Note of SAFESPUR Meeting

Radioactive vs non-radioactive contamination – tools and techniques showcase

Davis Langdon LLP, Birmingham
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This SAFESPUR meeting was held jointly with the BRMF (Brownfield Risk Management Forum) network and gave delegates the opportunity to hear the latest requirements of the regulatory regime for radioactive and non-radioactive contaminated land and discuss approaches for the investigation, assessment and management of contaminated land on nuclear and non-nuclear sites. During the morning session there were three presentations followed by a question and discussion session. The afternoon session featured a "tool and techniques showcase" with four brief presentations and open discussion. This meeting was attended by about 40 people. The meeting was chaired by Candida Lean from the NNL (National Nuclear Laboratory).

Introduction

The chair of the meeting opened the session by highlighting some of the differences and similarities between radioactive and non-radioactive contaminated land. The brownfield regeneration industry has significantly expanded over the past decades. Over 10,000 hectares of contaminated land has been remediated in the UK and this figure is increasing. Most of this land has been contaminated with non-radioactive contaminants, however, over the past few years increasing effort has been put into the characterisation and assessment of radioactive contaminated land. In 2006 the Nuclear Decommissioning Agency (NDA) estimated the contaminated land liability across its 20 sites to be of the order of £1.4 billion. There is a government driver to reduce NDA liabilities by 10% by 2010. The nuclear industry is responding to this challenge by further characterisation and assessment to refine these estimates, taking into consideration likely end states and site management requirements. At defence sites the driver is usually that Defence Estates has a remit to sell the land. At other sites the Radioactive Contaminated Land (RCL) regulations, which recently came in force, may become a driver.

Regulatory bodies and drivers differ between the assessment of radioactive and non-radioactive contaminated land and between nuclear licensed sites and other sites. The aim of the meeting was to enable delegates to hear the different approaches that industry has applied to investigate, assess and manage radioactive and non-radioactive contamination. It was hoped that one of the useful outcomes of the meeting would be the opportunity to highlight commonalities and differences between the two regimes in order to facilitate cross-sector learning and identify the major challenges that industry currently faces.

Regulatory Framework for Contaminated Land on Nuclear and Other Radioactively Contaminated Sites

The first presentation of the meeting was given by Marion Hill, an independent consultant who has over 30 years' experience in policies, strategies and standards for the management of radioactively contaminated land. Her clients include government departments, regulators and nuclear industry organisation. Marion's presentation covered the regulatory framework aspects for contaminated land on both nuclear and other radioactively contaminated land sites.

Marion began by defining the different types of contaminated sites. She distinguished "nuclear sites", including nuclear licensed sites, the associated land and non-licensed defence sites, from "other sites", including civil and defence sites, land in its current use and land for development. She then described the differences in the regulatory regimes between non-radioactive, radioactive and mixed contamination on both nuclear sites and other sites.

The principal regulator for radioactive contamination on nuclear sites is the Health and Safety Executive (HSE) Nuclear Installations Inspectorate (NII) under the terms of the Nuclear Installations Act 1965 and the Health and Safety at Work etc Act 1974. HSE principles for managing radioactively contaminated land are outlined in the Safety Assessment Principles for Nuclear Installations (the SAPs), The Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) have responsibility for regulation of radioactive waste disposal. On defence sites, the Defence Nuclear Safety Regulator (DNSR) works closely with the NII and EA/SEPA.

Although there is no single definition of 'contaminated land' that applies to both radioactive and non-radioactive contamination or nuclear and non-nuclear sites, Marion referred to the SAPs definition as most appropriate to radioactive contamination on nuclear sites. A safety case is required for all radioactively contaminated land and should reflect the extent and nature of contamination, the harm it could cause and how much it could spread. The SAPs state that each nuclear licensed site should have a strategy for managing radioactively contaminated land and this should be consistent with the decommissioning and radioactive waste management strategies for the site. The aim should be to reduce radiation exposures by using effective controlling and remediation techniques. In the case of delicensing a nuclear site there is a need to show that the annual risk associated with contaminated land is less than 10^{-6} and that risks are ALARP (as low as reasonably practicable).

For non-radioactive contamination on non-nuclear sites, Part 2A of the Environmental Protection Act 1990 applies; the sites are regulated as "special sites" by the EA/SEPA. After delicensing, permissions for new site uses will come under the planning regime and be regulated by the local authorities. For mixed contamination, both the radioactive and non-radioactive contaminated land regimes apply, with the HSE and EA/SEPA deciding how to fulfil their responsibilities using their memoranda of understanding as a basis.

The RCL Regulations under Part 2A apply to non-nuclear sites in their current use; the regulators are the EA and SEPA. Land is designated as 'radioactive contaminated land' if individual doses from lasting exposure exceed 3 mSv/year. The planning regime applies to the redevelopment of land with radioactive contamination and the Health Protection Agency (HPA) provides guidance on what levels of risk require the need for, or consideration of, remediation.

Marion ended in stating that the legislation is most likely to remain as it is. However, work is ongoing to review Exemption Orders (EOs). It is hoped that a new set of general radionuclide specific exemption levels will be derived. If these were derived using an annual risk criterion of 10^{-6} and based on a wide range of scenarios they could be used for both land and wastes. This would help to simplify the HSE delicensing process and improve consistency of regulation across other sites.

Worley Parsons Management of Radioactive Contaminated Land
The second presentation was given by Mark Liddiard of Worley Parsons who is the director of nuclear services within the Environment and Infrastructure Division. This is a new business area that has been recently been opened by Worley Parsons servicing the nuclear industry and supporting the remediation of sites contaminated with radioactive substances.

Mark began by briefly reviewing the non-radioactive and radioactively contaminated land regulatory requirements. In Scotland, 12 sites had been designated as contaminated land, two of which had been designated as "special sites" (neither radioactively contaminated). He highlighted some of the differences between the regulation of Part 2A in England and Scotland, emphasising that a recent legislative update in Scotland extended Part 2A to include land within the boundary of a nuclear licensed site. Does this mean that there should be an equal approach to regulation of radioactive contamination from both nuclear sites and other sources?

The NDA is responsible for the identification, investigation, assessment and management of radioactively contaminated land on its sites. This responsibility is fed down to the Tier 1 Management and Operator (M&O) contractors.

Remediation work has been undertaken on a number of nuclear sites. At Dounreay, remedial work has included removal of “hotspots” and capping of at Landfill 42 and the monitoring and removal of radioactive “particles” on Sandside Bay (over 120 particles have been identified). At the AWE Aldermaston nuclear site, a number of significant areas of solvent contamination have been remediated, whilst remediation of a landfill area has been shown not to be the most sustainable solution. With the exception of the solvent contamination at Aldermaston, regulation of this work has been undertaken under RSA 1993. The solvent contamination was remediated under Part 2A, with the site being designated a special site.

A number of non-nuclear sites in Scotland have been identified as having radioactive contamination. These include the Aberdeen beach area (NORM), Gowkthrapple clockworks in North Lanarkshire (radium 226 from luminising works) and Dalgety Bay in Fife (radium 226 from luminous aircraft dial scrap). None of these sites have yet been designated as radioactively contaminated land under Part 2A and remediation at these sites may be too expensive for redevelopment.

Mark concluded in saying that it seems that remediation of radioactive contaminated land only progresses when there is an identified person to manage this and who is funded. This is simple for NDA sites but not for non-nuclear sites. Sites which would appear to meet the definition of harm under Part 2A for radioactivity may not be remediated so quickly as similar levels of contamination on nuclear licensed sites. Mark felt the decommissioning targets can be open ended and the end points of such sites are not yet determined. Does this cause a costly clean-up or over/under shoot the target? Is this a cost effect effective approach? These questions remained for the delegates to consider. Future developments in the definition of “no harm” and end-point for clean up will be fundamental, especially in guaranteeing protection of public health and ecology. However, even if a site is cleaned up for future uses, there is the issue of blight.

Assessment of Risk from Radioactive and Chemical Contaminants: Similarities, Differences and Scope for Comparison

James Wilson of Quintessa specialises in geochemistry of radioactive waste disposal, including human health risk assessment of chemotoxic substances.

He began highlighting some of the differences and similarities in the exposure pathways for radioactive and non-radioactive contaminants in soil. The exposure – response relationship for radionuclides, as evidenced from A-bomb studies, shows the mechanisms are the same for all radionuclides, but are dependant on intensity, duration and organ type. Exposure – response relationships for chemicals are evidenced by key observations from animal experiments and human epidemiological studies and may comprise threshold or non-threshold behaviours. Important uncertainties remain for both radionuclide and chemical exposure-response.

Dose criteria for radionuclides are detailed in the Recommendations of the International Commission on Radiological Protection (ICRP), which are reflected in UK legislation (e.g. the HPA dose criteria for determination of radioactively contaminated land).

For chemicals, health criteria values (HCVs) have been determined by Defra/EA in the CLR Toxicological reports (currently being updated). These are based on a wide range of international guidance, in particular from the World Health Organisation. For threshold effects, the HCV is determined as the 'Tolerable Daily Soil Intake' (TDSI) which is mainly observed from NOAEL (No Observable Adverse Effect Level) animal experiments. For non-threshold effects, the HCV is equal to the 'Index Dose' representing a very low to negligible risk to human health. In the future, it may be possible to use Benchmark Dose data?

Soil Guideline Values (SGVs) are specified as concentrations of a contaminant in soil such that the HCV should not be exceeded and are designed for the protection of human health. Local authorities have reported difficulties in using the SGVs under Part 2A due to uncertainty in how much a HCV/SGV has to be exceeded to represent 'significantly possibility of significant harm'. In response to this, DEFRA issued a consultation exercise ('Way Forward') to address this. This is leading to an updated version of the Contaminated Land Exposure Assessment (CLEA) model and associated guidance including TOX and SGV reports.

The CLEA model and the Radioactive Contaminated Land Exposure Assessment (RCLEA) model are Defra/EA models which are used to calculate contaminant-specific guideline values (SGVs/RSGVs or Site Specific Assessment Criteria (SSACs)) for generic land use scenarios. The main differences between CLEA and RCLEA are:

- CLEA guideline values are contaminant specific, RCLEA allows additive effective dose to be calculated.
- CLEA has 18 age groups, RCLEA has three.
- RCLEA has two additional exposure pathways: external irradiation from contamination at a distance and irradiation of skin through direct contact.
- CLEA has one additional pathway: adsorption through the skin.
- Unlike CLEA, RCLEA considers one soil type due to uncertainties in solid: liquid partition coefficient values.

James gave a review of a hypothetical site to answer the question; can a common basis for comparison be made? By comparing radionuclides assessed by RCLEA and non-radionuclides assessed using CLEA UK (beta), it was concluded that comparisons of risk can be made. However, there are some key differences, such the lack of data for estimating risks posed by exposure to mixtures of chemicals. Communication of relative risks and risk perception can also be problematic. For non-radioactive contaminants HCVs may be equivalent to a 1 in 10,000-100 000 approximate lifetime excess cancer risk of death (depending on the substance and exposure route), whilst a 3 mSv/year dose rate included in RCLEA is roughly equivalent to a 1 in 100 lifetime excess risk of death.

Question and discussion session
The following key points were extracted from the open panel discussion session:

- NNL: Will RCLEA be updated in line with updates to CLEA?
  James Wilson: Unaware of any such plans at present.

- UKAEA: There are discrepancies in criteria for radioactive contamination, e.g. 3 mSv/year for RCL regulations, 0.3 mSv/year for planning and the HSE delicensing criterion (approximately 0.01 mSv/year). There is a tendency for regulators to ask for clean up to the current level in the Substances of Low Activity EO (SoLA,), ie 0.4 Bq/g for solid wastes) rather than using the HPA criterion.
  Marion Hill: A harmonised set of numbers would help This is why it is important to revise SoLA levels, giving radionuclide-specific numbers derived for a wide range of scenarios.

- WSP: In practice, planners consider the National Radiological Protection Board (NRPB) W36 and RCLEA guideline values to be acceptable in the absence of anything else. Some also use SoLA. There are big differences between different local authorities.

Marion Hill: There is a need for more guidance for Local Authorities for land being redeveloped, where Part 2A, its Statutory Guidance and, strictly, RCLEA do not apply. Revised exemption levels would help by specifying what is not radioactive contamination in a clear and comprehensive way.

- NUVIA: Sites have remediated under the planning regime, driven by RSA waste management requirements. An overhaul of EOs would have an effect. The driver for this remediation is primarily the developer wishing to divest liability.

- Taylor Wimpey: Radioactive contaminants are perceived by the public as a "show stopper". Due to public perception of blight, developers prefer the dig and dump option for radioactive contamination.

- It was stated that processes need to have coherent approach, the "dig and dump" analogy – do we really want this to happen? However, in order to redevelop brownfield sites it was agreed that risk needs to be taken on board.

- Selective use of surveys for desk studies, radiological non-intrusive surveys – are they being applied in a routine way?
  There is an increase in the use of non-intrusive survey techniques such as Groundhog to investigate large areas (NUVIA)

- Optioneering processes are used to determine the best practicable environmental option (BPEO) for the management of both radioactive and non-radioactive contamination. The use of these techniques and stakeholder involvement are advanced in the nuclear sector, less so in the non-nuclear sector where there tends to be less public involvement (results are often only disclosed as justification for options other than dig and dump). Even with these processes there is often the wish to do more than the BPEO to meet public expectations.
  - ENVIROS: There is a consultation on land contamination options appraisal via IEMA.
  - RPS: CLR 11 guidance on options appraisal supports the non-nuclear industry.
  - Gemco: Options are taken into account during decision making for non-radioactive contaminated land, but not as transparently as in the nuclear sector.

- Is there a cheap, commercially viable option for radioactive contamination? Is there a sampling process at a low cost?
  - AMEC – screening for radioactive contamination can be undertaken, however is not done routinely for non-nuclear sites. "The laboratory will only do if told to".

Technology – tools and techniques show case

Steven Wilcox (AMEC) – DQO an integrated approach to the characterisation of contaminated sites

Steve's presentation was about the data quality objectives (DQO) integrated approach to the characterisation of contaminated sites. This systematic planning process promotes better communication and enables decision makers to show what has been undertaken. This is a seven step process which has been adopted from the US Environmental Protection Agency's (EPA's) Data Quality Objectives to support a better, faster and cost effective method to meet the regulatory requirements. These steps ultimately lead to the production of detailed Sampling and Analysis Plans , which gives transparency to any assumptions being made. This approach relies on the use of statistical techniques to support decisions. This approach also helps to engage with a variety of stakeholder inputs from regulators, scientific officers, consultants to laboratories whilst meeting their objectives.

The delegates were shown building plans (2D and 3D), highlighting how the approach can be used to demonstrate multiple sampling goals and strategies, visualisation for the regulator and contamination mapping. This process was designed to ensure the right amount of data is collected and minimise bad data, produce a balance of resource against cost, reducing re-work and clean up. Once the data is collected it will enable decisions to be made within a reasonable uncertainty and to collect the minimum amount of data needed. This means that data is only collected for what you only need and will use.

Systematic planning has been tried and tested in the US and UK for both radiological and non-radiological sites. It promotes better communication between individuals and carries out best practice in achieving sampling plans with well documented samples. The software is freely available.

Craig Sillars (Churngold) – In-situ chemical oxidation project on former ICI site in Blackpool
Craig's presentation looked at a case study example of in-situ chemical oxidation using soil mixing. The Site Conceptual Model was based on an extensive site investigation and detailed quantitative risk assessment, revealing the geological and hydrogeological setting and contamination status. The key contaminants of concern (COCs) were chlorobenzenes. Key issues on the choice of remedial technique included the geology, the scale of the treatment, space, the presence of shallow groundwater and cost.

An options appraisal was undertaken to assess remedial options. However, the project specifications and site conditions were so tough that no in-situ options looked good. To overcome these issues, it was theorised that an in-situ soil mixing process could be adopted. To prove the concept, a detailed laboratory study was carried out to choose the most appropriate oxidant, followed by a week long pilot study. Following the success of these studies, remediation of the entire site was undertaken. .

The results from the remediation were:

- 100% of validation wells met site specific target levels after only one round of treatment in 3 of 5 treatment zones
- 80% of validation wells in two zones impacted with NAPL met site-specific target levels.
- About 11,493 kg of COC was oxidised.
- NAPL concentrations were oxidised.
- Non-tidal ditch results reduced from 1,000-1,900ug/l to 40 ug/l.

Sign-off from the EA was issued based up these results.

Lessons learnt from the study included that it is not possible to treat NAPL impacted areas with a single round of treatment, and oxidant concentrations needed to be increased to 40%. Contamination was mobilised by the lime based activators due to their surfactant properties. Sub-surface obstructions and infrastructure affected the process. The mixing plant needed to be sufficiently robust to keep up with the injection of the treatment rates.

In situ soil mixing was shown to be capable of delivering and distributing oxidants into a challenging geological environment. The understanding of where COCs were partitioned and the flexibility of the system meant that high concentrations could be cost effectively reduced. The process also treated the soil and groundwater in only 4 months (0.7 hectares; 46,500 m^3).

Pete Longley (ENVIROS) – Site characterisation – practical experiences
Peter's presentation looked at practical experiences of site characterisation and their application on nuclear licensed sites. Investigations for both radioactive and non-radioactive

contamination have similarities including the stringent health, safety and environmental requirements and interactions with other site operations. The key difference is the potential for radioactive contamination.

Management implications associated with radioactive contamination include preparation of project documentation, allowance for health physics monitoring, time needed for entry to controlled areas and release requirements for samples. It is not possible to send samples immediately to laboratories for analysis; this can be problematic if volatiles are believed to be present. The approval processes following this can be lengthy but are required.

In order to control contamination, clean drilling techniques (e.g. open flush drilling systems) need to be considered in order to minimise waste arisings and conscientious and experienced drillers used. To reduce waste, potential waste streams and disposal route should be identified. Narrow diameter drilling equipment and use of dry methods will minimise arisings.

Pete concluded with the importance of the lessons learnt from design and execution. The selection of investigation techniques needs to be based on site understanding. Site investigation programmes need to consider disposal of arisings. This can be critical in budgeting the programme and the overall consideration of health and safety aspects.

Alex Lee (WSP) – Green remediation: Sustainability and Carbon Calculators
Alex opened his presentation by quoting from NDA Briefing Paper NSG57/2008 – asking if the appropriate option of contaminated groundwater remaining in-situ (with or without engineering control or containment) and contaminated soil excavated and sent to a decommissioning facility or Final Site Clearance.
He believes that limited consideration is currently given to sustainability in determination of remediation strategies ("green remediation"). There is no definition of "sustainable remediation". Does sustainability happen on a policy level or on the ground? Huge volumes of soils have been transferred for land disposal – is this sustainable? This is a national policy question.

The nuclear industry needs to focus on the wider benefits to society from a given intervention. Why remediate? Benefits include:

- Benefits to the society.
- Less risk to human health.
- Clean up of gas, nuclear waste etc, which has low magnitude but high risk.
- Manage liability, Corporate Social Responsibility (CSR) and risk.
- Assess the land value options.

Shall we interfere in the first place? Many remediation projects just move the problem from one place to another – the hazard remains the same. Currently there are initiatives looking into these issues, such as the Sustainable Remediation Forum (SURF), to challenge the need for intervention and measuring else quantifying the hidden value of a given technical solution to a client. The remediation contractor is responsible for making such decisions and so is the regulator. Green remediation optimises and maximises benefits. However, there are key challenges, including the common perception that sustainable/green options mean greater costs. It is hard to put values on social issues – clients consider financial factors most important, then environmental factors and finally social factors. Communication is an important to benefit to wider social community.

The way forward to deliver this type of technique involves complex modelling which can be seen as subjective. The scenario of 'walk before we can run' was referred to, but there is a need to monitor the long term aims and objectives. Innovative technologies are available and well established (e.g. molecular biological tools) but are not widely used in the UK. Green remediation involves being more socially conscious (and easier to justify than the term ‘sustainability’). Green technologies are readily available but are not widely used. Taking into account carbon emissions, bioremediation is likely to be cheaper than off-site disposal (noting that carbon calculators vary across the industry (e.g. between the. EA, Atkins and WSP calculators)).. Non-intervention should be justified as a benefit to wider society and robustly proven.

Open discussion session
The following points were conclusions made from the open discussion session on the technology showcase.

- Churngold stated that there was a validation period of 3 months for their in soil chemical oxidation using soil mixing project, based on the nature of the contamination.

- Initiatives like SURF need R + D funding into defining generic models.

- Geophysical surveys can be of use, however, choice of technique is dependent on the target. Drilling within a cubic meter is dependant on the geology, such as sonic drilling involves heating at the tip of the borehole. Such techniques detect changes in the ground chemistry.

Chairman’s summary
There are inconsistencies between regulatory decision making and the use of guidelines (e.g. W36/SoLA/RCLEA) on non-nuclear sites. There is also inconsistency between regulatory expectations relating to management of radioactive contamination on nuclear and non-nuclear sites (e.g. requirements for planning differ from Part 2A which differ from HSE requirements). The EO review and potential radionuclide-specific SoLA levels could aid transparency. Contaminated land on non-nuclear sites is generally regulated under planning; local authorities need experts and guidance to support them in their role under the planning regime.

For developers, the ‘dig and dump’ option is preferred as it is seen as most acceptable to the public. However, is this a sustainable option? That is open for debate. There are also limited options for disposal of radioactive waste.

Communication of risk for sites with mixed contamination can be tricky given that risk criteria for nuclear sites and radioactively contaminated land seem to be higher than equivalent risks associated with HCVs for non-radioactive contaminants..

Optioneering studies are undertaken as a formal BPEO type process on nuclear-licensed sites. Less formal processes which involve less public participation are used on other sites, although in line with CLR11. However, even with these processes, site owners often do more than the BPEO to meet public expectations and to ensure that they have no further liabilities.

Work on nuclear sites is more onerous than on non-nuclear sites. Additional constraints include consideration of waste minimisation and disposal, health and safety requirements, significant amounts of paperwork and the length of time that it can take to get all approvals in place for a site investigation programme.

Potentially industry needs to be more adventurous with regards to use of innovative remediation technologies, e.g. in situ soil mixing and molecular biological tools.

Can we consider sustainability in remediation?