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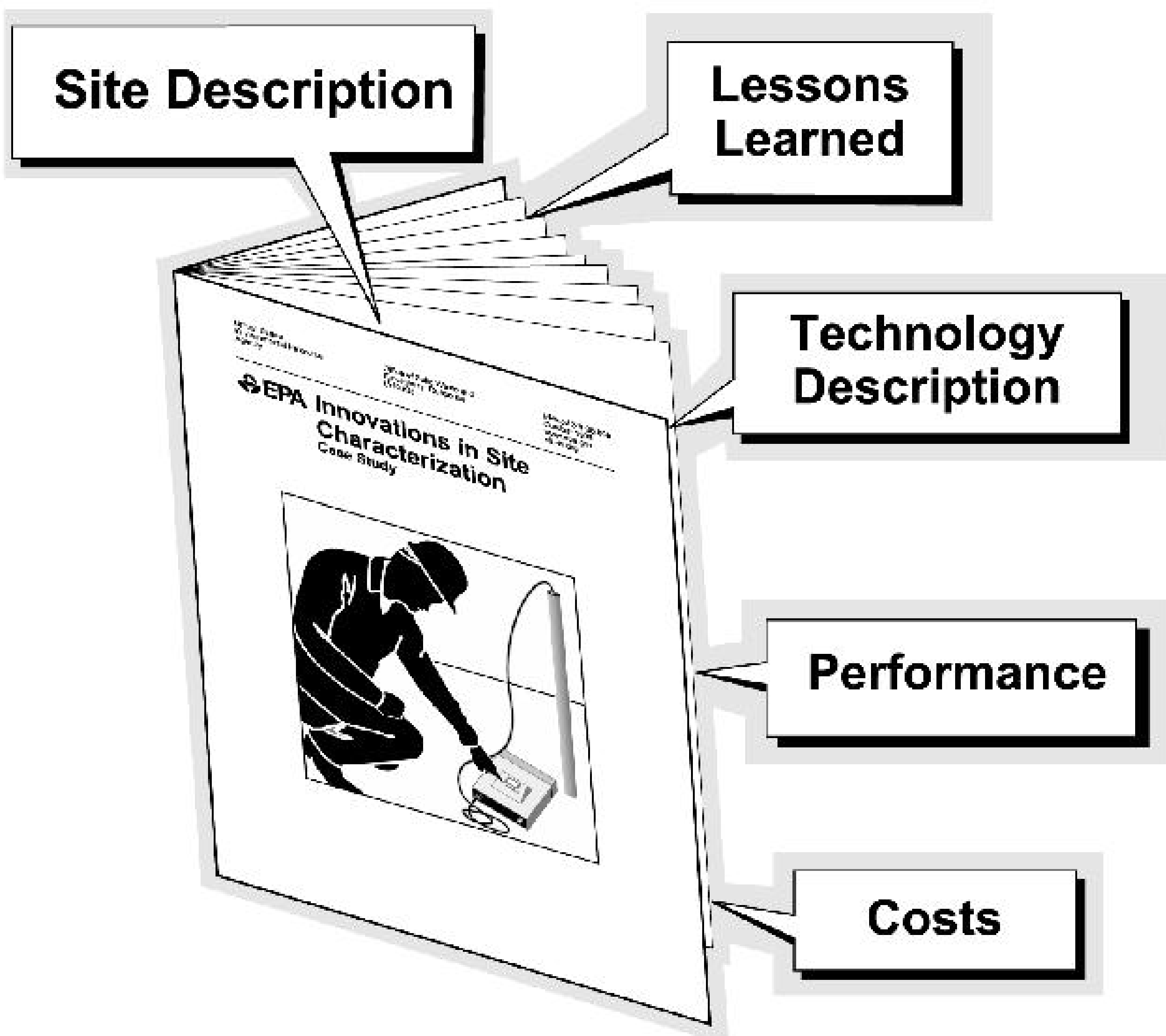
EPA Innovations in Site Characterization

Interim Guide to Preparing Case Studies



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Innovations in Site Characterization: Interim Guide to Preparing Case Studies

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, D.C. 20460

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Comments or questions about this report may be directed to the United States Environmental Protection Agency, Technology Innovation Office (5102G), 401 M Street, SW, Washington, D.C. 20460; telephone (703) 603-9910.

FOREWORD

Cost-effective cleanup (remediation) of hazardous waste sites cannot occur unless the type, quantities, and locations of chemical contaminants present at the site are adequately determined by a process called characterization. Sampling and chemical analysis of environmental media (water, soil, sediment, etc.) is vital to designing a remediation regimen that will accomplish the desired goal of reducing risk to human health and the environment. Unfortunately, site characterization has historically been very costly and time consuming because the technological options have been few and sometimes inefficient.

Recent technological advances promise better site characterization at less cost and in a shorter time frame, yet adoption of new technologies into mainstream engineering practice is very slow. Three widely acknowledged barriers to the adoption and use of innovative site characterization technologies at hazardous waste sites are:

- potential users lack personal awareness and/or experience with the technology,
- potential users lack the established performance criteria needed to assess the applicability of the technology for a prospective project, and
- potential users lack the cost and performance information needed to efficiently plan the project and allocate resources.

The collection and dissemination of cost and performance information is essential to overcoming these barriers. While technology developers and vendors can be valuable sources of this information, their claims often carry less weight than evaluations from colleagues who have used the technology themselves. Case studies are a means by which technology users and impartial observers may disseminate information about successful applications of innovative technologies and add to the pool of knowledge that helps move a technology past the "innovative" stage, thus significantly shortening the time required for widespread benefits to be realized. Case studies can also be a rich source of feedback to researchers and developers seeking to improve or refine technology performance under various site conditions.

Individual case studies may focus on a particular technology or on a characterization approach or process. Case studies focused on process can provide education about how efficient characterization strategies can be implemented on a site-specific basis, and thus can be valuable adjuncts in training courses. For many reasons, case studies are valuable tools for the environmental remediation community.

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1. INTRODUCTION

There is growing dissatisfaction with the long study periods and the high costs of traditional site investigations. Traditional approaches to collecting contaminant data are being challenged by innovative methods for collecting comparable data which are based both on process (strategy) changes, and on new technologies for collecting and analyzing samples. When used judiciously, innovative approaches can provide high quality data in a cost-effective and timely manner. However, they often evolve out of experimentation and pilot projects, so information on the costs incurred can be unrepresentative, and a technology's performance across a wide range of site conditions may be unknown or highly variable. Since project managers, on-scene coordinators, and quality assurance managers need that kind of information to properly direct their projects, the adoption of even highly promising technologies and strategies is hampered. The dissemination of case studies that report cost and performance information relative to specific project needs and conditions can help address this problem.

To reach their audience, case studies need to be brief; yet they must contain sufficient contextual detail (site history and project objectives) for the reader to understand why the innovative approach was appropriate and what benefits were derived from its use. Actual performance data is the most important aspect of a case study, as potential users may use this information to assess whether a technology might be applicable to their projects. Project costs related to implementation must be sufficiently itemized to permit comparison with more traditional scenarios in order to assess the cost-benefit of the innovative technology, and to permit users to plan future project budgets. Documenting actual costs, however, in a manner that serves these purposes is frequently difficult.

The Technology Innovation Office of the U.S. Environmental Protection Agency believes that site characterization case studies can assist project managers to

- have a wider menu of technology options at their disposal,
- select from that menu the most cost-effective characterization technologies that will meet the decision-making needs of a project, and
- use those tools to design a site characterization strategy that can produce quality data capable of supporting defensible site decisions.

2. PURPOSE

The purpose of this Interim Guide to Preparing Case Studies is two-fold. First, it provides guidelines that facilitate collecting and documenting the cost and performance information that will be needed to prepare the case study. This is especially useful if it is known during project planning that a case study is being considered. Documenting facts (especially costs) important to the case study as the project unfolds will considerably reduce the time and effort later required if that information must be extracted after the project is completed. It will also reduce the risk of errors associated with retrieving details from memory or from incomplete records.

Second, the Interim Guide offers a suggested format for case study reports in order to encourage consistency. The use of a standard presentation format not only facilitates reader comprehension and use, but also saves effort and money related to case study preparation since there is no need to constantly "reinvent the wheel" with each report. As a time-saving feature, an electronic copy of this file may be used as a template into which a case study preparer may build the specifics of a particular project. However, not all aspects of this Guide will be relevant to all case studies. Additionally, this document is designated as an *Interim* Guide because revisions are expected as more experience is gained with a range of case studies topics. The suggestions presented here are of a general nature and attempts for consistency should not be construed as rigidity. Modifications to any part of this template may be made as required to maintain relevance to the topic at hand, especially when methodologies outside the realm of analytical chemistry are surveyed.

Individual case studies may focus on a particular technology, such as a field analytical or geophysical technology, a software package that interprets data or facilitates decision-making, or a sample collection device. Case studies focused on "process" (rather than technology) could encompass characterization strategies, such as the use of a systematic planning approach or compression of the traditional phased approach into a single mobilization through the use of field analytical technologies and dynamic work planning. Process-oriented case studies might also describe successful cost-effective sampling designs used for determining background concentrations or for composite sampling.

A case study may focus on only one aspect of a larger project, with details about the rest of the project limited to providing a context for the selection and use of the technology, or might tackle the description of an entire project. Whatever the designated focus, the preparer should have a clear vision what information the case study seeks to convey.

3. THE AUDIENCE FOR THIS DOCUMENT

The primary audience for this guide are those charged with actually preparing case studies based on project reports (e.g., project sampling and analysis plans, work plans, and project reports). Secondary users of this guide are those charged *during the course of a project's execution,* with gathering the information that will be used to prepare a case study after project completion.

Who may be interested in preparing case studies? Within the government, EPA's Technology Innovation Office and other EPA Headquarters offices have a strong interest in case studies as information dissemination and teaching tools, as does the Federal Remediation Technologies Roundtable, which includes representatives from the Department of Energy, the Department of Defense, the Department of the Interior, and EPA. Personnel from EPA Regional offices and state environmental agencies may find that the preparation of case studies, which document well-planned and executed projects and the astute use of innovative technologies, may serve to comunicate these successes to colleagues and fiscal decision-makers.

Within the private sector, consulting engineering firms may find that case studies documenting successful projects may advertise their expertise to potential clients shopping for cutting-edge firms. Site owners may find that the openness of a case study builds good will with the public and with regulators. Vendors of technologies which have been showcased in a successful project would have another marketing tool which not only demonstrates that the technology *works*, but also explains how to achieve maximum performance under real-world conditions.

4. RECOMMENDED PROCEDURES AND FORMAT

This Guide is organized in the following manner. First, templates have been provided of two types of abstracts, a Case Study Abstract and a Technology Quick Reference Sheet (TQRS), both of which capture essential information in a single-page, tabular format. The Case Study Abstract summarizes the characterization project itself. The TQRS condenses information about the performance and commercial availability for each technology featured in the case study (one TQRS per technology). Case study preparers are free to modify these tabular templates as needed.

The body of the report follows the abstracts templates. The generic report template includes suggested headings to aid report organization. Within each heading is a brief statement of the purpose of that section and some general suggestions regarding the information that might be discussed. Some of the section headings that relate to historical background and site-specific information will undoubtably be relevant for any project. Other headings in this Guide are applicable for a case study focused on an analytical technology, and thus may not be relevant for other case study topics, such as a report on a composite sampling design. The case study preparer will have to adapt those portions of the Guide as necessary.

Experience leads to the following recommendations:

C Inclusion of information in any case study report should be limited to that which directly supports the clearly articulated focus of the case study. It must be short and easily understood. The tendency to clutter (and enlarge) the case study with tangential facts should be avoided.

C A case study should serve to advertise the existence and capabilities of a technology or strategy and arouse interest. The case study itself cannot serve as an exhaustive source of technical detail, but should offer enough evidence to convince a discerning reader that additional information is worth pursuing through the technology vendors, project contacts, or literature references.

C Certain sections, such as the "Observations and Lessons Learned" section should be readily accessible to non-technical readers.

To assist a case study preparer to use this template with minimum effort, electronic versions of this Guide may be downloaded in various word-processing formats from the Site Characterization/Application Support area of EPA's Technology Innovation Office website, http://clu-in.org/char1.htm#application. This same website area will post actual case studies as they become available, and these may serve as examples for case study preparers. The first site characterization case study prepared by EPA's Technology Innovation Office, entitled *Innovations in Site Characterization/Case Study: Hanscom Air Force Base*, is posted at the above web address and may serve as a model for case studies that focus on analytical chemistry technologies.

Case Study Abstract

Site Name
County, State

<table>
<tr><td>Site Name and Location:</td><td rowspan="2">Sampling & Analytical Technologies:</td><td>CERCLIS #</td></tr>
<tr><td>Period of Operation:

Operable Unit:</td><td>Current Site Activities:</td></tr>
<tr><td>Point of Contact:</td><td>Media and Contaminants:</td><td>Technology Demonstrator:</td></tr>
<tr><td colspan="3">Number of Samples Analyzed during Investigation:</td></tr>
<tr><td colspan="3">Cost Savings:</td></tr>
<tr><td colspan="3">Results:</td></tr>
<tr><td colspan="3">Description:</td></tr>
</table>

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TECHNOLOGY QUICK REFERENCE SHEET
Case Study Name

<table>
<tr><th colspan="6">Technology Name</th></tr>
<tr><td colspan="6">Summary of Case Study’s Performance Information</td></tr>
<tr><td>Project Role:</td><td colspan="5">Analytical Information Provided:</td></tr>
<tr><td colspan="3">Total Cost:</td><td colspan="3">Cost Per Sample:</td></tr>
<tr><td colspan="6">Project Cost Breakdown</td></tr>
<tr><td>Instrument Cost:</td><td colspan="2">Consumables Cost:</td><td colspan="2">Labor Cost:</td><td>Waste Disposal Cost:</td></tr>
<tr><td colspan="5">Site-Specific Accuracy/Precision Achieved:</td><td>Throughput Achieved:</td></tr>
<tr><td colspan="6">General Commercial Information (Information valid as of [insert date])</td></tr>
<tr><td>Vendor Contact:</td><td colspan="3">Vendor Information:</td><td colspan="2">Limitations on Performance:</td></tr>
<tr><td>Availability/Rates:</td><td>Principle of Analytical Operation:</td><td colspan="3">Power Requirements:</td><td>Instrument Weight and/or Footprint:</td></tr>
<tr><td colspan="6">General Performance Information</td></tr>
<tr><td colspan="6">Known or Potential Interferences:</td></tr>
<tr><td>Applicable Media/Matrices:</td><td colspan="2" rowspan="2">Analytes Measurable with Expected Detection Limits:</td><td colspan="3">Other General Accuracy/Precision Information:</td></tr>
<tr><td>Wastes Generated Requiring Special Disposal:</td><td colspan="3">Rate of Throughput:</td></tr>
</table>

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EXECUTIVE SUMMARY

The purpose of the executive summary is to concisely summarize the whole case study, providing the essential details of the site conditions, the actions taken, and the results obtained from those actions. The focus of the case study should be clearly defined, such as whether the case study is reporting on a particular site characterization technology as opposed to a characterization process, and whether the report will primarily summarize only a relevant portion of a project as opposed to an entire investigation.

The 'take home' message of the case study should be presented, along with a summary of the principal lessons learned. It is often best to write this section last.

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SITE INFORMATION

Identifying Information

The purpose of this section is to provide basic identifying information about the site. The standard items to report here include (as appropriate):

- Site Name
- City, State, Zipcode
- Operable Unit
- CERCLIS #
- Enforcement Decision Document Date

Background [may put citation number here]

A clear description of the site background acts as the foundation on which the site conceptual model was constructed to develop the characterization strategy. Without such a description, it can be difficult to understand the logical reasoning behind the characterization strategy. The description of the site background should provide a clear historical and physical description of the area that is the subject of investigation. The historical perspective should concisely present the history of the site as it relates to the release of contaminants. It may also include a short description of the enforcement and investigative history.

This information will likely be derived from other documents or reports, which should appear in the Reference section at the end of the case study, with a corresponding citation number in the body of the text or at the section heading, as illustrated above.

Some items to report might include:

Physical Description:

- Site location
- Nearest population center
- Site size
- Study area size
- Site topography
- Physical features: wetlands, rivers, etc.

Site Use:

- Historical use
- Changes in ownership

Release/Investigation History:

- Release history
- Initial discovery/ investigation
- Removal actions: type and volume
- Present investigation
- Site map

SITE INFORMATION continued

Regulatory Context:

- NPL listing
- ROD date
- Enforcement dates, including Consent on Decree/Administrative Order

Site Logistics/Contacts

This section contains the basic contact information for the project, such as.

Lead Agency or Party:
Oversight Agency:

Project Manager:

Technology Demonstrator:

Quality Assurance Contact:

Technical Site Contact:

MEDIA AND CONTAMINANTS

The purpose of this section is to describe the types of contaminants present at the site, and the characteristics of the matrices in which they are found. Include information on the listed topics as needed to aid case study coherence:

Matrix Identification

Type of Matrix Sampled and Analyzed: (e.g., Subsurface soil/Bedrock/ Groundwater)

Site Geology/Stratigraphy [may put citation number here if all information derived from a single reference]

The description of site geology might include:

- Lithography
- Depth to groundwater
- Depth to bedrock
- Confining layers
- Map of study area

If appropriate, describe:

- Aquifer name and classification, e.g., sole source drinking water, etc.
- Hydrogeology
- Direction of groundwater flow

MEDIA AND CONTAMINANTS continued

- Transmissivity/conductivity
- Potentiometric gradients

Contaminant Characterization

Primary Contaminant Groups: List contaminants of concern

Matrix Characteristics Affecting Characterization Cost or Performance

The specific matrix characteristics that might be included will vary from one investigation to the next. Report those that influenced the design of the study and/or affected the performance or deployment of the technologies employed during the investigation. Common characteristics might include:

- Complex lithology
- Soil moisture
- Topographical relief across site
- Cultural interferences (e.g., structures that restrict implemention of a geophysical technique)
- Depth to bedrock
- Depth to water table
- Presence of matrix interferences to analytical methods

SITE CHARACTERIZATION PROCESS

The purpose of this section is to describe clearly the process that led to the collection of information relevant to site characterization. The scale of the project should be clearly defined, such as whether is was a field test, a pilot project, or a full-scale application.

Goal of Site Characterization

When possible, the goal(s) of the investigation should be stated in terms of the type of site investigation performed and the site-specific decisions that were supported by data. Types of investigations that might be performed include:

- Preliminary assessment
- Brownfields assessment
- Risk assessment or other health and safety concerns
- Remedial design
- Remedial monitoring
- Site closure

Sampling Workplan [information source may be referenced here]

The description of the sampling plan can be used to establish the context for the investigation results. The discussion should focus on the scope of the investigation and the justification for the sampling approach. For example, prior knowledge of releases may have been used to locate

SITE CHARACTERIZATION PROCESS continued

hotspots by a judgmental sampling plan, or the use of statistical measures to derive representative statements about site contamination or risk. Action levels used to make site decisions should be presented and the justification for their selection noted. As appropriate, information may be displayed in tabular format.

Quality Assurance/Quality Control (QA/QC) Measures [Reference?]

Most site characterization projects will use QA/QC measures of some kind (depending upon the type of technology), with the necessary and appropriate measures having been determined during project planning. These measures (such as project-specific Data Quality Objectives, or analyte-specific Data Quality Indicators in the case of analytical technologies [1]) are used to assess the quality and useability of the data generated during site characterization and should be described in this section in concise terms or in tabular format, when appropriate. The QA/QC measures described in this section will be the standards by which technology performance will be assessed in the Performance Evaluation section of the case study (described below).

CHARACTERIZATION TECHNOLOGIES

The purpose of this section is to provide a technical description of the technologies used in the site characterization project if they are relevant to the purpose of the case study. Topics to cover in this section may include:

Sample Collection Technologies or Procedures

If sample collection was an important parameter for the case study, this section can be included to describe the specific technology used and principle(s) of operation. The name of the vendor, the model number, and the technical operating parameters should be presented (as applicable). It is not the purpose of this section to *evaluate* the performance of the technology, but rather to describe its role in the project (for example, the collection of soil gas samples for chlorinated solvent and BTEX target compounds).

Analytical Technologies

Any discussion of analytical technologies should include the specific technology used, the name of the vendor, the model number, and the technical operating parameters. As above, it is not the purpose of this section to evaluate performance, but merely to describe the technology's use and site-specific role (for example, field analysis for total PCBs in drummed soil to designate individual drums for disposal either by incineration or by landfilling). A *brief* summary of the operating principle may be helpful for novel technologies. Sample preparation technologies (such as an extraction method or a purge and trap device) might be described in this section as well.

PERFORMANCE EVALUATION

PERFORMANCE EVALUATION continued

The purpose of this section is to report the results of the site characterization activities. Although the nature of the information reported will vary depending on the technology or characterization strategy used, the outcomes should be evaluated based on whether the achieved performance was able to meet the the goal(s) of the investigation. Evaluation of a technology's performance should be linked to the corresponding QA/QC measures as described in the Site Characterization Process section of the case study.

Sample Collection

If sample collection efficiency was important to the case study focus, describe the scope of those activities here. To the degree possible, a discussion of deviations from the original sampling plan should be included, since such deviations can be used to assess whether the performance of the site characterization technologies was able to meet the expectations of the project's sampling and analysis plan (SAP). Deviation from an original SAP may also occur as a result of finding unanticipated site conditions or unexpected contamination. It is instructive to discuss the adaptability of the characterization technology or strategy in the face of unanticipated problems.

Sampling Results

This section can be used to describe the quantitative or qualitative results of the investigation. The discussion can focus on the overall findings and summarize the information that was obtained during the investigation and used to inform the decision-making process (e.g., the number of samples collected or analyses performed, the conclusions from a geophysical survey). A contour map showing concentration levels in spatial relation to source areas may help the reader to visualize the results.

Technology Performance

The specific topics to discuss will vary from technology to technology, and this section may be unnecessary if the topic of the case study is a strategy rather than a technology. This section evaluates technology performance in terms of the performance standards and QA/QC measures discussed in the Site Characterization Process section. Were project-specific Data Quality Objectives achieved? If analytical technologies are the focus of the case study, topics that might be discussed include:

- Initial and continuing calibration verification
- Detection limits
- False positive and negative analytical error rates
- Spike and surrogate recoveries
- Precision/duplicate and replicate results
- Accuracy/performance evaluation samples/check standards
- Field vs. traditional (confirmatory) laboratory comparisons

To the degree possible, performance results should be presented in tabular format.

COST COMPARISON

The purpose of this section is to provide as complete a description of the costs associated with the site characterization as possible. Actual costs taken from invoices or other documents serve best, but may not be available in some instances. In such instances, estimates should be provided along with an explanation of their source and underlying assumptions. To the extent possible, project costs should be separated into labor and capital components. Labor costs should be described in terms of the type of labor (e.g., a mid-level geologist) and the duration of involvement. Capital costs may be presented as purchase or rental costs, as appropriate. In instances where labor and capital are mixed together (as in a subcontracted task), this should be explained and some effort should be made to separate the two components. Finally, financial discounting of costs should be avoided because of the short duration of these projects.

If known or if possible, a similar cost breakdown should be presented for comparison to an alternate, more traditional scenario that might have been used to accomplish the same site work. If alternate scenarios were generated during project planning to select the most cost-effective option, they would obviously be useful sources of cost comparison information.

Where possible or available, “life-cycle” costing that considers technology costs and benefits in the context of a entire life of a project is a useful adjunct to the commonly used “cost-per-sample” comparisons. For example, the use of a field method or on-site laboratory may result in a higher cost per sample than sending the sample to an off-site laboratory, but if the rapid turn around time of the field methods permits the collection of fewer, more informative samples, or decreases the number of mobilizations to a site to reach the same decision, the overall cost of the project may be substantially reduced.

Preparing cost comparisons in this way is always very difficult, because a certain amount of prognostication is involved. No two sites will ever be exactly comparable, and there is no way to account for every option or variable that can affect a project’s costs. Any attempt at cost comparison will always be open to the criticism that some factor was either ignored or was given too much emphasis. With the current state of the art, there is little that can about this except for the case study preparer to be as clear and detailed as possible about how any economic analysis was performed so that readers can prepare their own cost es[redacted]

OBSERVATIONS AND LESSONS LEARNED

The purpose of this section is to report any important lessons learned about the particular technologies or processes used during project execution. The lessons learned should focus on the advantages, disadvantages, limitations, time or cost savings discovered during project execution. Lessons learned may be process-, technology-, or site-specific.

COST COMPARISON continued

The advantages of having back-up equipment or contingency plans in place may be emphasized here. Contingency planning acknowledges that unexpected mishaps, such as equipment failure or electrical power irregularities, sometimes happen. Anticipating these eventualities during project planning can save the time and costs of extended down-time.
Other important lessons may demonstrate how confidence in site decisions can be optimized by the use of systematic, advance planning and the judicious selection of site characterization technologies. Documentating the steps that site managers can take to improve the quality and cost-effectiveness of [redacted]

REFERENCES

Ref # Author. *Report Title.* Publisher. City. Report Number. Date of Publication

1. U.S. EPA. *EPA QA/G-5: EPA Guidance on Quality Assurance Project Plans.* Office
of Research and Development, Quality Assurance Division. Washington, DC. EPA/600/R-98/018. February 1998.