tax Credit Scheme (LTCS). The LCF enables Landfill Operators and their chosen grant-making partners to help create significant environmental and public benefits. They do this by supporting projects which either improve the life of communities or aid nature conservation.

Landfill site Operators (LOs) are able to redirect a small proportion of landfill tax liability (currently 6.8%) to support a wide range of community and environmental projects in the vicinity of their landfill sites through the Landfill Communities Fund (LCF). The LCF is regulated by ENTRUST on behalf of HM Revenue & Customs, and the projects are delivered by enrolled Environmental bodies (EBs). Since its inception in 1996, over £1.3 billion has been spent on more than 50,000 projects across the UK.

LCF grants can be used for a wide range of projects within three categories:

(1) **Public Amenity Projects**: To be eligible for funding, projects must provide, maintain or improve a public amenity such as a park, play area, community hall, activity centre, or cycle path. These projects need to be located within the vicinity of a licensed landfill site – typically no more than ten miles away. They must also be open to the general public – typically for no less than four evenings or two days a week, or 104 days a year.

(2) **Biodiversity and Nature Conservation Projects**: To be eligible for funding, projects must conserve or promote biological diversity, either: (i) by providing, conserving, restoring or enhancing a natural habitat; or (ii) by maintaining or aiding the recovery of a species in its natural habitat. Projects need to be located in the vicinity of a landfill site – typically no more than ten miles away.

(3) **Heritage Projects**: To be eligible for funding, projects must maintain, repair or restore religious buildings, or buildings of historical or architectural interest. The latter can include war memorials and monuments. These projects need to be located within the vicinity of a licensed landfill site – typically no more than ten miles away. They must also be open to the general public – typically for no less than four evenings or two days a week, or 104 days a year.

5.3 Warranties

It is common in the UK for new build houses to be warranted by the National House Builders Council or other insurers, to provide comfort to the purchasers that the properties have been built to a good standard. These insurers will undertake their own review and approval of the remediation works undertaken before providing a warranty, outside of any review or approval by the environmental regulators or the Local Planning Authority.

5.4 Environmental Liability Insurance

Environmental liability insurance (ELI) covers the cost of restoring damage caused by environmental accidents, such as pollution of land, water, air, and biodiversity damage.

Recent UK and EU legislation has significantly increased the potential costs of remediating damage caused by environmental incidents. Environmental liability insurance covers the cost of repairing environmental damage arising from both common law claims, and claims arising from UK and EU legislation.

In particular, ELI provides cover for:

- Both sudden pollution and gradual pollution
- First party (own site) clean-up costs imposed by regulatory authorities
- Third party liability including impact on property value
- Nuisance claims
- Legal costs and expenses

5.5 Development Phasing

It is usual in the UK for regeneration and remediation of larger brownfield sites to be phased, to spread costs and enable early phases to be released to fund later phases of remediation and development. Approaches to this vary. In some cases, less contaminated and “easier” plots are developed first. In others, early efforts concentrate on remediating the more heavily contaminated areas, often securing some form of funding subsidy (see **Section 5.2.2**) to offset costs.

Care needs to be taken to consider the impacts of later remediation works on early development phases. For example, undertaking extensive bioremediation of dusty and odorous soils immediately adjacent to new properties can cause problems, and environmental mitigation can be expensive.

5.6 Cost Estimation

Estimating costs for site remediation with any certainty can be complex and difficult due to the many uncertainties, particularly at early stages of the project when little is known about the extent and severity of any contamination, or the nature of the proposed development. Costs are strongly site-specific, and are dependent upon the details of a number of different aspects such as the geological, hydrogeological and chemical data available from the site investigation at an individual site. The costs are also strongly influenced by how stringent the remedial targets are, which in turn affects the duration.

Risks can be overestimated, resulting in budget estimates that can make development unviable. Risks can also often be underestimated, or not predicted, leading to increases in budget estimates as more is learnt about the ground conditions.

There are a large range of remediation techniques with varying costs, and selection of the appropriate technique does not occur until later stages of the design process. Factors such as the type of procurement contract, and level of risk transferred within it, programme and available working space also significantly impact remediation costs.

6 Sustainable Land Use

6.1 Drivers, definitions and activities

Contaminated land can pose significant health, environmental and social pressures, and its management imposes substantial economic costs, amounting to billions of pounds worldwide each year. China's share of this burden is very large. Under China's current 12th Five-Year Plan, the Ministry of Environmental Protection (MEP) has earmarked 30 billion RMB from central finances (equivalent to £3bn) to support national land remediation projects. Indeed, in 2013 the Chinese State Council acknowledged the environmental industry as a pillar for China's future development. The environmental industry is expected to grow by 15% annually, generating a turnover of 4.5 trillion RMB (£458 billion) by 2015.

The sheer scale of land-contamination problems, and of the responses to them needed in China, makes achieving sustainability in Chinese contaminated land remediation an important objective. ***Sustainable remediation*** is the process of effectively managing contaminated land risks to human health and the environment in a manner that minimises the environmental footprint, optimises societal benefits, and minimises the costs of those remediation activities. Ideally all three outcomes are achieved, but where trade-offs are necessary, sustainability assessment provides a rationale to identify and select the best remediation solution.

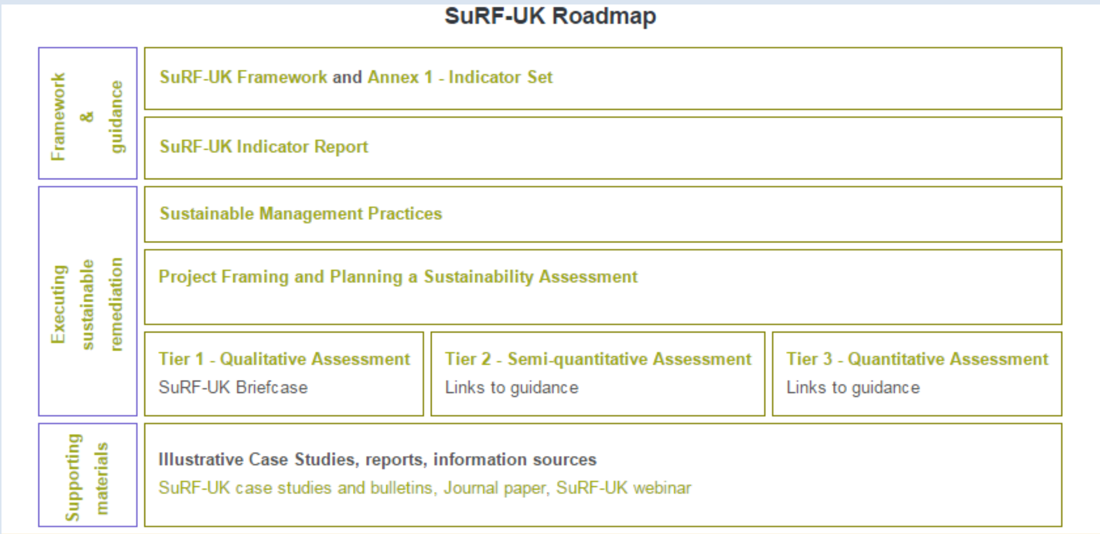
There is an active international debate about how best to ensure that land contamination is managed in a sustainable manner, and the UK has been a leading contributor to this debate with several countries adopting approaches first developed by "SURF-UK" (see case study). Other countries developing sustainable remediation thinking include: USA, Canada, Brazil, Colombia, Australia, New Zealand, Taiwan, Japan, Italy, the Netherlands, Austria as well as the European stakeholder networks NICOLE (www.nicole.org) and COMMON FORUM (www.commonforum.eu). Work is also underway to develop a sustainable remediation network in China and developing collaboration between the UK Sustainable Remediation Forum (SuRF-UK) and its Chinese equivalent will support the rapid progression of this debate in China and facilitate development of guidance and training. Within the UK, CL:AIRE also manage a secretariat linking the different international initiatives; and the convenor of the developing ISO descriptive standard on sustainable remediation is based at the University of

Nottingham, providing an additional range of collaborative opportunities and shared development.

Sustainability has also developed in importance as a criterion in decision making for brownfields redevelopment. Indeed explicit consideration of social and economic goals for land restoration took place as early as 1961 for the feasibility study for the Lower Swansea Valley restoration work in Wales (UK). Its terms of reference were to *'establish the factors which inhibit the social and economic use of land in the Lower Swansea Valley and to suggest ways in which the area should be used in the future*'. While brownfields restoration is a broader context than remediation, there are obvious cross-overs, not least that the management of land contamination is frequently required as part of a brownfields restoration. For this reason the SuRF-UK approach explicitly includes brownfields management considerations. However, in this broader context other sustainability domains can also be important, in particular those related to sustainable building. The UK has also been in the vanguard of developing sustainability thinking for construction, developing two world leading sustainable construction assessment and guidance systems: BREEAM and CEEQUAL.

Sustainable Remediation Forum in the UK (SuRF-UK)

The Sustainable Remediation Forum in the UK (SuRF-UK) is an initiative established in 2007 to support more sustainable remediation practice in the UK by providing guidance based on multilateral inputs from different practitioners and stakeholder interests (CL:AIRE 2010). SuRF-UK operates via a Steering Group who have overseen a series of meetings and projects. It is coordinated by an independent charity, Contaminated Land: Applications in Real Environments. Since 2009 SuRF-UK has produced a wide range of outputs, on the basis of funding and in kind contributions from a wide range of public and private sector contributors from across the UK. These are shown below and are freely downloadable from www.claire.co.uk/surfuk.



BREEAM and CEEQUAL

Remediation and brownfield development are starting to be incorporated within common sustainability assessment tools adopted in the UK.

BREEAM is a leading sustainability assessment method for master planning projects, infrastructure and buildings. It addresses a number of lifecycle stages such as new construction, refurbishment and in-use. Assessment categories include land use, with credits awarded for reuse of brownfield land.

CEEQUAL is another UK sustainability assessment system targeted at all types of civil engineering, infrastructure, landscaping and public realm projects. The scheme focuses more on land issues, and awards credits for the design for optimum land-take, previous use of the site, land contamination and remediation measures as part of the assessment criteria.

GREEN REMEDIATION

A related term to sustainable remediation is green remediation, which has a specific meaning in the USA (US EPA 2008): *the practice of considering all environmental effects of remedy implementation and incorporating options to maximize net environmental benefit of clean-up actions*. It is less broad ranging than "sustainable remediation" focusing environmental aspects at the stages of remedy selection and implementation. The context for this focus is specific to the US Superfund legislation which is used to manage priority sites identified at a federal level (www.epa.gov/superfund). Under the US EPA Superfund social and economic factors are felt to have been considered already in the decision process before remediation decision making takes place.

6.2 Practical Implementation of sustainable remediation

The emerging international consensus is that in broad terms sustainable remediation is the achievement of a net benefit overall across a range of environmental, economic and social concerns that are judged to be representative of sustainability. The scope of sustainability is broad ranging over the three elements of sustainability (environment, economy and society), as illustrated by the SuRF-UK indicator categories (Table 8; CL:AIRE, 2014).

Table 8: SuRF-UK indicator categories

Environment	Social	Economic
Emission to air	Human health & Safety	Direct economic costs and benefits
Soil and ground conditions	Ethics & Equity	Indirect economic costs & benefits
Groundwater and surface water	Neighbourhoods & locality	Employment and employment capital
Ecology	Communities & community involvement	Induced economic costs & benefits
Natural resources & waste	Uncertainty & evidence	Project lifespan & flexibility

There is also a developing consensus that what sustainability encompasses is highly site specific and depends on opinions from a range of stakeholders with interests in a particular site. As such sustainability is subjective rather objectively quantifiable. However, while sustainability is not capable of direct measurement, there is general agreement that it is possible to assess sustainability on a site specific basis, compare possible rehabilitation options, and monitor sustainability "performance" once a chosen option is implemented. It has been suggested that a tiered approach is likely to be the most efficient route to effective sustainability assessment, beginning with simple qualitative methods and focusing more complicated assessments only on aspects of sustainability where there is a failure to reach clear consensus. Taking a staged or tiered approach, starting with simple qualitative approaches, and moving through to more quantitative methods should the need arise, has advantages in terms of cost and resource efficiency as well as providing a structure that is as inclusive as possible and combines the relative strengths of the methods available. Within many European countries the contaminated land sector is very familiar with the use of tiered approaches in risk assessment for similar reasons, so this concept already links well with established practices.

Several initiatives around the world emphasise the importance of considering sustainable remediation early in decision-making when design decisions are being made that set the boundaries for risk management. This pro-active approach is most clearly predicated in a brownfield regeneration situation where different development decisions have different impacts on risk management needs, and a balanced approach across the regeneration process may optimise the overall value of a project and ensure satisfactory risk management. Earlier consideration is generally felt to increase the potential for enhancing sustainability gains. This approach is highlighted by the SuRF-UK framework (Figure 7).

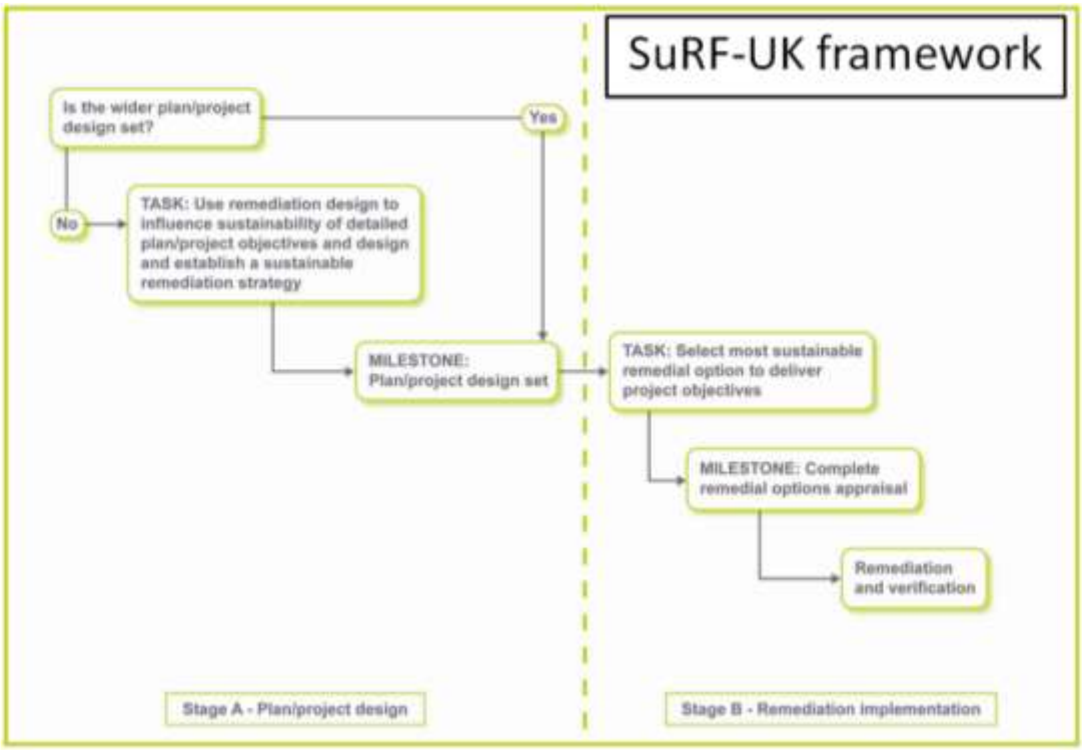


Figure 7: Overview of the SuRF-UK framework (Source: CL:AIRE, 2010)

In order to make these decisions there is a need for some form of at least comparative sustainability assessment as a basis for decision making. The general components of sustainability assessment comprise agreeing clear objectives for the assessment, clear boundaries, an agreed scope (range of sustainability considerations, i.e. indicators) and a methodology for combining individual comparisons for particular indicators into an over-arching view of sustainability. Figure 8 shows the SuRF-UK approach to sustainability assessment. Key features of this approach are its structure where assessment work is carried out in a progressive way to avoid hidden assumptions, and its concept of "framing" where there are stages of preparation for a sustainability assessment, followed by a stage for defining how the assessment will be done, before it is finally executed. The SuRF-UK approach is very much based on a "bottom-up" concept where those involved with a project set their own objectives, boundaries, cope and method based on their site specific requirements and local stakeholder requirements. In addition, SuRF-UK has published guidance on a series of "Sustainable Management Practices", which are easy to adopt measures which can be deployed across any contaminated land management project from site investigation onwards to reduce the impacts of site management activities[6].

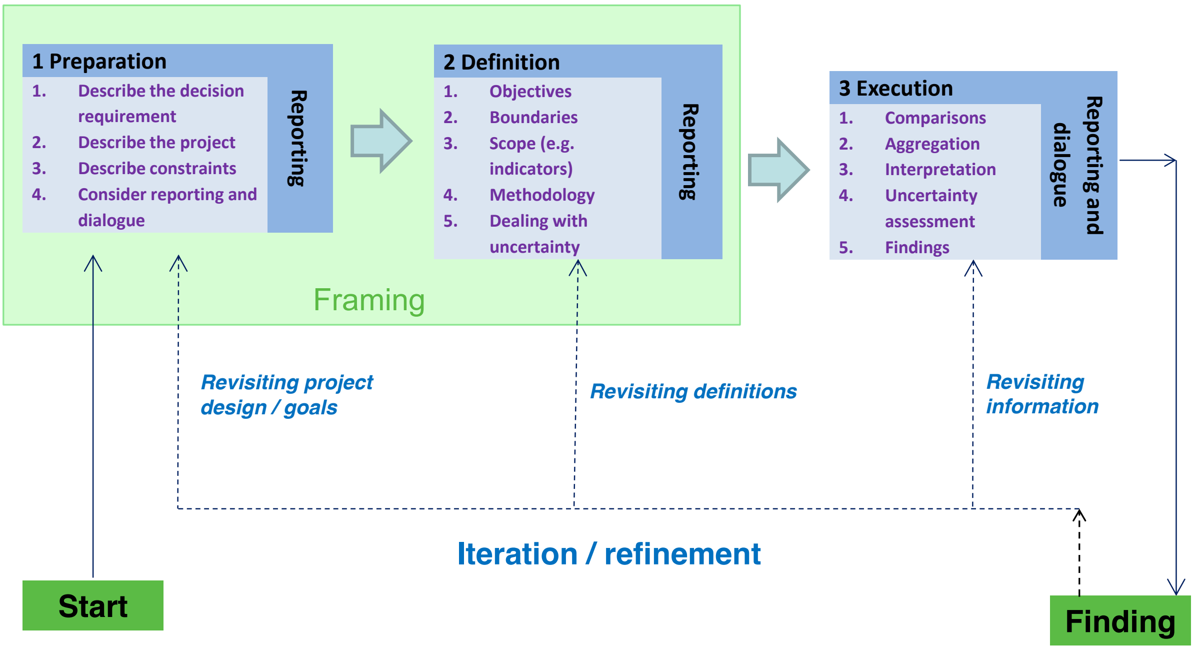


Figure 8: Framing sustainability assessment[7]

A number of underpinning principles are also broadly accepted as a part of sustainable remediation (Table 9). Fundamental to these is that the rationale for carrying out

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[6] See www.claire.co.uk/index.php?option=com_content&view=article&id=739:sustainable-management-practices&catid=964:executing-sustainable-remediation&Itemid=78

[7] See www.claire.co.uk/index.php?option=com_content&view=article&id=740:sustainability-assessment-project-framing-and-planning&catid=964:executing-sustainable-remediation&Itemid=78

remediation work is to manage risks. If there are no risks there is no case for remediation, conversely the urgency of the need for remediation depends on the importance of the risks identified. *Sustainability cannot be used as a general excuse to avoid a necessary risk management action*. Sustainable remediation is therefore a process of finding the optimum means of managing risks.

Table 9: SuRF-UK principles for sustainable remediation

1	**Protection of human health and the wider environment** Remediation [site-specific risk management] should remove unacceptable risks to human health and protect the wider environment now and in the future for the agreed land-use, and give due consideration to the costs, benefits, effectiveness, durability and technical feasibility of available options.
2	**Safe working practices** Remediation works should be safe for all workers and for local communities, and should minimise impacts on the environment.
3	**Consistent, clear and reproducible evidence-based decision-making** Sustainable risk-based remediation decisions are made having regard to environmental, social and economic factors, and consider both current and likely future implications. Such sustainable and risk-based remediation solutions maximise the potential benefits achieved. Where benefits and impacts are aggregated or traded in some way this process should be explained and a clear rationale provided.
4	**Record keeping and transparent reporting** Remediation decisions, including the assumptions and supporting data used to reach them, should be documented in a clear and easily understood format in order to demonstrate to interested parties that a sustainable (or otherwise) solution has been adopted.
5	**Good governance and stakeholder involvement** Remediation decisions should be made having regard to the views of stakeholders and following a clear process within which they can participate.
6	**Sound science** Decisions should be made on the basis of sound science, relevant and accurate data, and clearly explained assumptions, uncertainties and professional judgment. This will ensure that decisions are based upon the best available information and are justifiable and reproducible.

6.3 Sustainable remediation, policy and regulation

In the UK sustainable remediation is encapsulated in the SuRF-UK framework, which is *voluntary*. However, the framework is recognised by regulatory and policy agencies as representing best available practice and so is increasingly referred to in UK regulatory guidance. This has been an optimal approach because it has allowed for a free exchange of ideas between problem holders, service providers and regulators during the development of guidance. It has avoided the cost and complexity of legislative measures; and it has provided practitioner based guidance that regulators can refer to rather than creating their own.

In 2015 SuRF-UK published a detailed and systematic review of legislative, regulatory, and technical guidance documents relevant to the contaminated land regime in the EU and UK was undertaken. It identified sustainability principles embedded in a wide body of EU Directives, and UK legislation, regulation, and technical guidance. These included the Water Framework Directive (2000), the Environmental Liabilities Directive (2004), the Groundwater Directive (2006), the Waste Framework Directive (2008), the Industrial Emissions Directive

(2010) and the Priority Substances Directive (2013) as well as the Common Implementation Strategy (CIS) guidance for the Water Framework and Groundwater Directives. This report is freely downloadable from www.claire.co.uk/surfuk

7 Conclusions and Recommendations

The challenge of managing land contamination is not a new one. It has been recognised by governments internationally for at least thirty years and is closely associated, technically and legislatively with the issues of waste and hazardous waste disposal, the regeneration of derelict land, groundwater pollution and industrial site decommissioning.

While there is some evidence that the policies in China have had some effect, there is still considerable scope for strengthening the implementation of environmental policies. In order to increase efficiency of the environmental regulations and limit negative environmental and health impacts of rapid economic growth, the Chinese authorities should consider the following:

- Avoiding important discrepancies and gaps between the principal laws and executive regulations; environmental laws and regulations need to be more consistent, transparent and non-discriminatory.
- Allowing more public participation in the regulatory process at all stages.
- Strengthening capacities of environmental administrations in China and aligning responsibilities with funding.
- Setting out the Government's policy on dealing with land contamination through the planning process.
- The planning system should deal with land contamination as a 'material consideration'
- Pursuing the development for environmental policy tools suitable to address problems experienced in different parts of the country. The effectiveness of policy instruments including standards (i.e. deriving generic and site specific assessment criteria), planning permitting and economic instruments should be enhanced and 'fit for purpose' to tackle different environmental problems and different segments of the regulated community.
- Recommending an overarching guidance structure like the CLR11 model procedures, and independent information "agency" like CL:AIRE
- Encouraging linkage to multilateral discussions about issues such as sustainable remediation, and ensuring that the China overarching guidance structure is functional in a way that can accommodate additional stages of guidance moving forward. The UK model procedures have worked really well in that regard.
- Developing appropriate compliance assurance strategies through awareness raising, capacity building, public pressure and incentives for better environmental behaviour.
- Promoting voluntary schemes whenever possible and encouraging and supporting sector led initiatives
- Providing an international training cradle for developing innovative talents to meet the urgent need of land contamination and management in China.
- Enhancing international collaboration in the management and sustainable development of contaminated lands so as to achieve policy compatibility and joint action

Overall a move to more inclusive processes for environmental decision-making is needed. The regeneration of land contamination has always required a multi- and trans-disciplinary approach, but increasingly scientists, engineers, planners and lawyers are turning to the social sciences for a re-interpretation of the issues historically viewed as driven by technological and economic concern alone. As a result, China will gain valuable insights into the value of institutional trust, into 'process' issues in terms of involving others in decision-making, into issues of equity and the perceptions and reporting of risk.

8 Further Reading

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9 Appendix

9.1 Landfill Directive

The Landfill Directive was published in 1999 (1999/31/EC), and transposed fully in England and Wales into national legislation through the Landfill Regulations (England and Wales) in 2002. It was introduced bit by bit to allow industry to adapt, however it has had a major impact in the way the UK has approached remediation of land contamination. This directive aimed to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements for waste and landfills and setting targets for the reduction of biodegradable waste going to landfill. Historically the UK practiced what it known as co-disposal, whereby hazardous and non-hazardous wastes would be landfilled together within the same landfill. Since July 2004, landfills were divided into three classes:

- Landfills for hazardous waste
- Landfills for non-hazardous waste
- Landfills for inert waste

Now hazardous sites can only accept hazardous waste, non-hazardous can only accept non-hazardous waste and inert sites, only inert wastes.

In October 2007 liquid wastes and the requirement of pre-treated materials only was introduced. This treatment needed to include a physical, thermal, chemical or biological process - which can include sorting - to change the characteristics of the waste to either reduce its volume, reduce its hazardous nature, facilitate its handling, or enhance its recovery.

The Landfill Directive was later amended in 2004 and 2005 to transpose the requirements of the European Commission Council Decision 2003/33/EC on Waste Acceptance Criteria. These are the standards set by the landfill's permit that stipulates what type of waste it is able to accept. This provision was re-transposed as part of the Environmental Permitting (England and Wales) Regulations 2007.

9.2 Waste Framework Directive

With the implementation of the revised Waste Framework Directive (2008/98/EC) in England and Wales in 2010 there was a step change in the approach to soil remediation. The directive was introduced and provided an overarching legislative framework for the management of waste. It outlined the hierarchy which should act as a "priority order" in waste prevention, legislation and policy.

The primary aim of the Waste Framework Directive is the protection of human health and the environment and necessary measures are required to be taken to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment.

The directive then sets out a range of recycling and reuse targets, for both household and construction and demolition (C&D) waste.

The targets in the Directive are:

- to recycle or prepare for reuse 50% of household waste by 2020
- to reuse, recycle or recover 70% of non-hazardous C&D waste by 2020

Therefore with stricter and more costly landfill targets and disposing of waste to landfill, this provided the added incentive for the development industry to start to invest more time and effort into undertaking more remediation on site. An alternative to landfilling and following the Waste Framework Directive was to use the Definition of Waste Development Industry Code of Practice (DoWCoP). This is a voluntary system whereby material does not fall into the waste system by being discarded.

9.3 Definition of Waste: Development Industry Code of Practice

The DoW CoP provides a clear, consistent and efficient process which enables the reuse of excavated materials on-site or their movement between sites. The process supports the sustainable and cost effective development of land and provides an alternative to Environmental Permits or Waste Exemptions.

The DoW CoP enables:

- Direct transfer and reuse of clean naturally occurring soil materials between sites
- Conditions to support the establishment/operation of fixed soil treatment facilities
- Reuse of both contaminated/uncontaminated materials on their site of origin and between sites within defined Cluster project.

The principles for the reuse of material as non-waste are:

- Protection of human health and the environment
- Suitability for use, without further treatment
- Certainty of Use
- Quantity of Material

If materials are dealt with in accordance with this Code of Practice the Environment Agency (EA) considers that those materials are unlikely to be waste if they are used for the purpose of land development. This may be because the materials were never discarded in the first place, or because they have been submitted to a recovery operation which has been completed successfully so that they have ceased to be waste. Further information can be obtained from www.claire.co.uk/cop

9.4 Water Framework Directive

In December 2000 the Water Framework Directive was adopted and came into force in England and Wales. The aims of this Directive are to:

- Prevent further deterioration of aquatic ecosystems;

- Protect, enhance and improve the aquatic environment;
- Promote sustainable water use;
- Provide further protection to the aquatic environment; and
- Ensure the progressive reduction of pollution of groundwater and prevent its further pollution

The Directive requires European Member States to establish river basin districts and for each of these a river basin management plan. The Directive envisages a cyclical process where river basin management plans are prepared, implemented and reviewed every six years.

The Water Framework Directive places a restriction on pollutants directly being input in the groundwater and that all necessary measures must be taken to prevent the input of hazardous substances and to limit inputs of non-hazardous pollutants so as to avoid pollution.