Designation: E2893 – 13

Standard Guide for Greener Cleanups[1]

This standard is issued under the fixed designation E2893; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 Cleaning up *sites* improves environmental and public health conditions and as such can be viewed as "green." However, *cleanup* activities use energy, water, and natural resources. The process of *cleanup* therefore creates its own *environmental footprint*. This *guide* describes a process for evaluating and implementing activities to reduce the *environmental footprint* of a *cleanup* project in the United States while working within the applicable regulatory framework and satisfying all applicable legal requirements.

1.2 This *guide* may also be used as a framework for *sites* that are not located in the United States; however, the specific legal references are not applicable.

1.3 This *guide* describes a process for identifying, evaluating, and incorporating *best management practices* (*BMPs*) and, when deemed appropriate, for integrating a *quantitative evaluation* into a *cleanup* to reduce its *environmental footprint*.

1.4 This *guide* is designed to be implemented in conjunction with any *cleanup* process and should be used with other technical tools, guidance, policy, laws, and regulations to integrate *greener cleanup* practices, processes, and technologies into *cleanup* projects.

1.5 This *guide* provides a process for evaluating and implementing activities to reduce the *environmental footprint* of a *cleanup* and is not designed to instruct *users* on how to clean up contaminated *sites*.

1.6 ASTM also has a *guide* on Integrating Sustainable Objectives into *Cleanups* (E2876). That *guide* provides a broad framework for integrating elements of environmental, economic, and social aspects into *cleanups*. This *guide* may provide assistance with implementing E2876 and other sustainable remediation guidance, such as Holland, et al. (2011)(**1**).

1.7 This *guide* specifically applies to the *cleanup*, not the redevelopment, of a *site*. However, the reasonably anticipated use of a *site*, if known, may influence the *cleanup* goals and scope.

1.8 This *guide* should not be used as a justification to avoid, minimize, or delay implementation of specific *cleanup* activities. Nor should this *guide* be used as a justification for selecting *cleanup* activities that compromise *stakeholder* interests or goals for the *site*.

1.9 This *guide* does not supersede federal, state, or local regulations relating to protection of human health and the environment. No action taken in connection with implementing this *guide* should generate unacceptable risks to human health or the environment.

1.10 This *guide* may be integrated into complementary standards, *site*-specific regulatory documents, guidelines, or contractual agreements relating to sustainable or greener *cleanups*.

1.10.1 If the *cleanup* is governed by a regulatory program, the *user* should discuss with the regulator responsible for *site* oversight how this *guide* could be incorporated into the *cleanup* and whether the regulator deems it appropriate for the *user* to report the process and results to the regulatory program.

1.10.2 The contractual relationship or legal obligations existing between and among the parties associated with a *site* or *site cleanup* are beyond the scope of this *guide*.

1.11 This *guide* is composed of the following sections: Referenced Documents (Section 2); Terminology (Section 3); Significance and Use (Section 4); Planning and Scoping (Section 5); *BMP Process* (Section 6); *Quantitative Evaluation* (Section 7); Documentation and Reporting (Section 8); and Keywords (Section 9).

1.12 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1527 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process

[1] This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.04 on Corrective Action.

Current edition approved Sept. 15, 2013. Published November 2013. DOI: 10.1520/E2893-13.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E2091 Guide for Use of Activity and Use Limitations, Including Institutional and Engineering Controls

E2876 Guide for Integrating Sustainable Objectives into Cleanup

2.2 *USEPA Documents:*[3]

USEPA, Life Cycle Assessment: Principles and Practice, EPA/600/R-06/060 (May 2006)

USEPA, Green Remediation: Best Management Practices for Excavation and Surface Restoration, EPA 542-F-08-012 (December 2008)

USEPA, Principles for Greener Cleanups (August 2009a)

USEPA, Green Remediation Best Management Practices: Pump and Treat Technologies, EPA 542-F-09-005 (December 2009b)

USEPA, Green Remediation Best Management Practices: Site Investigation, EPA 542-F-09-004 (December 2009c)

USEPA, Green Remediation Best Management Practices: Bioremediation, EPA 542-F-10-006 (March 2010a)

USEPA, Green Remediation Best Management Practices: Soil Vapor Extraction & Air Sparging, EPA 542-F-10-007 (March 2010b)

USEPA, Green Remediation Best Management Practices: Clean Fuel & Emission Technologies for Site Cleanup, EPA 542-F-10-008 (August 2010c)

USEPA, Green Remediation Best Management Practices: Integrating Renewable Energy into Site Cleanup, EPA 542-F-11-006 (April 2011a)

USEPA, Green Remediation Best Management Practices: Sites with Leaking Underground Storage Tank Systems, EPA 542-F-11-008 (June 2011b)

USEPA, Green Remediation Best Management Practices: Landfill Cover Systems & Energy Production, EPA 542-F-11-024 (December 2011c)

USEPA, Methodology for Understanding and Reducing a Project's Environmental Footprint, EPA 542-R-12-002 (February 2012a)

USEPA, Green Remediation Best Management Practices: Implementing In Situ Thermal Technologies, EPA 542-F-12-029 (October 2012b)

2.3 *Other Documents:*[4]

International Standards Organization —Environmental Management—Life Cycle Assessment—Requirements and Guidelines, ISO 14044:2006 (2006)

NOTE 1—Appendix X1 of this *guide* lists relevant material available from other government agencies and non-government organizations.

3. Terminology

3.1 *Definitions:*

3.1.1 *activity and use limitations*—legal or physical restrictions or limitations (that is, institutional or engineering controls) on the use of, or access to, a *site* or facility: *(1)* to reduce or eliminate potential exposure to *contaminants* in the environmental media on the property, or *(2)* to prevent activities that could interfere with the effectiveness of a response action in order to ensure maintenance of a condition of no significant risk to public health or the environment. See Guide E2091 for more information on *activity and use limitations*.

3.1.2 *best management practices (BMPs)*—activities that, if applicable to the situation, typically will reduce the *environmental footprint* of a *cleanup* activity.

3.1.3 *BMP categories*—groupings of *BMPs* based on how the *user* would consider each activity during the planning stages of the *cleanup*. The *greener cleanup BMPs* are organized into ten categories: Project Planning and Team Management; Sampling and Analysis; Materials; Vehicles and Equipment; *Site* Preparations/Land Restoration; Buildings; Power and Fuel; Surface Water and Storm Water; Residual Solid and Liquid Waste; and Wastewater.

3.1.4 *BMP process*—a systematic protocol to identify, prioritize, select, implement, and report on the use of *BMPs* to reduce the *environmental footprint* of *cleanup* activities.

3.1.5 *cleanup*—the range of activities that may occur to address *releases* of *contaminants* at a *site* from the initiation of *site assessment* activities to achievement of *no further cleanup*. The environmental remediation industry also refers to *cleanup* as remediation or corrective action.

3.1.6 *cleanup phase*—the segments of a *cleanup* project that take place from the initiation of *site assessment* to achievement of *no further cleanup*. This *guide* divides a *cleanup* project into the following five segments: *site assessment*; *remedy selection*; *remedy design/implementation*; *operation, maintenance, and monitoring*; and *remedy optimization*. This terminology is generally consistent with standard industry terminology, but does not conform to every environmental *cleanup* program.

3.1.7 *CERCLA*—the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. § 9601 *et seq*., as amended, the primary federal statute that governs the imposition of liability for environmental *cleanups*. *CERCLA* is commonly referred to as Superfund.

3.1.8 *contaminant*—a *hazardous substance*, petroleum product, or other chemical that may pose a threat to human health or the environment when present in environmental media.

3.1.9 *core elements*—for purposes of this *guide*, five factors representing key areas for potentially reducing the *environmental footprint* of a *site cleanup*. These factors are: minimize total energy use and maximize use of renewable energy; minimize air pollutants and *greenhouse gas emissions*; minimize water use and impacts to water resources; reduce, reuse, and recycle materials and waste; and protect land and ecosystems.

3.1.10 *disturbance of vegetation*—removal, cutting, or alteration of plants, bushes, or canopy trees, particularly those that are mature, non-invasive, native species that provide food sources, micro-climates, nesting areas, or refuge supporting indigenous flora and fauna.

3.1.11 *emissions*—the discharge of a *contaminant* to air. However, in the context of *life cycle assessment (LCA)* and *footprint analysis*, this term refers to discharges to air, water,

[3] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Federal Building, 1200 Pennsylvania Ave., NW, Washington, DC 20004, http://www.epa.gov.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

and soil, including *site contaminants* as well as discharges not typically considered *contaminants* in *site cleanup* such as water, nitrogen oxides, and particulate matter.

3.1.12 *environmental footprint*—a qualitative or quantitative estimate of various environmental contributions of a *cleanup phase* or activity to the *core elements*. A quantitative *environmental footprint* may be obtained through either a *footprint analysis* or *LCA*. Appendix X4 provides further clarification on the use of *footprint analysis* or *LCA*.

3.1.13 *environmental law*—any federal, state, or local statute, regulation, or ordinance relating to: the protection of the environment; pollution, investigation, or restoration of the environment or natural resources; or the handling, management, use, presence, transportation, processing, disposal, *release*, or threatened *release* of any *contaminant*. The term *environmental law* in the United States includes, but is not limited to, *CERCLA*, *RCRA*, and *TSCA*.

3.1.14 *final cleanup goals*—the objectives established to address *contaminants* at a *site* by a regulatory agency or through a voluntary *cleanup* program that, when met, protect human health and the environment. Users should review the applicable regulatory program for more information on establishing *final cleanup goals* at a particular site.

3.1.15 *footprint analysis*—a quantitative estimate of an *environmental footprint* for a *cleanup phase* or activity. The analysis entails the compilation of inputs and outputs to estimate potential contributions (that is, *emissions* or resource use) to the *core elements*. A *footprint analysis* may include raw material acquisition, materials manufacturing, and transportation related to the *cleanup*, in addition to onsite construction, implementation, monitoring, and decommissioning. Results from a *footprint analysis* are typically reported as *emissions* (for example, nitrogen oxides, carbon dioxide equivalents, or total hazardous air pollutants) or resource use (for example, water, energy, or materials use) organized in terms of the five *core elements*.

3.1.15.1 *Discussion*—there are two fundamental differences between *footprint analysis* and *LCA*: *(1)* an *LCA* typically considers the full life cycle of the components of a *cleanup phase* or activity. In contrast, a *footprint analysis* may consider the full life cycle of the components of a *cleanup phase* or activity, but more commonly selects abbreviated boundaries; and *(2)* results from an *LCA* are described in terms of human health and environmental impacts whereas the results from a *footprint analysis* are reported in terms of quantities of *emissions* and resource use, without taking the next step to evaluate the human health and environmental impacts from those *emissions* and resource use.

3.1.16 *greener cleanup*—the incorporation of practices, processes, and technologies into *cleanup* activities with the goal of reducing impacts to the environment through reduced demands on natural resources and decreased *emissions* to the environment. A *greener cleanup* considers the five *core elements*, while protecting human health and the environment. In the environmental remediation industry, this term is used interchangeably with green *cleanup*, green remediation, and greener remediation.

3.1.17 *greenhouse gases*—vaporous constituents of the earth's atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

3.1.17.1 *Discussion*—Carbon dioxide, methane, and nitrous oxide have been the main focus of *greenhouse gas* emission evaluations within the environmental remediation industry.

3.1.18 *guide*—a compendium of information or series of options that does not recommend a specific course of action. A *guide* increases the awareness of information and approaches in a given subject area.

3.1.19 *habitat*—the physical and natural environment, including niche environments (micro-habitats) that support local indigenous species and related supporting vegetation, food sources, areas for nesting and refuge, soils, and hydrology; and larger environmental features (macro-habitats), such as a bank on a waterway or vegetated, open, wildlife corridors for foraging and natural migration. Areas of *habitat* may be used temporarily by species and timing of a disturbance may minimize impact.

3.1.20 *hazardous substance*—a substance defined as a *hazardous substance* pursuant to *CERCLA*, 42 U.S.C. § 9601(14), as interpreted by EPA regulations.

3.1.21 *impact category*—an *LCA* term representing a compilation of different *emissions* or other metrics, such as resource use, that contribute to a specific environmental or health effect. Examples of *impact categories* are global warming, aquatic acidification, smog formation, and respiratory effects. Some *emissions* and resource use contribute to more than one *impact category*.

3.1.22 *lead environmental professional*—for the purposes of this *guide*, a person possessing sufficient education, training, and experience to: *(1)* meet the requirements set forth in Practice E1527 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process *(2)* exercise professional judgment regarding the evaluation and implementation of *BMPs* for the *cleanup phases* being addressed by this *guide*, and, if applicable, *(3)* exercise professional judgment in conducting *footprint analyses* or *LCAs*. The person may be the *user*, an independent contractor, or an employee of the *user*.

3.1.23 *life cycle assessment (LCA)*—a quantitative estimate of an *environmental footprint* for a *cleanup phase* or activity. The assessment entails the compilation and evaluation of inputs and outputs to estimate the potential human health and environmental impacts from a *cleanup phase* or activity, from raw material acquisition, materials manufacturing and transportation, to onsite construction, implementation, monitoring, and decommissioning. Results from an *LCA* are reported in *impact categories*, which can be mapped to the five *core elements*. For a description of the differences between *LCA* and *footprint analysis*, see the discussion following 3.1.15, *footprint analysis* and Appendix X4.

3.1.24 *LUST program*—the Leaking Underground Storage Tank Program under *RCRA* that gives EPA and states, under cooperative agreements with EPA, authority to clean up *releases* from regulated underground storage tank systems or require owners and operators to do so (42 U.S.C. § 6991b). EPA's federal underground storage tank regulations require that contaminated *LUST sites* be cleaned up to restore and protect groundwater resources and create a safe environment for those who live or work around these *sites*.

3.1.25 *no further cleanup*—the point in time when *final cleanup goals* are achieved at a *site*, there is no active ongoing *cleanup*, and the *site* is protective of human health and the environment based on the property's *reasonably anticipated future use*. At some *sites*, *activity and use limitations* must be maintained to ensure protection after the *final cleanup goals* are achieved. At *sites* being cleaned up pursuant to a regulatory program, the regulatory agency providing oversight generally issues a determination that the *site* has achieved the *final cleanup goals* and, therefore, *no further cleanup* is required. This includes the term "*site* closure" used in some programs.

3.1.26 *operation, maintenance, and monitoring (OMM)*—the *cleanup phase* following *remedy design/implementation* where the *remedy* is periodically evaluated to ensure that it is operating as intended. Repairs or adjustments may be implemented to maintain or improve progress toward achieving *final cleanup goals*. This *cleanup phase* may include periodic sampling and analysis of environmental media to assist with *remedy* performance evaluation.

3.1.27 *opportunity assessment*—for the purposes of this *guide*, a review of *BMPs*, including those listed in Appendix X3, to determine which *BMPs* apply to the *cleanup phase* being evaluated. This is a screening level assessment. Additional sources of *BMPs*, such as checklists, guidelines, matrices, or industry-recognized tables of *BMPs*, may also be included. During an *opportunity assessment*, all potentially applicable *BMPs* are retained regardless of cost.

3.1.28 *petroleum products*—those substances included within the meaning of the petroleum exclusion to *CERCLA*, 42 U.S.C. § 9601(14), as interpreted by the courts and EPA: "petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a *hazardous substance*… the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas)."

3.1.29 *project team*—for purposes of this *guide*, the group of individuals and experts brought together to implement the activities identified by this document for a specific *site*. The group typically includes the *lead environmental professional*, the *user*, the state and/or federal regulator, the *site* owner representative, and additional experts, as needed. For some *sites*, the *project team* may include community *stakeholders*. The *lead environmental professional* and *user* can be the same person or work for the same entity.

3.1.30 *quantitative evaluation*—for purposes of this *guide*, the *site*-specific numerical estimate of contributions to the *core elements* for a *cleanup phase* or activity as calculated using *footprint analysis* or *LCA*.

3.1.31 *RCRA*—the Resource Conservation and Recovery Act, 42 U.S.C. § 6901 *et seq*., as amended, sometimes also known as the Solid Waste Disposal Act, the primary federal statute that, *inter alia*, establishes a framework for regulation of solid and hazardous waste and for promoting resource recovery through a federal-state partnership.

3.1.32 *reasonably anticipated future use*—the future use of a *site* that can be predicted with a reasonably high degree of certainty given historical use, current use, and local governmental planning and zoning.

3.1.32.1 *Discussion*—other factors that may be considered in determining *reasonably anticipated future use* include accessibility of the *site* to existing infrastructure, recent development patterns, cultural factors, environmental justice, regional trends, and community preference or acceptance.

3.1.33 *release*—as defined by Section 101(20) of *CERCLA*, 42 U.S.C. § 9601(22), any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment, including abandoning or discarding barrels, containers, and other closed receptacles containing any *contaminant*.

3.1.34 *remedial option*—for the purposes of this *guide*, a technology or activity that removes or controls exposure to *contaminants* present at a *site*. In the environmental remediation industry, this term is also referred to as a remedial alternative.

3.1.35 *remedy*—the technology or *cleanup* activity that is implemented to address *releases* of *contaminants* at a *site*.

3.1.36 *remedy design/implementation*—for the purposes of this *guide*, the *cleanup phase* following *remedy selection* which includes incorporating engineering and geologic studies to develop specifications for the *remedy* as well as the actual construction, to the extent construction is part of the *remedy*.

3.1.37 *remedy optimization*—for the purpose of this *guide*, the *cleanup phase* following *remedy design/implementation* that is implemented at some *sites* to improve *remedy* performance in meeting *final cleanup goals*, reducing its *environmental footprint*, or both. In some situations, *remedy optimization* leads to technology design refinements, such as changes in the type of pumps or the location of groundwater recovery wells. In these cases, *remedy optimization* is analogous to the *remedy design/implementation cleanup phase*. In other situations, *remedy optimization* leads to the selection and implementation of an alternative technology. In those situations, *remedy optimization* is analogous to the *remedy selection cleanup phase*.

3.1.38 *remedy selection*—the *cleanup phase* in which potential *remedial options* are evaluated and compared to one another and the optimum technology(ies) or activity is selected to meet *final cleanup goals* or interim *cleanup* objectives.

3.1.39 *site*—an area defined by the likely physical distribution of *contaminants* from a *release* warranting *cleanup* activities. A *site* can be an entire property or facility, a defined area or portion of a facility or property, or multiple facilities or properties. One facility may contain multiple *sites*. Multiple *sites* at one facility may be addressed individually or as a group.

3.1.40 *site assessment*—the *cleanup phase* in which the *site* is characterized to determine if the concentrations and distribution of *contaminants released* pose a potential risk to human health or the environment. More specifically, this *cleanup phase* involves collecting data on: soil, groundwater, air, surface water, and/or sediment quality; *site* characteristics (for example, subsurface geology, geochemistry, soil properties and structures, hydrology, and surface characteristics); land and resource use; and potential receptors. The *site assessment* generates data to develop a conceptual site model and inform decisions regarding the *cleanup*, if necessary (which may include a risk assessment). Regulatory requirements for *site assessment* may vary by program. In the environmental remediation industry, *site assessment* is also referred to as remedial investigation, *site* investigation, or *site* characterization.

3.1.41 *stakeholders*—for the purposes of this *guide*, individuals, organizations, or entities that directly or indirectly affect, or are affected by, *contaminant releases* or *cleanup* activities. *Stakeholders* are *site*-specific and can include members of the local community (for example, residents, elected officials, regular visitors, nearby businesses, economic development corporations), regulatory agencies, the *site* owner or responsible parties, and future *users* of the property.

3.1.42 *TSCA*—the Toxic Substances Control Act, 15 U.S.C. § 2601 *et seq*., the primary federal statute that, *inter alia*, provides EPA with the regulatory authority to require reporting, recordkeeping, and testing requirements for chemical substances and mixtures, and to establish restrictions for the manufacture, use, processing, storage, distribution in commerce, and/or disposal of certain chemicals and mixtures.

3.1.43 *user*—the party seeking to use this *guide* to complete a *greener cleanup*. The *user* can be the *site* owner, responsible party, an employee of these entities, or an agent of the *site* owner or responsible party (for example, a consultant).

4. Significance and Use

4.1 *Purpose*—This *guide* provides a process for evaluating implementing, documenting, and reporting activities to reduce the *environmental footprint* of a *cleanup* as defined by the following *core elements*.

4.1.1 *Minimize Total Energy Use and Maximize Use of Renewable Energy*—Reducing total energy use while also identifying means to increase the use of renewable energies throughout the *cleanup*. Possible methods may include reducing energy use, use of energy efficient equipment, use of onsite renewable resources (for example, wind, solar), and purchase of commercial energy from renewable resources.

4.1.2 *Minimize Air Pollutants and Greenhouse Gas Emissions*—Reducing total air *emissions*, including *emissions* of air pollutants and *greenhouse gases*, throughout the *cleanup*. Possible methods may include minimizing the generation and transport of airborne *contaminants* and dust, efficient use of emitting equipment (for example, vehicles and heavy equipment), use of advanced *emission* controls, and use of cleaner fuels or hybrid technologies.

4.1.3 *Minimize Water Use and Impacts to Water Resources*—Minimizing the use of water and impacts to water resources throughout the *cleanup*. Possible methods may include conserving water use in *cleanup* processes, use of water efficient products, water capture and reclamation for reuse, water efficient revegetation, and employing traditional *BMPs* for storm water, erosion, and sedimentation control.

4.1.4 *Reduce, Reuse, and Recycle Materials and Waste*—Minimizing the use of virgin materials and generation of waste throughout the *cleanup* as well as maximizing the use of recycled materials. Possible methods may include using recycled and locally generated materials, reusing waste materials (for example, concrete made with coal combustion products), diverting construction and demolition debris from disposal by recycling recovered resources, and using rapidly renewable materials or certified wood products.

4.1.5 *Protect Land and Ecosystems*—Reducing impacts to the land and ecosystem services throughout the *cleanup*. Possible methods may include minimizing the area requiring *activity and use limitations* by the removal or destruction of *contaminants*; identifying the presence of and limiting the disturbance of mature, non-invasive, native vegetation, surface hydrology, soils, and *habitats* in the *cleanup* area; and minimizing noise and light disturbance.

4.2 *Professional Experience*—This *guide* requires the skills of a *lead environmental professional* and *project team*, as appropriate, to evaluate and apply *greener cleanup* practices, processes, and technologies to each *cleanup phase* while meeting regulatory program-specific requirements and ensuring protection of human health and the environment. This *guide* presumes the *lead environmental professional* is knowledgeable in *cleanup* practices and experienced in identifying and satisfying applicable statutory or regulatory *cleanup* requirements and expectations.

4.3 *Uncertainty in Greener Cleanups*—Professional judgment, interpretation, and some uncertainty are inherent in the process even when decisions are based upon objective scientific principles and accepted industry practices. Although such uncertainties are inevitable, they typically will not detract from the ability of the *user* to achieve meaningful improvements in the *site cleanup*.

4.4 *Regulatory Context*—The *user* is responsible for determining the regulatory context, and associated constraints and obligations for each *site*, and shall comply with all applicable laws and regulations, including *CERCLA*, *RCRA*, *TSCA*, and other *environmental laws*.

4.4.1 The *user* shall comply with health and safety requirements under the Occupational Safety and Health Act and parallel state statutes and regulations.

4.4.2 This *guide* may not be appropriate for certain *cleanups*, such as some emergency response actions, that do not allow sufficient time for its application.

4.4.3 Implementation of this *guide* may involve additional costs or require changes to the *cleanup* schedule; however, its implementation should not unduly delay a *cleanup* or result in the imposition of unreasonable costs.

4.5 *Process Implementation*—This *guide* may be initiated at any time during any *cleanup phase*, including during: *site assessment*; *remedy selection*; *remedy design/implementation*; *operation, maintenance, and monitoring*; and *remedy optimization*.

4.6 *Process Overview*—At initiation, the *user* should review Section 3, Terminology, and then proceed to Section 4, Significance and Use, and Section 5, Planning and Scoping. *Users* who plan to implement the *BMP process* only, should proceed to Section 6. *Users* who plan to employ a *quantitative evaluation* should proceed to Section 7, prior to implementing Section 6. Section 8 describes documentation and reporting.

4.6.1 Section 5, Planning and Scoping, describes information the *user* should collect and consider to assist in making several *site*-specific, *user*-defined decisions for implementing the *guide*.

4.6.2 Section 6, *BMP Process*, describes steps for identifying, prioritizing, selecting, and implementing *BMPs*.

4.6.3 Section 7, *Quantitative Evaluation*, describes a process for implementing a *footprint analysis* or *LCA*. Section 7 is not designed to instruct the *user* on how to perform *footprint analysis* or *LCA*. It presumes that a member of the *project team* is knowledgeable in a *quantitative evaluation* approach applicable to the *site*.

4.6.4 Section 8 describes recommended documentation and reporting on the implementation of the *guide*.

4.6.5 Section 9 provides keywords for indexing and searching purposes.

4.6.6 This *guide* includes four appendices.

4.6.6.1 Appendix X1, Supporting Documentation, provides supplemental reference material for the *user* to consider when implementing this *guide*.

4.6.6.2 Appendix X2, Technical Summary Form, is a template for the *user* to report general information about the *site* (for example, location), document process steps, and describe *greener cleanup* outcomes from implementing the *guide*. The *user* may employ this template or another applicable format for reporting results from implementation of this *guide*.

4.6.6.3 Appendix X3, *Greener Cleanup BMP* Table, supports Section 6 by providing a comprehensive list of *BMPs* to assist the *user*. Standard best management practices for *cleanup* (that is, those related to engineering and technology, but unrelated to reducing *environmental footprints*) are generally not included in the *Greener Cleanup BMP* Table.

4.6.6.4 Appendix X4, Supplemental Information for a *Quantitative Evaluation*, supports Section 7 by providing general information on *footprint analysis* and *LCA*, including their uses, similarities, and differences.

5. Planning and Scoping

5.1 When applying this *guide*, the *user* should perform the following planning and scoping activities: select a *lead environmental professional*; assemble a *project team*; identify the applicable regulatory program and project objectives; compile *site* data; develop a project budget and schedule; determine which *cleanup phases* to apply the *guide* to and whether to apply the *BMP process* alone or perform a *quantitative evaluation* in conjunction with *BMPs*; and establish a plan for reporting results and for making those results publicly available. The *user* should perform these activities for each *cleanup phase* being evaluated in connection with the use of this *guide*. However, some of the activities will be identical from one *cleanup phase* to the next and should be carried forward and built upon whenever possible as the project progresses.

5.1.1 The *user* should select a *lead environmental professional*. The *lead environmental professional* may be an independent contractor or an employee of the *user*. In addition, the *user* can be the *lead environmental professional*.

5.1.2 The *user* should assemble the appropriate *project team* for the *greener cleanup*, considering factors such as: the technical expertise related to the *cleanup* activities being considered; the *greener cleanup* evaluation and implementation approach (that is, *BMP process* only or a *quantitative evaluation* followed by the *BMP process*); legal requirements; *stakeholder* interests and concerns; and project budget.

5.1.3 If the *cleanup* is governed by a regulatory program, the *user* should identify: the regulatory program governing the *cleanup*; the goals and requirements for each *cleanup phase* going forward to achieve a determination of *no further cleanup*; applicable *environmental laws*; and the program's *greener cleanup* policies. When appropriate, the *user* should discuss expectations for greener *cleanups* with a representative of the regulatory agency prior to implementing the *guide*.

5.1.4 The *user* should compile *site* data, such as environmental, demographic, and land use characteristics and other factors that influence the *cleanup*.

5.1.4.1 The *user* should identify the *site* size; potential or actual environmental media impacts; the types of *contaminants* present and their distribution, if known; and other *site* characteristics relevant to the use of this *guide*.

5.1.4.2 The *user* should identify the current and *reasonably anticipated future use* (if known) for the *site* and for properties located proximal to the *site*.

5.1.5 The *user* should identify key *stakeholders* and assess their interests and concerns regarding the *cleanup* activities being considered and/or the potential reuse options for the *site*.

5.1.6 The *user* should consider the budget and schedule, as well as any cost constraints or other limitations for the project, and determine how the *BMP process* or *quantitative evaluation* will be integrated into the project in light of those factors.

5.2 The *user* should determine whether to employ the *BMP process* alone or the *quantitative evaluation* followed by the *BMP process*. The *BMP process* relies on professional judgment to prioritize and select activities that will likely reduce the *environmental footprint*. The *quantitative evaluation* relies on estimated data inputs to quantify anticipated *environmental footprint* reductions prior to implementing *BMPs*. The *user* should consider the *site* information listed above in 5.1.4 through 5.1.6 and the following information to determine which evaluation is more appropriate for each *cleanup phase* at a *site*.

5.2.1 The *BMP process* and *quantitative evaluation* can be applied to all *cleanup phases*. However, for a few *cleanup phases* one approach generally may be better suited relative to the other. For example, while a *quantitative evaluation* is applicable to the *site assessment*, in many situations the likely *environmental footprint* reductions may not be great enough to justify the investment of additional time and effort to conduct the analysis. Similarly, implementation of the *BMP process* is generally not warranted at *remedy selection*; however, evaluating *BMPs* during *remedy selection* may be constructive. For example, if two remedies are equally protective and effective, evaluating *BMPs* prospectively can help the *user* identify which *remedy* has greater potential for *environmental footprint* reductions. The *user* should consult Fig. 1 and Table 1 for guidance on the applicability of the *BMP process* or *quantitative evaluation* to the *cleanup phases*.

5.2.2 The *BMP process* is appropriate at any *site*, regardless of its size or complexity, whereas the *quantitative evaluation* followed by the *BMP process* is best suited to relatively large-scale or complex *cleanups* where a range of approaches could be implemented to achieve the objectives for that *cleanup phase*.

5.2.3 The *BMP process* takes less time to complete than a *quantitative evaluation* followed by the *BMP process*. However, a *quantitative evaluation* followed by the *BMP*

TABLE 1 Timing for Entering and Implementing

Cleanup Phase	Enter	Implement	
		BMP Process	Quantitative Evauation
Site Assessment	Anytime during the investigation	✓	Generally not warranted
Remedy Selection	When evaluating *cleanup* options	Generally not warranted	✓
Remedy Design/ Implementation	When designing or implementing the remedy	✓	✓
Operation Maintenance and Monitoring (OMM)	Anytime during OMM	✓	✓
Remedy Optimization	Anytime during OMM	✓	✓

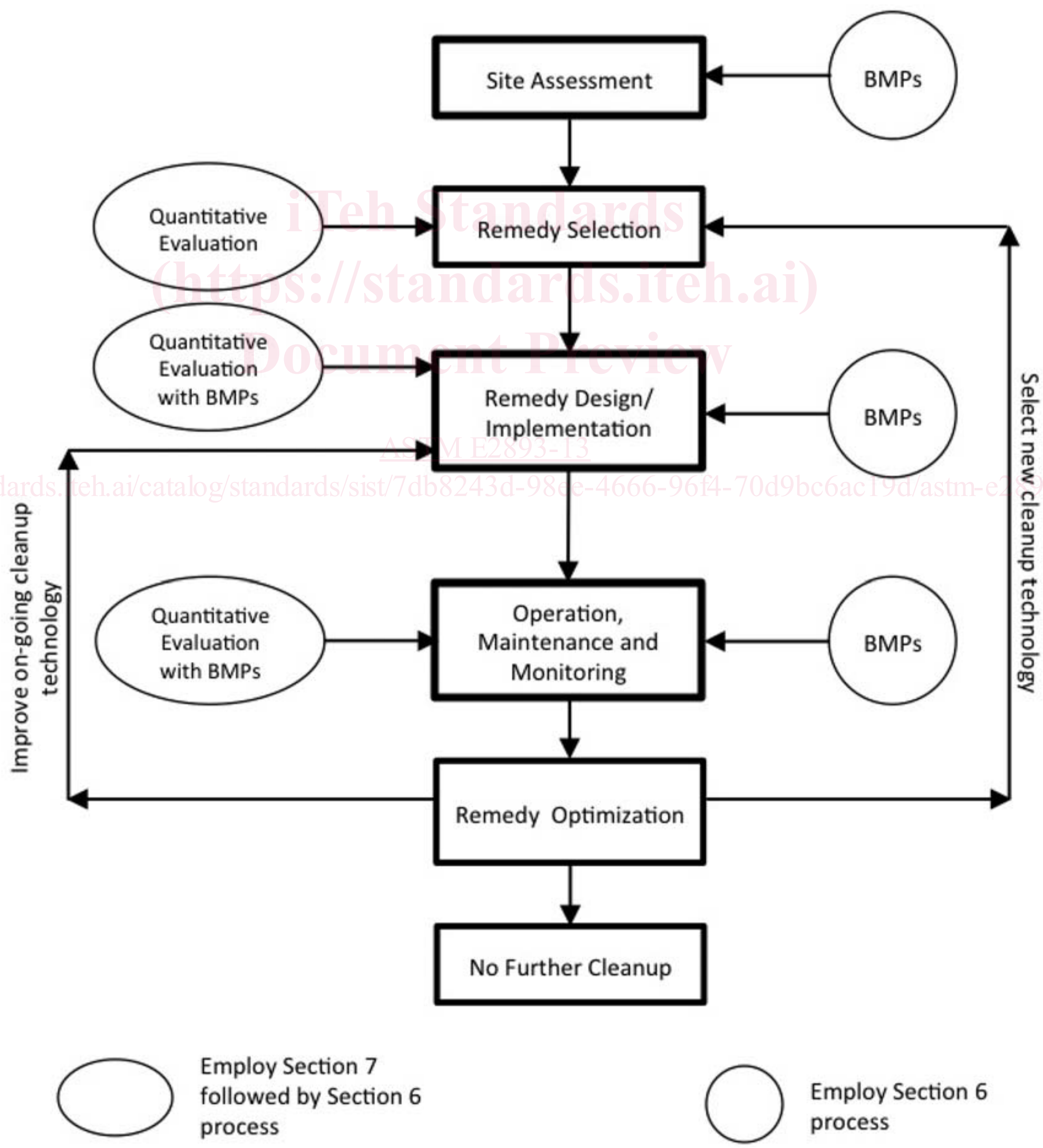

FIG. 1 ASTM Greener Cleanup Overview

process may identify more significant *environmental footprint* reductions than the *BMP process* alone.

5.2.4 A *quantitative evaluation* will need an individual on the *project team* who is knowledgeable in *footprint analysis* or *LCA*.

5.3 The *user* should review Section 8 for a discussion about the type of information to document and report, when to document and report it, and suggested options to make the information publicly available.

6. BMP Process

6.1 The goal of the *BMP process* is to enable the *user* to identify, prioritize, select, implement, and document the use of *BMPs* to reduce the *environmental footprint* of *cleanup* activities.

6.2 *Selection of Applicable Cleanup Phases*—The *user* should consider the information collected in the planning and scoping performed under Section 5 to determine the *cleanup phase(s)* that will be assessed when performing the *BMP process*.

6.3 The *BMP process* is applied to one specific *cleanup phase* at a time. If the *user* is implementing the *BMP process* during subsequent phases of a *cleanup*, all steps of the *BMP process* should be followed for each *cleanup phase* in which this *guide* is applied. When considering *BMPs* for subsequent *cleanup phases*, the experience of implementing *BMPs* in prior phases may be useful in determining whether to continue implementing the *BMPs* already selected or to seek different *BMPs*. The *user* should anticipate implementing and building upon the *BMPs* used in earlier phases of the project through the end of the project, if applicable.

6.4 *Greener Cleanup Core Elements*—When evaluating *BMPs*, the *user* should consider the best overall approach for reducing the *environmental footprint* of the planned *cleanup* activities by reviewing the *core elements* defined in Section 4.1.

6.5 The *user* should understand the following about the *BMP process*:

6.5.1 Appendix X3, *Greener Cleanup BMP* Table, provides a comprehensive list of *greener cleanup BMPs*. These *BMPs* are organized into the following *BMP categories*: *(1)* Project Planning and Team Management; *(2)* Sampling and Analysis; *(3)* Materials; *(4)* Vehicles and Equipment; *(5) Site* Preparation/Land Restoration; *(6)* Buildings; *(7)* Power and Fuel; *(8)* Surface Water and Storm Water; *(9)* Residual Solid and Liquid Waste; and *(10)* Wastewater.

6.5.2 The *user* is also encouraged to identify or develop and implement *BMPs* not included in Appendix X3 that are consistent with the spirit and intent of the *guide* because they reduce the *environmental footprint* of the *cleanup*.

6.5.3 All *BMPs* that are required by law or regulation should be implemented and documented, as described in Section 8.

6.5.4 As part of the *BMP process*, the *user* may elect to perform a *quantitative evaluation* to optimize performance of a specific *BMP* or to calculate the anticipated numerical *environmental footprint* reduction from implementing the *BMP*. The process of performing a *quantitative evaluation* is described in Section 7.

6.5.5 When evaluating *BMPs*, the *user* may find the following references helpful: Butler, et al., 2011(**2**); Ellis & Hadley, 2009(**3**); ITRC, 2011(**4**); U.S. Army Corp of Engineers, 2010(**5**); and USEPA, 2008, 2009a, 2009b, 2010a, 2010b, 2010c, 2011a, 2011b, 2011c, 2012a, and 2012b.

6.6 *BMP Process*—The *BMP process* involves the following five steps: Step 1: *BMP Opportunity Assessment*; Step 2: *BMP* Prioritization; Step 3: *BMP* Selection; Step 4: *BMP* Implementation; and Step 5: *BMP* Documentation. The *user* should follow all the steps described below and summarized in Fig. 2.

6.6.1 *Step 1: BMP Opportunity Assessment*—This is a screening level assessment. During this step, the *user* identifies all *BMPs* considered potentially applicable to the *site* conditions. Appendix X3 provides a robust list of *BMPs*. The *Greener Cleanup BMP* Table in Appendix X3 is not exhaustive, and the *user* is encouraged to identify additional *BMPs* as part of this step, using checklists, guidelines, matrices, or tables of *BMPs* recognized within the environmental remediation industry or within similar industries that utilize environmentally beneficial practices, evaluations, and technologies (see 6.5.5).

6.6.1.1 During this step, the *user* should consider only whether each individual *BMP* is potentially applicable to the *cleanup phase* under evaluation, without regard to factors that ultimately will influence the decision to use a particular *BMP*, such as cost, logistics, or the relative benefits of other *BMPs*.

6.6.2 *Step 2: BMP Prioritization*—The *user* reviews the *BMPs* retained in Step 1 and prioritizes the *BMPs* based on the relative ability of each *BMP* to reduce the *environmental footprint* of the *cleanup* activity.

6.6.2.1 The *user* should identify those *BMPs* that are relatively unlikely to result in a significant reduction of the *environmental footprint* and assign them lower priority. The purpose of this designation is to facilitate the elimination of those lower-value *BMPs* in Step 3, in favor of higher-value *BMPs*.

6.6.2.2 The prioritization is based on professional judgment and does not require a detailed analysis.

6.6.2.3 If there are numerous potentially applicable *BMPs*, the *user* may group *BMPs* into categories (for example, high, medium, low) based on the relative anticipated *environmental footprint* reductions.

6.6.2.4 If a *BMP* has potential negative impacts on one or more *core elements* but positive impacts on others, the *user* should factor in those anticipated outcomes in the prioritization process.

6.6.2.5 As part of this step, the *user* should prepare a prioritized list of *BMPs*.

6.6.3 *Step 3: BMP Selection*—The *user* should review each *BMP* in the prioritized list and select *BMPs* to retain for implementation. This selection should be based on potential *environmental footprint* reductions, relative to other pertinent factors such as implementability, effectiveness, reliability, short-term risks, community concerns, cost, and potential for

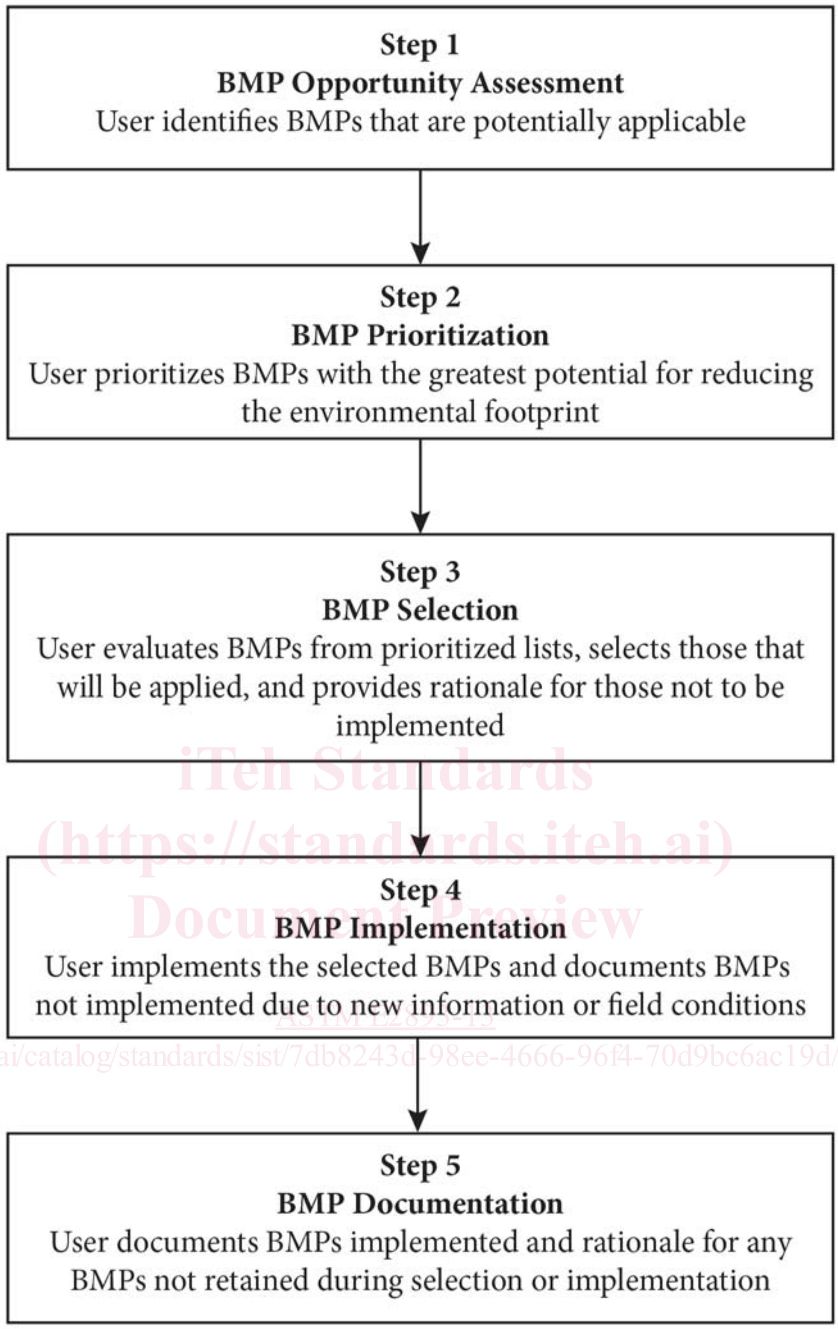

FIG. 2 BMP Process

environmental trade-offs. The *user* should consider the unwanted transfer of *contaminants* from one environmental media to another, or negative affects on one *core element* from implementing a *BMP* with a positive impact on another *core element*. The *user* should document the rationale for eliminating *BMPs* identified in Step 2.

6.6.3.1 The *user* should implement *BMPs* that reduce or have no effect on the project cost, unless there is a specific reason not to do so (see Section 6.6.3 above for examples of factors). Some *users* may elect to implement *BMPs* even if implementation results in an increase in project cost. The cost evaluation may assess the return on investment and other factors such as *environmental footprint* reductions achieved per unit cost and the degree to which the investment is beneficial to the overall project goals.

6.6.4 *Step 4: BMP Implementation*—The *user* should implement the selected *BMPs*.

6.6.4.1 If during implementation of the selected *BMPs*, new information or changed circumstances relevant to the *BMP* or the *site* render a *BMP* selected in Step 3 inapplicable, impracticable to implement, cost-prohibitive, or unacceptable to the public, the *user* may elect not to implement that specific *BMP*.

The *user* should document the rationale for not implementing any selected *BMPs* due to challenges that arise during implementation.

6.6.5 *Step 5: BMP Documentation*—The *user* should record Step 2 through Step 4 in a table. This includes a prioritized list of *BMPs* that apply to the *site* conditions, identifying those that are implemented and those that were not implemented, with the associated rationale.

6.6.5.1 If a *quantitative evaluation* is to be performed to assist in selecting applicable *BMPs* by providing numerical data to support the *BMP* selection or design, the *user* should follow the steps described in Section 7 for implementing the *quantitative evaluation*.

7. Quantitative Evaluation

7.1 *Selection of Applicable Cleanup Phases*—The *user* should consider the information collected in the planning and scoping performed under Section 5 to determine the *cleanup phases* that will be assessed with a *quantitative evaluation*.

7.2 The *user* should understand the following general considerations:

7.2.1 In the context of this *guide*, a *quantitative evaluation* is inclusive of the following: *emissions*, resource use, and wastes related to the *cleanup*, as estimated using either a *footprint analysis* or *LCA*.

7.2.2 This *guide* refers to *quantitative evaluations* using *footprint analysis* and *LCA*. Appendix X4 provides an overview and comparison of how a *quantitative evaluation* is completed with these two approaches. This appendix is intended to be instructive to *users* who are not familiar with *footprint analysis* or *LCA*.

7.2.3 The main purpose of a *quantitative evaluation* is to provide information on the most significant contributions to a *cleanup phase* or activity's *environmental footprint* relative to the *core elements*. In addition, a *quantitative evaluation* can facilitate decisions by estimating potential *environmental footprint* reductions achieved by specific *BMPs*.

7.2.4 The *guide* instructs the *user* to follow seven steps for conducting a *quantitative evaluation*. Other stepwise methodologies, such as ISO 14044 (ISO, 2006), SURF Guidance for Footprint Assessments and LCAs (Favara, et al., 2011(**6**)), USEPA's Life Cycle Assessment: Principles and Practices (USEPA, 2006), and USEPA's Methodology for Understanding and Reducing a Project's Environmental Footprint (USEPA, 2012) may be used, provided they embody the same steps.

7.3 *Quantitative Evaluation Scope and Application*—The *quantitative evaluation* is most appropriate for three *cleanup phases*: *remedy selection*, *remedy design/implementation*, and *remedy optimization*. However, the *user* is not precluded from applying a *quantitative evaluation* process at any time during a *cleanup*. The *user* should consult Fig. 1 and Table 1 for guidance on performing the *BMP process* or *quantitative evaluation* relative to the *cleanup phases*.

7.3.1 *Quantitative Evaluation for Remedy Selection or Remedy Optimization*—In the evaluation of *remedial options*, new or revisited, the *user* considers how various *remedial options* may contribute to the *environmental footprint*. Conducting a *quantitative evaluation* at this *cleanup phase* provides the *user* with information to help identify *environmental footprint* reduction opportunities for all alternatives that are protective of human health and the environment and comply with applicable environmental regulations and guidance and meet project objectives.

7.3.1.1 To compare all *remedial options* on an equal basis, the *user* should endeavor to improve each alternative, to the extent practicable, to reduce the projected *environmental footprint* of the *remedial option* before the *quantitative evaluation* is conducted. These improvements are based on professional judgment, but do not warrant detailed analyses.

7.3.2 *Quantitative Evaluation for Remedy Design/Implementation or Remedy Optimization*—In the evaluation of a single *remedial option*, new or revisited, the *user* assesses several permutations of the *remedial option*. This *quantitative evaluation* may assist with identifying resources (for example, materials, water, energy) with a lower *environmental footprint* to incorporate into the design process.

7.3.2.1 In assessing permutations, the *user* first makes a *quantitative evaluation* of the planned *remedy* or, in the situation of *remedy optimization*, the current *remedy*, to determine a baseline *environmental footprint*. Then the *user* evaluates permutations with respect to the baseline. The permutations may include variations such as, different treatment reagents, different equipment design or configuration, or different sources of energy. The assessment of permutations will assist the *user* in finding the optimal balance in *remedy design* and *environmental footprint* reductions relative to implementability, effectiveness, cost, and other relevant *cleanup* factors.

7.3.2.2 The *user* should conduct the *quantitative evaluation* as early as possible in the design or optimization process to identify opportunities to reduce the *environmental footprint* of the selected *remedy*.

7.4 *Quantitative Evaluation Process*—When conducting a *quantitative evaluation*, the *user* should follow these steps: Step 1: Goal and Scope Definition; Step 2: Boundary Definition; Step 3: *Core Elements* and Contributors to the *Core Elements*; Step 4: Collection and Organization of Information; Step 5: Calculations for *Quantitative Evaluation*; Step 6: Sensitivity and Uncertainty Analyses; and Step 7: Documentation. The main steps of the process are described below and summarized in Fig. 3.

7.4.1 *Step 1: Goal and Scope Definition*—The *user* should identify the need for a *quantitative evaluation* and document the goal and scope of the *quantitative evaluation*. The goal sets forth the environmental questions to be answered with the *quantitative evaluation* and how the *quantitative evaluation* will be used in decision-making. The scope provides the details of how the *quantitative evaluation* will be conducted (for example, tools, resources), reviewed, and documented.

7.4.1.1 The *user* should decide whether to employ *footprint analysis* or *LCA*. Appendix X4 describes attributes of each of these approaches.

7.4.2 *Step 2: Boundary Definition*—The *user* should determine the activity, geographic, and temporal boundaries of the study. In defining the boundaries, the *user* should take into

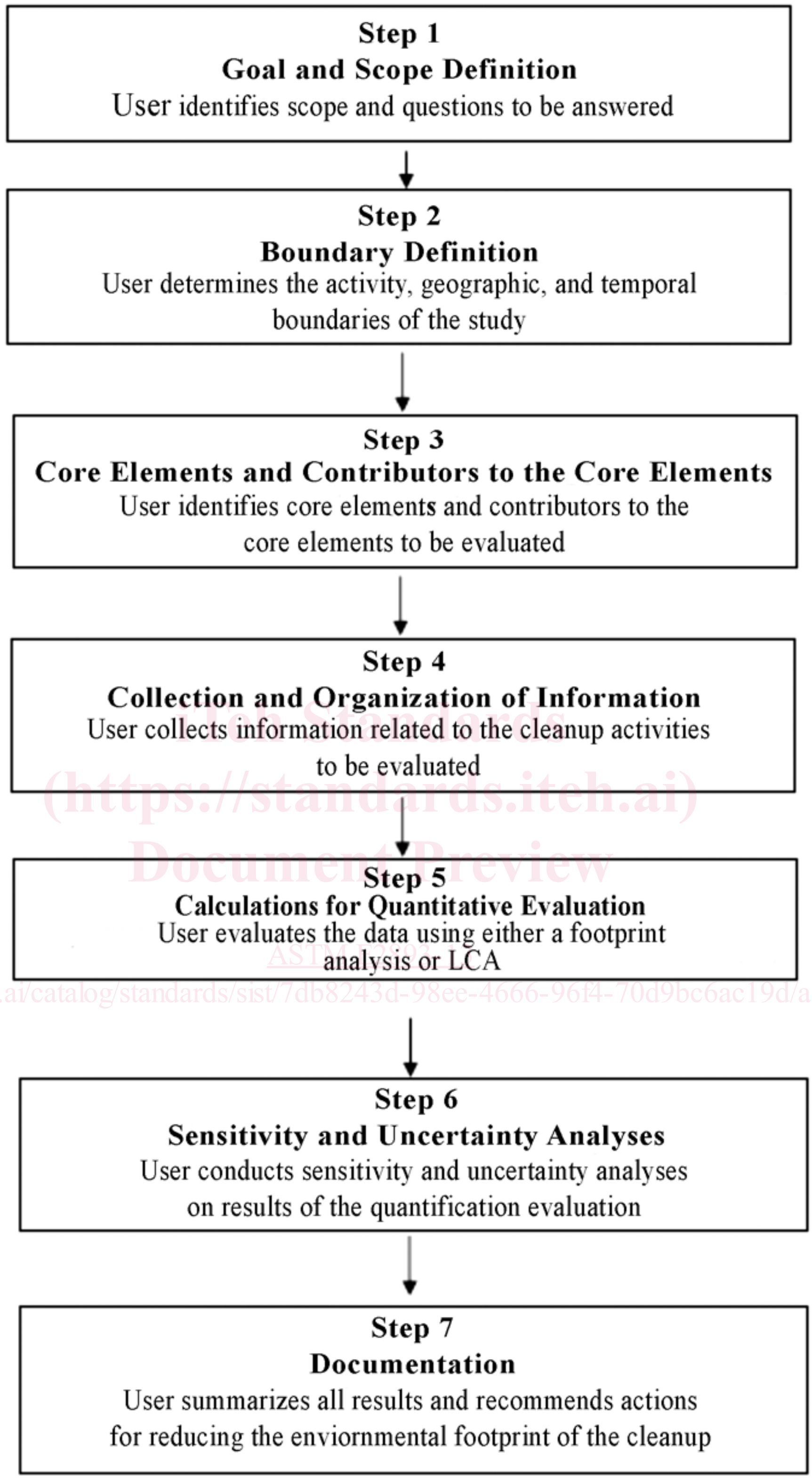

FIG. 3 Quantitative Evaluation