Designation: D6235 – 04

Standard Practice for Expedited Site Characterization of Vadose Zone and Ground Water Contamination at Hazardous Waste Contaminated Sites[1]

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1. Scope

1.1 *Applicability of the ECS Process*—This practice covers a process for expedited site characterization (ESC) of hazardous waste contaminated sites[2] to identify vadose zone, ground water and other relevant contaminant migration pathways and determine the distribution, concentration, and fate of contaminants for the purpose of providing an ESC client, regulatory authority, and stakeholders with the necessary information to choose a course of action.[3] Generally, the process is applicable to larger-scale projects, such as CERCLA (Superfund) remedial investigations and RCRA facility investigations.[4] When used as part of the Superfund response process, this Practice should be used in conjunction with U.S. EPA's guidance document titled *Using Dynamic Field Activities for On-Site Decision Making: A Guide for Project Managers* (**37**). The ESC process is also applicable to other contaminated sites where the ESC process can be reasonably expected to reduce the time and cost of site characterization compared to alternative approaches. The ESC process has been applied successfully at a variety of sites in different states and EPA regions. (See Table X1.1). It typically achieves significant cost and schedule savings compared to traditional site characterization. (See X1.2 and X1.3)[5].

1.2 *Features of the ESC Process*—The ESC process operates within the framework of existing regulatory programs. It focuses on collecting only the information required to meet characterization objectives and on ensuring that characterization ceases as soon as the objectives are met. Central to the ESC process is the use of judgement-based sampling and measurement to characterize vadose zone and ground water contamination in a limited number of field mobilizations by an integrated multidisciplinary team, led by a technical leader and operating within the framework of a dynamic work plan that gives him or her the flexibility of responsibility to select the type and location of measurements needed to optimize data collection activities. Table 1 identifies other essential features of the ESC process, and Fig. 1 presents a flow diagram for the entire ESC process.

1.3 *Investigation Methods*—The process described in this practice is based on good scientific practice but is not tied to any particular regulatory program, site investigation method or technique, chemical analysis method, statistical analysis method, risk analysis method, or computer modeling code. Appropriate investigation techniques in an ESC project are highly site specific and are selected and modified based upon the professional judgement of the core technical team (in particular the technical team leader). Whenever feasible, non-invasive and minimally invasive methods are used, as discussed in Appendix X3. Appropriate chemical analysis methods are equally site specific. Analyses may be conducted in the field or laboratory, depending on data quality requirements, required turnaround time, and costs.

1.4 *Sites Generally Not Appropriate for the ESC Process*—Generally, the ESC process is not applicable to: small petroleum release sites, real estate property transactions that require no more than a Phase I ESA, sites where contamination is limited to the near surface or there is no basis for suspecting that contaminant movement through the vadose zone and ground water is a matter of concern, sites where the cost of remedial action is likely to be less than the cost of site

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[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.01 on Surface and Subsurface Characterization.

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[2] The term hazardous waste in the title is used descriptively. The term also has specific meanings in the context of different regulatory programs. Expedited site characterization is also appropriate for radiologically contaminated sites and some larger petroleum release sites, such as refineries. Section 4.2 further identifies types of contaminated sites where ESC may be appropriate. See Appendix X1 for additional background on the ESC process.

[3] The text of this practice emphasizes vadose zone and ground water contamination because these contaminant migration pathways are the most difficult to characterize. An ESC project should also address all other relevant contaminant migration pathways, such as air, surface water, submerged sediments, and biota.

[4] A CERCLA preliminary assessment/site inspections (PA/SI) or a RCRA facility assessment (RFA) is generally required to provide information supporting a decision to initiate the ESC process. (See Appendix X2).

[5] This practice uses the term "traditional" site characterization to refer to the approach that has typically been used for characterizing contaminated sites at CERLA and RCRA sites during the 1980s and early 1990s.

characterization, or sites where existing statutes or regulations prohibit the use of essential features of the ESC process.[6]

1.5 *Other Potentially Applicable ASTM Standards for Site Characterization*—Guide E1912 addresses accelerated site characterization (ASC) for petroleum release sites, and Guide E1739 addresses use of the risk-based corrective action (RBCA) process at petroleum release sites. Section X1.5.1 describes the ASC process, and X1.5.2 discusses the relationship between ESC and the RBCA process. Practices E1527 and E1528 and Guide E1903 address real estate property transactions, and X1.5.3 discusses the relationship between the ESC process and investigations for real estate property transactions. Classification D5746 addresses environmental conditions of property area types for Department of Defense installations, and Practice D6008 provides guidance on conducting environmental baseline surveys to determine certain elements of the environmental condition of federal real property.

1.6 The values stated in both inch-pound and SI units are to be regarded separately as the standard. The values given in parentheses are for information only.

1.7 *This practice offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.8 *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:*[7]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D5717 Guide for Design of Ground-Water Monitoring Systems in Karst and Fractured-Rock Aquifers[8]

D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Ground Water

D5745 Guide for Developing and Implementing Short-Term Measures or Early Actions for Site Remediation

[6] The ASTM knows of no federal or state statutes or regulations that would prohibit use of the ESC process. Some elements of the ESC process may not be entirely consistent with existing federal and state guidance documents, and regulatory authorities are encouraged make appropriate exceptions.

[7] 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.

[8] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

TABLE 1 Minimum Criteria for a Project Using ASTM Expedited Site Characterization Process

NOTE—Other site characterization approaches may include many of the below elements, but all must be present for an investigation using the ASTM ESC process.

1. A technical team leader oversees the ESC project and leads the ESC core technical team. See Fig. 2, step 1.a in Fig. 3, 6.2 and 7.1.1.

2. Project objectives, data quality requirements, and performance criteria are defined by some process that includes ESC client, regulatory authority, and stakeholders. See Step 1b in Fig. 3 and 6.3.

3. The technical team leader and an integrated multidisciplinary core technical team with expertise in geologic, hydrologic, and chemical systems work together, as areas of expertise are needed, in the field and throughout the process. See Fig. 2, Step 2 in Fig. 3, and 7.1.

4. Intensive compilation, quality evaluation, and independent analysis and interpretation of prior data are used to develop a preliminary site model. See Step 3a in Fig. 3 and 8.1-8.5

5. Dynamic work plan, approved by ESC client and regulatory authority, provides framework for use of multiple complementary, site-appropriate geologic and hydrologic investigation methods, along with rapid site appropriate methods for containment analysis. See Step 4 in Fig. 3, 8.6, 9.2.4, and Appendix X3.

6. ESC project is based primarily on judgement-based sampling and measurements to test and improve the concepts and details of the evolving site model. See Steps 5 and 6 in Fig. 3, 3.1.16, 6.3.1, and X1.4.4.1.

7. Quality control procedures are applied to all aspects of ESC data collection and handling, including field work for geologic and hydrologic characterization. See Steps 5 and 6 in Fig. 3, 9.2.6, 10.1.2, and Appendix X4 and Appendix X5.

8. Field data collection is initially focused on geologic and hydrologic characterization of vadose zone, ground water and other relevant contaminant migration pathways (and on identifying contaminants of concern, if they are not already known), followed by delineating the distribution, concentration, and fate of contaminants, based on knowledge of the relevant contaminant migration pathways. This effort typically requires no more than two field mobilizations. See Steps 5a and 6a in Fig. 3 and Sections 10 and 11.

9. Field data are integrated, analyzed, and interpreted daily to refine the evolving site model and are used to optimize the type and location of subsequent field data collection until project objectives have been met. See Steps 5b and 6b in Fig. 3 and 10.1.3.

10. Final site model provides ESC client, regulatory authority, and stakeholders with the information required to choose a course of action based on risk analysis of regulatory standards-based cleanup criteria. See Section 12.

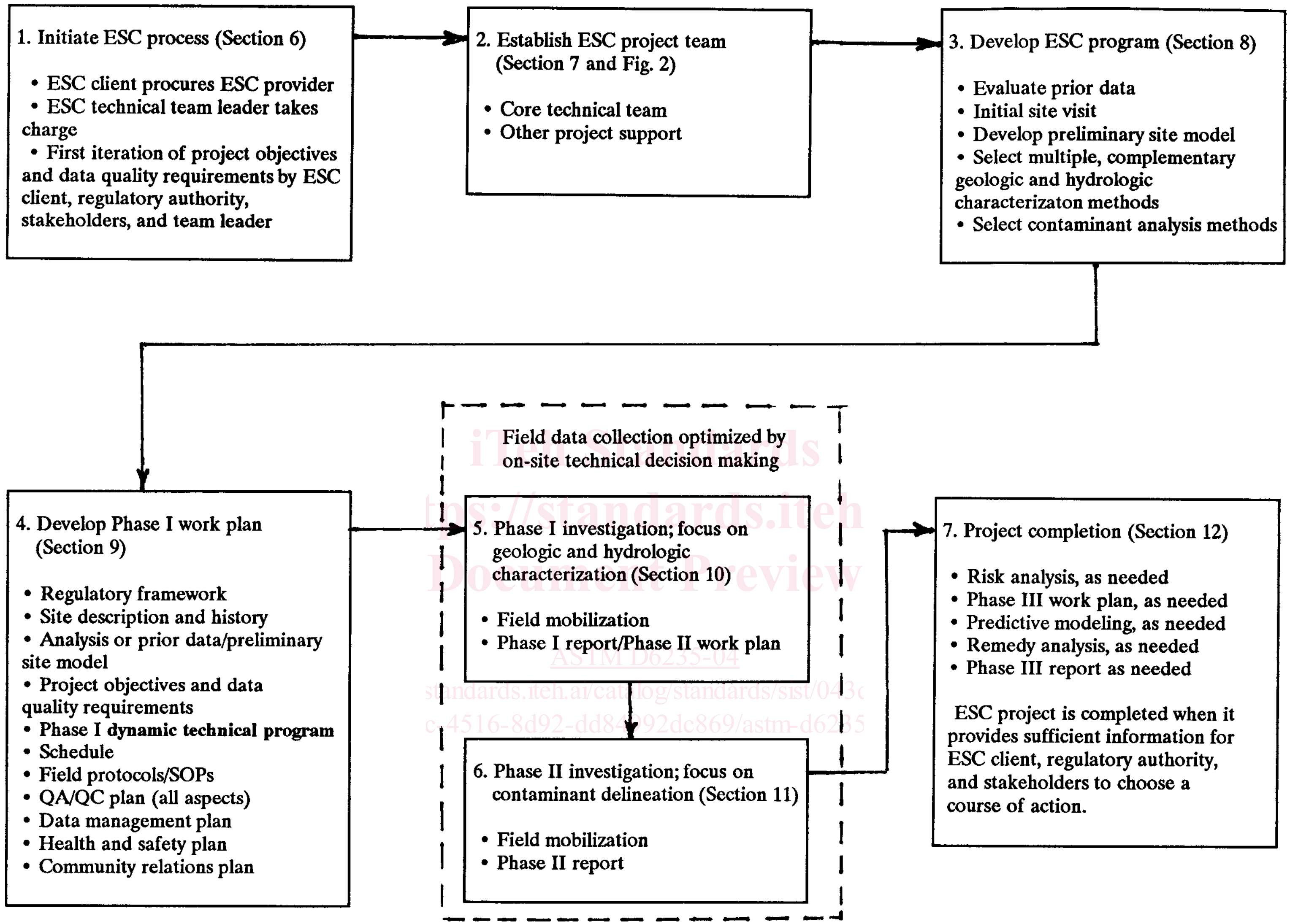


FIG. 1 Overview of the Expedited Site Characterization Process

D5746 Classification of Environmental Condition of Property Area Types for Defense Base Closure and Realignment Facilities
D5792 Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives
D5979 Guide for Conceptualization and Characterization of Ground-Water Systems
D6008 Practice for Conducting Environmental Baseline Surveys
D6044 Guide for Representative Sampling for Management of Waste and Contaminated Media
E1527 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process
E1528 Practice for Limited Environmental Due Diligence: Transaction Screen Process
E1689 Guide for Developing Conceptual Site Models for Contaminated Sites
E1739 Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites
E1903 Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process
E1912 Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:* The following terms are specific to this practice, unless otherwise indicated. Because much of the terminology is specific to this practice, this section should be read carefully. Other terms are in accordance with other ASTM standards as specified.

3.1.1 *contaminants of concern (COCs)*—specific constituents that are identified for evaluation in the site characterization process.

3.1.1.1 *Discussion*—Identification of COCs from a larger list of suspected contaminants, including possible degradation products, usually takes place as a separate effort before an ESC project begins, but it can also be integrated into an ESC project. Deletions or additions to the list of COCs may occur during an ESC project, as appropriate, with approval by the ESC client and regulatory authority. This definition is the same as for chemical(s) of concern used in Guide E1912, except that "contaminants of concern" is the more common usage in hazardous waste site investigations.

3.1.2 *Dynamic field activity*—a project that combines rapid on-site data generation with on-site decision making and is initiated through a process that includes systematic planning and development of a dynamic work plan (Adapted from U.S. EPA **(37)**).

3.1.2.1 *Discussion*—This practice focuses on dynamic field activities as they relate to site characterization

3.1.3 *dynamic work plan*—a site characterization work plan including a technical program that identifies the suite of field investigation methods and measurements that may be necessary to characterize a specific site, with the actual methods used and the locations of measurements and sampling points based on on-site technical decision making.

3.1.3.1 *Discussion*—The dynamic work plan, which must be approved by the ESC client and regulatory authority, provides a clearly defined framework (including geographic area, maximum depth (where appropriate), standard operating procedures for specific methods) within which the ESC technical team leader, supported by the appropriate technical core team members, has flexibility and responsibility to select the types and locations of measurements to optimize data collection activities. In contrast, a traditional site characterization work plan typically contains prescribed numbers and locations for field measurements, samples, and monitoring wells. (See Section 9).

3.1.4 *environmental receptor*—humans or other living organisms potentially exposed to and adversely affected by contaminants because they are present at the source(s) or along contaminant migration pathways. **(E1689)**

3.1.5 *environmental Site Assessment (ESA)*—the process by which a person or entity seeks to determine if a particular parcel of real property (including improvements) is subject to Recognized Environmental Conditions.

3.1.5.1 *Discussion*—This practice refers to ESC Phase I/II investigations to differentiate them from Phase I/II ESAs. The phases are not comparable. (See X1.5.3.) **(E1527)**

3.1.6 *ESC client*—the individual, agency, or organization responsible for a site or sites where ESC is being considered or has been initiated. An ESC client contracts with an ESC provider for an ESC project that characterizes a specific site.

3.1.7 *ESC core technical team*—the integrated multidisciplinary team, assembled by an ESC provider, that is responsible for an ESC project, consisting of a technical team leader and experienced individuals with expertise in geologic, hydrologic, and chemical systems; a working understanding of all elements and functions of contaminated site characterization; familiarity with risk analysis and remedial technologies; and capability to integrate and interpret all relevant data generated by the ESC project.

3.1.7.1 *Discussion*—The core technical team members are available for every stage of an ESC project and are involved in each stage as needed. The technical team leader is normally present in the field at all times. Other core technical team members are present during field data collection related to their area(s) of expertise. See 7.1 for further discussion of the responsibilities of the ESC core technical team.

NOTE 1—The core technical team should not be confused with the core team in the DOE SAFER process, which consists of a broader group of key decision makers for a DOE site. (See X1.4.5.) Normally, the ESC technical team leader would be a member of the SAFER core team.

3.1.8 *ESC Phase I investigation*—phase of ESC project focusing on geologic and hydrologic characterization of vadose zone and ground water migration pathways and all other relevant contaminant migration pathways, such as air, surface water, submerged sediments, and biota as appropriate.

3.1.8.1 *Discussion*—Contaminant sources and contaminants of concern will also be identified in Phase I, if they are not already known, and sampling to establish contaminant distribution will occur to the extent that it contributes to understanding the geologic and hydrologic system and other relevant contaminant migration pathways.

3.1.9 *ESC Phase II investigation*—phase of ESC project focusing on sampling and analysis to determine the spatial distribution, concentration, and fate of contaminants, based on knowledge of the relevant contaminant migration pathways identified in Phase I. Additional geologic and hydrologic characterization is carried out as needed.

NOTE 2—This practice describes the ESC process as involving two phases with two discrete field mobilizations, because experience has shown that the amount of time required to characterize the geology and hydrology and then delineate contaminants in terms of the geologic and hydrologic system is generally too long for a single mobilization. However, when sufficient data of acceptability qualify are available, it may be possible to complete both activities in a single mobilization. In contrast, at difficult, complex sites, more than two field mobilizations might be required. A single mobilization would be designated as Phase I/II. More than one mobilization of the ESC project team (as distinct from field visits by a few project team members for collection of time-series data, such as water levels in wells) would be designated as Phase Ia, Phase Ib, and so forth.

3.1.10 *ESC Phase III study*—the final phase of an ESC project that occurs when the results of the Phase II investigation indicate that predictive modeling for risk analysis, remedy analysis and design for remedial action, or both, are required before the ESC client, regulatory authority, and stakeholders can choose a course of action. (See Section 12).

3.1.10.1 *Discussion*—At sites where remedial action is required, a Phase III study would be the equivalent to a CERCLA feasibility study and a RCRA corrective measures study. It is beyond the scope of this practice to address Phase III in detail.

3.1.11 *ESC project*—application of the ESC process by an ESC provider to a specific site to give the ESC client, regulatory authority, and stakeholders the necessary information to analyze risk or apply regulatory standards-based cleanup criteria to choose a course of action (no action, ongoing monitoring, or remedial action).

3.1.11.1 *Discussion*—This practice focuses on use of the ESC process to characterize contaminant migration pathways (and sources if they are not already known). An ESC project may also be expanded to include fate and transport modeling for risk analysis and for remedial action as additional steps after characterization of the contaminant source and migration pathways is completed. (See Section 12.)

3.1.12 *ESC project team*—the technical team leader, other members of the ESC core technical team, and all other individuals who provide technical and other support during an ESC project.

3.1.13 *ESC provider*—organization that supplies the ESC project team to an ESC client.

3.1.14 *ESC technical team leader*—an individual with training and experience in geologic and hydrologic systems (and familiarity with chemical systems and risk analysis methods) and the additional necessary skills for project management, who oversees an ESC project and leads the ESC core technical team in the field. (See also 7.1.1.)

3.1.14.1 *Discussion*—During field investigation phases, the technical team leader relies heavily on the expertise of the other core technical team members and project support personnel, but the leader retains responsibility for all decisions concerning ESC project activities, subject to quality assurance and health and safety oversight. (See 7.3.3 and 7.3.4.)

3.1.15 *expedited site characterization (ESC)*—A process for characterizing vadose zone and ground-water contaminated sites using primarily judgement-based sampling and measurements by an integrated, multidisciplinary core technical team, led by a technical team leader and operating within the framework of a dynamic work plan that gives the flexibility and responsibility to select the type and location of measurements to optimize data collection activities during a limited number of field mobilizations.

3.1.16 *judgement-based sampling and measurement*—an approach that uses expert judgement based on knowledge of the geologic, hydrologic, and chemical systems, together with analysis and interpretation of all prior measurements and sampling results, to select the type and location of subsequent measurements and samples needed to further refine the site model.

NOTE 3—In the context of the practice this type of sampling is used to determine the spatial distribution of physical and chemical properties at a site that can be used in defining the physical characteristics of the vadose zone and saturated zone. This definition differs from the definition of judgement sampling contained in Guide D6044: "taking of sample(s) based on judgement that it will more or less represent the average condition of the population." The heterogeneity of most geologic and subsurface hydrologic systems means that statistical- and geostatistical-based sampling approaches will require a much larger number of samples to delineate accurately the extent and concentration of contamination. (See X7.5.4.) Because the ESC approach depends primarily on expert judgement for characterization of vadose zone and ground water contamination, the experience and competence of the core technical team are paramount.

3.1.17 *migration pathway*—the course through which a contaminant(s) in the environment may move away from the source(s) to potential environmental receptors.

3.1.17.1 *Discussion*—This definition is essentially the same as the term "exposure pathway" used in Guides E1912 and D5746. The ESC process focuses on vadose zone and ground water migration pathways because they are the most difficult to characterize, but it should address all other relevant contaminant migration pathways. **(E1689)**

3.1.18 *on-site technical decision making*—the use of judgement-based sampling and measurement and statistically based approaches, as appropriate, by the core technical team, led by the technical team leader, within a framework defined by a dynamic work plan, to optimize field data collection during as ESC Phase I or Phase II field mobilization.

3.1.18.1 *Discussion*—On-site technical decision making, used by the ESC core technical team for field data collection (see 10.1.3), should not be confused with decision making by the ESC client, regulatory authority, and stakeholders to define ESC project objectives and data quality requirements and to choose a course of action when the project is completed. The use of on-site technical decision making in the context of a dynamic work plan is the approximate equivalent to the on-site iterative process described in Guide E1912.

3.1.19 *quality assurance (QA)*—measures taken to independently check and verify that the quality control procedures specified in the QA/QC plan for an ESC project are being carried out.

3.1.20 *quality control (QC)*—the process of ensuring the quality of data during their collection, measurement, integration, interpretation, and archiving, through the application of defined procedures.

3.1.21 *regulatory authority*—the federal, state, or local agency, or combination thereof, with primary responsibility for ensuring compliance with the environmental statutes and regulations that prompted initiation of ESC at a site.

3.1.22 *regulatory standards-based cleanup criteria*—contaminant cleanup criteria that do not involve a site-specific risk analysis.

3.1.23 *remedial action*—a course of action chosen by an ESC client, regulatory authority, and stakeholders which includes an engineered solution to address contamination.

3.1.23.1 *Discussion*—As discussed in 4.4.2, the ESC process avoids a presumption that remedial action is required. In this practice, no action and ongoing monitoring are considered to be alternatives to remedial action.

3.1.24 *risk analysis*—the process by which an ESC client, the regulatory authority, and stakeholders evaluate the results of an ESC project to choose a course of action based on the risk posed by contaminant sources and migration pathways to environmental receptors.

3.1.24.1 *Discussion*—This practice uses the terms "risk analysis" and "analyzing risk" to avoid the more specific connotations associated with the terms "risk assessment" and "risk evaluation." An ESC project should be designed to accommodate any method(s) of risk analysis specified by the ESC client, regulatory authority, and stakeholders.

3.1.25 *risk-based action level criteria*—contaminant concentrations above which the potential for risk to environmental receptors requires some form of risk analysis.

3.1.25.1 *Discussion*—Risk-based action level criteria would normally be defined by the ESC client, regulatory authority, and stakeholders early in the ESC process. Typically such criteria are based on non-site specific risk analysis procedures, such as those used to develop drinking water standards and maximum contaminant levels (MCLs) for specific chemicals, but may also be developed based on site-specific considerations.

3.1.26 *risk-based cleanup criteria*—target contaminant concentrations, defined by site-specific risk analysis, to be achieved by remedial action.

3.1.27 *site, n*—a place or location designated for a specific use, function, or study. **(D5730)**

3.1.28 *site characterization*—the process by which geologic, hydrologic, and chemical system information relating to contaminant migration pathways; the distribution, concentration and fate of contaminants; and environmental receptors is gathered, interpreted, and documented.

3.1.29 *site model*—a testable interpretation or working description of a site resulting from iterative characterization of the geologic, hydrologic, and chemical systems to identify relevant contaminant pathways; determine the distribution, concentration, and fate of contaminants; and where appropriate, identify environmental receptors.

3.1.29.1 *Discussion*—This practice uses the term "preliminary" site model to refer to the initial model based on regional geology and other prior data, the term "evolving" site model to refer to the site model as it develops during an ESC project, and the term "final" site model when further refinement is no longer required to satisfy the objectives of the ESC project. The initial site model may include alternative hypotheses to explain significant site features, which are tested, accepted, modified, or rejected as the evolving site model develops. Depending on the objectives of an ESC project, the final site model may or may not be comparable to the definitions of "conceptual site model" in Guides D5745 and E1689, which include sources, migration pathways, and environmental receptors. Where only regulatory standards-based cleanup criteria are to be applied, the final site model includes sources and migration pathways (12.2). Where risk analysis is the objective, environmental receptors are usually incorporated into the final site model after source and migration pathways have been fully characterized (see 12.3).

3.1.30 *source*—the location at which contamination has entered the natural environment.

3.1.30.1 *Discussion*—This definition has a more restricted meaning than the definition of source in Guide E1689 which includes primary sources, such as leaking drums, and secondary sources, such as contaminated soil. The definition in 3.1.30 refers to primary sources of contamination, which are normally delineated before an ESC project begins. **(D5745)**

3.1.31 *stakeholder*—any individual or organization other than the ESC client and regulatory authority that may be affected by the consequences of initiating ESC at a site, generally including owners, organizations, and individuals or communities that may be affected by contamination at the site. (See 5.2.1)

3.1.32 *vadose zone*—the hydrogeological region extending from the soil surface to the top of the principal water table; commonly referred to as the "unsaturated zone" or "zone of aeration." The alternate names are inadequate as they do not take into account locally saturated regions above the principle water table (for example, perched water zones). **(D653)**

3.2 *Acronyms:* Acronyms and Abbreviations:

3.2.1 *ASC*—accelerated site characterization.

3.2.2 *ASTM*—American Society for Testing and Materials.

3.2.3 *BHC*—hexachlorocyclohexane (sometimes called benzene hexachloride).

3.2.4 *BLM*—Bureau of Land Management.

3.2.5 *CCC*—Commodity Credit Corporation.

3.2.6 *CERCLA*—Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 USC 9620 et seq. (also called Superfund).

3.2.7 *CMS*—corrective measures study.

3.2.8 *COCs*—chemicals of concern.

3.2.9 *CPT*—cone penetrometer.

3.2.10 *CPT/LIF*—cone penetrometer/laser-induced fluorescence.

3.2.11 *DNAPLs*—dense nonaqueous phase liquids.

3.2.12 *DQO*—data quality objectives.

3.2.13 *DOD*—U.S. Department of Defense.

3.2.14 *DOE*—U.S. Department of Energy.

3.2.15 *EM*—electromagnetic.

3.2.16 *ECPT*—electronic cone penetrometer.

3.2.17 *EPA*—U.S. Environmental Protection Agency.

3.2.18 *ESA*—environmental site assessment.

3.2.19 *ESC*—expedited site characterization.

3.2.20 *FS*—feasibility study (Superfund).

3.2.21 *GPR*—ground penetrating radar.

3.2.22 *IA*—Iowa.

3.2.23 *ICP/AES*—inductively coupled plasma/atomic emission spectrometer.

3.2.24 *ICP/MS*—inductively coupled plasma/mass spectrometer.

3.2.25 *IMA*—immunoassay.

3.2.26 *KS*—Kansas.

3.2.27 *MO*—Missouri.

3.2.28 *NE*—Nebraska.

3.2.29 *NM*—New Mexico.

3.2.30 *MCL*—maximum contaminant level.

3.2.31 *MDL*—minimum detection limit.

3.2.32 *MSL*—mean sea level.

3.2.33 *NPL*—National Priority List (Superfund).

3.2.34 *OSB*—oil seepage basin.

3.2.35 *PA*—preliminary assessment (Superfund).

3.2.36 *PA/SI*—preliminary assessment/site inspection (Superfund).

3.2.37 *PAHs*—polyaromatic hydrocarbons.

3.2.38 *PCE*—perchlorethylene (tetrachloroethylene).

3.2.39 *QA*—quality assurance.

3.2.40 *QA/QC*—quality assurance/quality control.

3.2.41 *QC*—quality control.

3.2.42 *RBCA*—risk-based corrective action.

3.2.43 *RCRA*—Resource Conservation and Recovery Act, as amended, 42 USC 6901 et seq.

3.2.44 *RI*—remedial investigation/feasibility study (Superfund).

3.2.45 *RI/FS*—remedial investigation/feasibility study (Superfund).

3.2.46 *RFA*—RCRA facility assessment.

3.2.47 *RFI*—RCRA facility investigation.

3.2.48 *RFI/CMS*—RCRA facility investigation/corrective measures study.

3.2.49 *RFP*—request for proposal.

3.2.50 *SACM*—superfund accelerated cleanup model (U.S. EPA).

3.2.51 *SAFER*—streamlined approach for environmental restoration (DOE).

3.2.52 *SC*—South Carolina.

3.2.53 *SI*—site inspection (Superfund)

3.2.54 *SOPs*—standard operating procedures.

3.2.55 *SDHEC*—South Carolina Department of Health and Environmental Control.

3.2.56 *SDWA*—Safe Drinking Water Act.

3.2.57 *SRS*—Savannah River Site.

3.2.58 *SVOCs*—semivolatile organic compounds.

3.2.59 *TCE*—trichloroethylene.

3.2.60 *TDEM*—time domain electromagnetic.

3.2.61 *TX*—Texas.

3.2.62 *UMTRA*—Uranium Mill Tailing Remediation Act.

3.2.63 *USDA*—U.S. Department of Agriculture.

3.2.64 *USDI*—U.S. Department of the Interior.

3.2.65 *VOCs*—volatile organic compounds.

4. Significance and Use

4.1 *The ESC Process*—This practice describes a process for characterizing ground-water contamination at sites, that provides cost-effective, timely, high-quality information derived primarily from judgement-based sampling and measurements by an integrated, multidisciplinary project team during a limited number of field mobilizations. (See Appendix X1 for additional background on the ESC process, its distinction from traditional site characterization, and its relationship to other approaches to site characterization and Appendix X6 and Appendix X7 for illustrative examples of the ESC process.)

4.2 *Determining Appropriateness of ESC*—The ESC process should be initiated when an ESC client, regulatory authority, and stakeholders determine that contaminants at a site present a potential threat to human health or the environment and the ESC process will identify vadose zone, ground water, and other contaminant migration pathways in a timely and cost-effective manner, especially when decisions concerning remedial or other action must be made as rapidly as possible. Situations where the process may be applicable are as follows:

4.2.1 *CERCLA*—CERCLA remedial investigation/feasibility studies (RI/FS). (See Appendix X2.) This practice should be used in conjunction with U.S. EPA **(37)**

4.2.2 *RCRA*—RCRA facility investigation/corrective measures studies (RFI/CMS). (See Appendix X2.)

NOTE 4—The ESC process can be continued to include CERCLA feasibility studies and RCRA corrective measures studies (see Section 12), but this practice focuses on its use for site characterization. Section X1.4.5 describes the relationship of the ESC process to the DOE SAFER and EPA SACM programs for accelerating the cleanup of contaminated sites.

4.2.3 *ESA*—Sites where environmental site assessments (ESAs) conducted by using Practice E1527, Practice E1528, and Guide E1903 identify levels of contamination requiring further, more intensive characterization of the geologic and hydrologic system of contaminant migration pathways. Section X1.5.3 discusses the relationship between ESAs and the ESC process.

4.2.4 *Petroleum Release Sites*—Large petroleum release sites, such as refineries. The user should review both this practice and Guide E1912 to evaluate whether the ESC or ASC process is more appropriate for such sites.

4.2.5 *Subsurface Radioactivity*—Sites or facilities with subsurface contamination by radioactivity not regulated by RCRA or CERCLA.

4.2.6 *Defense Department Base Closure Actions*—where vadose zone and ground water contamination are present.

4.2.7 *Other Subsurface Contamination*—Other sites or facilities where contaminant migration in the vadose zone and ground water is a matter of concern and heterogeneity of the vadose zone and ground water system or potential complex behavior of contaminants requires use of the ESC process.

4.3 *Defining Objectives and Data Quality Requirements*—The ESC process requires project objectives and data quality requirements that will provide the ESC client, regulatory authority, and stakeholders with the necessary information to analyze risk or apply regulatory standards-based cleanup in order to choose a course of action. Once these have been defined, the ESC process relies on the expert judgement of the core technical team, operating within the framework of an approved dynamic work plan, as the primary means for selecting the type and location of measurements and samples throughout the ESC process. An ESC project focuses on collecting only the information required to meet the project objectives and ceases characterization as soon as the objectives are met.

NOTE 5—This practice uses the term "data quality requirements" to refer to the level of data accuracy and precision needed to meet the intended use for the data. The U.S. EPA Data Quality Objectives (DQO) process is one way to accomplish this. The ESC process applies the concept of quality control and data quality requirements to geologic and hydrologic data as well as chemical data, but within a general framework of judgement-based rather than statistical sampling methods. Section X1.4.4 discusses the DQO process in more detail along with the role of judgement-based and statistically based sampling methods in the ESC process. Practice D5792 provides guidance on development of DQOs for generation of environmental data related to waste management.

4.4 *Use of ESC Process for Risk Analysis and Remedial Action*:

4.4.1 *Characterizing Contaminant Migration Pathways*—Normally an ESC project will characterize the contaminant migration pathways (and sources if not already known) before any detailed risk analysis involving exposure to environmental receptors is performed, because environmental receptors are not known until the migration pathways are known. Risk analysis expertise will normally be required as an input into defining project objectives and data quality requirements (see 4.3); such expertise is involved as appropriate during field data collection phases of an ESC project. Identification of contaminant sources and environmental receptors for risk analysis is straightforward at most sites and does not, per se, require the ESC process. The ESC process focuses on characterizing vadose zone and ground water contaminant migration pathways and determining the distribution, concentration, and fate of contaminants along these migration pathways, because these factors are more difficult to identify than sources and environmental receptors.

4.4.2 *Considering Remedial Action and Alternatives*—The ESC process is designed to avoid a presumption that remedial action is required (that is, an engineered solution rather than no further action or ongoing monitoring). In any ESC project, remediation engineering expertise is incorporated into the process at the earliest point at which a need for remedial action is identified. (See 13.3.) Guide D5745 provides guidance for developing and implementing short-term measures or early actions for site remediation.

4.5 *Flexibility Within ESC*—Modification of procedures described in this practice may be appropriate if required to satisfy project objectives or regulatory requirements, or for other reasons. The ESC process is flexible enough to accommodate a variety of different technical approaches to obtaining environmental data. However, for an investigation to qualify as an ESC project, as formalized by ASTM, modifications should not eliminate any of the essential features of the ESC process listed in Table 1. Alternative site characterization approaches that use some, but not all, of the essential elements described in Table 1 may be appropriate for a site, but these approaches would not qualify as an ESC project as defined in this practice. ASTM expects that as the ESC process becomes more widely used, modifications, enhancements, and refinements of the process will become evident and will be incorporated into future versions of this practice. ASTM requests that suggestions for revisions to the guide based on field application of the process be addressed to: Committee D18 Staff Manager at ASTM International.

NOTE 6—Users may prefer to use or develop alternative terminology for different aspects of the ESC process, depending on the regulatory context in which it is applied. However, precise or approximate equivalencies to steps or functions in the ESC process should be clearly identified. See, for example, RCRA and CERCLA equivalencies in Appendix X2.

4.6 *Use of ESC in Conjunction with Other Methods*—This practice can be used in conjunction with Guide D5730 for identification of potentially applicable ASTM standards and major non-ASTM guidance. In karst and fractured rock hydrogeologic settings, this practice can be used in conjunction with Guide D5717.

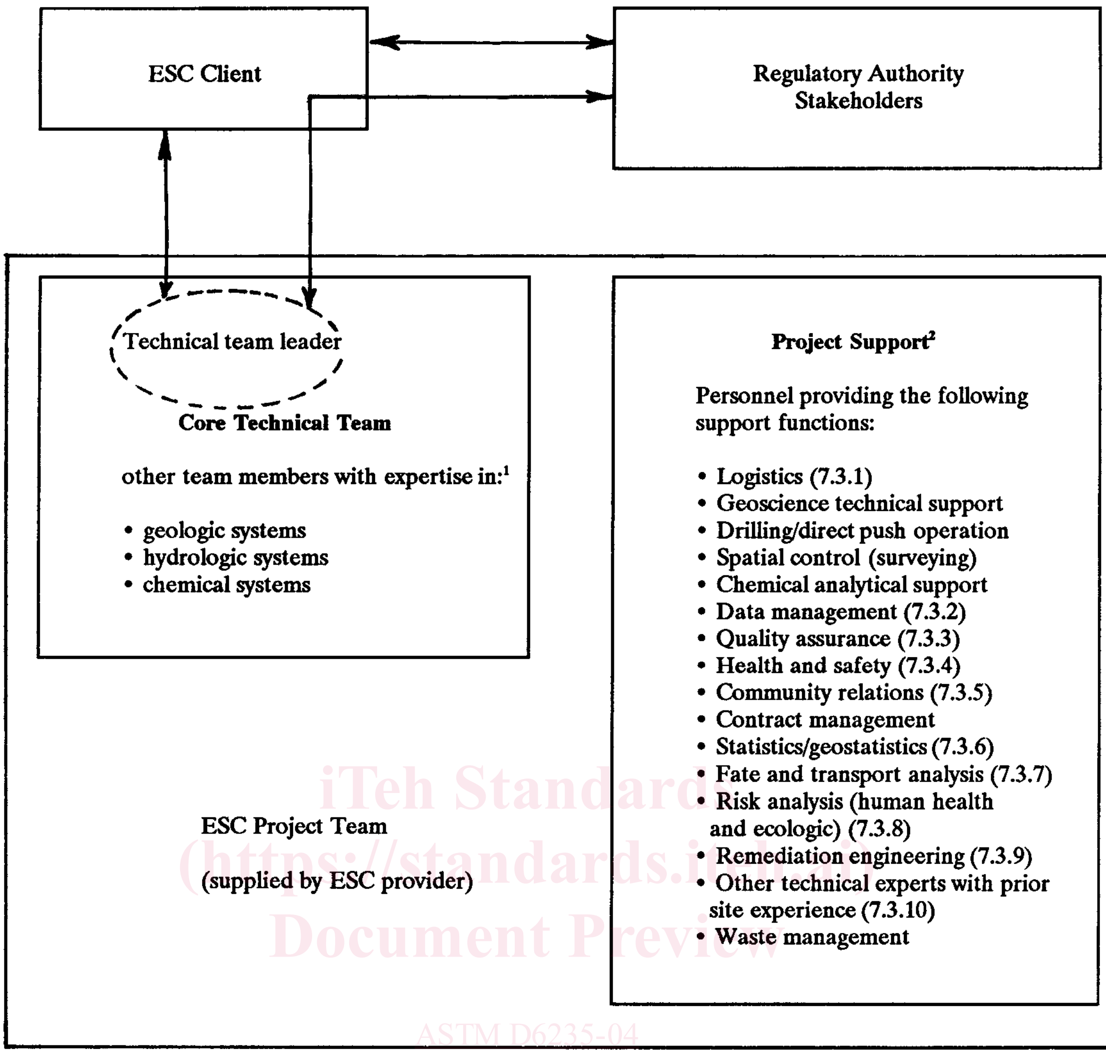
5. Summary of ESC Process

5.1 *Advantages of ESC*—The ESC process, when properly implemented, should provide higher quality information for decision making in a shorter period of time and a lower cost than traditional site characterization where contaminant migration in the vadose zone and ground water are a matter of concern. Appendix X1 discusses the features of ESC that make this possible. Many current problems with remedial action at contaminated sites can be attributed to inadequate understanding of the geologic and hydrologic system of contaminant migration pathways, which results in failure to delineate the full extent of contamination and the controls on contaminant migration and suboptimal design of remedial measures. The multidisciplinary and focused nature of the ESC process results in a final model of a site that minimizes uncertainty concerning the geologic and hydrologic conditions and the spatial distribution and concentration of contaminants, providing a sound basis for choosing the appropriate course of action.

5.2 *Organization of an ESC Project*—The ESC client is primarily responsible for deciding that the ESC process is the best way to obtain the information needed to choose a course of action to address contamination at a site (see 6.1). Fig. 2 illustrates key relationships in an ESC project.

5.2.1 *ESC Client, Regulatory Authority, and Stakeholders*—The ESC client, regulatory authority, and stakeholders provide the overall framework for an ESC project by defining project objectives and data quality requirements. The technical team leader along with other project team members as appropriate, also participate in this process to ensure that the objectives and data quality requirements are reasonable and technically feasible.

NOTE 7—The ESC client is responsible for defining the level of involvement of the regulatory authority and stakeholders in an ESC project and for setting protocols for their interactions with the ESC project team. The credibility of ESC project results will be seriously compromised if the ESC client does not provide for meaningful participation of



[1] Other areas of expertise may be included in the core technical team, as appropriate. The main criterion for determining whether a person with an area of expertise should be included in the core technical team is whether the type of expertise is required both for the process from beginning to end of an ESC project and for on-site technical decision making to optimize field investigations.

[2] Involved as needed throughout the process.

FIG. 2 ESC Project Team Relationships

stakeholders throughout the ESC process. The ESC client is encouraged to facilitate responsible stakeholder involvement in the ESC process. This practice normally refers to the ESC client, regulatory authority, and stakeholders as a group, but the extent of stakeholder involvement, in particular, will be determined by the willingness of the ESC client to allow participation and the extent to which stakeholders insist that they be involved in the process.

5.2.2 *Core Technical Team*—The core technical team, headed by a technical team leader and typically consisting of three or four individuals with expertise in geologic, hydrologic, and chemical systems appropriate to the site, provides a continuous, integrated, multidisciplinary presence throughout the process (see 7.1). The technical team leader operates in close communications with the ESC client, and with the regulatory authority and stakeholders, subject to protocols established by the ESC client. (See Note 7.) The core technical team members are involved, as needed, in all steps of the ESC process; they are present in the field during data collection involving their areas of expertise and participate in the data collection, processing, and interpretation. The optimization of field investigation activities and the quality of the final site model depend on the interaction of the different perspectives of the core technical team members.

5.2.3 *Project Support*—The ESC core technical team operates with the support of a larger project team that includes technical personnel and equipment operators involved in data collection and sampling, as well as personnel providing other support functions such as logistics, data management, QA/QC, health and safety, and community relations (see 7.3). Some areas of project support expertise, such as statistics/geostatistics, fate and transport analysis (including digital modeling), risk analysis, and remediation engineering, may have a special role early in a project in defining the type of data required for the project and data quality requirements and are involved throughout the project as needed.

5.2.4 *Individuals with Multiple Responsibilities*—Qualified individuals within the core technical and support team carry out several functions to decrease costs and increase integration of the team. The number of individuals required to provide project support for an ESC project is site specific. Although the number of project support functions shown in Fig. 2 is large, the total amount of time spent for each function varies considerably. For example, during field operations, project support personnel involved in data management and health and safety are present at all times, whereas personnel providing most other project support functions are present only as needed.

5.2.5 *ESC Work Plans*—Each phase of an ESC investigation take place within the framework of a dynamic work plan that is reviewed and approved by the ESC client, regulatory, authority, and stakeholders. The Phase I work plan provides the overall framework for an ESC investigation (Section 9). The word "dynamic" refers to the section of the work plan that identifies the suite of field investigation methods and measurements that may be necessary to characterize a site, and the field approach where the actual methods used and the location of measurements and sampling points is based on on-site technical decision making. Work plans for subsequent phases are generally incorporated into the report for the previous investigation phase and only include information about the next phase of investigation that is not already included in the Phase I work plan.

5.3 *Overview of ESC Process*—Figs. 3-5 present expanded flow diagrams illustrating important features and decision points in the ESC process. The steps outlined in this figure generally need to be followed in sequence. However, some steps are not strictly sequential. For example, Step 3b is the first iteration of the evolving site model that continues to be refined throughout the process. Major steps are as follows:

5.3.1 Initiate the ESC process and define project objectives and data quality requirements (see Section 6).

5.3.2 Establish ESC project team (see Section 7).

5.3.3 Develop ESC project (see Section 8), including review and interpretation of prior data, initial site visit, development of preliminary site model, and selection of multiple complementary investigation methods.

5.3.4 Develop Phase I dynamic work plan (See Section 9).

5.3.5 ESC Phase I investigation, focusing on geologic and hydrologic characterization (see Section 10).

5.3.6 ESC Phase II investigation, focusing on the distribution, concentration, and fate of contaminants (see Section 11).

5.3.7 Project completion (see Fig. 4 and Fig. 5, and Section 12).

5.4 *Implementation of ESC*—Section 13 discusses considerations in the implementation of ESC as follows:

5.4.1 Relationship to regulatory process (see 13.1 and Appendix X2).

5.4.2 Role of risk analysis in ESC process (see 13.2).

5.4.3 Relationship of remediation engineering design and implementation to ESC (see 13.3).

5.4.4 Role of modeling in ESC process (see 13.4).

5.4.5 Procurement and contracting procedures for ESC (see 13.5).

5.4.6 Performance indicators for evaluating the success of ESC (see 13.6).

5.4.7 Factors that may affect performance indicators (see 13.7).

6. Initiating the ESC Process and Defining Objectives and Data Quality Requirements

6.1 *Decision to Initiate ESC*—The ESC process is initiated when an ESC client, regulatory authority, and stakeholders determine that contaminants at a site present a potential threat to human health or the environment, and the ESC process will identify vadose zone, ground water, and other relevant contaminant migration pathways in a timely and cost-effective manner, especially when decisions concerning remedial or other action must be expedited as rapidly as possible. The decision to initiate the ESC process is based on chemical sample and other data from preliminary site characterization. This practice does not address specific procedures for such preliminary site characterization, but it assumes that the ESC client and regulatory authority have sufficient information to decide that the ESC process should be initiated. Acquiring this information generally requires a RCRA facility assessment (RFA) at RCRA sites or a preliminary assessment/site inspection (PA/SI) at CERCLA sites; see Appendix X2. At petroleum release sites, Guide E1739 may provide the basis for deciding whether the ASC or ESC processes should be initiated at a site (see X1.5.1 and X1.5.2). Some form of initial assessment would also be required at other types of contaminated sites to provide the basis for a decision to initiate the ESC process. Fig. 6 presents a flow diagram that can help determine whether the ESC process of other site characterization approaches may be appropriate for a site.

6.2 *Procuring an ESC Provider*—The ESC client is responsible for procuring an ESC provider. The ESC provider identifies the technical team leader at the outset, who then becomes responsible for the ESC project. Section 13.5 discusses some considerations in procuring an ESC provider. Section 7.4 describes criteria for evaluating qualifications of the ESC core technical team and other project support personnel.

6.3 *Defining Objectives and Data Quality Requirements*—Project objectives, data quality requirements, and criteria to evaluate when objectives have been met should be defined by some process that includes the ESC client, the regulatory authority, stakeholders, and the technical team leader, supported by other core technical team members.

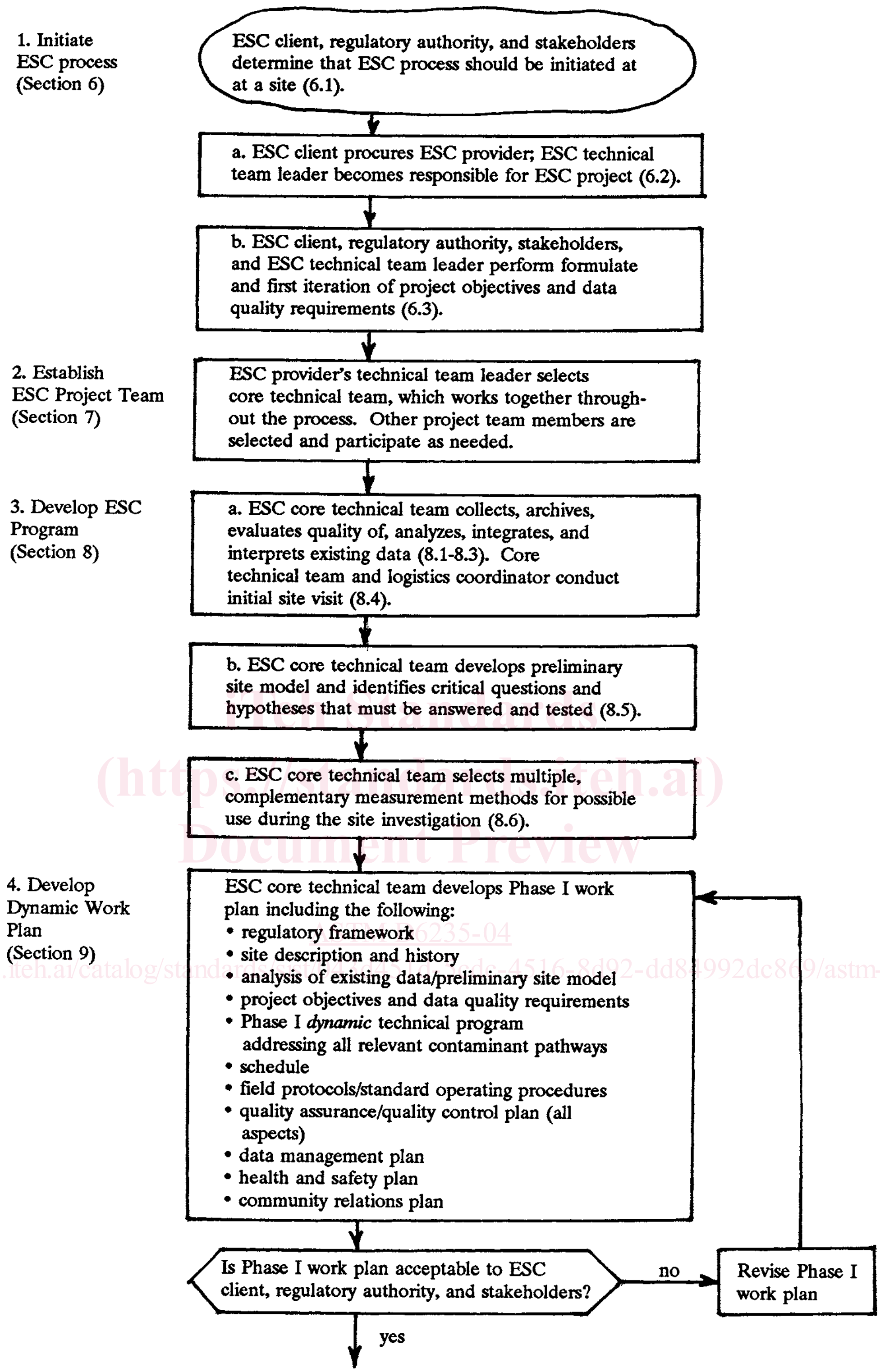


FIG. 3 Expedited Site Characterization Flow

6.3.1 *Data Quality Requirements*—The use of a primarily judgement-based sampling approach in the ESC process for delineation of the distribution and concentration of contaminants means that chemical analysis methods that provide definitive data for contaminants of concern are used from the beginning of an ESC project. This allows maximum acceptance of the analytical results by the ESC client, regulatory authority, and stakeholders and allows the data to be used for risk analysis without resampling. Screening-type chemical analysis methods for indicator geochemical and contaminant parameters, may be used as a complementary method for developing an understanding of the geologic and hydrologic

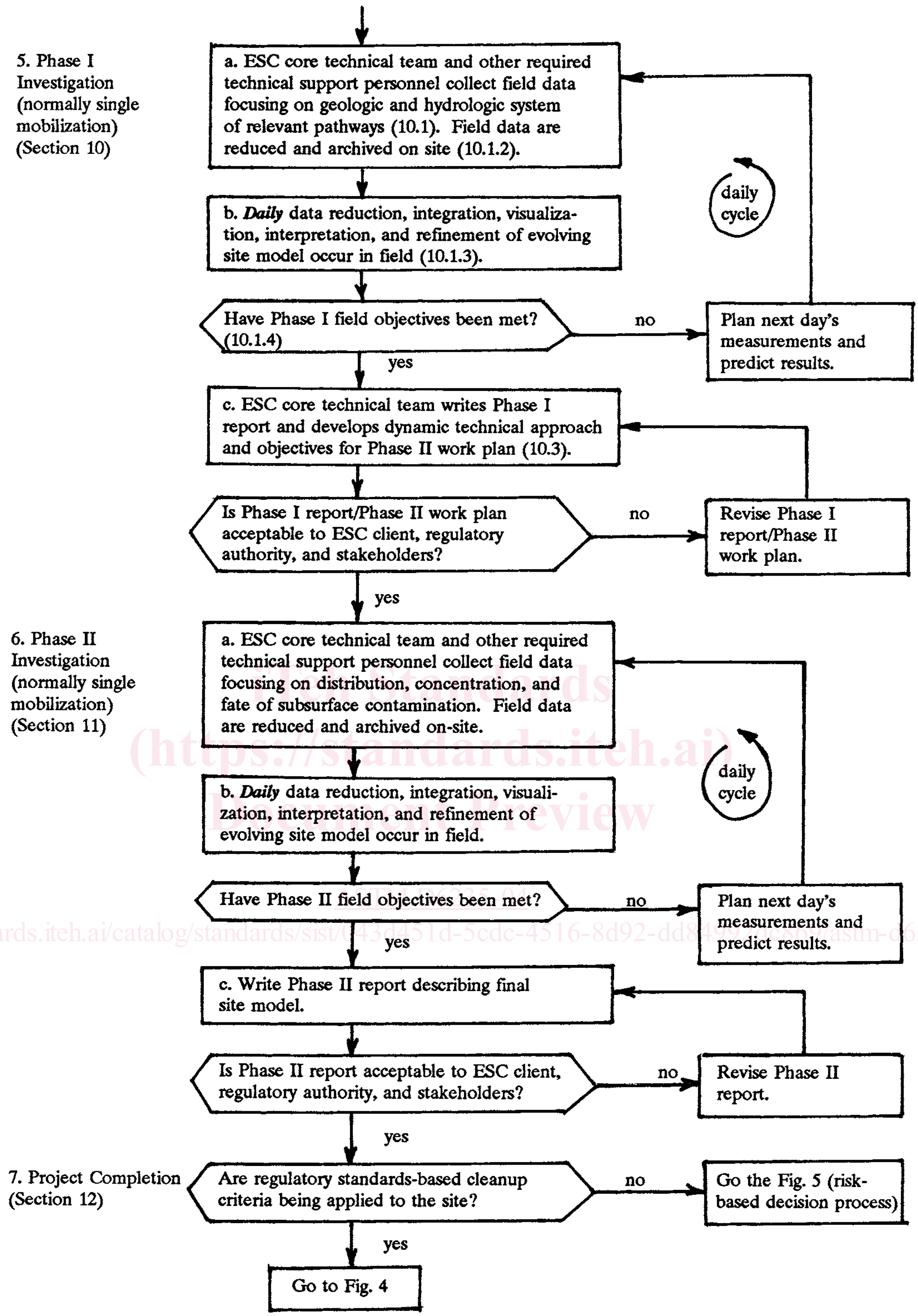


FIG. 3 Expedited Site Characterization Flow *(continued)*

system. Also, once the extent of contamination is known, additional sampling using less expensive analytical methods may be used to map contaminant concentrations in more detail.

NOTE 8—Chemical data quality classifications schemes vary somewhat between regulatory programs. The previous paragraph uses the term "definitive data" in the sense defined in U.S. EPA's *Data Quality Objectives Process for Superfund, Interim Final Guidance* (EPA/540/G-93/071). This would generally require methods meeting Data Quality Level 3 that is described in Appendix X2 in Guide E1912, which in turn is adapted from the data quality hierarchy used by the New Jersey Department of Environmental Protection.

6.3.2 *Modifications*—Definition of project objectives and data quality requirements is an iterative process that may require some modification as an ESC project proceeds. Where

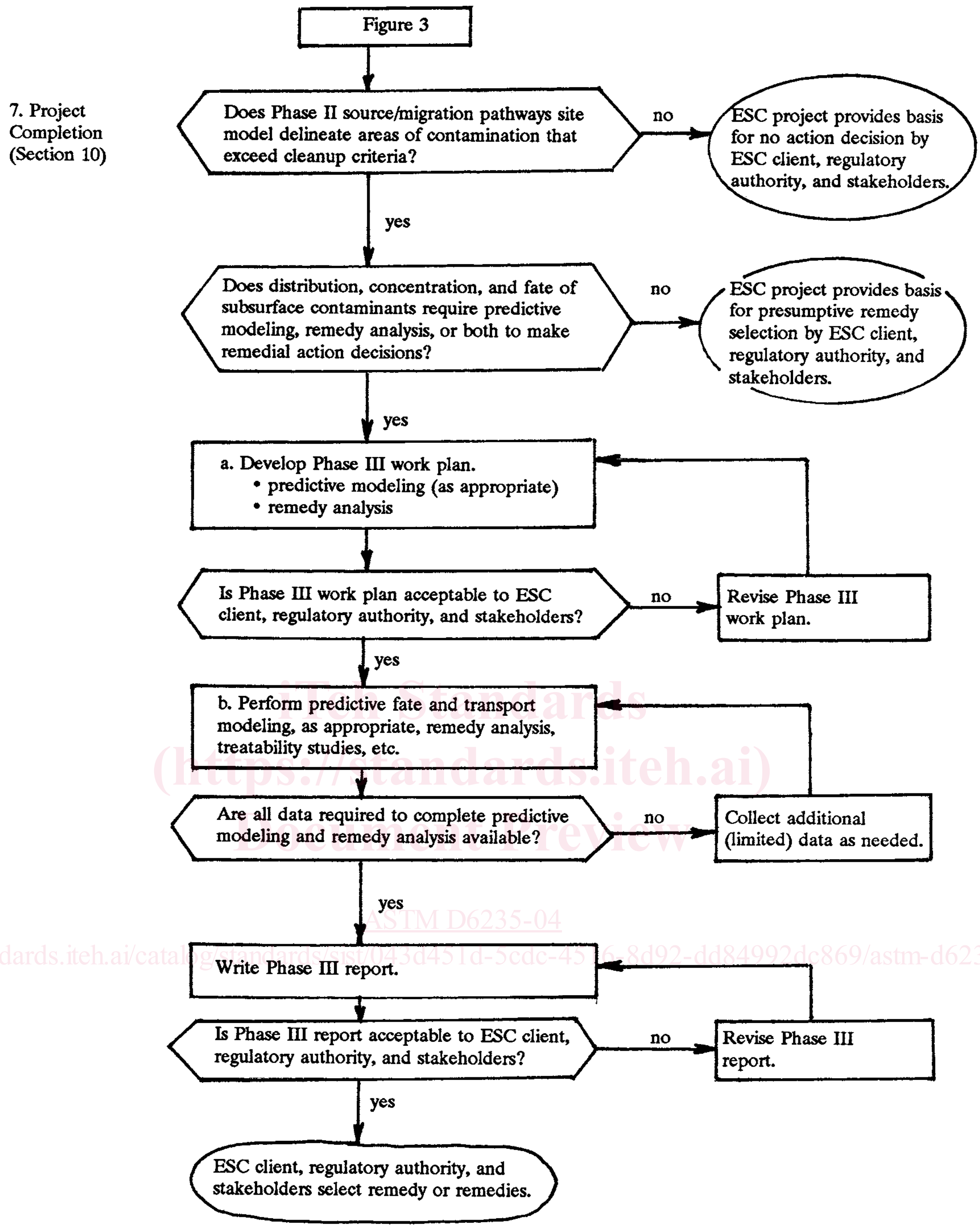


FIG. 4 ESC Project Completion Flow Diagram (Regulatory Standards-Based Cleanup Criteria)

an ESC project is to be used for risk-based decision making, the risk analysis method to be used will affect data quality requirements. If contaminant sources and contaminants of concern are not known, their definition can occur by additional sampling and analysis as a separate activity before an ESC project begins, or this activity can be incorporated as an objective of the ESC project.

7. Establishing the ESC Project Team

7.1 *ESC Core Technical Team*—The ESC process will not work without an effective, integrated technical team consisting of experienced individuals with expertise in geologic, hydrologic, and chemical systems. The ESC provider is responsible for establishing the ESC core technical team, which will typically consist of two or three members in addition to the technical team leader. The core technical team members are hands-on professionals who supervise all field operations in their area of expertise and are personally involved with much of the data acquisition. The technical team leader, with the support of other core technical team members, is responsible for all data and for ensuring proper data management, interpretation, and integration of data into a site model and reports.

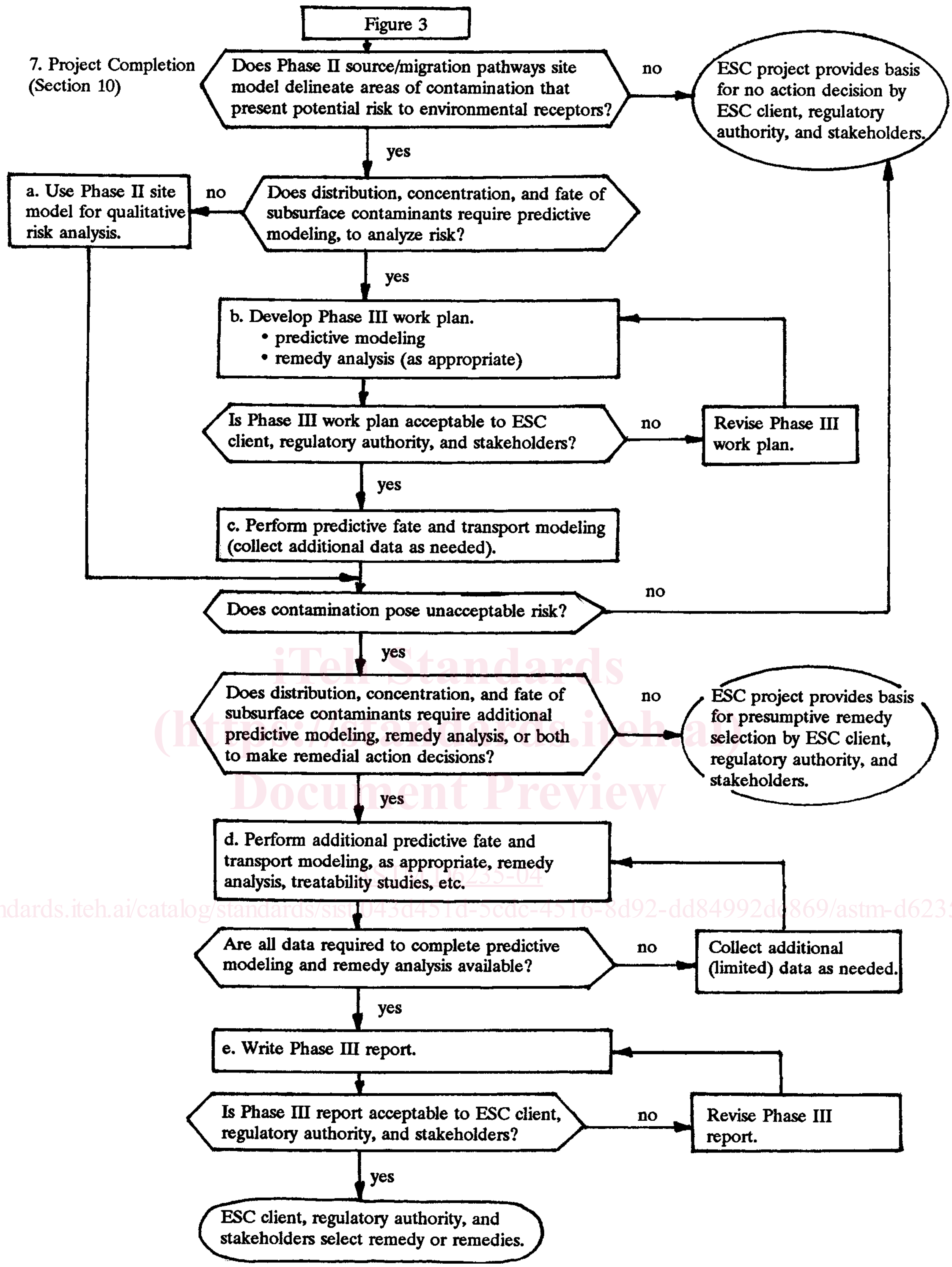


FIG. 5 ESC Project Completion Flow Diagram (Risk-Based Decision Process)

The technical team leader and other core technical team members are supported by appropriate personnel and on-site and off-site contracted personnel as needed (see 7.2 and 7.3). The members of the ESC core technical team must be qualified to perform the following functions:

NOTE 9—EPA guidance (**37**) recommends a project organization that includes a planning team and a field team. In this practice and in the EPA guidance, the team leaders are functionally and practically equivalent. Both this practice and the EPA guidance strongly emphasize the importance of the active involvement of highly experienced personnel in the