INTRODUCING NEW TECHNOLOGIES INTO TODAY'S CLEANUP ARENA

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ABSTRACT

The introduction of new technologies into the environmental cleanup arena has proven to be time-consuming, expensive, and encumbered by many institutional, regulatory, and technical obstacles. Therefore, cleanup contractors and regulators have tended to rely on established, historically proven technologies even though more effective approaches are needed. This paper addresses some of the key issues facing industry and the federal agencies in their attempts to use new technologies to meet expanding environmental management needs.

INTRODUCTION

The United States' enormous cleanup efforts must be accomplished within a rapidly expanding regulatory scheme, an advancing technology baseline, increasing public pressure, and a heightened awareness that significant progress must be made in cleaning up past contamination and minimizing future waste releases. Waste site cleanups must be accomplished by applying both new, innovative technologies and existing technologies. However, the need to conduct more site cleanups in a shorter amount of time does not appear to be promoting the adaptation of newer technologies. The current regulatory schemes often "force" the selection of established, historically-proven technologies. The challenge facing technology developers is to introduce new technologies more rapidly and efficiently to meet both near- and long-term waste management needs.

New technologies are one element in the campaign to decrease cleanup costs and accelerate successful site remediation. New technologies must be developed that take into consideration multiple contaminants, a variety of onsite environmental conditions, and complex regulations. In developing new technologies and selecting technologies for cleanup, four factors appear to account for over 90% of cleanup costs: waste volume excavated, waste site complexity, cleanup technology sophistication, and waste complexity (1). These are prime targets for new technology applications. For example, new in situ bioremediation or soil washing technologies could significantly reduce the volume of excavated waste--the leading cost factor in site cleanup.

While the need for new technologies is recognized, the market for new technologies remains unspecified because a central source of technology cost and performance information does not exist. There has been considerable discussion over the last 2 years about performing site remediation "faster, cheaper, and better" at DOE sites but no one has directly addressed the question "faster, cheaper, and better than what?"

Assessments to clearly define the nature and type of cleanup problems that can be addressed using existing technologies should be performed and compiled. These evaluations would form the basis for targeting new technology development dollars.

This paper addresses some of the key factors that have impeded the introduction of new technologies into the cleanup market such as an uncertain regulatory arena, performance standards, financial liability, and investment incentives.

BACKGROUND

In the mid-1980s, the Environmental Protection Agency (EPA) estimated that the average cost of a remedial cleanup was approximately $7 million. By the late 1980s, this figure had risen to $25 to $30 million per cleanup (2, p. 179). However, cleanup costs can vary significantly from just a few hundred thousand dollars for sites where wastes remain contained (e.g., in drums) to $50 to $100 million for sites where wastes have been released and populations and/or the environment are at risk. Cleanup costs of $100 million per site are becoming more common. Some site cleanup costs are even approaching the $1 billion mark (3). For example, approximately 3,500 waste sites exist within the responsibility of the nine major Department of Energy (DOE) field offices. Many of these sites contain mixtures of hazardous and radioactive wastes. It is estimated that the DOE will spend about $100 billion to cleanup its waste sites over the next 30 years (3). Similarly, the Department of Defense is projecting a cleanup cost of $50 billion for its facilities. Costs have increased because of the shift from temporary remedies such as containment and landfilling to more permanent solutions such as thermal destruction. Other factors in the skyrocketing cleanup costs include facing tougher contamination problems (such as those that exist at major industrial and federal sites where multiple contaminants are spread over large areas) and meeting increasingly restrictive cleanup standards.

Nationally, some 30,000 private and government-owned waste sites exist (4). Many of them will require onsite investigations to assess their existing or potential risks. Such studies will guide the selection of technologies that can most effectively remediate the sites.

While more waste sites are being discovered, the public and legislative bodies are growing increasingly impatient with the slow pace of environmental cleanups. Congress appropriated $1.6 billion in 1980 and an additional $8.5

billion in 1986 for cleaning up Superfund sites; however, only about 4% of the nearly 1200 waste sites on the National Priorities List (NPL) have been remediated as of March 1990 (4). While Congress appropriated $1.6 billion for the program's first 5 years, Superfund now spends that amount each year--and this budget outlay does not include cleanup costs incurred by other federal, state, and private responsible parties. Progress is slow and costly.

NEW TECHNOLOGIES

New technologies are those not commonly used for waste site cleanup. Creative adaptations of existing technologies and development of innovative technologies are also considered to be new technologies. Included are treatment processes that are established but are simply not in common use or that have not been proven for given waste forms or mixtures, new environmental conditions, or more restrictive performance standards.

The incorporation of new technologies into the portfolio of proven and accepted cleanup technologies has proven to be time-consuming, expensive, and encumbered by major regulatory, institutional, and technical obstacles. There are significant time delays between the research (basic and applied), development (bench and pilot scale), demonstration (to determine effectiveness and reliability), and full-scale implementation of technologies that make it "virtually impossible to get a new technology accepted in any reasonable time" (5). As stated in a Tufts University study on troublesome hazardous waste management issues (6):

> "...Technologies (innovative) often have not had the opportunity to be proven effective on a commercial scale or have not been used for specific applications at hazardous waste sites. Limited data on cost and operational history has resulted in screening out innovative technologies early in the evaluation process. Because of the liability for damages resulting from failure of the technologies, contractors, potentially responsible parties, and government alike are reluctant to recommend the use of innovative technologies that have not been fully demonstrated to remedy hazardous waste problems."

These uncertainties tend to increase reliance on older, traditional technologies rather than risk missing cleanup deadlines or remedial action goals using new technologies that could perform cleanups faster, cheaper, or better. There appear to be more penalties than rewards for searching for new, better cleanup solutions (2, p. 177).

The tendency to rely upon existing technologies is compounded by a somewhat adversarial relationship between regulators and industry. The perception is that the regulators want to keep new technologies out of the market while industry wants to avoid meeting environmental standards (7). Perhaps the real distinction is between a conservative regulatory community cautiously approaching cleanup standards and industry's desire to accelerate the introduction of innovative technologies into the marketplace.

Responsible parties are concerned about the long-term effectiveness of innovative technologies and their potential liability should the technologies not perform as predicted. They also worry about the liability that may develop when today's "acceptable" work is judged against tomorrow's standards; this concern seems especially valid considering the liability companies are incurring today for waste management activities that were considered acceptable practice in the past.

So herein lies a major dilemma--few companies can afford the risk of trying new cleanup technologies, yet technologies cannot mature (achieve commercial status) without use and, yes, sometimes failure.

SITE PROGRAM

In 1985, the EPA established the Superfund Innovative Technology Evaluation (SITE) Program to encourage the development, demonstration, and potential commercial use of alternative treatment technologies. This program provides a mechanism for the federal government and private industry to jointly evaluate and demonstrate treatment technologies. By establishing the program, the EPA was to help businesses work through the diverse informational, regulatory, legal, and financial impediments that block the introduction and acceptance of new technologies. The program was intended to mitigate these impediments and provide objective performance and cost data for technologies at or near commercialization.

While successful participation in SITE can greatly add to a technology's visibility, the program has had mixed results. Examples of concerns center on

- public statements by industries about the effectiveness of technologies despite an apparent lack of scientific/engineering data and successful operations to support such claims (2, p. 182)
- failure to focus on truly innovative technologies; some technologies examined were already commercially available or were just variations of established commercial techniques (2, p. 183)
- companies' potential loss of proprietary information (by sharing propriety details) thus possibly compromising or losing rights to the technology
- conflict of interest; treatability studies are performed by Superfund contractors rather than innovative technology developers who are less subject to the pressures of re-opening Superfund's Records of Decisions (RODs)

- the tradeoff between supporting the administrative burden of SITE participation and encouraging the positive publicity and increased regulatory comfort with the technology
- lack of firm cost and performance data on developing technologies.

MAJOR BARRIERS TO NEW TECHNOLOGIES

Perhaps the limited success of the SITE program is based on more fundamental regulatory and institutional concerns than those noted above. Some of these key issues are discussed below.

INFORMATION TRANSFER AND COMMUNICATION

While the development and selection of new technologies are key to making cleanup programs work more efficiently, no centralized source of technology information exists to capture the expanding knowledge base. New vendors are entering the market but wide dissemination of supportive scientific information for their technologies and the unbiased scrutiny of new technology performance claims remain poorly organized.

The information problem is compounded by the legitimate need for confidentiality by companies with financial interests in their technologies. Information released to the government or Superfund contractors who are potential competitors could result in the loss of exclusive patent rights.

With the increasing number of technologies coming into the marketplace, the possible combinations of varied technologies into treatment trains are also increasing. Capturing the experience of applying individual or combined technologies is critical to maturing and learning from our own experiences. Presently, many cleanup contractors rely upon their own internal experience when estimating a technology's cost and performance. Sources of unbiased, scientifically defensible, information for new technologies or the innovative use of existing technologies do not exist. As a result, contractors are forced to use traditional cleanup approaches or develop duplicate performance information that exists somewhere else in the industry, but is unknown to the contractor.

REGULATORY AND PERMITTING BARRIERS

The technology development process is closely tied to major regulatory developments that dictate how clean is clean and determine the timing of such actions as land disposal restrictions, incineration standards, and other waste release or handling restrictions. This regulatory information is used to guide the development of technologies to meet today's regulatory requirements. Therefore, a principal driver of new technology development is a determination of whether there is a regulatory standard that must be met and whether that standard will be enforced.

The regulatory arena is viewed as fragmented because of the different compliance standards or enforcement levels between states and localities (8) and the uncertainty associated with tomorrow's regulatory requirements. These concerns are barriers to new technology development because developers are uncertain about the extent to which cleanup standards will be enforced as well as whether or not the regulatory requirements will change before the technology is commercialized.

Permitting

The need for federal and/or state permits for conducting onsite cleanup activities is also an issue for technology developers. (This is not to be confused with offsite Resource Conservation and Recovery Act [RCRA] permitting requirements for treatment, storage, and disposal facilities.) Permitting requirements can significantly increase the cost and time needed to bring new technologies on line. This is particularly true for technologies with little historical performance data. There is also no assurance that a new technology will receive a permit even if considerable time and money have been spent on it. This uncertainty tends to destroy economic incentives for supporting a technology's development and discourages potential investors and corporate users.

Innovative technologies need to meet the same substantive standards as permanent, proven treatment facilities; however they should not be subject to the same permitting process. For new, innovative technologies with little potential for creating a safety or environmental discharge problem, exemption from the RCRA permitting process or a flexible permitting process is appropriate. For technologies with a higher potential for unacceptable waste releases, a permitting process might be imposed that is more extensive than the process used for technologies with few safety or environmental hazards yet less restrictive than the process required for a permanent facility.

Permits for new technologies are examined by regulators who are also dedicated to reviewing and approving RCRA permits for stationary treatment, storage, and disposal units. New technology permits are therefore not given a high priority. Thus, the development of new technologies requires increased regulatory attention for field verification of operational efficiency and compliance with permit requirements.

By law, experimental technologies used onsite under the jurisdiction of the Superfund program must meet substantive environmental standards but do not require federal, state, or local permits. On the other hand, offsite treatment may be subject to RCRA and other federal, state,

or local environmental permits. Permitting may be complicated by the fact regulatory standards do not exist for permitting cleanup technologies. A corollary issue is the issuance of permits for mobile treatment units. Such units are being increasingly looked upon to reduce the cost, time, environmental risk, and transportation difficulties associated with site cleanups especially those involving offsite treatment or disposal (6).

Thus, technology developers are encumbered by a complex array of multijurisdictional permitting requirements, including the following examples (9):

1. RCRA Permitting

   RCRA permitting is designed to ensure the proper handling, treatment, storage, and disposal of hazardous waste. RCRA permit rules were established with long-term waste management units in mind. However, innovative technologies are scrutinized repeatedly before reaching commercial use--and once they are available, they are sometimes mobile rather than stationary. The statutory provisions of the Hazardous and Solid Waste Amendments (HWSA) shed little light on the permitting requirements for new technologies.

2. Federal, State, and Local Non-RCRA Permits

   Technology developers must deal with an array of diverse multijurisdictional permitting requirements beyond those established under RCRA. Such requirements vary among states and localities. Developers must accommodate duplication, conflict, and inconsistency between jurisdictions, resulting in delays to develop and demonstrate new technologies. Permitting problems also appear to be highly variable, reflecting such factors as unique site contamination and physical characteristics, treatment technology design, public concerns, regulator familiarity with the proposed technology, and legal and institutional controls pertinent to each waste site.

3. Research, Development, and Demonstration (RD&D) Permits

   The final codification rule implementing HSWA included RD&D permitting. The EPA has issued Office of Solid Waste and Emergency Response (OSWER) Directive 9527.00-1A (Guidance Manual for Research, Development, and Demonstration Permits Under 40 CFR Section 270.65). This guidance outlines the substantive requirements and administrative procedures for permitting. RD&D permits are limited to 1 year but can be renewed three times. They are designed to expedite the permitting process in several ways without compromising health or environmental protection. A state may not issue RD&D permits until it requests and receives authority from the EPA. However, even if the EPA issues a permit, the state or local authority may impose additional and more stringent requirements. In addition, the RCRA RD&D permitting process is still unproven and not consistently applied.

   Technology developers foresee problems. The most significant issue is one of delays. Permitting may add a year or more to the schedule for testing new technologies with major design adjustments (resulting from the need for experimentation and learning from experience) possibly requiring several permit modifications. Such delays not only postpone the introduction of new technologies, but also lengthen an already multiyear cleanup process when such studies are undertaken as part of supportive treatability studies. In addition, developers contend that permit reviewers sometimes require substantial permit documentation--approaching that required for Part B permits.

4. Mobile Treatment Permits

   Mobile Treatment Units (MTUs) may play a significant role in the future management of hazardous waste sites (10). They have the economy of limited time onsite and minimal operational costs compared with traditional offsite, stationary facilities. However, in the past, MTU operators have been required to fully comply with RCRA interim status or Part B permitting requirements. A permit was required for each MTU operation. Each time an MTU was moved, it obtained a new RCRA permit, which triggered public notice and permitting processes. This process significantly reduced the incentive for using MTUs. An option being examined is one-time permitting of a MTU by the EPA (or state) rather than repeating the entire permitting process each time the unit is moved between waste sites. Uncertainties over time limitations and revisitation constraints for MTUs to remain onsite are regulatory hurdles that must still be overcome.

Waste Delisting Criteria

Under RCRA, the EPA has listed a number of wastes as hazardous. The EPA has also established criteria and procedures for facility-specific delisting of waste streams. Residues from treatment of listed hazardous wastes are considered hazardous and must be managed as such until they are determined to be nonhazardous (i.e., delisted).

Delisting requires RCRA proposed and final rulemaking. EPA has estimated that processing a delisting petition should take an average of 18 months (9). Such delisting applies to specific waste streams and treatment residues. Thus, a delisting petitioner would be required to go through

a time-consuming delisting procedure for every waste stream.

Technology developers are generally unfamiliar with delisting and are concerned about their ability to assure clients that a given innovative technology will produce delisted waste.

The EPA is working on alternative approaches to delisting waste residues. Where waste data are not yet available (e.g., from a new technology), the applicant would be required to submit a variety of information that the regulators would use to set delisting levels and sampling/analysis requirements. Public comment and a final evaluation would follow. Again, this process takes time and generally works against the rapid development and deployment of new technologies.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) INVOLVEMENT

To what extent do NEPA requirements or their DOE equivalents apply to the demonstration and testing of new technologies? NEPA requires preparation of a detailed statement for every major federal action that may significantly affect the quality of the human environment. Some states also have statues patterned after NEPA. Potential documentation needs span the full spectrum from simple environmental evaluation checklists to environmental assessments and full-scope environmental impact statements (EISs).

An outstanding issue at DOE facilities is how to effectively interface NEPA procedural requirements linking the DOE complex-wide programmatic EIS, site specific EISs, waste-site NEPA documentation, and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. Similarly, the development of some site cleanup technologies (e.g., treatment of single-shell tank wastes at the Hanford Site) will require NEPA determinations and commensurate public participation.

PERFORMANCE STANDARDS

Technology developers desire more definitive technology-based cleanup standards to guide decisions on where to invest their research and development dollars. For many, the RCRA Subpart X regulations that address alternative technologies by setting standards for miscellaneous cleanup units are too vague (9). On the other hand, the EPA has avoided setting specific technology standards because of their concern that such standards might preclude permitting new technology for which no standard has been set.

Also, EPA's implementation of the Superfund process has included many different cleanup levels for essentially the same types of sites; as a result, responsible parties can point to the least stringent cleanup as a precedent for providing effective environmental protection (2, p. 174). So what are the performance standard targets for new technologies? Why is there confusion? The Office of Technology Assessment (2, p. 175) suggests several reasons:

- use of different information bases for recommending cleanup levels and technology performance standards
- use of different technical criteria and analysis structures in the feasibility portion of the remedial investigation/feasibility study (RI/FS) process--often, the technology selection process is either superficial and qualitative or information does not provide clear distinctions between cleanup alternatives
- variable and inconsistent interpretations of statutory language-- for example, little progress has been made on clarifying the meaning of such terms as permanence, toxicity reduction, cost-effectiveness, or treatment. For that matter, the qualitative language of EPA's nine selection criteria can be used to support a wide range of treatment decisions and preferences
- regulatory emphasis on milestone and report completions rather than identification and/or development of treatment technologies to achieve site cleanup goals or meet given performance standards.

FINANCIAL LIABILITY

Another major issue is liability coverage for damages that result from the failure of technologies to perform as expected. Without well-documented cost information and operational history, contractors are reluctant to recommend, let alone apply, an innovative technology even when technologies are implemented prudently and responsibly. This caution has developed at a time when large environmental-damage lawsuits have led many insurance companies to stop writing liability policies for hazardous waste--or at least to raise premiums and limit coverage (11).

Technology developers cite the unavailability of environmental impairment insurance and inadequate contractor indemnification as a major impediment to new technology development. Liability concerns cause firms to carefully select cleanup technologies--and to rely on proven technologies even if they are less effective or more costly (8). Some believe that over the 10 years since Superfund was enacted, the liability system has not proven to be effective in the environmental cleanup arena (12).

Because of the liability concerns, smaller firms with less financial strength are unable to meaningfully participate in the technology development market. Larger firms can better afford insurance or assume the financial responsibility themselves. In general, increased knowledge about site characterization is sought to offset the chance of encountering unknown subsurface conditions or technology perfor-

mance. This need for increased knowledge serves to further increase the cost and time associated with demonstration and deployment of new technology.

In the past, contractors could receive indemnification from the EPA against claims brought for negligent liability (13). However, indemnification did not apply to RCRA permits nor does it preempt state laws that could hold contractors liable under a strict, joint, and several liability standard (i.e., not requiring determination of fault). A contractor could be required to pay full damages when responsible for only a limited percentage of a pollutant's release if an innovative technology releases unacceptable pollutant levels or if it does not meet agreed-to performance standards.

The EPA is working on this issue and has recently approved a cleanup liability insurance policy covering work performed at Superfund sites (14). EPA is working toward having contractors take out commercially available insurance to cover the risk of lawsuits for contract-wide (e.g., Alternative Remedial Contracting Strategy) work activities. Until recently, the EPA released contractors from responsibility (excluding negligent liability) because pollution liability was not available. Because the EPA contends that insurance is now available, contractor indemnification is contingent upon the firm having made an attempt to find insurance. EPA requires that firms provide quotes they have obtained for insurance or evidence that insurance was sought without success. The success of this new policy to encourage technology development is uncertain.

In addition, competitive procurement of supplies, services and construction is generally accomplished through solicitation or competitive bid processes. These processes generally require performance bonding, bid guarantees, and/or payment bonds (9). Because of the uncertainty of the cleanup market and the limited resources of small and medium-size firms, the inability to obtain bonds may prevent some companies from competing in the Superfund business.

CAPITAL INVESTMENT INCENTIVES

Capital investment support for developing a new technology is as critical to delivering a new technology as strong scientific, regulatory, and business backing. Presently, the uncertainty and roadblocks to introducing new technologies tend to undermine economic incentives for backing development investment. Even though the Federal Technology Act of 1986 called for federal agencies to forge partnerships with industry to commercialize innovative technologies (7), the rapid implementation and common acceptance of new cleanup technologies is difficult.

The difficulties in acquiring financial support for new technologies include (8):

- poor understanding of risk inherent in technology development
- unrealistic expectations for levels of investment return
- uncertainty over financial commitments needed to develop and commercialize technology
- inadequate understanding of potential financial liabilities and regulatory difficulties in having a technology accepted
- uncertainty about what the real technology development market is and how to obtain support services for developmental stages.

CONCLUSIONS

Traditional technology approaches are being used for waste site cleanup and hazardous waste treatment under increasingly stringent cleanup standards and stricter regulatory controls. Development and deployment of innovative technologies are impeded by the type of obstacles addressed in this paper. If innovative approaches to environmental management needs are to be available over the next several years, these obstacles must be overcome in a timely fashion.

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