REPORT

**PHASE I INVOLVEMENT FOR
POTENTIAL STAKEHOLDERS OF
THE VOC-ARID INTEGRATED
DEMONSTRATION**

(TTP NUMBER: RL 311101)

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DECEMBER 1992

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PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401, FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

CONTENT

EXECUTIVE SUMMARY	E-1
1.0 INTRODUCTION TO PHASE I REPORT.....	1-1
1.1 PURPOSE AND OBJECTIVES.....	1-1
1.2 ORGANIZATION OF REPORT	1-2
2.0 OUTREACH METHODOLOGY	2-1
2.1 STAKEHOLDER INTERVIEWS	2-1
2.2 STAKEHOLDER WORKSHOPS.....	2-2
3.0 RESULTS OF STAKEHOLDER INTERVIEWS.....	3-1
3.1 INTERVIEWEE INPUT ON DRAFT TECHNOLOGY EVALUATION CRITERIA.....	3-1
3.2 SUGGESTED NEW DRAFT TECHNOLOGY EVALUATION CRITERIA.....	3-3
4.0 RESULTS OF STAKEHOLDER WORKSHOPS.....	4-1
4.1 SUMMARY OF RESULTS OF STAKEHOLDER WORKSHOPS	4-1
4.1.1 Effectiveness Criteria.....	4-1
4.1.2 Operational Environmental Safety and Health Criteria	4-2
4.1.3 Socio-Political Interests Criteria.....	4-3
4.1.4 Regulatory Objectives Criteria.....	4-4
4.1.5 Overall Comments	4-5
4.2 RESULTS OF RELATIVE IMPORTANCE EXERCISE	4-5
5.0 RECOMMENDED CRITERIA FOR APPLICATION IN PHASE II	5-1
5.1 RECOMMENDED PHASE II TECHNOLOGY EVALUATION CRITERIA.....	5-1
5.2 RECOMMENDED DEFINITIONS FOR PHASE II CRITERIA.....	5-3
5.3 RECOMMENDATIONS FOR PHASE II OUTREACH ACTIVITIES.....	5-9

CONTENTS (Continued)

FIGURES

Figure 1	PHASE I STAKEHOLDER INVOLVEMENT PROCESS.....	
Figure 2	DRAFT TECHNOLOGY EVALUATION CRITERIA.....	
Figure 3	SUGGESTED TECHNOLOGY EVALUATION CRITERIA.....	3-
Figure 4	SUGGESTED TECHNOLOGY EVALUATION CRITERIA FOR APPLICATION IN PHASE II.....	5-2

TABLES

Table 1	CRITERIA SUGGESTED BY INTERVIEWERS.....	3-4
Table 2	PRELIMINARY RESULTS OF RELATIVE IMPORTANCE FAMILIARIZATION EXERCISE-SUMMARY CRITERIA.....	4-8
Table 3	PRELIMINARY RESULTS OF RELATIVE IMPORTANCE FAMILIARIZATION EXERCISE - SUBCRITERIA.....	4-9

EXECUTIVE SUMMARY

INTRODUCTION

This report describes Phase I of a three-phased study to support evaluation of new cleanup technologies for federal facilities. It directly supports the Volatile Organic Compounds (VOC)-Arid Site Integrated Demonstration (VOC-Arid ID) being conducted at the Hanford Site. The purpose of the activity, sponsored and directed by the U.S. Department of Energy's Office of Technology Development, is to develop and demonstrate new technologies for cleaning up carbon tetrachloride and other VOCs in soils and groundwater. Ultimate deployability of those innovative technologies will be the measure of success.

The institutional assessment task of the VOC-Arid ID, which is being performed by Battelle Seattle Research Center, is assessing regulatory and public acceptability of new technologies. Phase I of the institutional assessment task focuses on gathering Hanford stakeholder input on how to evaluate technologies. Phase II will involve stakeholders applying the technology evaluation criteria to actual demonstration technologies. In Phase III, the task will evaluate stakeholder acceptability of innovative technologies at other DOE candidate sites. Only if a technology performs effectively during demonstration, and is accepted by the regulatory community and the public, can it be recommended for deployment.

Phase I consisted of a series of stakeholder interviews and two stakeholder workshops, both designed to receive input about the criteria to be used to evaluate innovative technologies. Figure 1 on the following page illustrates the Phase I flow of activities. This report documents both those activities and their results.

STAKEHOLDER INTERVIEWS

Approximately 40 people were interviewed during July - September 1992. They included representatives of the following categories:

FIGURE 1. PHASE I STAKEHOLDER INVOLVEMENT PROCESS

- Regulatory agencies
- Federal, state and local governments
- Native American Tribes
- Public interest groups
- Business and labor groups
- Agriculture
- Education
- Industry
- DOE site contractors
- Hanford retirees

The purpose of the interviews was to obtain stakeholder input on the important factors in evaluating new cleanup technologies. The complete interview methodology is described in Section 2. A set of draft technology evaluation criteria served as the basis for discussion. A computerized information system (ProTech) was used to provide an understanding of the VOC-Arid ID and the potential technologies. Interviewers explained that the results of this activity will be used to assess technologies for application nationwide. Feedback was promised, as well as use of the input in developing technology test plans and technology designs, and evaluating the technologies' performance.

INTERVIEW RESULTS

Interviewees represented a range of perspectives on Hanford cleanup issues, and many were very familiar with the facility and the environmental restoration program. Interviewees contributed many new and valuable insights, which are described in Section 3 of this report. In some cases, new criteria were suggested, or information provided that will be valuable in applying the criteria.

The draft evaluation criteria were initially grouped into eight preliminary categories, including: public acceptability, regulatory acceptability, technical effectiveness, impacts, residuals, time to achieve objective, cost, and implementability. After completing the interviews and analyzing the input received, revised criteria categories were suggested:

- Effectiveness
 - Cost
 - Time
 - Performance
- Operational environmental safety and health
 - Worker safety
 - Environmental impacts
 - Public health and safety
- Socio-political Interests
 - Public perception
 - Tribal rights
 - Socio-economic interests
- Regulatory Objectives
 - Timeliness
 - Regulatory infrastructure/track record
 - Regulatory compliance

These criteria were developed as the basis for discussion at the stakeholder workshops which followed. A report summarizing the interview results and the new suggested criteria was circulated to workshop attendees.

STAKEHOLDER WORKSHOPS

Participation in the two stakeholder workshops held in October was enthusiastic, and represented a cross section of Hanford stakeholders in terms of interests and geography. Many comments were received about the suggested criteria and the overall approach to incorporating public and regulatory acceptability into the ID program. They are documented in Section 4 of this report and in a detailed report on interview results. For a complete list of the criteria and their definitions that were used in the workshops, refer to Appendix A. The primary input received in the workshops can be summarized as follows:

Effectiveness Criteria

Criterion Modifications:

- Addition of a criterion to address contamination remaining in the environment after use of the technology
- Addition of criteria to measure the ability to control a failure of the technology, for needed maintenance, and for required safety measures
- Addition of a criterion to address years until a technology is available for deployment

Other Criterion Comments:

- Reference to materials produced by the technology itself as process waste
- Simplification of the measure of whether a technology functions as intended
- Consideration of total life cycle cost of a technology where feasible

Operational Environmental Safety and Health Criteria

Criterion Modifications:

- Modification of the criterion for measuring offsite releases to "routine releases"

Other Criterion Comments:

- Deletion of the term "operational" from the category title
- Preference for remote handling techniques

Socio-Political Interests Criteria

Criterion Modifications:

- Addition of future land uses to tribal rights criterion, and inclusion of an emphasis on the preference for a return to pristine conditions
- Deletion of property values as a criterion

Other Criterion Comments:

- Addition of an emphasis on involving stakeholders in DOE decision making using techniques such as this process

Regulatory Objectives Criteria

Criterion Modifications:

- Deletion of timeliness as a regulatory objective criterion, replaced by ability to comply with regulatory cleanup milestones

Other Criterion Comments:

- Consideration of regulatory flexibility as applied to technologies not yet feasible for meeting regulatory standards

Workshop participants were asked to complete a preliminary exercise designed to capture the relative importance of different criteria. The results were not conclusive, but indicate that for the limited sample size, participants rated effectiveness as the most important category of criteria (at 34 mean points out of 100), environmental safety and health second, regulatory objectives third, and socio-political interests fourth.

RECOMMENDED TECHNOLOGY EVALUATION CRITERIA FOR APPLICATION IN PHASE II

Based on the workshop results, a set of revised criteria were developed for application in Phase II. While there were some changes to the full list of criteria based on the input summarized above, the primary input involved additions to the definitions of the criteria and how they will be applied. Section 5 of this report describes the recommended criteria and defines them.

It is recommended that these criteria be used in a series of small-group stakeholder exercises during Phase II to apply them to a series of actual technologies. Providing stakeholders the opportunity to personally work through that exercise, facing issues of criterion overlap and measurability, will help further refine the criteria and the approach for their use. Furthermore, the stakeholders will have the opportunity to evaluate the technologies and, thereby, influence technology selection and modification.

1.0 INTRODUCTION TO PHASE I REPORT

1.1 PURPOSE AND OBJECTIVES

This report describes Phase I of a three-phased study to support the Volatile Organic Compounds (VOC)-Arid Site Integrated Demonstration (VOC-Arid ID) being conducted at the Hanford Site. The purpose of the VOC-Arid ID, sponsored and directed by the U.S. Department of Energy's Office of Technology Development, is to develop and demonstrate new technologies for cleaning up carbon tetrachloride and other VOCs in soils and groundwater. The success of the ID will be measured by the extent to which these new technologies are actually used at various DOE sites and at other contaminated sites around the country for remediation of VOCs in soils and groundwater.

Decisions on the technologies to be developed, demonstrated, and deployed for use at DOE sites will involve evaluation of the technical performance of new cleanup technologies compared with current technologies. Equally important, however, is the regulatory and public acceptability of these new technologies. Only if a technology performs effectively during demonstration, and is accepted by the regulatory community and the public, can it be recommended for deployment.

The institutional assessment task of the VOC-Arid ID, which is being performed by Battelle Seattle Research Center, will assess regulatory and public acceptability of new technologies. Phase I of the institutional assessment task focuses on gathering Hanford stakeholder input on technology evaluation criteria and their application. Stakeholders are defined as those groups and individuals with an interest in federal facility cleanup, including a regulatory interest.

Phase II will apply criteria developed through the stakeholder outreach process to the design and evaluation of the demonstration technologies. Information received from stakeholders bears directly on the likelihood of successful deployment of the new cleanup technologies. In Phase III of the institutional assessment task, the team will evaluate stakeholder acceptability of these technologies at other DOE candidate sites.

Information acquired during each phase will be used by the VOC-Arid ID team as criteria for evaluating proposed technologies. Specifically, the criteria will, in part, determine the

format for technology test plans that will serve as the basis for assessing the performance of the demonstrated technologies. A public and regulatory acceptability report on a specific technology will follow the technology's demonstration and serve as one measure of the technology's ultimate deployability.

The purpose of this report is to document the outreach activities conducted in Phase I of the institutional assessment task. This includes a series of interviews and workshops held with stakeholders to determine appropriate technology evaluation criteria. The results of these activities, and recommendations for criteria to be applied in Phase II, are presented.

1.2 ORGANIZATION OF REPORT

This report has been organized to document the interview and workshop tasks of Phase I outreach in a form for implementation in Phase II. Reference is made to a more detailed report on the results of stakeholder interviews, Results of Stakeholder Interviews for VOC-Arid ID Project, for additional background.

Section 2 of this report describes the methodology used to plan for, conduct, and report on the VOC-Arid ID technology evaluation interviews and workshops. In Section 3, the results of the stakeholder interviews are summarized, along with the set of draft technology evaluation criteria developed from stakeholder input. Working definitions for those criteria are included in Appendix A.

Section 4 summarizes the results of the stakeholder workshops which were held. Section 4 also includes workshop participants, suggestions for revising the draft technology evaluation criteria, and the results of a preliminary exercise designed to determine participants' values regarding the relative importance of the criteria.

Based on the foregoing results, recommendations are made for using the results of Phase I in Phase II of the institutional assessment task. Included in Section 5 are recommended Phase II technology evaluation criteria and their definitions, and suggestions for involving stakeholders in applying the criteria during Phase II.

2.0 OUTREACH METHODOLOGY

2.1 STAKEHOLDER INTERVIEWS

A series of interviews were conducted with representatives of groups with an interest in the Hanford cleanup. This section summarizes the interview methodology. The list of potential stakeholders included:

- Regulatory agencies
- Federal, state and local governments
- Native American Tribes
- Public interest groups
- Business and labor groups
- Agriculture
- Education
- Industry
- DOE site contractors
- Hanford retirees

From approximately 300 people contacted, approximately 40 people were interviewed during July - September 1992. This included 28 interviews, with some being multi-party interviews. The interviewees represented a broad range of stakeholder interests and viewpoints, although it was not a randomly selected sample. Each interview ranged from 45 minutes to 2 hours, and were conducted face-to-face. Interviewers included Battelle staff and staff from its subcontractor organization, Environmental Issues Management, Inc.

The purpose of the interviews was to obtain stakeholder input on what is important in evaluating a new cleanup technology. The interviews thus focused on defining evaluation criteria and discussing ways to evaluate their relative importance. As preparation, the team prepared draft technology evaluation criteria for use as a basis for discussion. The discussion was open-ended, encouraging wide-ranging input on technology evaluation criteria and values. Interviewers also used a computerized information management tool, Prospective Technology Information System (ProTech), to share information about the ID and about the draft evaluation criteria.

The interviews included an explanation of the VOC-Arid ID institutional assessment task and the role of stakeholder input. The introductory comments emphasized the following information:

- The VOC-Arid ID is being conducted at Hanford, but technologies to be demonstrated are selected and assessed for their applicability to remediate other DOE sites and other non-DOE facilities across the country.
- Deployability of the technologies is the ultimate goal, and evaluating public and regulatory acceptability is necessary to support that goal.
- The VOC-Arid ID is committed to providing feedback to involved stakeholders and ensuring that the information received is actually used in selecting and designing technologies for demonstration.
- A key use for the information gained will be as input to the technology test plans -- those plans that define the goals and objectives of a technology demonstration and define the data needed to be collected to demonstrate that the technology satisfies those goals and objectives.
- Stakeholder input will also be used to determine future public information and involvement strategies in the area of cleanup technology.

After the interviews were complete, interviewees were given an opportunity to review the results of their interviews and provide additional information if desired. Stakeholder perspectives and input were invaluable in creating the revised set of draft technology evaluation criteria that were used as the basis for stakeholder workshops.

The results of the interviews are summarized in Section 3 of this report and are detailed in Results of Stakeholder Interviews for the VOC-Arid ID, Battelle Seattle Research Center, 1992.

2.2 STAKEHOLDER WORKSHOPS

Two stakeholder workshops were planned to discuss the revised draft technology evaluation criteria. Letters of invitation were sent to the original potential stakeholder mailing list and to other groups and individuals suggested by interviewees. Approximately 350 letters of invitation were mailed, including letters to individuals and groups that had participated in the interviews. People expressing interest received telephone calls and a workshop preparation package that included the summary of the interview results and the revised draft technology evaluation criteria.

The workshops were held on October 26 in Kennewick and on October 29 in Seattle. Twenty-eight (28) people participated in Kennewick and 8 in the Seattle workshop. Participants in Kennewick were divided into three discussion groups to address the various categories of criteria. Each discussion group was assigned a facilitator. In Seattle, the

entire list of criteria was discussed by the group as a whole, as fewer people attended. Participants were asked to express their understanding of the draft criteria, to suggest changes or new criteria, and to provide an understanding of what should be considered in evaluating new technologies. Participants also completed a brief exercise designed to evaluate the relative importance of the criteria to each individual.

Discussion was enthusiastic at both workshops and a great deal of useful input was received. Section 4 of this report summarizes the results of the workshops, which serve as the basis for the recommended set of technology evaluation criteria found in Section 5.

3.0 RESULTS OF STAKEHOLDER INTERVIEWS

3.1 INTERVIEWEE INPUT ON DRAFT TECHNOLOGY EVALUATION CRITERIA

Achieving a broad cross section of perspectives is an important goal of the institutional assessment task. Interviews were thus conducted with a range of categories of stakeholders designed to capture the spectrum of ideas and viewpoints. Representatives of federal and state regulatory and resource agencies, Native American tribes, state and local elected officials and their staffs, interest groups, labor and business, agriculture, and current and retired environmental industry representatives were interviewed. Geographic representation included the entire state of Washington and a number of Oregon stakeholders.

The backgrounds of the people interviewed included a significant level of familiarity with issues of Hanford cleanup. In most cases the individuals interviewed have participated in public outreach activities, regulatory oversight functions, advisory roles, technical activities, or other capacities in relation to the facility. They thus represented informed, and in many cases technically knowledgeable, perspectives about alternative cleanup technologies. Insights also were gained, however, about informing and involving the general public in evaluating new cleanup technologies, and in the overall Hanford cleanup mission.

The draft technology evaluation criteria shown in Figure 2 illustrate the starting point for the interview discussions about evaluating new cleanup technologies. As anticipated, interviewees contributed many new and valuable insights. While input from particular stakeholder categories reflected the background and training of those contacted, there was also wide-ranging dialogue about the full range of applicable technology evaluation criteria. In some cases new criteria were suggested for consideration. Often, the points discussed had bearing on the various categories of evaluation criteria already identified, but the perspectives of the interviewees added further meaning and definition to those criteria. The overall level of response from those interviewed was thoughtful and thorough, and a great deal of input was received.

Figure 2. Preliminary List of Technology Evaluation Criteria

Table 1 on the following pages summarizes the results of the interviews in relation to the original criteria categories.

3.2 SUGGESTED NEW DRAFT TECHNOLOGY EVALUATION CRITERIA

Based on analysis of these suggestions, and the contexts in which they were offered, a suggested new set of draft evaluation criteria was developed (See Figure 3). The suggested criteria included all of the elements of the original draft criteria, but added criterion elements and reorganized the categories to better reflect the interview results. These new criteria were far from final, representing the basis for workshop discussion. Appendix A provides definitions for each of the criteria shown in Figure 3 as they were defined for discussion at the workshops.

The ultimate goal is to assess the acceptability of a technology or a suite of technologies according to technical, public and regulatory acceptability. The factors that comprise "acceptability" can be organized into the following major categories:

- Effectiveness of the technology
- Operational environmental safety and health
- Socio-political interests
- Regulatory objectives

The suggested list of criteria was meant to address all of the input received from the interviewees. It was intended that the stakeholder workshops would provide an opportunity for participants to discuss the suggested criteria. The objective was to develop a full understanding of each criterion and criteria category, and to reach agreement that the list correctly reflects what stakeholders saw as important.

TABLE 1
CRITERIA SUGGESTED BY INTERVIEWEES

<p>REGULATORY ACCEPTABILITY</p> <ul style="list-style-type: none"> • Ability to achieve standards (other terms such as targets, objectives, endpoints, and criteria were used somewhat synonymously with "standards") with a degree of certainty; now and in future • Ability to achieve regulatory equity with other entities (federal and non-federal) • Simplicity of technology as applicable to regulatory acceptance • Ability to demonstrate compatibility with state waste management priorities • Ability to start quickly to fulfill regulatory and political commitments of Tri-Party Agreement • Availability of regulations, regulatory guidance regarding technology • Historical record of same or similar technology • Time required to permit • Ability to accommodate future changes in cleanup standards
<p>COST</p> <ul style="list-style-type: none"> • Capital costs • Operating and maintenance costs • Total life-cycle costs (includes cost of residuals management, training, decommissioning, regulatory oversight, and future liability) • Cost effectiveness; cost-to-benefit ratio, degree of additional benefit for additional cost • Likelihood of being funded (public and private) • Fairness of funding among DOE priorities

TABLE 1 (Continued)
CRITERIA SUGGESTED BY INTERVIEWEES

PUBLIC ACCEPTABILITY

- Credibility of technology proponent(s)
- Future site use compatibility after cleanup completion; includes aesthetics
- Commercial market and viability on as broad a basis as possible
- Potential for local (Tri-Cities) hiring
- Public access to the working unit(s) during cleanup operations and to the location after cleanup
- Spinoff industry and economic development
- Familiarity and simplicity of technical concepts, designs, and terms
- Effect on market perception of local products (e.g. wheat, grapes, etc.)
- Likelihood of catastrophic failure (fear and dread factor)
- "Acceptability" of risk levels
- Public participation in actual decision-making process

NATIVE AMERICAN CULTURAL VALUES

- Impacts on sacred lands, historic hunting, fishing, habitation lands
- Long-term (7 generations) insult to nature and the earth
- Transportation across native lands, with resulting risks

TECHNICAL EFFECTIVENESS

- Ability to meet standards (targets, objectives, etc.) in short and long term, under potentially adverse conditions, using simplest possible technologies
- Applicability to other sites nation-wide with similar contamination
- Certainty or uncertainty associated with the technology's ability to meet objectives
- Flexibility to also apply other cleanup technologies at a future time
- Ability to monitor
- Ability to minimize further spread of contamination (across media or within the same medium -- relates to timeliness in the sense that contaminant spread continues with time)
- Reliability/durability/long-term-effectiveness/efficiency of technology
- Integration of technology with overall system

TABLE 1 (Continued)

CRITERIA SUGGESTED BY INTERVIEWEES

IMPACTS

- Consider cumulative/additive impacts, possible detriment to other site activities and goals
- Public health and safety (present, future, extreme future); certainty and uncertainty associated with each (regulatory standards were generally seen to provide reasonable protection of public health and safety and therefore these remarks overlap with Technical Effectiveness and Regulatory Standards)
- Future site use compatibility (very divergent responses: no institutional controls, no unusable land; maximum institutional controls, restricted land use; minimization of area with restricted use to maximize unrestricted use)
- Worker health and safety (very divergent responses on this issue)
 - not a large concern
 - a significant concern
 - hire the best people
 - get the best training
 - use radiation workers
 - use non-radiation workers
 - remote handling potential
- Environmental impacts
 - Likelihood of air pathway emissions (negative outcome)
 - Ability to preserve fisheries; sensitive issue due to other negative impacts on fishery (e.g., dams)
 - Minimizing or eliminating impacts/discharges to water
 - Ability to preserve natural/wildlife habitat
 - Risks from transportation
 - Amount of land needed (present and future) to implement technology
 - Use of energy/natural resources by technology
- Irretrievability/sterilization of land (resources) after use
- Risk reduction across all risk categories (attempt to balance worker, public, environmental risks)

RESIDUALS

- Ability to minimize waste produced
- Methods and safety of transportation of residuals (water, rail, road); acute versus chronic hazards from transportation exposures
- Need for treatment of residuals; potential for recycling
- On-site versus off-site disposal (off-site preferable in terms of unrestricted use in future, but minimizing transportation risks is important, and there are socio-political implications of moving residuals off-site)
- Retrievable storage of residuals versus disposal

TABLE 1 (Continued)

CRITERIA SUGGESTED BY INTERVIEWEES

TIMELINESS <ul style="list-style-type: none">• Timeliness of start of remedial action; linked to timeliness of funding• Availability when needed• Time required to complete and achieve objectives• Timeliness of procurement process
IMPLEMENTABILITY <ul style="list-style-type: none">• Previous experience with technology• Ease of procurement• Ease of safety and industrial hygiene interface• Ease of QA/QC interface• Qualified staff availability• Degree of training required

FIGURE 3. SUGGESTED TECHNOLOGY EVALUATION CRITERIA USED IN PHASE I WORKSHOP

4.0 RESULTS OF STAKEHOLDER WORKSHOPS

4.1 SUMMARY OF RESULTS OF STAKEHOLDER WORKSHOPS

Participants in the workshops discussed the suggested draft technology evaluation criteria in some detail. This section summarizes the comments made in regard to each criterion category.

4.1.1 Effectiveness Criteria

The criteria intended to differentiate among technologies on the basis of their effectiveness include several sub-categories. These include technology performance, cost, and time. Comments received included the following:

Performance: Participants suggested adding a criterion to address contamination remaining in the environment after using a technology (e.g., residual levels of contamination in groundwater after treatment). This would include reducing contaminant mobility, volume, and toxicity. Remaining contamination is differentiated from process waste, or secondary waste produced by the technology itself (previously called waste in the criteria listing). It was suggested that the need for and residuals from decontamination and decommissioning be added to the process waste criterion. Within the criterion of practicality, participants suggested adding a measurement of how easy it would be to control and mitigate a failure of the technology. Also suggested were criteria for the level and type of maintenance needed for a technology, as well as the safety measures required to protect workers. The criterion of “works” - functions as intended - was simplified to mean just a determination of whether a technology fulfills its objective. Does, for example, a drilling technology designed for use in cobbles actually drill through cobbles?

Cost: Participants confirmed that the cost criteria should consider start-up cost, operations and maintenance cost, and total life-cycle cost. Discussions pointed out, however, that major levels of uncertainty are associated with estimating life-cycle costs. It was therefore suggested that start-up and operating and maintenance costs be used as the primary discriminators, with life-cycle cost evaluated as feasible and as a factor to augment the other cost evaluations. Use of cost/benefit analysis wherever possible was encouraged as an overall theme.

Time: Participants suggested that a criterion be added to the time category to differentiate based on the time required before a technology can be deployed. Thus the criterion “years until available” was added to the criteria for speed/rate of the technology and years to finish the work.

4.1.2 Operational Environmental Safety and Health Criteria

The criteria for operational environmental safety and health include worker safety, public health and safety, and environmental impacts. It was suggested that more than operational impacts be considered in this criterion category, as there are concerns about pre-operational, post-operational, and long-term impacts as well. Though no long-term data exist to allow comparative measurement, there is a desire to capture long-term concepts in at least a qualitative way. The category was thus retitled “Environmental Safety and Health.” Another overall theme discussed in relation to environmental safety and health involved the desire to consider cumulative impacts of technologies. While this is recognized as a desirable approach to impact analysis, it appears that discriminating among technologies on the basis of unit impacts may be a more practicable approach. Unit impacts of different technologies can then be incorporated in overall system assessments of cumulative impacts when evaluating total deployment systems.

Suggested modifications to the other specific criteria as proposed included the following:

Worker Safety: A preference for technologies employing remote handling techniques was expressed as a way to discriminate on the basis of worker safety impacts. Other than that, participants confirmed that the level of exposure to hazardous materials and hazards, the physical requirements of using the technology, and the number of people required to use the technology, were all applicable criteria.

Public Health and Safety: There was discussion about changing this criterion to “nonworker” health and safety, as workers are also considered members of the public from a regulatory perspective. That terminology will be added to the definition of the criterion of public health and safety. There was also concern over the term “offsite releases,” as it is not clear whether “site” means the area of contamination, building housing of the technology apparatus, or overall federal facility boundary. The term “routine releases” better distinguishes between planned and unplanned emissions, and can serve as an

important discriminator. Participants also pointed out the difficulty in projecting non-anticipated releases as an evaluation criterion.

Environmental Impacts: Participants believed that environmental impacts are very broad in scope, creating difficulty in evaluating them at a pre-application stage. Nevertheless, there was a desire to try to consider environmental impacts, including ecological impacts, aesthetics, natural resources, and energy demands. Caution was expressed about trying to be quantitative about environmental impacts at the early stages of technology evaluation, but it was suggested to perform qualitative comparisons where no good quantitative data exist. Participants were concerned about the value of not destroying the surface environment in order to remediate a subsurface problem.

4.1.3 Socio-Political Interests Criteria

Three types of criteria were grouped into the category of socio-political interests - public perception, tribal rights, and socio-economic interests. An overall theme from several participants was the need for the Department of Energy to include stakeholders in decision making regarding use of cleanup technologies. One participant suggested that the outreach effort for the development of technology evaluation criteria serve as a model for DOE in obtaining public involvement in other issues. There was general agreement that overall understanding and acceptance of DOE actions would be increased by such an inclusive public process.

Specifically, participants suggested the following:

Public Perception: Participants confirmed the role of proponent (technology developer and, ultimately, technology deployer) reputation and credibility in evaluating the public and regulatory acceptability of a technology. They agreed that familiarity and understandability of the technology are factors in its acceptability, and should be included as criteria. Their level of technology acceptance is also influenced by the quality of the proponent's explanations of the technology.

Tribal Rights: It was suggested that this category be broadened to include future land uses, as those are tied inexplicably to cleanup issues. The criterion has thus been retitled "Tribal Rights/Future Land Uses." Emphasis was also added to the definition of "capacity for unrestricted use" for the element of returning the land to a pristine environmental condition. This is a key element of tribal concerns, and of others providing comments,

suggesting the goal of returning an area to as close to pristine as possible. This was an aesthetic concern as well as a land use concern.

Socio-Economic Interests: Participants confirmed the appropriateness of considering economic impacts and labor force demands as discriminators among different technologies. They suggested, however, that property values be possibly deleted as a criterion, as there may be no data available on how different technologies will impact property values in a surrounding area. Whether negative or positive, property value impacts are really a subset of economic impacts. There was a suggestion, however, that the economic value of the land when it has been remediated be considered as part of the economic impacts consideration.

4.1.4 Regulatory Objectives Criteria

The proposed criteria within this category included consideration of a technology's differentiation based on timeliness, existing regulatory infrastructure and track record, and capacity for regulatory compliance. Specific comments were received as follow:

Timeliness: The original proposed criteria suggested evaluating availability of technology as a regulatory criterion. Participants suggested that it would be better addressed as part of the time category under effectiveness, where it is to be included in the evaluation of years until a technology is available. Thus, only the ability of a technology to comply with regulatory cleanup milestones (e.g., the Tri-Party Agreement) will be considered here.

Regulatory Infrastructure/Track Record: Participants recognized the difficulty of addressing this criterion for a range of different, new technologies. They believed, however, that it bears consideration. Discussion also suggested the need for incentives for use of innovative technologies, as in the case of EPA approval of untried or innovative remedies in response action decisions.

Regulatory Compliance: Considerable discussion took place about whether it is critical for new technologies to be able to achieve all regulatory requirements, or whether making substantial progress toward regulatory compliance may sometimes be sufficient. Participants stressed the desirability of achieving regulatory standards, but acknowledged that, on a comparative basis, a technology may be favorably evaluated if it approaches the regulatory standard and demonstrates promise for ultimately meeting it. Regulatory

flexibility may be helpful; for example, issuing a conditional record of decision so that innovative approaches can be used on a trial or interim basis.

4.1.5 Overall Comments

In addition, several other underlying themes emerged from the discussions. There was general acknowledgement of the uncertainty involved in attempting to evaluate future use of unproven technologies. Technology design and operating parameters, potential impacts, long-term costs, and other factors can only be projected with a significant level of uncertainty. Nevertheless, participants validated the importance of considering those factors in making decisions, using the best data available. This would apply to programmatic and technical decision makers as well as involved stakeholders.

Another underlying theme was simplicity in technology. Regulatory personnel, interest groups, industry representatives, and others reinforced that the simplest technology that can do the job should be used. For reasons of regulatory acceptability, public confidence, worker safety, and others, simple technologies are rated highest. Participants cautioned against pursuing sophisticated, complex technologies if existing methods can be modified or applied differently and still achieve acceptable results.

Public involvement was another major theme. Participants appreciated the opportunity to be involved in this program at an early and meaningful stage, and expressed their willingness to continue to be involved. Several participants emphasized that this type of participatory decision making is key to DOE's success in cleanup of Hanford and other federal facilities, and may serve as a model for other parts of the facility and other issues.

4.2 Results of Relative Importance Exercise

Following discussion of the proposed criteria and their definitions, workshop participants were asked to complete an exercise designed to elicit preliminary ideas about their views on the relative importance of the criteria. In addition, a group of technical program participants (principal investigators for DOE-funded technology demonstrations) was asked at another meeting to complete the same exercise.

The purpose was to elicit technical program input and to familiarize technical personnel with the technology evaluation process.

Evaluating first the four criterion categories, then individual criteria within each category, participants distributed points from a total set of 100 points to demonstrate relative importance. The results of those exercises are shown below in Table 2. Seven respondents were participants at the Seattle meeting, 19 in Kennewick, and 31 at a DOE program technical meeting. It is important to note that this was only a preliminary attempt to introduce the concept of relative criteria importance and to familiarize participants with the process of assigning points to different criteria to illustrate their personal values. It is likely that a more rigorous weighting process will be required to achieve reliable results.

Only a short time was available for the exercise at the workshops, and participants completed their rankings quickly. In addition, at this preliminary stage, the data are weakened by several factors, including (1) nonrandom samples, (2) small sample size, (3) inconsistencies with sub-criteria, and (4) individuals' interpretations of weighting scales. The results should not be assumed to be statistically significant, but they do provide an initial look at how workshop participants view the relative importance of the proposed criteria.

Table 2 displays the weighting means for each group as well as means for the group as a whole. Although there are some differences in the rankings assigned by each group, all three groups similarly ordered the importance of the criteria: effectiveness criteria were ranked as the most important, followed by safety and health, regulatory objectives, and socio-political criteria. While a wide range of stakeholders perceives a roughly *similar ranking order of importance* across the criteria, individual groups (and individuals) assign *different weights or values* to that importance.

Table 3 displays the sub-criteria weightings made by workshop participants. The table reflects the fluid nature of the sub-criteria definitions at the time of the workshops. The technical group, for example, was asked to rate a reduced set of effectiveness sub-criteria while the Kennewick group rated an expanded set of regulatory sub-criteria. Although this makes comparisons across groups more difficult, at least one difference stands out. While the Kennewick and technical groups gave their highest rankings to cost-effectiveness sub-criteria, the Seattle group rankings were more evenly distributed across all effectiveness sub-criteria. This suggests that as participants are asked to rank finer divisions of sub-criteria, it may be the case that ranking order and weight assignments will vary across groups, individuals, and technologies. In order to observe reliable patterns in these

complex exercises, a rigorous method for soliciting, measuring, and analyzing individual and group weightings of relative importance will be needed.

The kinds of questions to be answered in application of these criteria during Phase II include:

- How easy is it for respondents to make value judgments or new cleanup technologies expressed as weighting factors or rankings?
- Are the judgements useful in differentiating among criteria?
- Do groups differ in the relative importance values they place on the criteria?

TABLE 2**PRELIMINARY RESULTS OF RELATIVE IMPORTANCE
FAMILIARIZATION EXERCISE-SUMMARY CRITERIA**

SUMMARY CRITERIA			
Criteria	Group	Mean	Standard Deviation
Effectiveness	Technical	38	13.5
	Seattle	29	
	Kennewick	31	
	All 3	34	
Safety and Health	Technical	27	10.3
	Seattle	29	
	Kennewick	28	
	All 3	27	
Socio-political	Technical	14	13.8
	Seattle	17	
	Kennewick	19	
	All 3	16	
Regulatory Objectives	Technical	21	9.5
	Seattle	26	
	Kennewick	22	
	All 3	22	

TABLE 3

**PRELIMINARY RESULTS OF RELATIVE IMPORTANCE
FAMILIARIZATION EXERCISE-SUBCRITERIA**

EFFECTIVENESS SUB-CRITERIA		
Criteria	Group	Mean
Performance	Technical	35
Cost	Technical	39
Time	Technical	26
Practical	Seattle	22
	Kennewick	14
	Both	18
Works	Seattle	17
	Kennewick	17
	Both	17
Residual	Seattle	17
	Kennewick	11
	Both	14
Time	Seattle	17
	Kennewick	8
	Both	13
Cost	Seattle	13
	Kennewick	37
	Both	25
Waste	Seattle	14
	Kennewick	13
	Both	14

SAFETY SUB-CRITERIA		
Criteria	Group	Mean
Worker Safety	Technical	31
Cost	Seattle	31
Time	Kennewick	32
	All 3	31
Public Health and Safety	Technical	40
	Seattle	31
	Kennewick	32
	All 3	31
Environmental Impacts	Technical	29
	Seattle	37
	Kennewick	30
	All 3	31

TABLE 3 (Continued)

**PRELIMINARY RESULTS OF RELATIVE IMPORTANCE
FAMILIARIZATION EXERCISE-SUBCRITERIA**

SOCIO-POLITICAL SUB-CRITERIA		
Criteria	Group	Mean
Public Perception	Technical	48
	Seattle	35
	Kennewick	36
	All 3	44
Tribal Rights	Technical	17
	Seattle	36
	Kennewick	31
	All 3	23
Socio-Economic	Technical	35
	Seattle	28
	Kennewick	33
	All 3	34

REGULATORY OBJECTIVES SUB-CRITERIA		
Criteria	Group	Mean
Timeliness	Kennewick	20
Infrastructure	Kennewick	7
Compliance	Kennewick	55
Innovation	Kennewick	18
Timeliness	Technical	34
	Seattle	41
	Both	35
Infrastructure	Technical	20
	Seattle	20
	Both	20
Compliance	Technical	46
	Seattle	40
	Both	45

5.0 RECOMMENDED CRITERIA FOR APPLICATION IN PHASE II

5.1 RECOMMENDED PHASE II TECHNOLOGY EVALUATION CRITERIA

Based on the results of the workshops, as well as the earlier developmental work of the interviews, a recommended revised set of technology evaluation criteria was developed. The criteria are intended for use in Phase II to test their applicability, usefulness, and ability to evaluate the issues related to regulatory and public acceptability of deployability of different cleanup technologies.

Figure 4 illustrates the recommended revised criteria. As shown, many of the comments received at the workshops have been incorporated as changes in the criteria set. In some cases, input received did not change the criteria themselves, but will be included in the criterion definitions. These criteria represent one structure that reflects all the input received. They may not yet be appropriately structured, however, to serve a formal decision analysis function. In formulating evaluation criteria for a formal decision-analysis based process, the criteria are typically oriented in an "objectives hierarchy" or "value tree." The hierarchy should be complete, representing all important factors. Each criterion should be concise, mutually exclusive (independent, not redundant), and measurable.

Workshop participants and interviewees recognized the difficulty of developing such a set of measurable, precise criteria at this stage. It is recognized that the set of criteria represented in Figure 4 include some that are relatively easy to measure and define. One such example is the relative energy demands made by a particular technology, which should be definable fairly early in the process. Other criteria, however, may be very difficult to measure or use as discriminators. For example, projected accidental releases of materials that affect public health and safety will have little data available. There are also numerous linkages between and among the criteria, they may not be unique and independent.

At the same time, there is recognition that all of the elements discussed are important considerations in evaluation of alternative technologies. The purpose of Phase II of the institutional assessment task is to test these criteria by applying them, with stakeholder participation, in evaluating actual technologies. At that time ID team, with stakeholder

FIGURE 4. SUGGESTED TECHNOLOGY EVALUATION CRITERIA FOR APPLICATION IN PHASE II

involvement, will determine which ones are precisely measurable and represent unique criteria. It is probable that Phase II will result in a refined version of the criteria based on experience in applying them to the technologies.

5.2 RECOMMENDED DEFINITIONS FOR PHASE II CRITERIA

The criteria shown in Figure 4 represent a great deal of discussion. To ensure that the meaning of each criterion is captured for use by technology evaluators, researchers, and reviewers, a set of definitions accompanies the figure. While these definitions include most of the information provided in the original criterion definitions (See Appendix A), there is additional information incorporated that captures the results of the workshop discussions.

This section summarizes the intended meaning for each of the criteria shown in Figure 4.

EFFECTIVENESS

Three primary criterion categories are associated with the evaluation of technology effectiveness. These include performance, cost, and time.

PERFORMANCE:

The elements that comprise the performance criterion include remaining contamination, process waste, practicality, and whether the technology "works" or functions as intended. The criterion for remaining contamination refers to contaminants remaining after the technology has been applied (e.g., the 1 percent remaining after a 99 percent-effective groundwater treatment technique is completed). The remaining contamination is to be measured according to how much contaminant mobility, volume, and toxicity are reduced by the technology.

The criterion for process waste refers to waste produced by the technology itself, or the process of its application. The status of the waste can be assessed, including consideration of waste mobility, volume, degree of hazard represented by the character of the waste, and recycle potential. The ability to characterize the waste, handle it safely, and transport it with minimal risk, are also important. Waste treatment requirements needed to address a given technology's residuals can be assessed, and the availability

of the needed treatment technology defined. Requirements for decontamination and decommissioning of a technology, and the resulting waste, can be evaluated. The technology can also be evaluated according to the need for waste disposal, and whether such disposal capacity is available. The nature of available disposal (e.g., landfill versus more progressive disposal method) should also be considered.

Practicality is defined by several criteria. It assesses whether use of a given technology will preclude or foreclose future cleanup options. It evaluates whether a technology is reliable, and can be expected to operate with minimal operational problems and production downtime. If the technology fails, it should be possible to control the effects of that failure easily and rapidly. Other criteria include whether the technology is easy to use and capable of operating with the existing facility infrastructure (e.g., buildings, power sources, personnel). Versatility of the technology to address other types of contamination, in other media, or at other locations, can also be assessed.

A systems analysis perspective on the technology will evaluate whether the technology is compatible with the other elements of the remediation system. The ability to procure the technology "off the shelf", with the simplest possible development approach, is another criterion. How easy the technology is to routinely maintain, and how often maintenance is required, should be considered. Also, the safety measures required to protect workers and the public can be evaluated. Finally, determining whether a technology actually works as intended is also a consideration.

COST: Two elements that comprise the cost criterion include technology startup cost, and operations and maintenance cost. These factors are to be considered first, as they represent some certainty in the data available for evaluation. Startup cost is intended to cover reasonable developmental costs, procurement and construction costs, permitting costs, and other elements prior to starting operation and conducting full-scale deployment. Operations and maintenance costs cover the elements of labor, supplies, maintenance, replacement parts, process waste management, ongoing regulatory compliance, etc., for the life of the use of the technology.

Total life-cycle cost should be considered as a secondary criterion. Total life-cycle cost considerations typically include not only facility capital cost, startup and operation costs, and maintenance, but also less distinctly attributable costs such as decommissioning costs, ongoing regulatory or institutional oversight, and future liability. While it is probably a more meaningful overall measure, the elements of defining total life cycle cost are highly uncertain. Therefore, it should be considered only as a secondary criterion following evaluation of startup and operations and maintenance costs. Workshop participants encouraged the use of cost/benefit analyses wherever feasible.

TIME: The elements that comprise the time criterion include the length of time until the technology is available, the speed or rate at which the technology operates, and the total time needed to achieve the given objectives. Years until available, while an estimate, is directly comparable between and among technologies. Speed or rate is measured differently for different categories of technologies (e.g., feet per hour for a drilling technology, pounds per day for an extraction technology), but is a useful measure of comparison of technologies within a category. Years to finish measures the total time required for setup and removal, as well as the total length of time needed for a given technology or combination of technologies to achieve the given objective(s).

ENVIRONMENTAL SAFETY AND HEALTH

There are three elements included in the category of environmental safety and health. They include worker safety, public health and safety, and environmental impacts. In many ways these criteria are related to the regulatory compliance standards addressed in a later category, but they also represent stand-alone objectives to be addressed by specific criteria where possible.

WORKER SAFETY:

The criteria for evaluating a technology according to its worker safety aspects include the level of exposure of workers to hazardous materials or other hazards resulting from use of the technology, the physical

requirements of developing and operating the technology, and the number of workers required. Factors to evaluate worker safety may include the number of days lost due to accidents or exposure, the concentration of contaminants in the workplace, or operational considerations such as the need for protective clothing or equipment. Technologies using remote handling techniques are preferred.

PUBLIC HEALTH AND SAFETY:

The term public health and safety is intended to refer to all those people who are not workers at the facility. Public health and safety aspects of a given technology can be evaluated based on the number, type and severity of accidents postulated to occur related to that technology's development, operation, and decommissioning. Routine releases to air, ground or water pathways from a technology can be evaluated, as can the potential impacts from transportation of equipment, samples, wastes, or other materials associated with the technology. Careful consideration needs to be given as to whether the risks from transporting contaminants offsite are offset by the risks of disposing of them onsite.

ENVIRONMENTAL IMPACTS:

The criteria for evaluating a technology's environmental impacts include effects on the ecology of the remediation site (e.g., wildlife, vegetation, air, water, soil, people), and aesthetic impacts (e.g., visual impacts, noise). Technologies are preferred in which contaminants are destroyed, not just dispersed. Preservation of undisturbed habitat should be emphasized. The use of natural resources in development, manufacture, or operation of the technology should be evaluated, including the energy demands of the technology.

SOCIO-POLITICAL INTERESTS

Acceptability of a technology by the range of various "publics" depends on many factors, including those described above. In addition, however, there are three categories of criteria termed socio-political interests. These include public perceptions of a technology, tribal rights and future land uses associated with technology demonstration and deployment, and socio-economic interests.

PUBLIC PERCEPTION:

The reputation of the proponent of a technology, whether the technology developer or deployer, affects public perception of that technology. This may apply to a government agency, national laboratory, academic institution, contractor firm, or private industry partner. The degree of familiarity of a technology and its use is a key factor affecting public perception of a given technology. Information needed for decision making (e.g., cost projections) is often unavailable or unreliable, thus causing public concerns. The ability to explain the technology in understandable terms is important to public acceptability. Involvement of the public in decisions about the use of different technologies is a key element of public acceptability of those technologies. Other factors that have been addressed elsewhere also affect public perception, including elements such as related employment, and the overall benefit a person perceives that would result from deployment of the technology. In addition, generalized public fear and dread of hazards, high technology solutions, and government actions may be factors affecting acceptability of some technologies.

TRIBAL RIGHTS/FUTURE LAND USES:

Native American values related to the land and its uses offer criteria for evaluating alternative cleanup technologies. In addition to the affected tribes, many other groups and individuals have interests in future uses of currently-contaminated land. The return of the land to a pristine state is a major goal. Capacity for future unrestricted use of the contaminated areas, including both terrestrial and aquatic uses, is a key criterion. This relates to spiritual values as well as traditional uses (e.g., hunting, fishing, recreation, living areas). To the degree possible, the physical nature of the land itself should not be changed (e.g., not vitrifying large solid blocks of earth in place).

SOCIO-ECONOMIC INTERESTS:

Effects of a technology or suite of technologies on the economic base of the community should be considered, including fiscal as well as less tangible impacts. Impacts may include local infrastructure requirements (e.g., sewer, fire protection, etc.), labor force turnover (if new or different capabilities are needed), housing values, or other factors. Availability of the

required labor force can be evaluated for different technologies, including the need for personnel training.

REGULATORY OBJECTIVES

Discussions with the regulatory community as well as other stakeholders revealed several criteria related to meeting regulatory objectives for the technologies to be evaluated. These include compatibility with facility cleanup milestones, regulatory infrastructure and track record, and regulatory compliance.

COMPATIBILITY WITH CLEANUP MILESTONES:

Evaluating the ability of a technology to support compliance with cleanup milestones involves assessing its ability to contribute to meeting the regulatory cleanup requirements that have been established for a given site, in a timeframe and in compliance with standards that would be applied in any other remediation situation.

REGULATORY INFRASTRUCTURE/TRACK RECORD:

The experience of regulators with a specific technology or a similar technology may result in the regulators being predisposed to find the technology acceptable. Furthermore, if a regulatory agency has experience with a type of technology, it can be expected that regulatory uncertainty about that technology will be reduced. The number and complexity of the regulatory programs that apply to a given technology should be evaluated.

REGULATORY COMPLIANCE:

The ability of a technology or suite of technologies to achieve regulatory cleanup standards, as well as ongoing protection of public and worker health and safety and the environment, can be evaluated. Permanent solutions are preferable, as well as the simplest possible technologies that will do the job. Substantial compliance with regulatory requirements, if full compliance is not yet possible, should be evaluated on a case-by-case basis. Compatibility with state waste management priorities is part of this criterion, as is compliance with NEPA. The level of uncertainty associated with regulatory compliance is also a factor that affects the ability to measure this criterion.

5.3 RECOMMENDATIONS FOR PHASE II OUTREACH ACTIVITIES

The usefulness of these criteria will only be demonstrated when they are actually applied to a set of cleanup technologies. That is the objective of Phase II of the institutional assessment task. It is suggested that a series of small working sessions be conducted, bringing in representatives of the stakeholder groups as well as program personnel with technical resource capabilities. Hypothetical application of the recommended criteria to several sample technologies will allow consideration of each criterion's usefulness in terms of measurability, availability of data, uniqueness, and other factors. This will also provide a good setting for determining participants' more considered perspectives on the relative importance of the evaluation criteria.

The results of the small group sessions during the workshops confirmed that a small, focused group can best grasp and discuss the complex elements of evaluating cleanup technologies. Phase II outreach activities should provide valuable insights into how workable and applicable the criteria are to actual evaluation of new technologies. They will also serve as the basis for Phase III outreach, in which stakeholders with interest in other federal facilities will be involved in similar efforts.

APPENDIX A

DRAFT TECHNOLOGY EVALUATION CRITERIA
DEFINITIONS
USED FOR DISCUSSION AT WORKSHOPS

APPENDIX A

DRAFT TECHNOLOGY EVALUATION CRITERIA DEFINITIONS USED FOR DISCUSSION AT WORKSHOPS

The following summarizes the intended meaning of each of the criteria shown in Figure 2 in the body of the report. The draft criteria and their definitions were developed based on interviews conducted during Phase I with stakeholders. These criteria definitions were used as the basis for discussion at the workshops. Modifications to these definitions to reflect the workshop results are included in Section 5.

EFFECTIVENESS

Three primary criterion categories are associated with the evaluation of technology effectiveness. These include cost, time, and performance.

COST: The elements that comprise the cost criterion include startup cost, operations and maintenance cost, and total life-cycle cost. Startup cost is intended to cover reasonable developmental costs, procurement and construction costs, permitting costs, and other elements prior to starting operation, and during full-scale deployment. Operations and maintenance costs cover the elements of labor, supplies, maintenance, replacement parts, residual management, ongoing regulatory compliance, etc., for the life of the use of the technology. Total life-cycle cost considerations typically include not only startup and operation and maintenance, but also less distinctly attributable costs such as decommissioning costs, ongoing regulatory or institutional oversight, and future liability.

TIME: The elements that comprise the time criterion include the speed or rate at which the technology operates (e.g., feet per hour for a drilling technology, pounds per day for an extraction technology), time required for setup and removal, as well as the total length of time needed for a given technology or combination of technologies to achieve the given objective(s).

PERFORMANCE:

The elements that comprise the performance criterion include waste, practicality, and whether the technology functions as, or better than, it is intended. The element of waste refers to the residuals produced by the technology in accomplishing its objectives. The status of the residuals produced can be assessed, including consideration of waste mobility, volume, degree of hazard, and recycle potential. Waste treatment requirements needed to address a given technology's residuals can be assessed, and the availability of the needed treatment technology defined. The technology can also be evaluated according to the need for waste disposal, and whether such disposal capacity is available.

Practicality is defined by several criteria. It assesses whether use of a given technology will preclude or foreclose future cleanup options. It evaluates whether a technology is reliable, easy to use, available within a reasonable time, and capable of operating with the existing facility infrastructure (e.g., buildings, power sources, personnel). Versatility of the technology to address other types of contamination, in other media, or at other locations can also be assessed. A systems analysis perspective on the technology will evaluate whether it is compatible with the other elements of the remediation system. The ability to procure the technology "off the shelf", with the simplest possible development approach, is another criterion. Reducing the complexity of a technology, having it be simple, is a criterion. Finally, determining whether a technology actually works is also a consideration. For example, does a new drilling technology drill through cobbles, as it is intended, or does it fail?

OPERATIONAL ENVIRONMENTAL SAFETY AND HEALTH

There are three elements included in the category of operational environmental safety and health. They include worker safety, public health and safety, and environmental impacts. In many ways these criteria are related to the regulatory compliance standards addressed in a later category, but they also represent stand-alone objectives to be addressed by specific criteria where possible.

WORKER SAFETY:

The criteria for evaluating a technology according to its worker safety aspects include the level of exposure of workers to hazardous materials or other hazards resulting from use of the technology, the physical requirements of developing and operating the technology, and the number of workers required.

PUBLIC HEALTH AND SAFETY:

Public health and safety aspects of a given technology can be evaluated based on the number, type and severity of accidents postulated to occur related to that technology's development, operation, and decommissioning. Off-site releases to air, ground or water pathways from a technology can be evaluated, as can the potential impacts from transportation of equipment, samples, wastes, or other materials associated with the technology.

ENVIRONMENTAL IMPACTS:

The criteria for evaluating a technology's environmental impacts include effects on the ecology of the remediation site (e.g., wildlife, vegetation, air, water, soil, people), and aesthetic impacts (e.g., visual impacts, noise). The use of natural resources in development, manufacture, or operation of the technology should be evaluated, including the energy demands of the technology.

SOCIO-POLITICAL INTERESTS

Acceptability of a technology by the range of various "publics" depends on many factors, including those described above. In addition, however, there are three categories of criteria termed socio-political interests. These include public perceptions of a technology, tribal rights associated with technology demonstration and deployment, and socioeconomic interests.

PUBLIC PERCEPTION:

The reputation of the proponent of a technology affects public perception of that technology. This may apply to a government agency, contractor firm, or private industry partner. The degree of familiarity of a technology and its use is a key factor affecting public perception of a given technology. Other

factors that have been addressed elsewhere also affect public perception, including elements such as related employment, and the overall benefit a person perceives that would result from deployment of the technology. In addition, generalized public fear and dread of hazards, high technology solutions, and government actions may be factors affecting acceptability of some technologies.

TRIBAL RIGHTS:

Native American values related to the land and its uses offer criteria for evaluating alternative cleanup technologies. The capacity for future unrestricted use of the contaminated areas, including both terrestrial and aquatic uses, is the key criterion. This relates to spiritual values as well as traditional uses (e.g., hunting, fishing, recreation, living areas).

SOCIOECONOMIC INTERESTS:

Effects of a technology or suite of technologies on the economic base of the community should be considered, including fiscal as well as less tangible impacts. Availability of the required labor force can be evaluated, as well as potential impacts on local property values.

REGULATORY OBJECTIVES

Discussions with the regulatory community as well as other stakeholders revealed several criteria related to meeting regulatory objectives for the technologies to be evaluated. These include timeliness, regulatory infrastructure and track record, and regulatory compliance.

TIMELINESS:

Evaluating the timeliness of a technology involves assessing its ability to contribute to meeting the regulatory cleanup milestones that have been established for a given site, in a timeframe and in compliance with standards that would be applied in any other remediation situation. Another element of timeliness is the availability of a technology for deployment within a timeframe that meets those regulatory and political milestones.

REGULATORY INFRASTRUCTURE/TRACK RECORD:

The experience of regulators with a specific technology or a similar technology may result in the regulators being predisposed to find the technology acceptable. Furthermore, if a regulatory agency has experience with a type of technology, it can be expected that regulatory uncertainty about that technology will be reduced.

REGULATORY COMPLIANCE:

The ability of a technology or suite of technologies to achieve regulatory cleanup standards, as well as ongoing protection of public and worker health and safety and the environment, can be evaluated. Compatibility with state waste management priorities is part of this criterion, as is compliance with NEPA. The level of uncertainty associated with regulatory compliance is also a factor.