Integrating the Social Dimension in Remediation Decision-Making: State of the Practice and Way Forward

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Sustainable remediation guidance, frameworks, and case studies have been published at an international level illustrating established sustainability assessment methodologies and successful implementation. Though the terminology and indicators evaluated may differ, one common theme among international organizations and regulatory bodies is more comprehensive and transparent methods are needed to evaluate the social sphere of sustainable remediation. Based on a literature review and stakeholder input, this paper focused on three main areas: (1) status quo *of how the social element of sustainable remediation is assessed among various countries and organizations; (2) methodologies to quantitatively and qualitatively evaluate societal impacts; and (3) findings from this research, including challenges, obstacles, and a path forward. In conclusion, several existing social impact assessment techniques are readily available for use by the remediation community, including rating and scoring system evaluations, enhanced cost benefit analysis, surveys/interviews, social network analysis, and multicriteria decision analysis. In addition, a list of 10 main social indicator categories were developed: health and safety, economic stimulation, stakeholder collaboration, benefits community at large, alleviate undesirable community impacts, equality issues, value of ecosystem services and natural resources, risk-based land management and remedial solutions, regional and global societal impacts, and contributions to other policies. Evaluation of the social element of remedial activities is not without challenges and knowledge gaps. Identification of obstacles and gaps during the project planning process is essential to defining sustainability objectives and choosing the appropriate tool and methodology to conduct an assessment. Challenges identified include meaningful stakeholder engagement, risk perception of stakeholders, and trade-offs among the various triple bottom line dimensions.*

INTRODUCTION

Over the past decade, the remediation community has begun to realize and consciously embrace remediating contaminated sites in a more sustainable way, a practice known as sustainable remediation. Sustainability evaluations support and improve the remediation strategy selection decision-making process by providing a broader context of the beneficial and detrimental impacts of remediation activities. Guidance, frameworks, and case studies have been published at an international level illustrating established sustainability assessment methodologies and successful implementation within the remediation industry

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(ASTM, 2013; Butler et al., 2011; CL:AIRE, 2009, 2010, 2011, 2014a; Favara et al., 2011; Holland et al., 2011; Hunt & Smith, 2015; ITRC, 2011a, 2011b; NICOLE, 2010, 2011, 2012; Reddy & Adams, 2015; SURF, 2013; USDOE, 2011; USEPA, 2010; U.S. Navy, 2012). Although the terminology and indicators evaluated may differ, one common theme among international organizations and regulatory bodies is more comprehensive and transparent methods are needed to evaluate the social sphere of sustainable remediation (Bohmholdt, 2014; Frantál et al., 2015; Hadley & Harclerode, 2015; Harclerode et al., 2013; Oughton, 2013; Reddy et al., 2014; Ridsdale, 2015).

The social aspect of sustainable remediation is one of the three integrated dimensions of the triple bottom line (i.e., environment, society, and the economy).

The social aspect of sustainable remediation is one of the three integrated dimensions of the triple bottom line (i.e., environment, society, and the economy) (Pope et al., 2004). As such, a sustainable remediation evaluation includes assessing the potential impacts to all three of these *sustainability dimensions*. Currently, the majority of sustainability assessments conducted on remediation projects evaluate local, and to a lesser extent, global environmental impacts, project implementation cost, and, occasionally, local community impacts from proposed remediation activities. Due to the complexity of the concept of sustainability, stemming from the interrelations among the three dimensions of the triple bottom line, relevant and applicable indicators can be lost in the assessment process (Ridsdale, 2015).

This paper seeks to provide the remediation community with a synthesis of information on the current practice of sustainable remediation, analytical approaches, and recommendations for new ways to integrate social aspects into the remediation process. The authors of this paper are collaborators and representatives of international Sustainable Remediation Forum (SURF) organizations, policy-maker networks, academia, and standardization committees. The following sections present the (1) *status quo* of how the social dimension of sustainable remediation is assessed among various countries and organizations; (2) methodologies to quantitatively and qualitatively evaluate societal impacts; and (3) findings from this research, including challenges, obstacles, and a path forward. Case studies illustrating the successful use of methodologies focused on the social dimension are presented as an appendix to this paper, as well as archived on the SURF website—sustainableremediation.org.

The Societal Effects of Sustainable Remediation

Interrelations among the triple bottom line dimensions are shown in Exhibit 1, illustrated as four overlapping dimensions have been taken forward to understand the societal effects of remediation: (1) socio-environmental, (2) socio-individual, (3) socio-institutional, and (4) socio-economic. These dimensions represent the inter-related effects of the triple bottom line dimensions within the social sphere (Reddy et al., 2014). As the remediation community advances its understanding of sustainability, it is important to acknowledge the interconnections of these dimensions (Pope et al., 2004) and consider a flexible, integrated, and objective-led approach when evaluating the sustainability indicators of remediation activities (Ridsdale, 2015).

Potential benefits of considering the social impacts from remediation activities within each of the four dimensions include, but are not limited to, the following (see Ridsdale, 2015, p. 17):

 Remediation DOI: 10.1002/rem

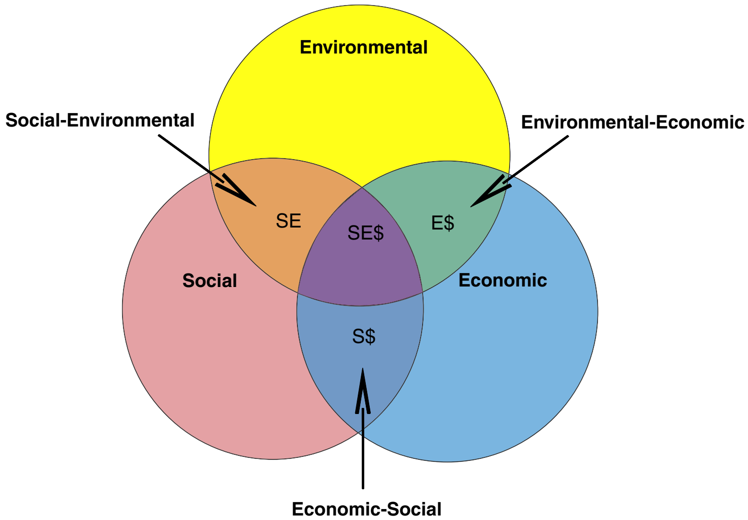

Exhibit 1. Three interrelated dimensions of sustainability (USEPA, 2012; adapted from Beach, 2010 and Sikdar, 2003)

- Restoration of land and other natural resources into sustainable eco-community and ecological assets.
- Revitalization of urban environments with public gathering places, housing developments, transit infrastructure, providing jobs and skills training through the remediation project.
- Minimization of natural resource loss and contributions to global impacts (e.g., climate change mitigation).
- Protection of human health, including incidentals from site activities (e.g., contributing to local safety risks and air pollution).
- Optimization of stakeholder engagement, involvement, and community empowerment.
- Implementation of remediation activities that do not detrimentally impact, and preferentially improve upon, the quality of life for the local community and wider global society.

It is important to recognize that the dimensions comprising the social dimension of remediation and redevelopment are not only represented as impacts, but can also be presented as drivers for achieving sustainable practices (Alexandrescu et al., 2013; CABERNET, 2006; CLARINET, 2002; Dixon, 2007; HOMBRE, 2014; RESCUE, 2005; REVIT, 2007). Drivers are those characteristics of a given country, region, or project, which can be of regulatory, economic, or institutional/cultural in nature, that foster the regeneration of contaminated properties (see Ridsdale, 2015, p. 6). Barriers, in contrast, are characteristics that have the opposite effect, such as outspoken aversion to the process, opposition to cleanup, and avoidance of the redevelopment (Alexandrescu et al., 2013). Recent research on sustainable regeneration has indicated that the sustainable management of contaminated sites is driven, in part, by stakeholder demands from site owners, regulators, or consultants and also by institutional processes, including social norms and public policy (CABERNET, 2006; Cundy et al., 2013; HOMBRE, 2014; Hou & Tabbaa, 2014; RESCUE, 2005; REVIT, 2007). In addition to impacts, social drivers and barriers should be identified during project planning and integrated into sustainability objectives for the site.

STATE OF THE PRACTICE

The focus of this paper is to examine the societal effects of remediation. The expanding interest and development of the concept of sustainable remediation has created an opportunity for a more in-depth consideration of how the local community and global society are beneficially and detrimentally impacted by remediation and redevelopment activities, as part of evaluating the triple bottom line during a sustainable remediation assessment.

According to the *Superfund Community Involvement Handbook*, the primary objective of community outreach is to identify and communicate community concerns and interests to remediation decision makers.

The understanding of what sustainable remediation means, as a whole, has evolved over the past five years, largely driven by the work of the Sustainable Remediation Forum (SURF), Sustainable Remediation Forum–United Kingdom (SuRF-U.K.), and SuRF Australia and New Zealand (ANZ; Ridsdale, 2015). Other organizations such as the Interstate Technology and Regulatory Council (ITRC), the Network for Industrially Contaminated Land in Europe (NICOLE), the Common Forum on Contaminated Land in Europe (Common Forum), the Environment Agency of England and Wales, ASTM International, the Canadian government, SuRF Canada, SuRF Italy, SuRF Taiwan, the U.S. Department of Defense (DOD), U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (USEPA) are also active in the field of sustainable remediation or related topics (e.g., green remediation, and green and sustainable remediation).

Remediation practitioners from these organizations and others have made substantial progress in developing guidance and tools to assess impacts to the triple bottom line from remediation activities; however, how the social dimension of the triple bottom line is defined and measured varies significantly within individual countries and organizations (Frantál et al., 2015; Hadley & Harclerode, 2015; Nathanail, 2011). *Section 2—State of Practice* presents the *status quo* of evaluating the social dimension among the different organizations referenced above. Background information about these organizations, including their primary goals and definitions of sustainable remediation can be found in the framework guidance referenced within this section.

United States

In the United States, federal and state regulatory "sustainable" remediation guidance emphasizes the quantification of environmental impacts of remediation processes more than social and economic impacts (Hadley & Harclerode, 2015; USEPA 2010). Federal regulators identify and address social impacts from remediation activities primarily in the form of community outreach. According to the *Superfund Community Involvement Handbook*, the primary objective of community outreach is to identify and communicate community concerns and interests to remediation decision makers (USEPA, 2005). Local community needs are then considered for integration into remediation and redevelopment activities. Economic impacts are primarily focused on project implementation cost (i.e., comparing the cost of each proposed remediation strategy).

The U.S. Navy, U.S. Army Corps of Engineers (USACE), and U.S. Air Force have incorporated remediation worker safety and accident risk into their established

Remediation DOI: 10.1002/rem

sustainability evaluation frameworks and tools. These agencies also include social responsibility metrics to evaluate potential beneficial and detrimental impacts to the local community from remedial activities (e.g., noise, odor, traffic) (USDOE, 2011; U.S. Navy, 2012).

Other organizations, such as the SURF, ITRC, and ASTM International, have developed sustainable remediation frameworks. Summaries of each organization's contributions to the social dimension of sustainable remediation are presented in the following paragraphs.

SURF publications to date (Butler et al., 2011; Favara et al., 2011; Holland et al., 2011) illustrate the importance of integrating the social dimension of sustainability into remediation by considering potential impacts on worker and community safety, stakeholder involvement, stimulating the local economy, and linking local emissions to regional and global health impacts. SURF's *Sustainable Remediation White Paper* referenced tools that evaluated social outputs pertaining to community acceptability, risk reduction, socioeconomic cost of secondary emissions, human health, and barriers. The tools referenced are among international and private organizations that may not be publicly accessible (SURF, 2009).

In 2013, SURF published a paper presenting the concept of sustainable reuse. The paper described how implementing this concept during remediation can lead to numerous social and economic benefits such as the protection of undeveloped land (i.e., "greenfields"), reduction in urban blight, creation of employment opportunities and expanded tax base, development of infrastructure and renewable energy resources, ecosystem enhancement, and increases in the health of neighborhoods and property value (Holland et al., 2013). SURF has also acknowledged barriers to implementing sustainable remediation practices due to factors within the social dimension. In its guidance *Groundwater Conservation and Reuse at Remediation Sites*, SURF acknowledges that the reuse of treated groundwater is often inhibited due to social constraints such as public perception, economics, and actual and perceived liabilities. The guidance presents several case studies that overcame these challenges and illustrate the successful reuse of treated groundwater for agricultural, industrial, and potable use. The case studies also highlight the social benefits to the local and regional communities from reusing treated groundwater (SURF, 2013).

The U.S. Navy, U.S. Army Corps of Engineers (USACE), and U.S. Air Force have incorporated remediation worker safety and accident risk into their established sustainability evaluation frameworks and tools.

The ITRC published a framework "to help users incorporate sustainability factors into site management decision-making" (ITRC, 2011a, 2011b). These factors include the following social indicator categories: impacts on human health and safety; ethical and equity considerations; impacts on neighborhoods and/or regions; community involvement and satisfaction; compliance with policy objectives; and strategies, uncertainty, and evidence. The ITRC framework notes the importance of understanding the socio-cultural impacts of remedial processes and actions, and if conducted during the project planning stage, can lead to a reduction in antagonistic working relationships, increase community involvement, and facilitate negotiation and selection of remedies that are consistent with community needs.

In 2013, ASTM International published a framework that includes the social dimension of sustainable remediation (ASTM, 2013) and guides remediation practitioners to focus on the socio-economic benefits of site remediation and redevelopment. The scalable framework helps users achieve sustainability through the use of best management practices (BMPs), which are categorized by core dimensions. Social core dimensions include community involvement, economic impacts to the local community, enhancements of individual human environments, and local community vitality.

Europe

Several guidance documents on incorporating and addressing sustainable indicators of remediation activities have been developed by European organizations. These documents were developed as a collaborative effort among governmental, private, and professional organizations such as the Common Forum (CF) on Contaminated Land in Europe and the pending International network of regulators—the International Committee on Contaminated Land (ICCL), NICOLE, SuRF-U.K., and SuRF Italy. Overall, the documents developed by these countries emphasize stakeholder involvement as a crucial aspect of sustainable remediation and recommend that stakeholder engagement occur early in a remediation project. In addition, guidance alleviates impacts to society and the local community from remediation activities by implementing risk-based cleanup approaches. European policy on contaminated site management has evolved since the 1990s and is now entering a fourth generation of so called "risk-informed and sustainable land management," which integrates three key principles: being risk-informed, managing adaptively, and taking a participatory approach. The concept of risk-informed and sustainable land management integrates the three dimensions of the triple bottom line into the remediation strategy selection (decision-making) process, rather than evaluating impacts to each dimension separately from a proposed remediation technology, in isolation or as part of a strategy (CL:AIRE, 2009, 2010, 2011, 2014a; NICOLE, 2010, 2011, 2012).

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The risk-based land management (RBLM) concept was developed by CLARINET, mainly composed by CF members, in 2002. This concept places emphasis on sustainable solutions for recovering the usability and economic value of land and integrating protection of environmental quality. The CF, initiated in 1994, is a network of contaminated land policy makers and advisors from national ministries and Environment Agencies in EU Member States. CF's general objectives are to share knowledge and experiences on contaminated land management between its members and other stakeholder communities, and to develop new and efficient strategies for the management and remediation of contaminated sites and land recycling with respect to "sustainable resource protection." This concept is now implemented in some European countries such as the Netherlands and France.

The SuRF-U.K. Framework is the most widely used sustainable remediation guidance in the EU, Australia, and New Zealand. The framework lists five overarching social categories to evaluate during a sustainability assessment of remediation options: (1) human health and safety; (2) ethics and equality; (3) neighborhoods and locality; (4) communities and community involvement; and (5) uncertainty and evidence (CL:AIRE, 2011). Owing to the synergistic effects among the social and economic sphere, overarching categories representing the economic dimension are also relevant to the social aspect of sustainable remediation. The economic overarching indicator categories are: (1) direct economic costs and benefits; (2) indirect economic cost and benefits; (3) employment and employment capital; (4) induced economic costs and benefits; (5) project life-span and flexibility. Indirectly, also due to the synergistic effect of the dimensions of the triple

 Remediation DOI: 10.1002/rem

bottom line, the environmental dimension also has an influence on the social and economic spheres. The framework stresses that the indicators are integral to the communication and promotion of sustainable development to stakeholders. This framework also recommends decision support techniques that can be performed as part of a sustainability assessment to evaluate social and economic indicators. These techniques include scoring/ranking systems (including multicriteria decision analysis), best available techniques, cost-benefit analysis, cost effectiveness analysis, financial risk assessment, industrial ecology, and quality of life assessment (Bardos et al., 2011; CL:AIRE, 2010).

Currently, SuRF-Italy is working on developing a technical document suggesting operative criteria and practices for evaluating impacts to the social dimension of remediation and redevelopment activities, in concurrence with economic and environmental ones. Recommendations will be provided on key dimensions such as objective setting, indicator selection, option appraisal and selection, technologies, and BMPs in order to support sustainable remediation applications in a project-specific and a balanced way (SuRF Italy, 2014).

NICOLE, the *Network for Industrially Contaminated Land in Europe*, is a European Network comprised of industry and service providers, as well as individual academics. It initiated a Sustainable Remediation Working Group in 2008. This group published a “Sustainable Remediation Road Map” in 2010 with further supporting guidance in 2012 (NICOLE, 2010, 2012). In 2013, the CF and NICOLE (2013) published a Joint Statement on “Risk-based & Sustainable Remediation.” To promote the importance, the Joint Statement is published in nine European languages. The Joint Statement highlights goals to:

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- Define and highlight key messages of Sustainable Remediation as a concept
- Promote the concept through a visible commitment from all parties, Europe wide
- Encompass a broader uptake of SR principles, approaches and tools by everyone
- Link to the wider European policy arena and provide thematic strategies

International Organization for Standardization

The International Organization for Standardization (ISO) TC190/SC7/WG12 working group on sustainable remediation has defined sustainable remediation as an approach that eliminates and/or controls unacceptable risks in a safe and timely manner, and optimizes the overall environmental, social, and economic benefits of the remediation work. The worldwide interest in the concept of sustainable remediation has led to the formation of many national and regional groups and projects. While information is widely shared, its national provenance means that there is substantial duplication of effort among these groups. Since most of the individuals are involved on a voluntary and unpaid basis their time is limited. The wide range of contemporary documents on this subject is potentially confusing to practitioners, clients, and regulators about which guidance is the most appropriate to use. In response to this, the ISO set up a working group to draft a technical specification on sustainable remediation. The work is under the auspices of the ISO Technical Committee 190’s Subcommittee 7 (TC190/SC7/WG12).

The ISO document on sustainable remediation would be publicly “visible” and accessible in all countries and, therefore, would allow an international collaboration to take place to ensure maximum benefit is gained from the volunteer time available. In addition, for those organizations operating across national borders, ISO guidance would help create a standard approach or at least a shared understanding around the world. While it recognizes the importance of the social dimension alongside the economic and environmental as well as governance issues, it does not propose a list of social—or other—indicators. This reflects both the lack of consensus on such a list and the dynamic state of thinking on useful indicators.

The ISO document concludes that the need for remediation is determined by risk assessment and the process of choosing the remediation strategy involves seeking the viable strategy that will deliver the best overall environmental, social, and economic benefits from the remediation work.

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Canada

While there are no Canadian-specific frameworks for sustainable remediation, the remediation community and government (e.g., municipal, provincial, national) are focusing on transparency and stakeholder involvement when integrating the social dimension of the triple bottom line into cleanup and redevelopment. SuRF Canada is finalizing a white paper that highlights the role of stakeholder involvement in ensuring an optimal remediation project outcome. In addition, a new decision-making framework has been developed by the Federal Contaminated Sites Action Plan (FCSAP) to address the lack of attention given to the social dimension of sustainable remediation in a previous iteration (Government of Canada, 2014). The revised framework includes a tool to integrate triple bottom line dimensions into remediation. The Sustainable Decision Support Tool (SDST), which is not available to the public, is based on the tool GoldSET designed by Golder and Associates (also not available to the public, see Golder.com). The SDST is both quantitative and qualitative, with the following social indicators: cultural heritage, public and worker safety, project duration, quality of life during the project, public benefits, and the federal government's image. The tool uses a scoring and rating system to evaluate each social indicator in relation to the "level of concern to the federal government" versus the "level of concern to stakeholders," for each proposed remedial alternative (Klassen, 2012).

Taiwan

SuRF Taiwan and the Taiwan Environmental Protection Administration are working together to develop guidance to incorporate and evaluate sustainable principles during remediation activities. In the guidance, the social dimension of the triple bottom line is categorized into two core dimensions supported by a list of principles to consider during a sustainability assessment. The first core dimension, human health and safety, is comprised of the following principles: human health and risk before remediation, human health risk during remediation (considering both local residents and cleanup employees), risk of accidental injury, avoid secondary contamination, and prevent exposure pathways. The second core dimension, social justice and acceptance, is comprised of the following principles: stakeholder participation, information disclosure, considering remedial related effects on local residents, and preserve cultural heritage. These principles are used to develop BMPs that can be implemented during remediation to alleviate social impacts of remediation. In general, human health and safety is primarily addressed by performing a human health risk assessment to understand the current health risk for local residents and

 Remediation DOI: 10.1002/rem

evaluate the health risks among the remediation alternatives. Common social indicators evaluated include worker operation and traffic accidental risks, and site activity related effects including noise, odor, and vibration.

Australia and New Zealand

SuRF ANZ adopted the SuRK-U.K. framework and list of social and economic core dimensions presented in the guidance. The SuRF ANZ guidance suggests conducting a semi-quantitative assessment of the core dimensions along with evaluating the effectiveness and practicability of proposed remedial technologies. The semi-quantitative assessment ranks, scores, and weighs each core dimension based on their advantages and disadvantages (i.e., relative performance of each indicator) to a specific project (Hunt & Smith, 2015).

COMMON THEMES

As presented in the previous sub-sections, the identification of indicators varies among countries and organizations within countries themselves. The authors do not conclude that one framework is superior or more comprehensive than others. Rather, the various frameworks provide the initial foundation for further developing approaches to comprehensively evaluate beneficial and detrimental sustainable impacts of remediation. When using a prescribed framework and set of indicators, the upmost importance is stakeholder collaboration and understanding the context in which the assessment should take place (Ridsdale, 2015).

The authors contend that a wide range of factors across the three dimensions of sustainability (economic and environmental as well as social) have societal impacts and so give rise to societal costs and benefits. This paper proposes a series of considerations translated from across the triple bottom line that may be helpful where an understanding of societal impacts are required. We identified ten societal impact categories based on review of the frameworks presented in the previous sections. These have been suggested as a basis of conducting a comprehensive social cost or social impact assessment by remediation professionals, which can be used to supplement existing frameworks/protocols. Note impacts listed may be either positive or negative.

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The intention of suggesting these social impact categories presented below is, during the project planning stage, to provide remediation professionals with a checklist to assist with identifying and defining social indicators that are predominately impacted by site-related activities. Once site-specific social indicators have been identified, stakeholders can determine the applicable metrics and tools to evaluate impacts to the social dimension. As stated previously, the triple bottom line dimensions are interrelated and, therefore, lead to impact categories that have an overlap of sustainability dimensions. Therefore, the societal impact categories listed below may be represented under the environmental and/or economic dimension of sustainability in other sustainable remediation frameworks.

Main Societal Impact Categories

1. **Health and Safety** of site workers and the surrounding community including, but not limited to, the alleviation, prevention, or mitigation of contamination

risks on-site, generation of emissions and dust, and hazards of construction and operation of remedial systems.

2. **Economic Vitality** by contracting local vendors and resources, developing and investing in new skilled training and education, and incorporating redevelopment into the remediation strategy selection.
3. **Stakeholder Collaboration** to identify beneficial and undesirable impacts, to discuss perceived risks, to develop future land use and design, and to help aid in assessment goals and indicators used in the assessment in order to maximize buy-in for the eventually implemented remediation strategy.
4. **Benefits Community at Large** by promoting the community's quality of life, including increased property value, social and human capital, reuse of treated media/materials to meet community needs, and redevelopment of the property.
5. **Alleviate Undesirable Community Impact** at the neighborhood and locality scale, including noise, traffic, odor, congestion, business disruptions, compromising local heritage and cultural concerns.
6. **Social Justice** during urban revitalization, through increased housing availability for all community members, widened access to employment opportunities, and reused brownfields for equitable use throughout the community.
7. **Value of Ecosystem Services and Natural Resources Capital** altered by site activities and consumption, reuse of treated media, and restoration of ecosystems, hydrological functions, fauna and indigenous flora habitat, in ways that enhance local quality of life and otherwise address societal challenges.
8. **Risk-Based Land Management and Remedial Solutions** to distribute additional resources (e.g., energy, raw materials) in a manner to effectively address the site-specific human health, environmental justice, and community issues associated with contaminated sites.
9. **Regional and Global Societal Impacts**, such as long-term, chronic public health impacts and financial implications (e.g., mitigating effects of climate change and limited water resources) due to the generation of emissions and consumption of nonrenewable resources.
10. **Contribution to Local and Regional Sustainability Policies and Initiatives**, such as renewable energy initiatives, climate change legislation (e.g., carbon-trading economy and climate adaptation), eco-job strategies, regional land use policies, regional and local sustainability objectives (e.g., ecological restoration goals, water use), and sustainable resource consumption.

Tools and methodologies are needed to evaluate social impacts of remediation activities. Furthermore, the paucity of established tools is seen as an obstacle to conducting a comprehensive sustainability evaluation.

SOCIAL IMPACT ASSESSMENT TECHNIQUES

Tools and methodologies are needed to evaluate social impacts of remediation activities. Furthermore, the paucity of established tools is seen as an obstacle to conducting a comprehensive sustainability evaluation (Harclerode et al., 2015, 2013; Hou & Al-Tabbaa, 2014; Hou et al., 2014; Reddy et al., 2014; Ridsdale, 2015). However, established sustainable remediation frameworks reference various levels of social impact assessment techniques and recent publications (Alexandrescu et al., 2012, 2013; Anderson et al., 2008; Bohmholdt, 2014; Harclerode et al., 2013, in press; Petelina et al., 2014; Postle et al., 1999; Reddy et al., 2014) illustrate the successful incorporation of social science

Remediation DOI: 10.1002/rem

and environmental economic methodologies into a sustainability evaluation for a remediation site. It can be concluded that several social impact assessment techniques are readily available for use by the remediation community.

As remediation decision-makers consider social impacts from remedial activities, it is important to do so while simultaneously evaluating the environmental and economic impacts. Pope et al. (2004) suggest that the sum of separate environmental, social, and economic assessments does not equal the whole (i.e., sustainability). Rather they argued that the sum of an integrated impact assessment incorporating the inter-linkages among the three dimensions of the triple bottom line would be greater than the whole. Unfortunately, a single tool does not currently exist that considers both quantitative and qualitative data among all three dimensions of the triple bottom line. Therefore, remediation decision-makers may choose to implement more than one technique/tool to meet projects objectives.

In addition, sustainability evaluations that seek to combine social-environmental-economic dimensions in a site-specific risk assessment and broader regulatory context can only rarely do so using exclusively quantitative data. While disciplines such as engineering and natural sciences are largely dependent on numerical information, other disciplines (e.g., law, anthropology, psychology) deal with qualitative evidence. Therefore, the social impact assessment techniques presented consider both quantitative and qualitative data. Due to the inter-relations among the triple bottom line dimensions, the techniques presented may also evaluate economic and environmental impacts in addition to social impacts.

This section is a compilation of broad social impact assessment techniques and examples of specific tools used by remediation practitioners. Case studies highlighting the successful application of these techniques are provided in Exhibit 2, included as a supplemental online appendix. The authors recognize that not all available tools are represented.

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Rating and Scoring System Evaluations

Rating and scoring system evaluation is a technique used to summarize and communicate information crucial to the decision making process. This method includes a rating metric and an aggregation rule that combines individual ratings into a single overall score. Remediation decision-makers are then able to draw conclusions based on the results of the scoring (Bargagliotti, 2013). This technique is referenced in established sustainable remediation guidance and has been utilized as part of sustainability assessments for remediation projects (Petelina et al., 2014). When these techniques are employed, the user has the ability to quantify socialindicators that would otherwise be only qualitative. At times, quantifying social indicators allows for easier communication between disciplines. This is important as the quantitative/qualitative information gap is seen as a barrier to integrating social indicators in dominantly biophysically driven assessments (Hou & Al-Tabbaa, 2014; Hou et al., 2014; Ridsdale, 2015).

Established sustainable remediation frameworks do not necessarily touch upon all the main social indicator categories listed in Section 2—*State of Practice*. If these frameworks are used for conducting a rating and scoring system evaluation for a remediation project, missing indicators should be incorporated at the request of the stakeholders involved and should be aligned with the relevancy of the site specifically.

Exhibit 2. Case study summary

Case Study Number	Case Study Title	Contaminants of Concern	Social Impact Assessment Tool	Summary
1	Former Matthiessen and Hegeler Zinc Superfund Site, near Hegeler, Illinois, USA	Heavy metals	SSEM tool	The Matthiessen and Hegeler Zinc smelting site in Illinois was designated as a Superfund site in 2005 for its high concentration of heavy metals.The large surface area of the contaminated site, over 40 hectares (100 acres), poses a challenge for treatment. Two alternative treatment methods were evaluated for long-term sustainability—the traditional method of excavation, hauling, and disposal in a hazardous waste landfill, and an in-situ remediation approach via solidification/stabilization. The life cycle assessment for each alternative was performed using SimaPro for energy inputs and environmental releases through all stages of manufacturing of materials needed for remedial operations, transportation, and remedial implementation. It was found that due to the large quantity of contaminated soil that is required to be excavated and hauled to the nearest landfill, the in-situ method of stabilization was the more environmentally sustainable option in the long term. Other aspects associated with sustainability include social and economic impacts. SSEM was used to assess the social sustainability.
2	Indian Ridge Marsh Site, Chicago, Illinois, USA	Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), petroluem hydorcarbons, and heavy metals	SSEM tool	The remediation and restoration of heavily industrialized former wetlands and mesic prairies in the Great Lakes region pose several special challenges due to: 1) widespread and heterogeneous distribution of contaminants; 2) the variety of contaminant classes present; 3) complex hydrogeologic regimes due to extensive and variable industrial filling and dredging; and 4) the presence of sensitive ecological receptors and habitats, including nesting areas for several threatened bird species. Indian Ridge Marsh is one of several degraded wetlands in the Calumet region that are slated for remediation and redevelopment as part of the Calumet Open Space Reserve. The goal of this study was to evaluate the remedial options available based on applicability, cleanup efficiency and sustainability metrics. SRT, SiteWise and SSEM were used to assess sustainability and phytoremediation was recommended as the most sustainable remedial option.

(*Continued*)

Exhibit 2. Continued

Case Study Number	Case Study Title	Contaminants of Concern	Social Impact Assessment Tool	Summary
3	Sustainable Return on Investment Analysis of Recycling Materials from a Closed Landfill, USA	Polyethylene terephthalate (PET)	Sustainable Return on Investment	A former manufacturing site for electrical components and x-ray film disposed of waste and off-spec plastic film material in two on site landfills. To repurpose the land for parks and public space, the recyclable film materials were removed. Overall, approximately 40 million pounds of polyethylene terephthalate (PET) were recycled creating additional unrestricted use areas at the site. Considering the triple bottom line aspects (social, environmental, and economic), the sROI analysis estimated a net benefit of nearly $0.5 million dollars.
4	Targeted Brownfield Assessment of Former Augsbury Tank Farm Site, Ogdensburg, New York, USA	Light nonaqueous phase liquid (LNAPL)	Costs Borne by Society Evaluation (monetizing global impacts)	The Brownfields site is a former petroleum tank farm occupying approximately 23 acres. A phased-focused approach was implemented to evaluate the nature and extent of on-site light nonaqueous phase liquid (LNAPL) contamination. Sustainable remediation practices implemented during site characterization included geophysical methods to identify historical infrastructure and the ultraviolet optical screening tool to delineate LNAPL and focus sampling efforts. In order to quantify the reduction of impacts to the triple bottom line by implementing a phase-focused approach, a sustainability assessment was conducted for both the implemented approach and a conventional investigation for comparison.
5	Nexsus research project study site (Area 2)	• Heavy metals (Cu, As, Pb, Zn) in soil • Hydrocarbons (benzene, ethylbenzene, toluene, etc.) in soil • Metals, hydrocarbons, and fluorides in groundwater	Interviews and Focus Groups and social network analysis	Area 2 of Porto Marghera, Italy is part of a broader brownfield undergoing regeneration, known as the Vega Science and Technology Park (Vega PST). The Vega PST is subdivided into four areas, numbered from 1 to 4. Area 1 has undergone a regeneration process between 1993 and 2006, which resulted in the creation of the Vega science park that specialized in the development of scientific research, technology development and advanced service provision for the industrial enterprises still operating in the Porto Marghera area. After a few years of standstill in the regeneration process, new activities have taken place on Area 2 since 2012. These represent a new stage in regeneration, as the current process aims not only at brownfield regeneeration but also at a more comprehensive and sustainable urban regeneration, developed around the construction of an expositional and commercial space linked to the Expo 2015 in Milan.

(*Continued*)

Exhibit 2. Continued

Case Study Number	Case Study Title	Contaminants of Concern	Social Impact Assessment Tool	Summary
6	Tar Ponds and Coke Ovens, Sydney, Nova Scotia, Canada	Primary COCs included PAHs, Petroleum hydrocarbons, PCBs, Dioxins, Heavy metals	Community Survey, with time-based comparison analysis	One hundred years of steel and coke production resulted in >1M tonnes of contaminated soil and sediment, as well as groundwater impacts, over 240 acres (97 hectares) in Sydney's downtown. The selected remedial method included solidification/stabilization, surface capping, active groundwater treatment and cut-off walls. There was a heavy focus on the incorporation and validation of socio-economic metrics throughout the project. Methods were developed to quantitatively assess apparently qualitative socio-economic factors.
7	Gunnar Mine Project, Northern Saskatchewan, Canada	Arsenic, copper, lead, radium-226, uranium and gamma radiation in all media.	ExpertChoice, MCDA tool	The contaminated site is part of several abandoned cold war-era uranium mines and mills in Northern Saskatchewan (Canada). The site is remote and in traditional indigenous peoples territory with approximately 80 inhabitants within 100 mile radius. The SRC team carried out a pilot sustainability assessment to assess, among other things, stakeholder opinions on the design of the vegetative tailings cover. ExpertChoice®, is a web-based multicriteria analysis and engagement tool that allows stakeholders to assess the value of the objectives of a project as well as compare project alternatives. The software allows meaningful engagement with remote participants, and supports sound decisions when diverging and/or conflicting stakeholders' perspectives are involved. The survey tool processes the survey data and generates results on stakeholders' preference. Additionally, the software has built-in data analysis tools such as a range of sensitivity tests that help determine the validity and limitations of the study.

In response to seeking a rating and scoring system framework that is more comprehensive and considers interrelations among the triple bottom line dimensions, the remediation community has developed a tool and has acknowledged another, both of which are summarized below.

Social Sustainability Evaluation Matrix

Reddy et al. (2014) developed the Social Sustainability Evaluation Matrix (SSEM).This method is an Excel-based tool that evaluates impacts across the four key social dimensions: (1) social-individual; (2) socio-institutional; (3) socio-economic; and (4) socio-environmental. A series of key measures (i.e., impact indicators) are listed for each dimension (see Reddy et al., 2014, p. 834). The socio-individual and socio-institutional dimensions consist of 18 key measures that pertain to overall impacts on standard of living, education, population growth, justice and equality, community involvement, and fostering local heritage. The socio-economic dimension consists of 11 key measures that represent business ethics, fair trade, and worker's rights. The socio-environmental dimension consists of 13 key measures associated with natural resource consumption, environmental management, and pollution prevention. A scoring system allows the evaluation of key indicators for each social dimension. Remediation decision makers rate the key indicator presented as either (1) ideal or improved positive impact, (2) no impact, or (3) diminished or unacceptable negative impact. Each impact has a score associated with it; the scores for each dimension are calculated and used to compare the degree of social-related impacts among the remedial activities being evaluated for a specific site.

Currently, the SSEM tool has only been used in a classroom setting. Two pilot case studies were conducted to select sustainable remediation options and SSEM was used for the assessment of social sustainability; these case studies are presented as Case Studies 1 and 2 in Exhibit 2, included as a supplemental online appendix.

Envision™ Rating System

The remediation community has recently acknowledged the Envision™ tool, which was developed as part of a collaboration between the Institute for Sustainable Infrastructure (ISI) and Harvard University's Zofnass Program for Sustainable Infrastructure. The framework was developed in response to the need to design, build, and operate our built infrastructure in a more efficient and resilient manner while contributing to a more sustainable future. Although Envision™ was specifically developed to address horizontal infrastructure projects, the overall framework can be successfully applied or adapted to remediation projects. Social indicators were broadly considered in the development of the rating system by defining a project's contribution to sustainability as a balance of efficiently or effectively improving sustainability performance while aligning with overall community needs and enhancing quality of life. The tool categorizes the social dimension of sustainability in two ways: quality of life and leadership. Quality of life credits address how a project impacts the surrounding community—from an individual's wellbeing to broader societal aspects. Credits in the leadership category focus on a project's need to maintain a collaborative approach while understanding and managing the long-term project life cycle impacts.

The remediation community has recently acknowledged the Envision™ tool, which was developed as part of a collaboration between the Institute for Sustainable Infrastructure (ISI) and Harvard University's Zofnass Program for Sustainable Infrastructure.

The companion tools to the rating system also contain social components. The Envision™ checklist mirrors the categories of the rating system, including Quality of Life and Leadership sections, but can be more quickly applied for use in pre-planning a remediation project or for a qualitative alternative evaluation. The Zofnass Economic Process Tool is a web-based platform available in the public domain that provides preliminary quantification and monetization of sustainability externalities. Currently, the economic tool includes three Envision™ credits including one social indicator, namely Enhancing Public Life.

Enhanced Cost-Benefit Analysis

A cost-benefit analysis (CBA) accounts for and compares all the benefits and costs of particular courses of action. Traditionally, a CBA is based on the commercial feasibility in which the cost of implementing a specific action is compared against the financial benefits in terms of profit (Field, 2001). In remediation, remedial activities are unprofitable to the responsible party; therefore, traditionally, only the implementation cost of potential remedial alternatives are compared during the decision-making process.

Recently, the cost analysis of remedial activities has been extended to include socio-economic factors, resulting in a CBA focused on social feasibility (Bohmholdt, 2014; Cappuyns & Van Passen, 2014; Harclerode et al., (in press), 2013). This enhanced CBA evaluates whether the monetized benefits to society exceed the monetized costs to society of undertaking particular courses of action. While a traditional CBA based on commercial feasibility addresses only inputs and outputs that are associated with market sectors, the enhanced CBA involves estimating the value of both market and nonmarket inputs and outputs (Field, 2001). The market and nonmarket inputs that remediation practitioners should consider when conducting an enhanced CBA are provided in Exhibit 3.

The majority of market inputs can be obtained from engineering data and invoices, tax assessment information, and interviews with local businesses. Obtaining nonmarket inputs is more challenging; however, is feasible by utilizing methodologies established in the environmental economics discipline. Nonmarket inputs can be divided into two categories: local community and global society.

The monetary value associated with local community aesthetics and quality of life as it pertains to remediation and redevelopment can be quantified using nonmarket economic valuation methods such as hedonic pricing, travel cost, contingent valuation, and choice modeling (Field, 2001). Examples of integrating local community nonmarket values in an enhanced CBA for a remediation project is quantifying the willingness to pay for cleanup

Exhibit 3. Cost-benefit analysis market and nonmarket inputs

Market Inputs	Nonmarket Inputs
• Capital costs • Operation and maintenance costs • Decommissioning costs • Redevelopment costs • Property value increase (benefits) • Employment opportunities (benefits) • Local business stimulation/revenue (benefits) • Local business interference/loss of revenue (cost)	• Externalities associated with societal dis-amenities (costs) • Aesthetic value of natural resources protected (benefits)/damaged (cost) • Improvement in quality of life from remediation/redevelopment (benefits)

Remediation DOI: 10.1002/rem

to different end use scenarios and reuse of treated material. The economic valuation method used on a project is dependent upon site-specific variables and stakeholder input.

Global society nonmarket values represent externalities associated with societal dis-amenities caused from the local consumption of natural resources. Societal dis-amenities are financial implications on society for alleviating and mitigating global impacts from resource consumption (e.g., sea level change and water stressed regions). Societal dis-amenities are represented by the social cost of environmental metrics, which incorporate the private costs of that metric plus environmental externalities. For example, the social cost of carbon dioxide (CO_2) encompass production and manufacturing expenses (i.e., private cost), as well as cost associated with mitigation of climate change impacts (i.e., externalities) (Greenstone & Looney, 2011; U.S. Government, 2013).

Fortunately, the social cost of environmental metrics associated with greenhouse gases, nitrous oxides (NO_x), sulfur oxides (SO_x), particulate matter, and energy are readily available in published literature (Greenstone & Looney, 2011; Marten & Newbold, 2012; Muller & Mendelsohn, 2010; U.S. Government, 2013). However, the challenge is determining a reputable literature source that uses an economic framework and model that quantifies a value on societal dis-amenities (i.e., externalities) that is representative of site-specific sustainability objectives. In addition, published social cost values are often quantified at various discount rates and quantities within one literature source. The economic and climate models that the social costs of environmental metrics are developed from may be controversial among varying stakeholder groups and often approached with some resistance (Ackerman, 2008; Atkinson & Mourato, 2008; Cellini & Kee, 2010). Therefore, careful consideration needs to be taken to identify the appropriate value to use in an enhanced CBA. Postle et al. (1999), Anderson et al. (2008), Harclerode et al. (2013, in press), and Bohmholdt (2014) provide frameworks and case study examples on how to conduct an enhanced CBA for the remediation industry. Agencies that have embraced the social cost of environmental metrics include the U.S. DOE's consideration of the social cost of carbon (USDOE, 2011), and the Australian government (via Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC Care)), who is in the process of developing a CBA guidance for sustainable remediation.

Global society nonmarket values represent externalities associated with societal dis-amenities caused from the local consumption of natural resources. Societal dis-amenities are financial implications on society for alleviating and mitigating global impacts from resource consumption (e.g., sea level change and water stressed regions).

Lastly, not all environmental metrics have published social costs. Therefore, these values will need to be estimated using the economic valuation methods previously mentioned. Alternatively, enhanced CBA can be implemented in conjunction with another tool, primarily focused on qualitative metrics, to comprehensively meet sustainability objectives.

Case Studies 3 and 4 in Exhibit 2, included as a supplemental online appendix, present enhanced CBAs for a remediation project.

Social Science Methodologies

In a widely cited article, Reed et al. (2009) reviewed a variety of stakeholder analysis methods that can be usefully applied to environmental management, urban planning, brownfield regeneration, impact assessment, and remediation projects. Some of these methodologies can be used to understand and assess which social processes are drivers of or barriers to sustainable remediation. Others can be used to explore the social impacts of remediation, redevelopment, and revitalization. The following presents methodologies from the social science disciplines that can be integrated into a sustainability assessment for a remediation project.

The social science methodologies presented can be applied individually or in conjunction with one another. By using these methods, remediation practitioners are able to understand and identify (1) the social factors that may work in favor of or against sustainable remediation and (2) the social factors and stakeholders that are affected by remediation.

Each remediation project is site-specific and, therefore, beneficial and/or undesirable impacts may arise based on the unique community characteristics and the context of the project.

Each remediation project is site-specific and, therefore, beneficial and/or undesirable impacts may arise based on the unique community characteristics and the context of the project. These drivers, benefits, and impacts may not be represented in tools currently available to remediation practitioners. Surveys, semi-structured interviews, and focus groups can be implemented to address this knowledge gap (Reed et al., 2009).

A properly constructed survey is a flexible, inexpensive method that allows the remediation practitioner to evaluate generalizable social impact indicators, perceived local economic benefits, and community well-being. Surveys can be transparent communication tools, as there is negligible subjectivity in compiling answers, and the community can fully participate in the review of survey results. The results can be used to address community concerns and identify areas where knowledge transfer to the community is needed.

Once baseline information is obtained from the surveys, more in-depth information can be collected from community members. This can be achieved via two methods known as focus groups and interviews. The semi-structured interviews consist of a succession of questions asked by the interviewer and responses provided by the respondent to provide in-depth insight into stakeholders' practices and relationships. A focus group is a small group-moderated discussion in which the attitudes and practices of several stakeholders can be explored simultaneously and within a context of face-to-face interaction. The added benefit of these two methods is that the results from one can be triangulated (i.e., compared and assessed) with those of the other (Reed et al., 2009).

Survey questions presented and the distribution method of the survey must account for potential bias. One method to account for bias is to conduct a comparative analysis to uncover relationships between impacting events (i.e., remediation and redevelopment activities) and natural social change (Schrimer, 2011).

Reed et al. (2009) specify more precise methods that are useful in identifying the potential impacts of a remediation project:

- *Snowball Sampling*—interviewed stakeholders identify other relevant stakeholders to be interviewed. Can be used to interview marginalized stakeholders who may be affected by remediation decisions (Hart & Sharma, 2004).
- *Interest-Influence Matrices*—tools that allow the remediation decision-makers to identify the stakes that social actors (i.e., stakeholders) have in a remediation project. Identified stakeholders are placed in a matrix according to their relative interest and influence (Reed et al., 2009).
- *Actor-Linkage Matrices*—tools that allow the remediation decision-makers to describe relationships among stakeholders through codes or social network analysis (further discussed below). The aim of the latter is to identify the network of stakeholders and measure relational ties (Reed et al., 2009).

Case Study 5, in Exhibit 2, included as a supplemental online appendix, illustrates the successful incorporation of interviews and focus groups into a sustainability assessment of a remediation project (Alexandrescu et al., 2015).

A second method to account for bias is to build this aspect of the study into the survey questions. A successful use of building bias into survey questions is the Water Reuse Research Foundation's study on increasing awareness and fostering acceptance of direct potable reuse (Millan et al., 2015). Schrimer (2011) presents three common types of comparative analysis techniques to account for bias:

- *Time-Based Comparison*—consists of issuing the survey at two or more points in time throughout the project's life cycle to evaluate socio-economic characteristics, trends, and impacts in the community over time.
- *Comparison to an Average Study*—consists of comparing socio-economic characteristics and trends of the community to that of the larger region to identify social impacts that are a result of remedial activities and not from other factors influencing social trends in the community.
- *Comparison to Other Case Studies*—seeks to compare impacts of study sites where communities have similar socio-economic characteristics and trends. The study can be conducted after remediation, in which the comparison sites consists of the remediation project and a control site that does not require remediation. Or the study can be conducted pre-remediation, in which the comparison sites consist of a pre-remediation and a post-remediation project with similar characteristics.

A successful use of a time-based comparison analysis is presented as Case Study 6 in Exhibit 2, included as a supplemental online appendix.

Social network analysis allows an assessment and quantification of how stakeholders are involved in a remediation and redevelopment project at multiple levels.

Social Network Analysis

Social network analysis is a complex method that has been recently introduced in environmental management (Bodin & Prell, 2011; Prell et al., 2009). For sustainable remediation, the method appears to be promising (Alexandrescu et al., 2015) as it can offer valuable insights into how stakeholders are involved in remediation processes rather than how remediation practitioners choose to involve them. By definition, social networks are "sets of relations that apply to a set of social entities and any additional information on those actors and relations" (Prell, 2012). Social network analysis allows an assessment and quantification of how stakeholders are involved in a remediation and redevelopment project at multiple levels (Bodin et al., 2011). At the individual level, researchers can calculate how central certain stakeholders are within the network. This is also known as degree centrality and helps identify stakeholders with a high number of ties to other stakeholders in comparison to stakeholders with only a few ties with others. There are also more technical indicators such as betweenness centrality, which allows the identification of actors' broker roles within the network (Prell, 2012). At the network level, one can calculate how cohesive a network is (which would correspond to a more level playing field for all stakeholders) or whether the network is highly centralized, in which one or a few stakeholders hold the majority of ties. Finally, social network analysis can also be applied at the sub-group level to see whether one can locate cohesive subgroups in a network. The latter case would correspond to a remediation project in which not all stakeholders are equally well connected. For example, decision-makers might be well connected among themselves, but the affected parties might have few effective ways (ties) to communicate with this group.

Case Study 5 in Exhibit 2, included as a supplemental online appendix, illustrates the successful incorporation of social network analysis into a sustainability assessment of a remediation project (Alexandrescu et al., 2015)

Multicriteria models help remediation practitioners evaluate multiple conflicting criteria in order to make sustainable remediation decisions at contaminated sites.

Multicriteria Decision Analysis

Often stakeholder consultation involves many different groups with opposing sets of views, knowledge, or beliefs. This also extends to stakeholders with different views within the same group. Getting unbiased, collective agreement that is representative within and between groups is a taxing and complicated task, but offers significant benefits to the project and within the community. Multicriteria models help remediation practitioners evaluate multiple conflicting criteria in order to make sustainable remediation decisions at contaminated sites. Four main groups of multicriteria decision analysis (MCDA) methods exist: linear additive models, single synthesizing criterion approaches, outranking approaches to synthesizing process, and analytical hierarchy process (AHP) (Kain & Söderberg, 2008). AHP is the most common method utilized by the remediation community, and is further discussed below.

AHP allows users to compare two sets of criteria and note their preferences on the proposed project, remediation alternative, or preferred land use. Data are stored and retrieved easily, ensuring transparency during the final decision making process. The remediation practitioner's role in this process is to ensure that stakeholders are engaged prior to using the tool so that the resulting indicators and alternatives are based on their input. In addition, remediation practitioners can use a sensitivity test to increase the importance (or value) of a specific indicator to reflect stakeholders' changing views. For example, during a severe drought, stakeholders may place an increase value on water quality issues. By using the sensitivity test, the remediation practitioner is able to increase the importance (or value) of water and observe the associated relationship changes among other criteria. AHP tools can also analyze the statistical significances and bias of certain selected indicators or alternatives that are easy to report back to stakeholders and project proponents. If a bias is identified, remediation decision-makers can clarify with the individual or group, and determine if this is a result of purposely skewing data, or more likely, data entry error, or misunderstanding of the information.

Web-based AHP tools (e.g., Experts Choice and WebGIS-MCDA) are available to minimize travel to communities and may allow more productivity than large meetings, which can often result in the "loudest person being heard." Adopting less face-to-face meetings requires a delicate balance and should only be encouraged if alternate methods are being proposed, like using web-based MCDAs, surveys, or other meaningful engagement such as focus groups.

Case Study 7 in Exhibit 2, included as a supplemental online appendix, is an example of MCDA implemented on a remediation project in Saskatchewan for internal research purposes (Petelina et al., 2014).

 Remediation DOI: 10.1002/rem

CHALLENGES AND FUTURE RESEARCH NEEDS

Evaluation of the social dimension of remediation activities is not without challenges and suffers from knowledge gaps. Identification of obstacles and gaps during the project planning process is essential to defining sustainability objectives and choosing the appropriate tool and methodology to conduct an assessment. In addition, continued discussion of these factors promotes innovation and development. This section touches on the opportunities, challenges, and future research needs as it pertains to the social dimension of sustainable remediation.

Opportunities and Challenges

Meaningful Stakeholder Engagement

Stakeholder engagement is currently required for both federal and state-lead remediation projects in the USA, throughout the European Union and in many other parts of the world. Sustainable remediation aims to improve this process by introducing sustainability aspects that will directly affect the community, and thus be incorporated into stakeholder outreach and discussion. The success of stakeholder engagement relies on identifying the appropriate stakeholders and knowing how and when to engage them most effectively. While engaging stakeholders meaningfully can be a complex process, when undertaken, meaningful stakeholder engagement can streamline projects, enhance transparency, and alleviate stakeholder concerns. Stakeholders can be defined as any organization, group, or individual who takes an interest in a project and can influence project outcomes (Cundy et al., 2013). Remediation projects generally involve stakeholders such as regulators and planners. Ultimately site owners and operators are responsible for decisions about the land they manage, however, remediation professionals practicing sustainable remediation should consider engagement with other interested parties because these parties often provide valuable insight and understanding as to what constitutes sustainability on a specific site. Generally, sustainable remediation projects involve stakeholder engagement that focuses on early involvement and transparent, consistent communication. These two basic principles form part of a wider set of stakeholder engagement principles summarized by Cundy et al. (2013) (see Exhibit 4).

Exhibit 4. Basic principles for stakeholder engagement for remediation projects*

1. Identify and engage all stakeholders early in the process.
2. Adopt a proactive approach.
3. Engage stakeholders at all stages of the process.
4. Plan for long-term stakeholder engagement.
5. Develop effective communication structures that allow a reciprocal, two-way dialogue.
6. Ensure engagement is transparent and recorded.
7. Recognize that criteria for assessing indicators may be subjective OR objective.
8. Set out all assumptions clearly at the start of each engagement.
9. Follow a logical, stepwise approach to avoid circular arguments and clearly address subjective issues.

*Cundy et al. (2013).

Obtaining stakeholder input early in a remediation project can avoid conflict, reduce unnecessary remedial steps, and help define the appropriate (i.e., agreeable to stakeholders) sustainability indicators. Transparent and consistent communication reduces conflict or disagreement between stakeholders and remediation decision-makers. When remediation decision-makers engage stakeholders, it is important to consider the following factors (Government of Canada, 2005; Pope et al., 2013):

Obtaining stakeholder input early in a remediation project can avoid conflict, reduce unnecessary remedial steps, and help define the appropriate (i.e., agreeable to stakeholders) sustainability indicators. Transparent and consistent communication reduces conflict or disagreement between stakeholders and remediation decision-makers.

- Account for barriers to stakeholder groups like political structures.
- Resolve mobility issues to ensure adequate involvement.
- Be aware of socio-cultural barriers like gender, age, and agreeable meeting times (e.g., after business hours, not on religious or cultural holidays).
- Communicate in nontechnical, appropriate terms and account for the psycho-social barriers (e.g., diversity in individuals' beliefs, attitudes, values, hang-ups, and inhibitions) of stakeholder involvement.

Effective stakeholder engagement is meaningful and enables remediation decision-makers to move towards an integrated impact assessment, in which impacts to the four dimensions of the social dimension are identified. In addition, engagement does not involve multiple, long, unproductive, or expensive meetings. As presented above, social impact assessment techniques can be used to facilitate productive collaboration between and within stakeholders.

Risk Perception of Stakeholders

As stated previously, the social dimension does not only encompass impacts but also drivers and barriers influencing the implementation of sustainable remediation practices. Barriers to implementing sustainable practices that are achievable for a project can be influenced by the perceived risk of stakeholders. For example, the perceived risk to human health from reusing treated groundwater for potable use prevents re-use of this resource (SURF, 2014).

Risk perception refers to the differences between an expert's and layman's perception of whether something is risky or not or the degree of risk. Statistical risk, represented by an expert's perception of risk, is measured by results of experimental studies, epidemiology, surveys, and probabilistic risk analysis. While subjective and objective risk, represented by the layman's perception of risk, can lead to misperceptions or misunderstandings of risk.

Public attitudes toward risk are shaped by a variety of factors (Bickerhoff, 2004; Botzen et al., 2009; Galtron, 2008), including:

- Direct perceptual experiences associated with site-specific characteristics (e.g., geographic location, demographics, knowledge of site contaminants and sources, and experience of visual and olfactory impacts);
- Sense of trustworthiness of the controlling regulatory institutions and stakeholders; and,
- Individual's ability to bring about change.

Remediation DOI: 10.1002/rem

To address the role of perceived risk on dictating the implementation of sustainable remediation practices, remediation decision-makers can conduct surveys, interviews and other forms of stakeholder engagement to identify factors contributing to the stakeholders' perception. Once factors are identified, decision makers can provide direct support and education to communicate actual risk and overcome perceived risk. In addition, having a comprehensive understanding of stakeholders' perception of risk assists remediation decision-makers in supporting legitimacy and compliance with policies and protective measures, as well as improving communication concerning risk reduction policies to the stakeholders (Botzen et al., 2009).

Trade-Offs Among Triple Bottom Line Dimensions

Currently, the process of conducting a sustainability assessment for a remediation project is comparing impacts among each dimension of the triple bottom line (i.e., the environmental, economic, and social dimension). This process usually consists of conducting three assessments to quantitatively/qualitatively evaluate impacts to each dimension separately. By conducting three separate assessments, remediation decision-makers are challenged by inconsistencies in the methods and paradigms among the various assessments (Lee, 2002). These inconsistencies can unintentionally result in an unbalanced distribution of benefits and trade-offs among the triple bottom line dimensions.

Trade-offs can also occur among the interrelated dimensions of a dimension. In context of the social dimension, remediation decision-makers should ask: (1) Who is paying the monetary and social costs? (2) Who is benefiting? and 3) Can benefits be increased? Oughton (2013) reveals that some sections of the population may profit from site remediation activities while other sections do not. For example, local contractors may profit solely from selling and hiring equipment while remediation activities may adversely impact businesses adjacent to the site. This unbalanced distribution of benefits and costs can create or exacerbate any social inequities currently existing in the community.

In order to identify, avoid, and mitigate trade-offs, sustainability assessments and tools for remediation projects should advance toward a more integrated assessment approach. This approach focuses on defining sustainability objectives upfront with all stakeholders accounted for. The objectives are then used to identify indicators and methods to develop an integrated assessment approach for a site. Sustainability objectives must be consistent and compatible with each other to avoid conflicts among the triple bottom line dimensions (Pope et al., 2004). The social impact assessment techniques presented earlier are tools to assist in defining sustainability objectives with stakeholders. The main social indicator categories presented in the section on *State of the Practice* should be considered during development of project-specific sustainability objectives.

To address the role of perceived risk on dictating the implementation of sustainable remediation practices, remediation decision-makers can conduct surveys, interviews and other forms of stakeholder engagement to identify factors contributing to the stakeholders' perception.

Future Research Needs

As the international remediation community furthers its understanding of the social dimension of sustainable remediation, it is important to acknowledge and encourage future research in this subject. Based on a review of frameworks (section on *State of the Practice*) and impact assessment techniques (section on *Social Impact Assessment Techniques*), as well as stakeholder input, the following areas were identified as research opportunities in the social dimension of remediation:

- **Value of Social Cost Metrics**: The literature on social cost metrics is limited and often not site specific. Research is needed to assist remediation professionals in estimating site-specific social costs that can be incorporated into enhanced CBAs. Particularly, data gaps exist for monetizing societal benefits and dis-amenities associated with remediation's impacts on water consumption/availability, ecosystem services, urban services, and social and human capital.
- **Risk Perception of Reuse**: The layman's perception of risk for reusing treated media, such as remediated groundwater or soil, often inhibits reuse. Future research is needed to understand factors contributing to society's perception of the risk associated with reuse. An increased knowledge base on this subject will assist remediation practitioners in educating stakeholders and addressing community concerns pertaining to reuse.
- **Integrated and Objective-Led Assessment Approach**: The development and performance of an integrated assessment approach for remediation sites is needed to evaluate interrelations among the three dimensions of the triple bottom line. This methodology attempts to value the effects, identify beneficial interventions, and fully expose unavoidable tradeoffs (Pope et al., 2004). The development of this approach should consider integration and evaluation of qualitative and quantitative data sets. Future research is needed to expand and/or combine existing assessment frameworks into one single approach to address trade-off concerns.
- **Life-Cycle Assessment**: Life-cycle assessment (LCA) techniques conducted by remediation professionals are predominately driven by environmental metrics. In addition, software used (e.g., SimaPro) has placeholders within the program to input social and economic impacts for integration into the sustainability assessment. Future research is needed to determine how methodologies and impact assessment results from the social science and environmental economics discipline can be integrated into LCA techniques. Recent research on adapting the rigor of life cycle thinking to sustainability assessments (Calcas Consortium, 2009) should also be considered.

The indicators and assessment techniques to evaluate the social dimension of remediation are more mature and further developed than widely believed.

CONCLUSIONS AND CLOSING THOUGHTS

The indicators and assessment techniques to evaluate the social dimension of remediation are more mature and further developed than widely believed. No one specific tool, methodology, or framework is preferred over the others. Further, no one tool can encompass the breadth and complexity of the social dimension of a project, thus it is suggested to use a collaborative approach with multiple tools and processes. In general, it is better to have a simple, perhaps qualitative, assessment of all social indicators than to focus on a few in finer detail. The principle of Occam's Razor (parsimony) (Hiroshi, 1997) should apply. It is better to be comprehensive in the coverage of social issues than to be sophisticated in the quantification of a few.

Similar to the site characterization and remediation techniques implemented during remedial activities, the tools used to conduct a sustainable remediation assessment are based on site-specific variables or contexts (including legal and regulatory contexts) that

Remediation DOI: 10.1002/rem

are unique to every project. In conclusion, successful consideration of the social dimension during a sustainability assessment is performance core part of an integrated assessment that helps all stakeholders involved identify the most sustainable, viable strategy for remediating a site.

Sustainable remediation expertise is widely accessible in academia, consulting companies, regulatory agencies, and private organizations. Remediation decision-makers should take advantage of these experts not only to choose appropriate tools and methodologies, but also to assist in identifying experts from other disciplines (e.g., ecology, urban planning, economics, sociology, and anthropology) that can address site-specific social concerns and accurately characterize the remediation context.

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DISCLAIMER

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