CL:AIRE

CONTAMINATED LAND: APPLICATIONS IN REAL ENVIRONMENTS

# PRIORITIES FOR TECHNOLOGY DEMONSTRATION AND RESEARCH

**November 2006**

## Executive Summary

The purpose of this document is to communicate CL:AIRE's priorities for technology demonstrations and research in the context of UK contaminated land remediation to technology vendors, research organisations and other interested parties involved in site remediation, in order to encourage project applications in certain priority areas.

It sets out CL:AIRE's broad requirements for CL:AIRE Technology Demonstration Projects and CL:AIRE Research Projects within the three categories of site investigation, monitoring and remediation, and points to the inherent compatibility between components of the risk-based approach advocated by the Environment Agency's Model Procedures for the Management of Land Contamination document (CLR11) and CL:AIRE's activities.

The document further outlines CL:AIRE's unique position within the contaminated land industry with respect to government departments and organisations, and points to CL:AIRE's overall strategy for building confidence in the contaminated land marketplace.

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# 1. INTRODUCTION

## 1.1 Purpose

CL:AIRE is a public private partnership which was established by the UK Government and the Soil and Groundwater Technology Association (SAGTA) in 1999 to facilitate the field demonstration of technologies and research on contaminated sites throughout the UK, and to link and support the main stakeholders in contaminated land. Working with these organisations, CL:AIRE has examined the current state of the contaminated land market and opportunities for the future. This has identified certain priorities for the next five years.

The purpose of this document is to communicate CL:AIRE's priorities for technology demonstrations and research in the context of UK contaminated land remediation to technology vendors, research organisations and other interested parties and to encourage further applications in certain priority areas. It presents the broad requirements for both Technology Demonstration Projects and Research Projects in terms of site, contaminant and technology type and describes the overall CL:AIRE strategy for building confidence in the contaminated land marketplace.

## 1.2 Background

CL:AIRE is recognised as an important player in delivering both technology demonstrations and technology research. Indeed, the Department for Communities and Local Government (formerly Office of the Deputy Prime Minister (ODPM)) requires that the Regional Development Agencies engage CL:AIRE on all major regeneration schemes that involve remediation. Similarly, the Research Councils recognise the value of CL:AIRE's dissemination programme to UK research and pay CL:AIRE a facility cost for these services up to an amount of £10,000 per year of each Research Council project that is also approved as a CL:AIRE Research Project.

The three main benefits of having a project approved by CL:AIRE are, firstly, the added value created by the CL:AIRE Technology and Research Group (TRG) who provide independent evaluation of projects; secondly, market recognition of this peer review process; and, thirdly, global dissemination of the project.

To date, CL:AIRE has facilitated 34 innovative technology demonstration and research projects across the UK with the involvement of over 70 organisations. Once a project is complete, information is shared with all sectors of the contaminated land community, to provide confidence in new technologies and to inform and improve best practice in the UK.

## 1.3 The strategic fit to the UK contaminated land industry

CL:AIRE's activities in contaminated land in the UK support policy and decision-making from three main Government departments: Department for Communities and Local Government (and English Partnerships); Department for Environment, Food and Rural Affairs (and the Environment Agency); and Department of Trade and Industry (through the Technology Strategy Board). Similarly, the devolved administrations are covered by CL:AIRE's interactions with the Department of the Environment, Northern Ireland, the Scottish Environment Protection Agency and the Welsh Assembly Government.

Acting as the Government's specialist adviser on brownfield land, **English Partnerships** advocates sustainable remediation practices. Following the restriction on the volume of material relocated to landfill imposed by legislation, new and innovative technologies have come to the fore and are now of primary importance to the regeneration industry. The role of English Partnerships is to enable the use of these technologies and to provide examples and disseminate best practice through working in close partnership with CL:AIRE and key stakeholders. English Partnerships' role compliments CL:AIRE's remit as the catalyst for cost-effective methods of investigating and remediating contaminated land in a sustainable way.

The management of contaminated land in the UK is guided by the **Environment Agency's** Contaminated Land Report 11 - *Model Procedures for the Management of Land Contamination* (2004), which advocates a risk-based approach. The basic risk management process in the *Model Procedures* has three main components: risk assessment, options appraisal and implementation. CL:AIRE, through its programme of technology demonstration and technology research, helps to build confidence in technologies by providing examples of best practice and by feeding back lessons learned from successes or when optimum results are not obtained. The CL:AIRE project evaluation procedure supplements the decision-making process in all three main components outlined by the *Model Procedures* as illustrated in Table 1 below:

Table 1: Illustration of the relationship between the *Model Procedures* and CL:AIRE

| **Three components of the risk management process (taken from the Environment Agency's *Model Procedures*)** | **Elements of CL:AIRE's activities that reinforce the *Model Procedures*** |
|---|---|
| Risk assessment – establishing whether unacceptable risks exist and, if so, what further action needs to be taken to manage them. | Demonstration of, or research into, cost-effective, sustainable methods for site characterisation and site monitoring. |
| Options appraisal – evaluating feasible remediation options and determining the most appropriate remediation strategy for the site. | Demonstration of, or research into, cost-effective, sustainable methods for site remediation. |
| Implementation – carrying out the remediation strategy and demonstrating that it is, and will continue to be, effective. | Evaluation of technology demonstrations, whether successful or not, and reporting back of lessons learned. |

The **Department of Trade and Industry's (DTI) Technology Strategy Board** determines the framework for public and business investment in research so as to achieve a step change in UK performance. DTI launched six medium term strategies in April 2006, one of which relates to Sustainable Production and Consumption ("SPC") covering waste minimisation, waste treatment and pollution control. This strategy – aimed at developing innovative technologies central to achieving the goals of sustainable economic growth – identifies promising new technologies and commercial applications. The document notes the UK's £1 billion (and growing) market for land assessment and remediation, and potential global markets, and identifies key pollution technologies - prevention; site investigation and monitoring; and risk assessment/management. CL:AIRE's work is important to the achievement of these DTI aims and as such CL:AIRE is specifically mentioned in the SPC strategy document.

In addition to the above, representation on the **CL:AIRE Board of Trustees** by the following cross-sectoral organisations ensures a multi-stakeholder input into CL:AIRE's activities:

- English Partnerships
- The Soil and Groundwater Technology Association
- Land Restoration Trust
- Environment Agency
- Department of Environment, Northern Ireland
- Welsh Assembly Government
- Scottish Environment Protection Agency
- Research Councils
- Local Authorities
- Small and medium sized enterprises

### 1.4 Priority sites and contaminants

The scope of CL:AIRE's activities, through its technology demonstration and research projects, includes both soil and groundwater contamination and covers a wide variety of types of contaminated sites. These include but are not limited to:

- Coalfields;
- Gas works;
- Railway lands;
- Metal mine sites;
- Petroleum manufacturing, distribution and retailing;
- Chemicals production facilities; and
- Pharmaceuticals production facilities.

and also sites with particular contaminants, such as:

- Chlorinated compounds;
- Hydrocarbons;
- Pesticides;
- Fertilisers;
- Explosives;
- Radionuclides;
- Toxic heavy metals and semi-metals; and
- Hormone disrupters and mimickers.

These site types and substances account for the majority of contaminants and land contamination found in the UK*. CL:AIRE has an interest in all chemical contaminants.

CL:AIRE places a priority on the following difficult types of contaminated environments:

- Mixed contaminants;
- Made ground; and
- Aquifers in consolidated rock (primarily sandstone and chalk).

*DOE Industry Profiles provide further information on contamination that may be associated with specific industries.

## 2. PRIORITIES FOR TECHNOLOGY DEMONSTRATIONS

One of CL:AIRE's core objectives is to demonstrate the application of technologies which may offer improved site investigation techniques, monitoring or remedial solutions. In order to meet this objective, CL:AIRE has developed a process in which demonstration projects are submitted, evaluated by a team of independent experts and, if approved, monitored and reported so that the industry as a whole can benefit from the results.

This section sets out CL:AIRE's priorities for technology demonstrations and will answer the following questions:

- What is a technology demonstration?
- What type of project is CL:AIRE interested in?
- Who can submit a demonstration project to CL:AIRE?
- How does CL:AIRE allay concerns over confidentiality?

### What is a technology demonstration?

*Applications in real environments* is what the AIRE in CL:AIRE stands for and this sets the scene for technology demonstrations, i.e. a **technology must be applied on a real contaminated site**. CL:AIRE is interested in demonstrating both **established technologies** and **innovative** ones, at several scales – **field or pilot trial**, **small** and **large-scale** remediation. In order to carry out a successful demonstration with CL:AIRE, a technology vendor must clearly identify their approach, display a thorough understanding of the application of their technology and back this up by using appropriate treatability studies and statistically robust sampling and monitoring. Even if the demonstration is not completely successful, this approach will ensure valuable lessons are learned to guide and inform a future application of the technology. By constructively reporting all aspects of a demonstration project, CL:AIRE is able to improve confidence and awareness in the remediation marketplace.

### What type of project is CL:AIRE interested in?

CL:AIRE wants to demonstrate cost-effective, sustainable methods for site characterisation, site monitoring, and site remediation on contaminated sites in the UK. Site remediation includes the broad treatment method categories of:

- Biological;
- Chemical;
- Physical;
- Electrical; and
- Thermal.

and extends to various combinations of such methods within a treatment train. There are many technologies within these categories, examples of which are given on the United States Environmental Protection Agency CLU-IN website (http://clu-in.org/techfocus/). However, in order to build confidence, a technology needs to be demonstrated not just once, but under a range of conditions. Figure 1 illustrates this point by depicting factors that could differ between two similar demonstrations. For this reason CL:AIRE welcomes a technology demonstration despite statements that "it has been done before". In particular, Figure 1 highlights the site-specific nature of contaminated land investigation and remediation.

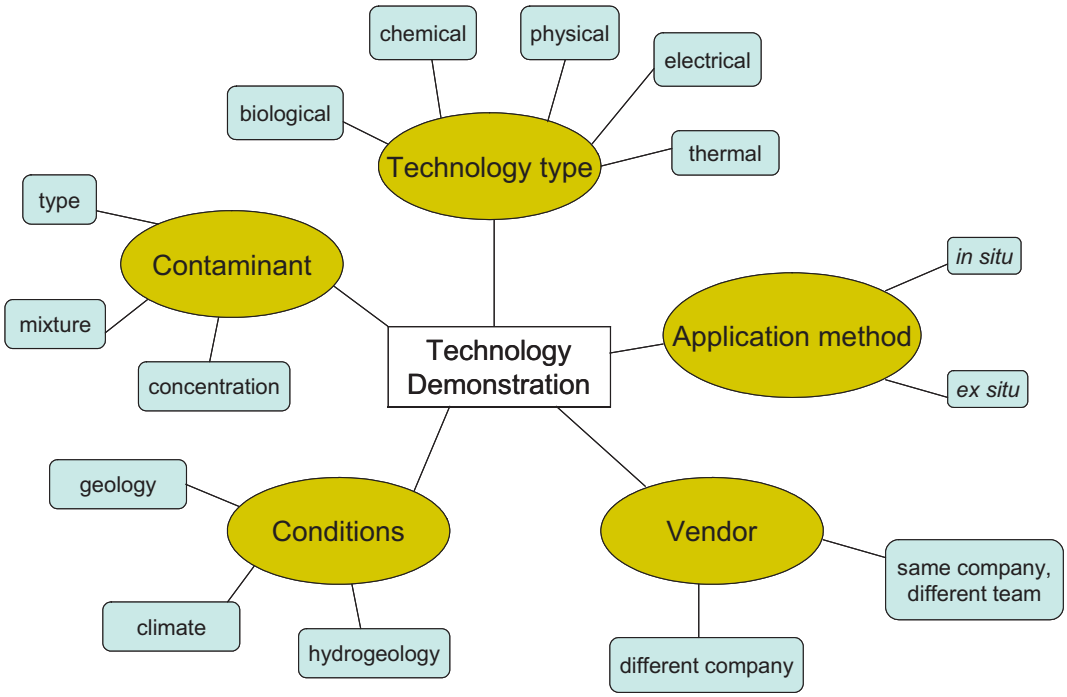


Figure 1: Factors affecting a technology demonstration

The aim, therefore, is for CL:AIRE to build up a portfolio of demonstrations, using different technology vendors, under a range of contaminant and site conditions, where there are successes and lessons to be learned, until a thorough understanding of the application of the technology in the UK is achieved. This obviously applies to all characterisation, monitoring and remediation technologies. The objective is to develop operational envelopes of individual technologies to identify the conditions under which there is a high degree of certainty that a technology will or will not meet the remediation objectives of a project. Over time and through CL:AIRE's activities, the grey area where there is uncertainty between technology success and failure should diminish for each individual technology (as illustrated in Figure 2), leading to increased confidence and informed decision-making.

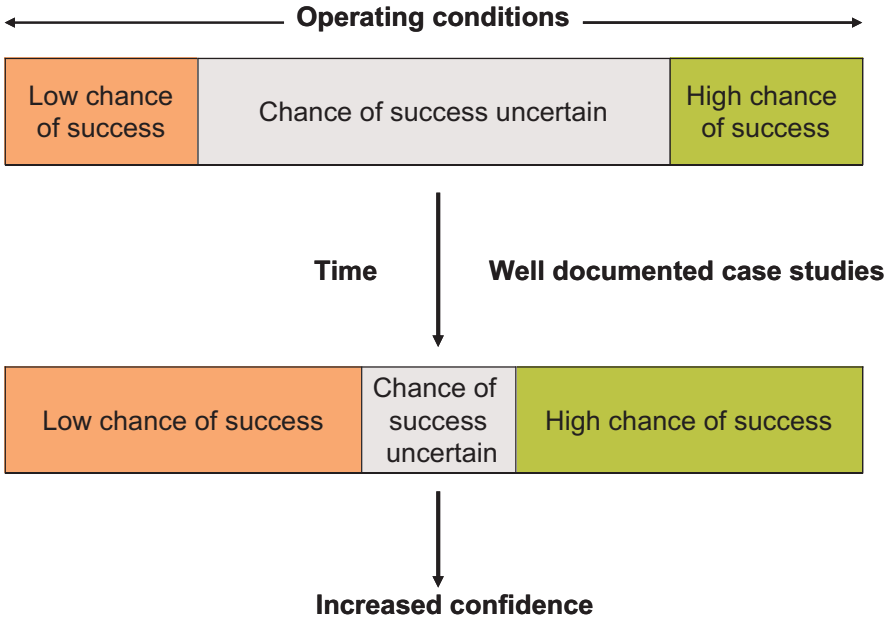


Figure 2: Defining the operational envelope of site investigation and remediation technologies

Readers who are looking for further guidance on the type of project CL:AIRE is interested in are encouraged to refer to the priority research areas detailed in Section 3 which expands on the three areas of characterisation, monitoring and remediation from a research and development perspective, in which priority is given to "novel" technologies. It may also be useful to note current and previous CL:AIRE demonstration projects in Appendix 1.

**Who can submit a demonstration project to CL:AIRE?**

Although technology demonstrations must be undertaken on sites in the UK, there is no restriction on whether the project operator or technology vendor is UK or non-UK based.

Typically, technology vendors, contractors or consultants will apply to carry out Technology Demonstration Projects. However, there have been examples at the most applied end of applied research in which research organisations have conducted demonstration projects. Conversely, there will be occasions when technology vendors submit a research project to CL:AIRE. The most appropriate project type can be discussed when contacting the CL:AIRE team.

**How does CL:AIRE allay concerns over confidentiality?**

If a project partner does not want the site or project team to be known, this information does not need to be passed to CL:AIRE. In addition, all CL:AIRE staff, the CL:AIRE Board and the Technology and Research Group subscribe to CL:AIRE's code of confidentiality.

## 3. PRIORITIES FOR RESEARCH

Another of CL:AIRE's core objectives is to develop a strategy for contaminated land research in the UK. The strategy is driven by the needs of the contaminated land user community, which includes site owners, practitioners, regulators and others. It takes into account changes arising from new legislation, economics, developing technologies and changing market conditions.

CL:AIRE's role in contaminated land research is explained below:

**CL:AIRE will not undertake research itself but will**
- identify priority research areas;
- facilitate the efficient delivery of research outcomes;
- encourage the focus of research activities on a limited number of well-characterised contaminated sites; and
- ensure dissemination of the results of its activities.

**CL:AIRE will identify priority areas for research using the following generic criteria**:
- those problems that are most costly to UK industry and contaminated land owners;
- those problems that have a significant impact on environmental quality;
- areas of research interest that offer the greatest benefit for research investment;
- those problems which are deemed most frequently occurring in the UK; and
- those that are currently difficult to solve.

**CL:AIRE will ensure efficient progress of research by**
- encouraging and supporting submission of good quality research proposals;
- receiving proposals from research providers and commenting on the proposed approach, suggesting recommended improvements to the research where appropriate; and
- brokering sites and projects.

**CL:AIRE will ensure communication and publicity for**
- the results of its identification of priority areas to potential providers of solutions; and
- the solutions to contamination problems, especially to problem holders.

CL:AIRE supports a broad range of research interests into the characterisation, monitoring and remediation of contaminated land. However, there are key areas of research that CL:AIRE ranks highly, although the areas listed below are neither comprehensive nor exclusive:

**1. Novel, cost-effective methods for site characterisation**
- Tools for more cost-effective site investigations including:
  - non-invasive geophysical methods;
  - those which provide more information from each intrusive hole;
  - methods to distinguish 'bioavailable' from 'total concentrations' of contaminants;
  - statistical methods for selection of sampling locations; and
  - *in situ* (or at least on-site) analysis tools, in particular those which deliver real-time (or near real-time) data to allow immediate selection of further sampling points or identification of required changes to the conceptual site model.

**2. Novel, cost-effective methods for *in situ* monitoring**
- Statistical methods to validate environmental sampling protocols;
- Development and application of *in situ* monitoring tools, in particular those which can deliver real-time (or near real-time) data.

**3. Novel, cost-effective methods for site remediation**

(i) Destructive technologies

- Comparative trials of destruction technologies;
- Modelling and designing effective *in situ* destructive processes (e.g. bioremediation), taking into account the fate and transport of intermediate products, or any process amendment substances, within the subsurface.

(ii) Integrated technologies

- Comparative trials of integrated technologies for example; thermal removal technologies (e.g. steam);
- Management of metals on building land (also applicable to priorities 1, 2, 3(i), 3(iii), and 3(iv));
- Phytoremediation including biomass destruction and toxic substance recovery from the biomass.

(iii) *In situ* technologies

- Cost-effective remedial technologies for methyl tertiary butyl ether (MTBE), including evaluation of monitored natural attenuation (MNA);
- Characterisation and removal/destruction of chlorinated solvents from consolidated aquifers, particularly from chalk (also applicable to priorities 3(i), 3(ii) and 3(iv));
- Improved predictive capability of behaviour of free-phase light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) (e.g. When and how far will it move? When will it not move?). This is also applicable to priorities 3(i), 3(ii) and 3(iv);
- Process flowsheet design for the scale-up and development of effective *in situ* remedial treatments in both the saturated and unsaturated zone;
- Permeable reactive barriers;
- Chemical oxidation or reduction; and
- Stabilisation/solidification.

(iv) Low energy demand technologies

- MNA of contaminants within the unsaturated zone including:
  - understanding the leachability and attenuation of chemical contamination under site conditions; and
  - understanding natural attenuation of organic vapours in the unsaturated zone.
- MNA of groundwater contamination including:
  - definition of operational window under UK conditions;
  - improved monitoring and predictive tools to minimise costs and length of time that monitoring is required; and
  - definition of minimum technically defensible dataset to demonstrate that the attenuation is effective.

(v) Monitoring, verification and validation of remedial treatments

- Design of effective monitoring programmes to verify, and subsequently validate, successful remedial treatments of contaminated soils and groundwater;
- Application of statistical tools to assess the effectiveness of remedial treatments; and
- Evaluating the use of remedial treatments for risk reduction.

A list of current CL:AIRE Research Projects is provided in Appendix 1.

## 4. FURTHER INFORMATION

Information to support this document, including the following, can be found on the CL:AIRE website at www.claire.co.uk.

- Benefits of undertaking a project through CL:AIRE
- Application Forms for Technology Demonstration and Research Projects
- The TRG members and their areas of expertise
- Evaluation criteria used by the TRG
- TRG Annual Report 2005
- Project summaries from completed and current CL:AIRE Projects

To discuss any of the details in this document, please contact Dr Rob Sweeney, Senior Project Manager, at the following address:

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Appendix 1

**Status of CL:AIRE Technology Demonstration Projects**

| Project Code | Project Title and Project Operator | Status |
|---|---|---|
| TDP 1: | Remediation Trial Using Low Temperature Thermal Desorption to Treat Hydrocarbon Contaminated Soil - British Aerospace Systems | Project Completed + Report Available |
| TDP 2: | Remediation of Basford Gasworks Using Soil Washing – National Grid Property/VHE | Project Completed + Report Available |
| TDP 3: | Design, Installation and Performance Assessment of a Zero Valent Iron Permeable Reactive Barrier in Monkstown, Northern Ireland- Nortel Networks/Golder Associates/Queen's University Belfast/Keller Ground Engineering Ltd | Project Completed + Report Available |
| TDP 4: | Slurry-Phase Bioreactor Trial - Parsons Brinckerhoff/National Grid Property | Project Completed + Report Available |
| TDP 5: | A Reducing and Alkalinity Producing System (RAPS) for Passive Treatment of Acidic, Aluminium Rich Leachates from Mine Spoils - University of Newcastle/Durham County Council | Project Completed + Report Available |
| TDP 6: | Bioremediation Trial at Avenue Coking Works, Chesterfield - DEC NV/Jacobs/East Midlands Development Agency/English Partnerships | Project Completed + Report Available |
| TDP 8: | Avenue Coking Works: A Field Demonstration of Accelerated Carbonation Technology (ACT) for the Remediation of Contaminated Soil – Jacobs/East Midlands Development Agency/English Partnerships | Project Completed + Bulletin Available |
| TDP 9: | Use of an Air Sparge Treatment Curtain to Remediate Groundwater at a Former Gas Works - Komex/National Grid Property | Project Completed + Report Available |
| TDP 10: | Avenue Coking Works Remediation Trials: Enhanced Thermal Conduction (ETC) - MEL Limited/Jacobs/East Midlands Development Agency/English Partnerships | Project Completed + Report in Progress |
| TDP 11: | Avenue Coking Works, Chesterfield: Soil Washing Remediation Trial - DEC NV/Jacobs/East Midlands Development Agency/English Partnerships | Project Completed + Report in Progress |
| TDP 12: | Bioremediation of the Coke Works and Former Colliery at Askern, Doncaster - Ecologia Environmental Solutions Ltd/Mowlem Remediation/Yorkshire Forward | Project Completed + Report Available |
| TDP 13: | A Permeable Reactive Barrier for Remediation of Extremely Polluted Groundwater Associated with a Highly Pyritic Abandoned Colliery Spoil Heap - University of Newcastle upon Tyne and Northumberland County Council | Project Completed + Report Available |
| TDP 14: | Soil and Process Water Remediation Trial, at Avenue Coking Works - Norwest Holst Construction Ltd/Jacobs/East Midlands Development Agency/English Partnerships | Project Completed + Report in Progress |
| TDP 16: | Remediation of Chlorinated Hydrocarbon Contaminated Soils using *Ex Situ* Soil Vapour Extraction – RemedX and ABB | Project Completed + Report in Progress |
| TDP 17: | *In Situ* Bioremediation of Cyanide, PAHs and Heterocyclic Compounds using Engineered SEquenced REactive BARrier (SEREBAR) Techniques - Queen's University Belfast/National Grid Property/Parsons Brinckerhoff | Project Completed + Report in Progress |
| TDP 18: | Remediation Technologies Development Forum (RTDF) - UK In Situ Source BioREmediation (SABRE) | Project ongoing |
| TDP 19: | Application of Controlled Release Electron Donors for Accelerated In Situ Reductive Dechlorination of Chlorinated Solvents in a Deep Low Permeability Aquifer - Regenesis, Golder Associates | Project Completed + Report in Progress |
| TDP 20: | Design, Installation and Performance Assessment of a Permeable Reactive Barrier (PRB) to Treat Carbon Disulphide Contaminated Groundwater at a Former Chemicals Site in Manchester - CEL International Ltd, ESI | Project Completed + Report in Progress |

**Status of CL:AIRE Research Projects**

| Project Code | Project Title and Principal Project Operator | Status |
|---|---|---|
| RP 2: | Hydro-biological Controls on Transport and Remediation of Organic Pollutants for Contaminated Land - Professor Howard Wheater, Imperial College of Science, Technology and Medicine; Professor Jeremy Mason, Kings College, London; and National Grid Property | Project Completed + Report in Progress |
| RP 3: | Processes Controlling the Natural Attenuation of Fuel Hydrocarbons and MTBE in Chalk - Dr Steve Thornton, University of Sheffield | Project Completed + Report Available |
| RP 4: | The Development of a Statistical Model to Optimise Investigation to Characterise Contaminated Land - Professor Mike Ramsey, University of Sussex | Project Completed + Report in Progress |
| RP 5: | The Use of Bonemeal Phosphates to Stabilise Metal Contamination - Dr Eva Valsami-Jones, The Natural History Museum | Project Completed + Report in Progress |
| RP 6: | Phytoextraction of Metals: Investigation of Hyperaccumulation and Field Testing - Professor Steve McGrath - Rothamsted Research | Project Completed + Report Available |
| RP 9: | The Development of an Indicator Methodology to Determine the Plant Availability of Potentially Toxic Elements - Tony Hutchings, Forest Research/Martina Juvara – Arup | Project ongoing |
| RP 10: | Comparative Assessment of Approaches for Predicting the Fate and Transport of Dissolved Phase Hydrocarbons in Chalk Aquifers - Natalyn Ala, Atkins Environment | Project ongoing |
| RP 11: | Indigenous Microbial resPonse to *in situ* RemediAL Technologies (IMPART) - Dr Ian Thompson, Centre for Ecology and Hydrology, Oxford | Project Completed + Report in Progress |
| RP 12: | Development of an *In Situ* Aquifer Assessment Tool with Risk Management Calculator for Natural Attenuation - Professor Steve Banwart, University of Sheffield | Project Completed + Report in Progress |
| RP 13: | *In situ* Source Treatment for Enhanced Bioremediation Processes (IN-STEP) - Professor Bob Kalin, Queen's University Belfast | Project Completed + Report in Progress |
| RP 14: | Use of Longitudinal STREAMTUBE-Based Monitoring Approaches to Determine Contaminant Fate Within the SABRE Intra-Source/Plume Test Cell.- Dr Mike Rivett, University of Birmingham | Project ongoing |
| RP 15: | Ferric Iron Remediation and Stabilisation (FIRS): electrokinetic remediation of heavy metal-contaminated back garden sites - Dr Andrew Cundy, University of Sussex, Dr Laurence Hopkinson, University of Brighton | Project ongoing |
| RP 16: | Performance Assessment of Stabilised/Solidified Waste Forms (PASSiFy) – Dr Colin Hills, University of Greenwich | Project ongoing |
| RP 17: | The Use of Recycled Construction/Demolition and Industrial Waste as a Substrate in a Novel Manganese Removal Passive Treatment System - Dr Selina Bamforth, University of Newcastle upon Tyne and Dr Karen Johnson, University of Durham | Project Completed + Report in Progress |
| RP 18: | Optimising Biopile Processes for Weathered Hydrocarbons within a Risk Management Framework - Professor Simon Pollard, Cranfield University | Project ongoing |
| RP 19: | Process Envelopes for Cement-based Stabilisation/Solidification (ProCeSS) - Dr Julia Stegemann, University College London | Project ongoing |