

Progress in Sustainable Remediation

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ABSTRACT

In the past decade or so management of historically contaminated land has largely been based on prevention of unacceptable risks to human health and the environment, to ensure a site is ‘fit for use’, i.e. achieves suitability for beneficial uses. More recently, interest has been shown in including sustainability as a decision-making criterion. Sustainability concerns include the environmental, social, and economic consequences of risk management activities themselves, and also the opportunities for wider benefit beyond achievement of risk-reduction goals alone. This paper provides a global round up of progress by these initiatives and provides signposting to their documentation. It reviews common themes and points of divergence. Information is based on literature review and surveying the various networks involved, with a particular focus on recent developments in the UK. The global round-up updates a previous global roundup presented in Europe in 2013 at Aquaconsoil 2013 (Bardos *et al* 2013A and B).

INTRODUCTION

Land contamination, by industrial activities emissions, mining and smelting practices, agricultural chemicals or improper disposal of waste, affects large areas across the world. For example it is estimated that 2.5 million sites are potentially contaminated across Europe (Van Liedekerke *et al.* 2014). 1. Its remediation is a major challenge for the reuse of land and hence avoiding the take up of green field sites, as well as being a significant environmental protection issue. The 2004 EU market for “remediation & clean-up of soil and groundwater” was estimated to be €5.2 billion (Ernst and Young, 2006). The UK contaminated land market alone is thought to be worth in the region of £1 billion per annum at 2009 prices (CLAIRE, 2010A). The scale of land contamination problems and of the responses to them makes achieving sustainability in contaminated land remediation an important debate. “Sustainable Development” has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). We should be concerned not just with curing the “illness” of contaminated land, but also *how* it is cured, given that we wish to maximise the health of the patient.

DEFINITIONS AND NETWORKS

The NICOLE Road Map for Sustainable Remediation (NICOLE 2011) describes a sustainable remediation project is one that *represents the best solution when considering environmental, social and economic factors – as agreed by the [project] stakeholders.*

A number of networks worldwide are debating how to achieve sustainable development when remediating or regenerating damaged sites or land area. These include established national initiatives such as SURF in the USA, SuRF-UK, SuRF-NL, SuRF-ANZ and SURF-Canada as well as newer initiatives in other countries, e.g. Italy, Brazil, Taiwan, Japan and China; and two major European stakeholder networks, NICOLE and COMMON FORUM, see Table 1.

There is a remarkable degree of consensus across these initiatives about what a vision “sustainable remediation” might be. In broad terms concepts of sustainable remediation are

based on the achievement of a net benefit overall across a range of environmental, economic and social concerns that are judged to be representative of sustainability.

In the context of brownfields management a complementary approach of *sustainable regeneration* has been described (CABERNET, 2006). A related term to sustainable remediation is green remediation, which has a specific meaning in the US and other countries (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 because it is clean-up programmes and regulatory frameworks, such as CERCLA, where social and economic factors are felt to be considered already (Bardos *et al.* 2013B).

Table 1 lists networks involved with sustainable remediation. A number of these meet quarterly by teleconference facilitated by CL:AIRE in the UK (www.claire.co.uk/surfinternational). A number of networks also met face to face at the 2013 AquaConSoil conference in Spain (Bardos *et al.* 2013A), SURF 21 Washington DC 2012, and will meet at Battelle 2014 and the 2014 Sustainable Remediation conference in Italy (www.sustrem2014.com). Table 2 provides a listing of the definitions in use for sustainable remediation. In 2012 the International Standards Association (ISO) subcommittee which deals with soil and site assessment issues (ISO/TC 190/SC 7) established a new working group for the preparation of a new informative standard “Soil quality - Guidance on sustainable remediation”. Members of various networks take part in this initiative. (www.iso.org/iso/home/standards_development/list_of_iso_technical_committees/iso_technical_committee.htm?commid=54408).

TABLE 1 Networks involved in sustainable remediation and sustainable brownfield regeneration (updated from Bardos *et al.* 2013B)

Name and coverage	Key activities, outputs and web links
<i>Europe</i>	
COMMON FORUM, EU network, regulator and policy-makers led	Developing a technical paper on the linkage of sustainability with risk based land management (CLARINET 2002). It has issued joint position statement on sustainable remediation with NICOLE (NICOLE and COMMON FORUM 2013) www.commonforum.eu
NICOLE, EU network, industry and business led	NICOLE is a European Network of service providers, problem owners and academic organisations. It has a Sustainable Remediation Working Group whose outputs have included a “Road Map for Sustainable Remediation” in 2010, supporting guidance in 2012 on integrating risk assessment and sustainable remediation; economics and tools and sustainable remediation indicators and a series of sustainable remediation case studies recently published in 2014. It issued a joint position statement on sustainable remediation with the COMMON FORUM (NICOLE and COMMON FORUM 2013) www.nicole.org
SuRF-Italy, informal Italian network from 2012	SuRF--Italy is a cross-sectoral working group constituted in late 2012, associated to RECONnet (National network for contaminated land management). As main activities, it is currently drafting a White paper on sustainable remediation and will host the next Sustainable Remediation conference to be held in Ferrara (IT) in September 2014.
SuRF-NL, informal Dutch network from 2011	The SuRF-NL network includes consultants, regulators, industry, contractors and research institutes. Its scope is “sustainable soil management” which is broader than sustainable remediation. A White Paper was issued in 2011 (SuRF-NL 2011) and after a series of workshops and case studies SURF-NL is currently preparing for a reference booklet. www.surf-nl.com

Name and coverage	Key activities, outputs and web links
SuRF-UK, UK based projects, from 2007	<p>To date SuRF-UK publications include the first “sustainable remediation framework” (CL:AIRE 2010) and guidance on sustainability indicators (CL:AIRE 2011) based on 15 overarching categories. It provides a series of case studies, and in 2014 published guidance on sustainability assessment framing and qualitative procedures (CL:AIRE 2014A). It has also published a set of <i>Sustainable Management Practices</i> which are “relatively simple, common sense actions that can be implemented at any stage in a land contamination management project to improve its environmental, social and/or economic performance” (CL:AIRE 2014B)</p> <p>www.claire.co.uk/surfuk</p>
North and South America	
ITRC, Interstate Technology & Regulatory Council, Public-private partnership producing technical reports, USA and Canada	<p>ITRC have a large working group reviewing “green and sustainable remediation” (GSR). Their report of 2011 describes the process of sustainable site decision making across three aspects: environmental, social, and economic. The report is intended to help state programs develop guidance and eventually formal GSR policy and may help some federal agencies that have not developed programs formulate a GSR policy.</p> <p><i>ITRC 2011</i></p> <p>www.itrcweb.org</p>
Sustainable Remediation Forum (SURF), since 2006, largely USA based	<p>SURF was established in 2006. They published a white paper in 2009 and a framework, a metrics toolbox and a life cycle assessment guidance paper (Holland <i>et al.</i> 2011). Two additional technical publications were completed:</p> <ul style="list-style-type: none"> • Integrating Remediation and Reuse to Achieve Whole-System Sustainability Benefits. Published Spring 2013. • Groundwater Conservation And Reuse At Remediation Sites. Published December 2013. <p>Their 2013 technical initiatives include compilation of case study examples of sustainable remediation, a white paper focused on the social aspect of sustainable remediation, guidance on water conservation and reuse and the Sustainable Remediation Initiative (SRI) comprised of the supporting organizations (API Energy, ITRC, SURF) focused on coordinating and combining sustainable remediation engagement, communication and outreach efforts. The education and outreach committee are looking to expand the membership and form partnerships with other organisations both nationally and internationally.</p> <p>www.sustainableremediation.org</p>
SuRF-Brazil, informal network since 2011	<p>The Brazilian Sustainable Remediation Forum has over 30 members from a range of sectors. It has produced a “White paper” and has had some success in persuading regional legislatures to include sustainability considerations.</p>
SuRF-Canada, since 2011	<p>SURF-Canada is a network of predominantly consultants, private industry and government agencies. It has provided input to Environment Canada and Public Works and Government Services Canada on a sustainable remediation strategy to be used in the management of contaminated sites on federal properties. SURF-Canada is developing a document outlining the context of sustainability remediation across Canadian environments and how this may be encouraged within the regulatory system. Several outreach activities also occur in parallel in the different Canadian regions through regional leads.</p> <p>www.surfcanda.org</p>
Asia	
SuRF-China	<p>The Centre for Site Remediation (SiteRem), Institute of Soil Science, Chinese Academy of Science will work with the newly established E3 platform comprising three engineering centres of the Ministry of Environmental Protection in order to form Surf China in 2014</p>
Japan	<p>ASuRF Japan has yet to be founded, but, consultants, contractors carrying out the investigation and countermeasures and regulators are very interested in</p>

Name and coverage	Key activities, outputs and web links
	Sustainable Remediation and its concepts. A Working Group has recently started to study sustainable (and green) remediation at the GEPC (Geo Environmental Protection Center).
SuRF-Taiwan, since 2012	SuRF-Taiwan is a working group under the Taiwan Association of Soil and Groundwater Environmental Protection (TASGEP) and is established in 2012. The major mission is to advocate sustainable remediation concepts in Taiwan.
<i>Australia and New Zealand</i>	
SuRF-Australia and New Zealand, formed in 2009 as SURF- Australia but recently rebranded to SURF-ANZ to include Australia and New Zealand	SURF-ANZ exists to help promote the use of sustainable practices within Australia and New Zealand, in terms of environmental, economic and social indicators, during the remediation and development of contaminated land. It is a collaborative forum of industry, regulatory, academic and consultancy members. It has published a <i>draft</i> framework document and has working groups to identify remediation planning/tools relevant to Australian and New Zealand practice. They are also a special practice group of the Australasian Land and Groundwater Association) in 2014 <i>SURF-Australia et al 2009</i> www.surfanz.com.au
<i>Africa - Please see ICCL entry below</i>	
<i>International</i>	
International Committee on Contaminated Land – ICCL, international regulators and policy-makers network allied to the COMMON FORUM	ICCL is discussing synergies between sustainability and risk based land management. Its 2013 meeting in Durban, South Africa, hosted by the South African Department of Environmental Affairs, included a session on “green and sustainable remediation”. The issue was also discussed with other stakeholders during the additional open workshop. www.iccl.ch

GENERAL THEMES

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 example from the UK in Table 3 (CL:AIRE 2010B).

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 (Bardos *et al.* 2013B). 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. (Bardos *et al.* 2011, Holland *et al.* 2011, Smith and Kerrison 2013).

Several initiatives (e.g. SURF, SuRF-UK, NICOLE, SuRF-NL) 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.

TABLE 2 Example descriptions and definitions of sustainable remediation and sustainable brownfield regeneration (updated from Bardos *et al.* 2013B)

Europe	
NICOLE	A sustainable remediation project is one that represents the best solution when considering environmental, social and economic factors – as agreed by the stakeholders”.
SuRF Italy	The process for remediation and management of contaminated site, aimed at identifying the best solution when considering environmental, social and economic factors, through a balanced decision process, agreed by stakeholders
SuRF-Netherlands	“Sustainable soil and subsurface quality management is the practice of demonstrating in terms of environmental, economic and social indicators, that the benefits of the preferential approach are greater than the negative consequences, and that from appraisal to execution use is made of a transparent process
SuRF-UK	The practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process
North and South America	
ITRC	“Green and sustainable remediation” is the site-specific employment of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while making decisions that are cognizant of balancing community goals, economic impacts, and environmental effects.
Sustainable Remediation Forum (SURF)	Sustainable remediation is the practice of protecting human health and the environment while maximizing the environmental, social, and economic benefits throughout the remediation project life cycle (SURF 2013).
SuRF Canada	“...considers the environmental, social, and economic impacts of a project to ensure an optimal outcome, while being protective of human and environmental health, both at a local level and for the larger community.”
Australia and New Zealand	
SuRF-Australia and New Zealand	“A remediation solution selected through the use of a balanced decision making process that demonstrates, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than any adverse effects”
Asia	
Taiwan EPA and SuRF-Taiwan	Any technique, strategy, or management plan that consider environmental, economic and social aspects, which can reduce environmental footprints, negative social economic impacts throughout the remediation process, from site investigation, remedy design, operation and management to site closure, while still meeting the regulatory requirements.

TABLE 3 SuRF-UK Sustainable Remediation Indicator Categories (CL:AIRE 2010)B

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

A number of underpinning principles also seem to be broadly accepted. These are largely consistent with the six key sustainable remediation principles published by SuRF-UK (CL:AIRE 2010)B, set out in Table 4. The fundamental rationale for carrying out 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. Several initiatives emphasise the importance of considering sustainable remediation early in decision.

TABLE 4 SuRF-UK Principles for Sustainable Remediation (CL:AIRE 2010)

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.

SUSTAINABILITY ASSESSMENT / SUSTAINABILITY MANAGEMENT / CONCEPTUAL SITE MODELS

NICOLE (2011) suggests that, similar to the concept of risk management and risk assessment, sustainable remediation can be divided into two inter-related components:

1. Sustainability management: the discipline of integrating sustainability assessment into contaminated land management decision making
2. Sustainability assessment: the process of gaining an understanding of possible outcomes across all three elements (environmental, social and economic) of sustainable development.

While the other networks have been less explicit than this, SURF describes the use of site conceptual models for understanding sustainability (Holland *et al.* 2011) analogous to the use of conceptual models for summarising for risk management. This idea has been extended to incorporate specific cause-mechanism-receptor linkages into conceptual site models for sustainability by Bardos and Menger (2013).

All networks recognise the need for some form of at least comparative sustainability assessment as a basis for decision making, for example for options appraisal (as described above). The 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 (e.g. CL:AIRE 2010, Holland *et al.* 2011, NICOLE 2011). Figure 1, below shows the SuRF-UK approach to sustainability assessment (CL:AIRE 2014A). 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.

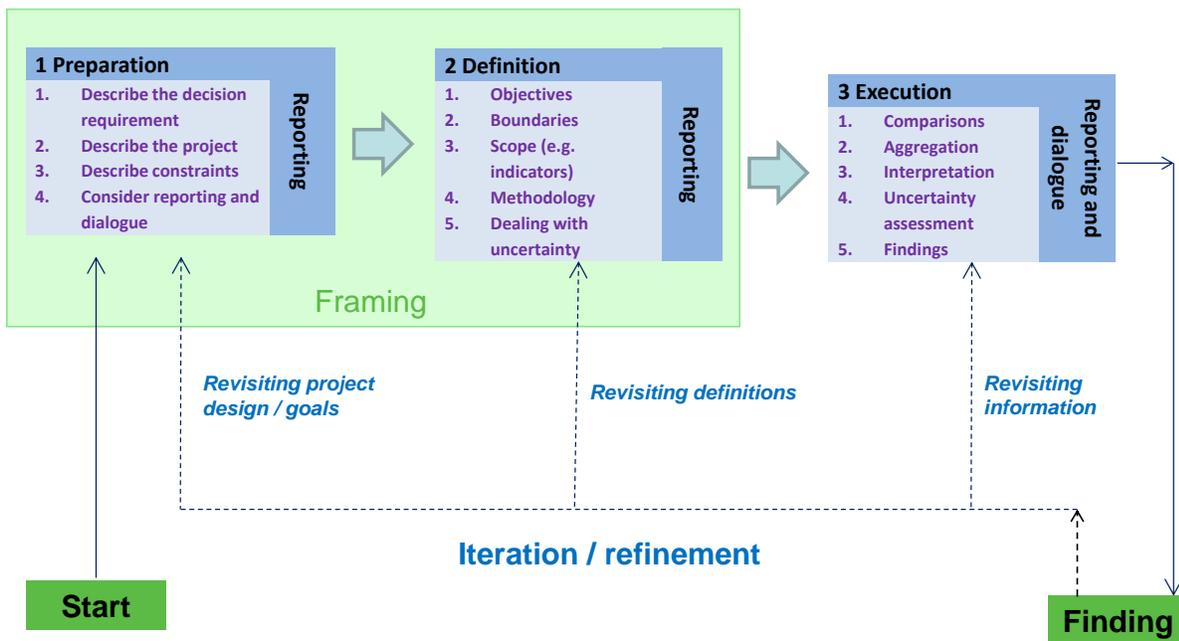


FIGURE 1 SuRF-UK Approach to Sustainability Assessment (CL:AIRE 2014A)

However methodologies proposed by different networks and organisations differ in details, for example in the order in which deliberations are made, the use of quantitative “metrics”, the extent to which indicators are predetermined vs. selected on a project by project basis, and the extent to which weightings (measures of importance) are used. For example, the approach used for sustainability assessment when applying for public funding for remediation in Austria is, compared to SURF and SuRF-UK, fairly prescriptive and uses predetermined weightings (Döberl *et al.* 2013). Compared to the SuRF-UK framework, guidance from SURF tends to focus more on quantitative metrics (SURF 2009). The “bottom-up” approach of SuRF-UK may be suited to a UK or Dutch context, but would not be attractive to public authorities in, for example, Austria or Germany.

These differences between approaches depending on country appear to be intrinsic and likely reflect cultural differences, for example, about the role of public authorities in specifying measures, desires for strict consistency, and indeed fundamentally the overall prevailing policy and regulatory framework. Therefore the exact sustainability assessment approach used in one country may not always be directly transferable to another, even although there is a significant degree of consensus on underpinning approach.

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