CERCLA Remedy Selection: Abandoning the Quick Fix Mentality

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INTRODUCTION

With images of the Love Canal chemical nightmare fresh in the nation's mind, Congress hastily enacted the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)\(^1\) in the final days of the Carter Administration.\(^2\) With this statute, Congress intended to establish a program that would deal expeditiously with the perceived national hazardous waste emergency and force those responsible for the problem to pay for the cleanup. However, it is unlikely that anyone foresaw the magnitude of the hazardous waste contamination problem or the difficulty of cleaning it up. Today, there are an estimated 75,000 uncontrolled hazardous waste

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2. Many consider the Love Canal incident to be the major factor behind the enactment of CERCLA. See U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 540/8-89/007, A MANAGEMENT REVIEW OF THE SUPERFUND PROGRAM i (1989) [hereinafter A MANAGEMENT REVIEW] (stating that Superfund was "[s]peedily launched in response to such dramatic episodes as the Love Canal"); see also Keith Schneider, EPA'S SUPERFUND AT 13: STAINS ON THE WHITE HAT, N.Y. TIMES, Sept. 6, 1993, at A7 [hereinafter SUPERFUND AT 13] (CERCLA was "[s]et up in response to the public concern about widespread chemical contamination found at Love Canal.").

Love Canal was an abandoned hydroelectric channel located in Niagara Falls, New York. Between 1942 and 1953, the Hooker Chemical Company filled Love Canal with more than 21,000 tons of chemical waste. In 1953, Hooker covered the waste with clay and other soils, and sold the property to the Niagara Falls Board of Education for $1. A school and playground were built on the site, and the surrounding area was residentially developed. In the years that followed, residents noticed foul odors after heavy rains, but attributed these odors to nearby industry. After increased precipitation in the early 1970s raised groundwater levels, thick, black, oily sludges seeped into basements of homes and accumulated on the surface. In August 1978, New York's Health Commissioner declared a public health emergency based on groundwater and epidemiological studies. OFFICE OF PUBLIC HEALTH, NEW YORK STATE DEP'T OF HEALTH, LOVE CANAL: A SPECIAL REPORT TO THE GOVERNOR AND LEGISLATURE 4-7 (1981). The media descended on Love Canal, broadcasting images of a middle class community mired in a toxic waste swamp. For a comprehensive history of the Love Canal incident, see ADELINE G. LEVINE, LOVE CANAL: SCIENCE, POLITICS AND PEOPLE (1982).
sites in the United States.\textsuperscript{3} The total cost to remediate all of these contaminated sites could reach as high as $1 trillion.\textsuperscript{4}

CERCLA utilizes a variety of tools to obtain funding for cleaning up hazardous waste sites. The Superfund\textsuperscript{5} was created in part by imposing taxes on corporations with taxable incomes in excess of $2 million,\textsuperscript{6} and on chemical feedstock and petroleum products.\textsuperscript{7} The Environmental Protection Agency (EPA), entrusted with implementing CERCLA, can use Superfund money to clean up sites and later seek reimbursement from liable parties through a cost recovery action.\textsuperscript{8} Moreover, CERCLA casts a wide net of liability. Potentially liable parties include current owners and operators of a facility, past owners and operators who owned and operated a facility at the time of hazardous waste disposal, parties who transported hazardous waste to a facility, and generators of hazardous waste who sent any of their waste to a facility.\textsuperscript{9} Parties found liable are strictly, jointly, and severally liable for cleanup.\textsuperscript{10}

Hazardous waste cleanup under CERCLA is very expensive. To date, an estimated $30 billion has been spent under CERCLA to clean up hazardous waste sites.\textsuperscript{11} Of the contribution provided by private

\begin{itemize}
  \item \textsuperscript{3} Philip H. Abelson, \textit{Remediation of Hazardous Waste Sites}, 255 Sci. 901, 901 (1992). By uncontrolled hazardous waste site, we mean a site where hazardous waste has been purposefully or accidentally released into an area where there are no engineering controls to contain the hazardous waste in compliance with the Resource Conservation and Recovery Act (RCRA). \textit{See} 42 U.S.C. \textsection 6924 (1988 & Supp. IV 1992) (establishing standards for hazardous waste disposal facilities).
  \item \textsuperscript{4} \textit{See} Abelson, supra note 3, at 901.
  \item \textsuperscript{5} 42 U.S.C. \textsections 9604, 9611 (1988).
  \item \textsuperscript{7} Id. \textsections 4611, 4661, 4671, 9507.
  \item \textsuperscript{8} 42 U.S.C. \textsections 9604, 9607, 9611. Alternatively, EPA can issue an administrative order to a responsible party requiring them to fund a private cleanup of a contaminated site. \textit{Id.} \textsection 9606; New York v. Shore Realty Corp., 759 F.2d 1032, 1041 (2d Cir. 1985).
  \item \textsuperscript{9} 42 U.S.C. \textsection 9607. CERCLA defines facility broadly to include any place where hazardous substances come to be located. \textit{Id.} \textsection 9601(9). A release is defined as “any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment.” \textit{Id.} \textsection 9601(22).
  \item \textsuperscript{10} United States v. Chem-Dyne Corp., 572 F. Supp. 802, 808-10 (S.D. Ohio 1983) (establishing a uniform federal rule allowing imposition of strict, joint, and several liability in appropriate CERCLA cases). The legislative history of the 1986 Superfund Amendments and Reauthorization Act (SARA) explicitly supported the \textit{Chem-Dyne} court’s imposition of joint and several CERCLA liability. \textit{Id.} at 805 (citing 126 \textit{CONG. REC.} S14,964 (daily ed. Nov. 24, 1980) and 126 \textit{CONG. REC.} H11,787 (daily ed. Dec. 3, 1980)). Courts impose joint and several CERCLA liability where harm is indivisible, following the \textit{Chem-Dyne} standard. \textit{See} O’Neil v. Picillo, 883 F.2d 176, 178 (1st Cir. 1989). Thus, CERCLA has altered fundamental concepts of liability to facilitate rapid cleanup of hazardous waste dump sites.
  \item \textsuperscript{11} Superfund Program (Part I): \textit{Hearings Before the Subcomm. on Transp. and Hazardous Materials of the House Comm. on Energy and Com.}, 103d Cong., 1st Sess. 470, 479-80 (1993) (statement of Carol M. Browner, Administrator, EPA) [hereinafter \textit{Browner Statement}]. Roughly $10.4 billion has been allocated to the Superfund program from
parties, an estimated 25% to 27% has been spent on transaction and litigation costs. In 1993-94, CERCLA cleanup will consume more than one-quarter of the federal environmental budget of $38 billion.

Despite Congress' intention to facilitate a rapid solution to the hazardous waste contamination problem, and despite the allocation of significant resources to accomplish this task, few sites have been cleaned up relative to the number of identified sites. Of the approximately 1200 sites currently on the Environmental Protection Agency's (EPA's) National Priorities List, remedial construction has been completed at only slightly more than 200 sites.

Most criticism of CERCLA has focused on its liability scheme, although this is only one aspect of CERCLA. The liability scheme has engendered strong criticism for many reasons, but particularly because the process of apportioning liability among large numbers of potentially responsible parties (PRPs) is an expensive and time consuming process. Despite this criticism, Congress is unlikely to radically overhaul CERCLA's liability scheme. Unfortunately, even with an altered liability scheme, CERCLA's problems would not be solved. We believe the remedy selection process has more to do with

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Superfund tax revenues. Id. Of this $10.4 billion, $7.1 billion has actually been spent. Id. Private responsible parties have contributed another $7.4 billion toward cleanups. Id. Finally, the Department of Defense and the Department of Energy have spent about $10 billion cleaning up contamination on sites that they operate. Id.

12. LLOYD S. DIXON, RAND CORP., PRIVATE-SECTOR CLEANUP EXPENDITURES AND TRANSACTION COSTS AT 18 SUPERFUND SITES xv (1993). Thus, approximately $1.8 to $2.0 billion has been spent on transaction costs. However, the remaining $5.4 to $5.6 billion contributed by private parties has been spent on cleanup activities. Id.


17. Id. at 1, 32; see DIXON, supra note 12, at xv (estimating that transaction costs, the majority of which are litigation expenses, account for 25% to 27% of the potentially responsible parties' expenditures necessary to clean up a Superfund site).

18. The Clinton Administration supports continuation of the current liability scheme. See Browner Statement, supra note 11, at 472, 475; Raymond B. Ludwiszewski, Superfund Liability at Issue, NAT'L L.J., June 14, 1993, at 29, 34-35 (stating that EPA resists a change to the liability scheme, but may support technical changes to clarify the issues of lender liability and municipal liability). It would be difficult politically to eliminate the liability scheme. The public seems to like the "polluter pays" principle that is roughly the basis of the liability scheme. See 132 CONG. REC. H9610 (daily ed. Oct. 8, 1986) (statement of Rep. Schneider). Further, powerful national environmental groups would probably not allow elimination of the liability scheme without a vigorous fight. These groups would likely portray any bill proposing an alternative financing scheme as backtracking on polluters' responsibility.
EPA’s difficulty in concluding hazardous waste cleanup projects than the cost recovery scheme. Thus, we avoid focusing on who should pay for cleanup, and instead tackle the difficult issue of how EPA can more effectively clean up contaminated sites.

Cleaning up contaminated sites is a complex, expensive, and elusive task not amenable to quick fixes. Over the past fourteen years of CERCLA cleanup experience, EPA and cleanup contractors have discovered that hazardous waste contamination in the subsurface environment is incredibly complex. Superfund sites often have intricate, heterogeneous geologic features, making it difficult to predict the movement of contaminants in the subsurface. Further, Superfund cleanups are very expensive, with the average cleanup estimate around $32 million. Regulators often cannot accurately predict cleanup costs because they are unsure of the efficacy of the designed remedy. In fact, particular cleanup goals themselves may be beyond our current technological capabilities.

We believe that CERCLA should be reevaluated and adjusted in light of what is now known about the limitations and expense of hazardous waste remediation technology. EPA must be directed to select efficient and effective remedies for the largest number of sites possible. With CERCLA reauthorization pending, this comment provides suggestions for improving CERCLA’s remedy selection process.

We suggest that CERCLA should be amended to incorporate five basic improvements. First, the lead agency should tailor remedies to the most appropriate subsequent use of the site. Second, spending limits should be established to cap the amount we are willing to spend to fully remediate a site. Third, a minimum level of treatment should

19. DIXON, supra note 12, at xiv.

20. See infra part III.B. CERCLA is premised on a quick fix to hazardous waste contamination, and thus has created the false perception that current technology is capable of cleaning up all of our hazardous waste problems. Such expectations were illustrated when Rep. Hancock of Missouri asked an EPA official whether “we ever say, ‘okay this job is done and that’s it’ . . . I mean . . . why can’t we say ‘okay this is what it is going to cost,’ and then once you get through, why can’t we quit spending money on [the sites]?” Sussman Statement, supra note 14, at 65.

21. Along with other parties, the Clinton Administration has proposed major revisions to CERCLA. See Summaries of Clinton Administration Proposal for Superfund Reform, Daily Rep. for Executives (BNA) No. 23, at M-2 (Feb. 4, 1994), available in LEXIS, Nexis Library, NWLTRS File, at 1 [hereinafter Clinton Summaries]; H.R. 3800, 103d Cong., 2d Sess. (1994); S. 1834, 103d Cong., 2d Sess. (1994). As this comment was going to press, the clock ran out on Superfund reauthorization in 1994. Reform Efforts Pronounced Dead; Amendments Threatened Compromise, Nat’l Env’t Daily (BNA) (Oct. 6, 1994), available in LEXIS, BNA Library, BNAED File. However, the Clinton Administration is committed to reintroducing the reform bill to the 104th Congress. Id. During the interim, the current Superfund program will remain in effect as the House attached provisions to extend the reauthorization period to the EPA appropriations bill. Id.

We discuss the Clinton proposal in the last section of the comment along with our proposals. See infra part IV.
be established for all sites. Fourth, responsible parties should pay a fee proportional to the amount of contaminants remaining on site after remediation. This fee should be used to pay for research and development of new remediation technologies. Finally, EPA should be required to establish a systematic national site identification program in cooperation with the states.

To begin the process of evaluating the CERCLA remedy selection process, Part I of this paper describes the statutory provisions addressing remedy selection. To provide a sufficient basis for understanding and criticizing the remedy selection process, Part II presents a comprehensive overview of EPA's remedy selection program. Based on this overview, Part III provides some criticism of the remedy selection process, focusing on risk assessment, groundwater remediation technical issues, case-by-case discretion, and uncontrolled hazardous waste sites neglected by EPA. Section IV concludes with an exploration of our specific recommendations on how to reduce the risks posed by hazardous waste contamination more effectively.

1 THE STATUTORY PROVISIONS

CERCLA includes a number of provisions intended to guide EPA in cleaning up hazardous waste contaminated sites. Some of these provisions were included in the original CERCLA statute, while others were added by the 1986 Superfund Amendments and Reauthorization Act (SARA).22

A. Original Statutory Provisions

The original CERCLA legislation gave EPA significant powers to address hazardous waste emergencies. For example, EPA has the power to order private parties to abate actual or threatened release of hazardous substances that pose an imminent and substantial threat to human health or the environment, or to require the Department of Justice to seek injunctive relief.23 Alternatively, EPA is empowered to abate directly such an emergency and later seek reimbursement from responsible parties.24

EPA was also directed to revise the already existing National Oil and Hazardous Substances Pollution Contingency Plan (NCP) "to reflect and effectuate the responsibilities and powers created" by

24. Id. § 9604(a).
CERCLA. EPA was specifically required to include a new section of the NCP that "establishes procedures and standards for responding to releases of hazardous substances, pollutants and contaminants." Congress required EPA to include the following elements in this new section of the NCP:

1. methods for discovering and investigating facilities at which hazardous substances have been disposed of or otherwise come to be located;
2. methods for evaluating, including analyses of relative cost, and remediating any releases or threats of releases from facilities which pose substantial danger to the public health or the environment;
3. methods and criteria for determining the appropriate extent of removal, remedy, and other measures authorized by [CERCLA]; . . . [and]
4. means of assuring that remedial action measures are cost-effective over the period of potential exposure to the hazardous substances or contaminated materials . . ..

In addition, CERCLA required EPA to develop criteria for setting priorities among sites with hazardous waste problems throughout the country. Based on these criteria, EPA established a National Priorities List (NPL) of contaminated sites.

These minimal remedy selection provisions in the original CERCLA statute proved to be ambiguous, leaving EPA with virtually uncontrolled discretion. Under the Reagan Administration, former EPA Administrator Anne Burford used this discretion to stall CERCLA's implementation. In response to this recalcitrance and the resulting public outcry, Congress passed the Superfund Amendments and Reauthorization Act in 1986.

B. SARA Provisions

SARA addressed remedy selection in a number of provisions. First, SARA directed EPA to revise the national ranking system for the NPL to "assure, to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to

25. Id. § 9605(a). For federally incurred cleanup costs to be recoverable from responsible parties under the liability provisions, the costs must not be inconsistent with the NCP. Id. § 9607(a)(4)(A). For privately incurred cleanup costs to be recoverable, the costs must be consistent with the NCP. Id. § 9607(a)(4)(B).
26. Id. § 9605(a).
27. Id. § 9605(a)(1)-(3), (7).
28. Id. § 9605(a)(8)(A).
29. Id. § 9605(a)(8)(B).
31. Id. at 878-82.
32. See id. at 880.
human health and the environment posed by sites and facilities subject to review.\textsuperscript{34} EPA was directed to assess the health risks associated with the contamination or potential contamination of surface water that is or could be used for recreation, or potable water consumption.\textsuperscript{35}

SARA also added section 121,\textsuperscript{36} containing specific provisions to address hazardous waste cleanup. Unfortunately, these new provisions are subject to a variety of interpretations and provide little specific guidance in determining cleanup standards. Some of the section 121 directives for EPA's use in selecting site-specific remedies are internally inconsistent. For example, section 121(a) provides that EPA should choose cost effective remedies.\textsuperscript{37} Yet at the same time, section 121 establishes a statutory preference for expensive remedial alternatives that treat hazardous wastes to permanently and significantly reduce volume.\textsuperscript{38} EPA is also directed to disfavor alternatives that include offsite transport and disposal of untreated hazardous waste where practicable treatment technologies are available.\textsuperscript{39} Further, EPA is required to conduct assessments, presumably at every site, of permanent solutions that permanently and significantly decrease the toxicity, mobility, or volume of the hazardous substances at a site.\textsuperscript{40} Moreover, if EPA selects a remedial action that results in hazardous substances remaining at a site, EPA must review the site every five years to ensure that the remedial action is protecting human health

\begin{itemize}
  \item \textsuperscript{34} \textit{Id.} § 9605(c)(1) (1988).
  \item \textsuperscript{35} \textit{Id.} § 9605(c)(2).
  \item \textsuperscript{36} \textit{Id.} § 9621 (1988 & Supp. IV 1992).
  \item \textsuperscript{37} \textit{Id.} § 9621(a) (1988). This provision goes on to say that: "In evaluating cost effectiveness of proposed alternative remedial actions, \ldots \textit{[EPA]} shall take into account the total short- and long-term costs of such actions, including the costs of operations and maintenance for the entire period during which activities will be required." \textit{Id.}
  \item \textsuperscript{38} \textit{Id.} § 9621(b)(1).
  \item \textsuperscript{39} \textit{Id.} If EPA takes a remediation action that includes a transfer of hazardous substances to another site, these substances must be taken to a facility operating in compliance with the Resource Conservation and Recovery Act, \textit{id.} §§ 6924-6925, and all applicable state requirements. \textit{Id.} § 9621(d)(3) (1988).
  \item \textsuperscript{40} \textit{Id.} § 9621(b)(1). In making such assessments of permanent solutions and alternative treatment technologies, EPA is required to consider:
    \begin{itemize}
      \item \textit{A} the long-term uncertainties associated with land disposal;
      \item \textit{B} the goals, objectives and requirements of the Solid Waste Disposal Act (42 U.S.C. §§ 6901 et seq.);
      \item \textit{C} the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents;
      \item \textit{D} short- and long-term potential for adverse health effects from human exposure;
      \item \textit{E} long-term maintenance costs;
      \item \textit{F} the potential for future remedial action costs if the alternative remedial action in question were to fail; and
      \item \textit{G} the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.
    \end{itemize}
\end{itemize}
\textit{Id.}
and the environment.\textsuperscript{41} Thus, despite the cost effectiveness provision, there is a clear statutory preference for more expensive remedies.

SARA's most significant cleanup provision requires that all remedial actions assure that human health and the environment are protected.\textsuperscript{42} This section provides that remedial actions must achieve the level of cleanup that "at least attains such legally applicable, or relevant and appropriate [state or federal] standard, requirement, criteria or limitation" for each hazardous substance found at a site.\textsuperscript{43} With this provision, commonly referred to as the ARAR mandate,\textsuperscript{44} EPA is required to look to other federal and state environmental statutes to determine the required level of cleanup.\textsuperscript{45}

SARA also added specific provisions addressing remedies for contamination of groundwater or surface water. Section 121(d)(2)(A)(ii) requires remedies for contaminated water to meet the Maximum Contaminant Level Goals (MCLGs) under the Safe Drinking Water Act and water quality criteria established by the Clean Water Act where EPA determines that such standards are relevant and appropriate.\textsuperscript{46} In determining whether any of the Clean Water Act water quality standards are relevant and appropriate, EPA must consider "the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed, and the latest information available."\textsuperscript{47} As will be discussed in part III.B, these considerations are essential to effective assessment and remediation of difficult water contamination problems.

EPA may waive the ARAR cleanup requirement for all media where EPA finds that the statutory waiver provisions apply.\textsuperscript{48} In addition, an alternative concentration limit (ACL) can be used where exposure to groundwater contamination will occur beyond the borders

\textsuperscript{41} Id. § 9621(c). These reviews must be submitted to Congress. Id.
\textsuperscript{42} Id. § 9621(d)(1).
\textsuperscript{43} Id. § 9621(d)(2)(A)(ii).
\textsuperscript{44} ARAR is the acronym for "applicable, or relevant and appropriate . . . requirement." OFFICE OF EMERGENCY AND REMEDIAL RESPONSE, U.S. ENVTL. PROTECTION AGENCY, OSWER DIRECTIVE NO. 9234.1-01, EPA/540/G-89/006, CERCLA COMPLIANCE WITH OTHER LAWS MANUAL PART I: INTERIM FINAL xiii (1988).
\textsuperscript{45} Id. at 1-1 to 1-4.
\textsuperscript{46} 42 U.S.C. § 9621(d)(2)(A)(ii). MCLGs under the Safe Drinking Water Act are established by id. § 300g-1(a). MCLGs for various contaminants are codified at 40 C.F.R. § 141.11-.16 (1993). Water quality criteria under the Clean Water Act are set by each state pursuant to 33 U.S.C. § 1314 (1988).
\textsuperscript{47} 42 U.S.C. § 9621(d)(2)(B)(i). This provision does not address Maximum Contaminant Levels (MCLs) and MCLGs established by the Safe Drinking Water Act.
\textsuperscript{48} See 42 U.S.C. § 9621(d)(4). For a list of CERCLA waiver provisions, see infra note 257 and accompanying text.
of a particular site. These two provisions give the EPA and other lead agencies a great deal of discretion in selecting the required level of cleanup for a site. As we will discuss, this discretion is critical in the selection of a site-specific remedy.

In addition, SARA added procedural requirements to EPA's remedy selection process. Section 121(f) mandates EPA to provide for "substantial and meaningful involvement by each state in initiation, development, and selection of remedial actions to be undertaken in that state." EPA must provide opportunities for states to comment on proposed actions in the remedy selection process and to participate in negotiations with potentially responsible parties regarding the scope of remedial action. If a remedial action conducted by potentially responsible parties will not achieve ARARs, the state has automatic standing to challenge the proposed remedial action in a consent decree proceeding.

As well as increasing state participation, SARA established public participation requirements for the remedy selection process. Under section 117, EPA must publish a notice and a brief analysis of a proposed remedial action plan in a major local newspaper of general circulation. EPA also must provide the public with a reasonable opportunity to make oral or written comments regarding any proposed remedial action plan. Moreover, EPA must publish a final plan that

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49. 42 U.S.C. § 9621(b)(2)(B)(ii). Under such circumstances, SARA requires EPA to achieve ARARs for all of the water contaminants, unless: (1) there are known and projected points of entry of such groundwater into the surface water; (2) the groundwater contamination will not degrade the surface water quality upon entry or downstream; and (3) human exposure to the contaminated groundwater can be effectively precluded. Id. If these findings are made, EPA may assume that the point of human exposure will be at the known and projected points of entry into the surface water. See id. When the offsite contaminated groundwater will not degrade the quality of the surface water, EPA is not required under SARA to clean up the unused contaminated aquifers. This statutory provision, allowing for the use of these alternative concentration limits (ACLs) for groundwater, gives the site decisionmaker broad discretion in deciding how much an aquifer should be remedied. As long as the remedial action includes institutional controls that prevent exposure to the contaminated groundwater, the remedial action need only achieve a level of cleanup needed to protect the surface water. See, e.g., Donald A. Brown, EPA's Resolution of the Conflict Between Cleanup Costs and the Law in Setting Cleanup Standards Under Superfund, 15 Colum. J. Envrnl. L. 241, 292-96 (1990) (describing a site where ACLs were used to justify only minimal remediation of a highly contaminated aquifer).

50. See infra part III.C.
51. See infra parts II.B.4.c, III.C.
53. Id. § 9621(f)(1)(E).
54. See id. § 9621(f)(2)(B).
55. See id. § 9617(a), (d).
56. Id. § 9617(a)(2). To enable a community to participate in the remedy selection process to the fullest extent, EPA may make technical assistance grants to community groups affected by a CERCLA site. Id. § 9617(e). These grants can be used by the com-
CERCLA REMEDY SELECTION

includes an explanation of any significant changes to the proposed plan.57

Finally, SARA includes judicial review provisions that direct courts to limit judicial review of issues concerning the adequacy of any response taken or ordered by EPA.58 A court must uphold an EPA decision selecting a certain response action unless the objecting party can demonstrate on the administrative record that the decision was arbitrary and capricious.59 Based on this language, courts have generally refused to substitute their judgment for the expertise of EPA officials, thereby limiting judicial review to searching for procedural errors and serious omissions of substantive evidence.60

II
EPA's remedy selection process

In practice the CERCLA provisions addressing remedy selection provide little more than general goals and guidance to EPA. Actual cleanup decisions are guided by EPA regulations more than by the statute. The regulations, in turn, leave considerable discretion to the decisionmakers at each site. In this section, we provide a comprehensive overview of the regulatory framework guiding EPA's cleanup decisionmaking process. This overview will resolve common misperceptions about the cleanup process and provide background for our recommended changes to that process.

The Superfund cleanup process begins with site identification. Within nine years after the adoption of CERCLA, EPA had identified more than 31,000 sites potentially requiring cleanup and inclusion in the CERCLA Information System (CERCLIS).61 Despite this staggering number of identified sites, EPA has no comprehensive or systematic method of searching for sites.62 Thus, most of the identified

munity to hire technical experts to interpret complex information about cleanup of the contaminated site. Id. § 9617(e)(1).

57. Id. § 9617(b)-(c).
58. Id. § 9613(j)(1).
59. Id. § 9613(j)(2).
60. \textit{See In re Acushnet River & New Bedford Harbor Proceedings,} 722 F. Supp. 888, 892-93 (D. Mass. 1988) (discussing the scope and standard of review under CERCLA after SARA); \textit{United States v. Akzo Coatings of Am., Inc.}, 949 F.2d 1409, 1424 (6th Cir. 1991). However, where EPA seeks a court order under § 9606(a) forcing a potentially responsible party (PRP) to perform a selected remedy, some courts have applied de novo review to EPA's selected remedy. \textit{See United States v. Ottati & Goss}, 900 F.2d 429, 434 (1st Cir. 1990).


62. \textit{Id.} This report quotes former EPA Administrator Russell Train, who, in response to the question of how serious the hazardous waste contamination problem is, stated: "Dis-
sites have been discovered haphazardly, usually through informal contacts with local or state regulators. Although EPA officials once claimed that most sites had been identified, EPA now recognizes that there may be numerous undiscovered, abandoned hazardous waste sites. EPA's continued failure to develop a site discovery program is likely the result of an agency overburdened in addressing the already identified sites. Discovering more sites would "simply choke the system."

After a site has been identified, but before cleanup activity begins at the site, EPA must determine a lead agency to direct the cleanup. The lead agency for a privately operated Superfund site will most often be EPA, but may also be a state under contract or cooperative agreement with EPA. The designated lead agency may direct two types of cleanup actions at a site. If a site requires an immediate response, the lead agency may conduct or order a responsible party to conduct removal actions. In addition or alternatively, the lead agency may initiate remedial actions intended to be the site's final remedy. These remedial actions are intended to permanently eliminate, reduce, or control risks to human health and the environment posed by the site. Before delving into the remedial action process, it is important to review the removal action process because that is the primary means of quickly abating immediate health and safety risks at hazardous waste sites.

A. Removal Actions

If necessary to abate serious health risks or to prevent increased contamination at a site before a remedial action can be implemented, the lead agency may perform a removal action or order a responsible party to do so. Because of the emergency nature of removal actions,
they may occur at any time after site discovery, even before invoking
the complex assessment procedures leading to a listing on the NPL.71
Initiation of a removal action may be based on a site evaluation con-
ducted by the lead agency or on a petition by a person who is or may
be affected by a hazardous substance release from a site.72 An on-
scene coordinator, who is predesignated by the lead agency, directs
removal actions performed by the lead agency or by responsible
parties.73

Removal actions must be consistent with the NCP.74 Removal
actions may involve constructing physical barriers to prevent contam-
nant migration and human or animal contact,75 removing and excavat-
ing soils, drums, and other bulk containers,76 and providing an
alternative water supply.77 In determining whether certain removal
actions are appropriate, the on-scene coordinator must consider,
among other factors, whether compliance with ARARs is practicable
and the availability of other state and federal response mechanisms to
respond to a release. Further, the on-scene coordinator must evaluate
whether contaminants at a site will cause actual or threatened expo-
sure to humans, animals, or the food chain through the water supply
or surface soils.78

EPA has taken removal actions and eliminated immediate risks at
nearly 2600 sites.79 EPA contends that it has been generally effective
in addressing emergency situations at identified sites.80 While EPA
may be effectively carrying out removal actions, neither EPA nor

1980); 42 U.S.C. § 9604(a)-(b).
72. 40 C.F.R. § 300.410(b).
73. See id. §§ 300.5, .120.
74. 42 U.S.C. § 9604(a)(1).
75. Such barriers may include fencing, site security, drainage controls, stabilization or
berms, dikes or impoundments, capping of contaminated soils or sludges, and using chemi-
cals to prevent spread of the release. 40 C.F.R. § 300.415(d)(1)-(5).
76. Such actions may be used only if they reduce the spread or likelihood of spillage
of hazardous substances and if they reduce the exposure to humans, animals, or the food
chain. Id. § 300.415(d)(6)-(8).
77. Id. § 300.415(d)(9).
78. Id. § 300.415(b). Removal actions undertaken by private parties pursuant to set-
tlement agreements or abatement orders are subject to fewer requirements. For example,
they are exempt from the requirement that the removing party ensure an orderly transition
from removal to remedial action. Id. § 300.415(j)(4).
79. Browner Statement, supra note 11, at 472. Over 3300 individual removal actions
were taken at these 2600 sites. Id.
80. See id.
other lead agencies have been as successful at implementing the long-term remediation necessary to protect human health and the environment permanently.

B. Remedial Actions

Before a remedial action can begin, a site must be listed on the NPL. To become an NPL site targeted for remedial action, a site must be screened through a series of increasingly detailed assessments. First, a site must undergo a preliminary assessment and site inspection, which may result in the site receiving a score according to the Hazardous Ranking System. If the site is deemed hazardous enough after these initial steps, EPA will add it to the NPL. Once listed, the lead agency must conduct a remedial investigation/feasibility study (RI/FS). The end product of an RI/FS is a Record of Decision (ROD), documenting the selected remedy. The entire remedy selection process from discovery of a site to the beginning of cleanup takes, on average, about ten years.

1. Preliminary Assessment and Site Inspection

For a site to be listed on the NPL, it must undergo a preliminary assessment and site inspection. The preliminary assessment consists of reviewing "existing information about a release such as information on the pathways of exposure, exposure targets, and source and nature of release." The preliminary assessment helps EPA to eliminate from consideration any sites that pose no threat to public health or the environment. The preliminary assessment also enables EPA to determine if removal action is necessary, to set priorities for the subsequent site inspection phase, and, if necessary, to gather information used in evaluating sites under the Hazard Ranking System. After the preliminary assessment, EPA may advance a site for a site inspection. If sampling and field investigation performed during the site inspection indicate that further action is warranted, the lead agency will score a

81. 40 C.F.R. § 300.425(b)(1).
83. Id.
84. Id.
85. Id.
86. Id.
88. 40 C.F.R. § 300.420(b)(2). The preliminary assessment may include onsite and offsite reconnaissance. Id.
89. Id. § 300.420(a), (c).
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site according to the Hazardous Ranking System to assess the site’s risk relative to other sites.90  

A site’s Hazardous Ranking System score is based on EPA’s assessment of four potential contaminant exposure pathways: 1) exposure to contaminated groundwater; 2) exposure to contaminated surface water; 3) exposure to contaminated soil; and 4) exposure to chemicals that volatilize into the air.91 Each exposure pathway is scored according to specified criteria that include the likelihood of a release, the likelihood of exposure, the quantity of contamination, the toxicity and mobility of the contaminants, the number of people potentially exposed to the chemicals, and the potential for disruption of sensitive environments.92 EPA combines the scores from the four exposure pathways, which results in an overall score between one and 100.93 Sites with scores above 28.5 are eligible for listing on the NPL.94 This 28.5 cutoff line is completely arbitrary and was originally established to ensure that EPA would fulfill the initial congressional mandate to list at least 400 sites on the NPL.95 Accordingly, some have criticized the Hazardous Ranking System as having only a tenuous relationship to a site’s hazard potential.96

2. Establishing Remedial Priorities

Only those sites that EPA places on the NPL are eligible for Superfund-financed remedial action.97 EPA lists only about 10% of

90. See id. § 300.420(c)(5)-.425(c)(1).

91. See id. § 300 app. A § 2.1. The Clinton Administration’s proposed amendments to CERCLA would require EPA to amend the Hazard Ranking System to take into account the presence of multiple sources of risk and the cumulative risk to the affected community. Clinton Summaries, supra note 21, at 8. Increasing the Hazard Ranking System score is intended to tip the balance toward placement on the NPL of sites in communities with heightened health hazards. Id. This would change the current Hazard Ranking System to reduce bias toward many urban communities. Id.; see also infra notes 436-47 and accompanying text for a discussion of environmental inequities in poor, urban and nonurban communities. However, under the existing NCP, EPA does not have to remediate sites in order of their ranking in the Hazard Ranking System. 40 C.F.R. § 300.425(b)(2).

92. See 40 C.F.R. § 300 app. A § 2.1.3.

93. Id. § 300 app. A § 2.1.1.

94. John A. Hird, Superfund Expenditures and Cleanup Priorities: Distributive Politics or the Public Interest?, 9 J. POL’Y ANALYSIS & MGMT. 455, 462 (1990). However, EPA may place other sites on the NPL if: (1) they are designated as a state’s highest priority; or (2) they pose a significant threat to public health, the Agency for Toxic Substances and Disease Registry has issued health advisories for the sites, and EPA determines that remedial action will be more cost efficient than removal action. 300 C.F.R. § 300.425(c).

95. Hird, supra note 94, at 462.

96. Id.

97. 40 C.F.R. § 300.425(b)(1). Even if a site is not included on the NPL, EPA or a state agency may pursue actions under CERCLA §§ 9606, 9607, and 9622. Id. § 300.425(b)(4).
Lead agencies, including EPA regional offices and states, may propose sites for inclusion on the NPL by performing a Hazardous Ranking System evaluation and providing appropriate background documentation to EPA. EPA reviews these NPL submissions, and publishes those sites that it proposes to add to the NPL in the Federal Register to solicit public comments. After a notice and comment period, EPA publishes a final rule in the Federal Register stating whether or not each proposed site has been added to the NPL.

Although the Hazardous Ranking System score establishes a ranking of identified sites, the ranking serves only as a resource allocation guide, since EPA is not required to remediate sites according to their ranking. Thus, despite the Hazardous Ranking System and the NPL public participation requirements, deciding the order in which the NPL sites are remediated is largely a matter of EPA discretion.

3. Remedial Investigation

Once an NPL site has been selected for remediation, the lead agency initiates the remedy selection process. The stated goal of the remedy selection process under the NCP is to "select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." EPA has set forth the following six "expectations" to guide the lead agency in its development and selection of appropriate remedies: (1) wherever practicable, EPA will treat the principal threats posed by a site, including liquids and highly mobile or concentrated contaminants, rather than remove them; (2) EPA will use engineering controls such as containment where contaminants present a low long-term threat or where

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98. See supra note 61.
99. COMING CLEAN, supra note 61, at 7 (box 1-A). Many states with their own hazardous waste remediation programs have their own lists of sites, including many sites that are not on the NPL. Id.
100. 40 C.F.R. § 300.425(d).
101. Id. § 300.425(d)(5).
102. Id.
103. Id. § 300.425(b)(2).
104. Eagle-Picher Indus., Inc. v. Environmental Protection Agency, 759 F.2d 905, 911 (D.C. Cir. 1985). The major purpose of the NPL and the Hazard Ranking System is narrowly focused to quickly and inexpensively identify sites that may warrant further CERCLA action. Id. Listing does not represent a determination by EPA that action is necessary, or that EPA will take action. Id. Thus, EPA has chosen to limit its discretion by making NPL sites merely eligible for Fund-financed remedial actions. Id. at 911 n.26.
105. 40 C.F.R. § 300.430(a)(1)(i). This is consistent with EPA’s statutory mandate. See 42 U.S.C. § 9605(a)(8)(B). Further, a remedial action may be split into multiple stages, known as operable units, where appropriate, given the conditions, size, and/or complexity of a site. See 40 C.F.R. § 300.430(a)(1)(ii)(A)-(B); id. § 300.5 (defining “operable unit”).
treatment is impracticable; (3) EPA will use a combination of treatment, institutional controls, and engineering controls on a given site to achieve protection of human health and the environment; (4) EPA will use institutional controls, such as water use and deed restrictions, for both long-term and short-term management as appropriate to prevent or limit exposure to contaminants; (5) EPA will consider using innovative technology; and (6) where practicable, EPA expects to return usable groundwater to its beneficial uses.\(^{106}\) Guided by these expectations, the lead agency performs a remedial investigation/feasibility study,\(^{107}\) selects a remedial alternative,\(^{108}\) and documents its selection in a ROD.\(^{109}\)

The purpose of the RI is to allow the lead agency to assess the physical characteristics of a site and the nature of the contamination, and to generate information on the risks to human health posed by the site.\(^{110}\) The lead agency uses all of this information to develop various remedial action alternatives and to evaluate these alternatives during the feasibility study.\(^{111}\) The lead agency often conducts the RI and FS concurrently, using new information from the RI to refine the alternatives under consideration in the FS.\(^{112}\) The RI includes two components: the field investigation and the risk assessment.

\section*{Field Investigations}

Any meaningful characterization of a contaminated site begins with site visits to conduct field studies. During the remedial investiga-

\begin{footnotesize}
\begin{itemize}
\item\(^{106}\) 40 C.F.R. § 300.430(a)(1)(iii)(A)-(F).
\item\(^{107}\) See id. § 300.430(a)(2). Before beginning actual field work on the remedial investigation, the lead agency must pursue required community relations activities. Id. § 300.430(c). These activities include conducting interviews with local officials, residents, and public interest organizations to solicit both concerns and information about how they would like to be involved in the cleanup. Id. § 300.430(c)(2)(i). The lead agency must also develop a community relations plan to ensure that the public has appropriate opportunities to be involved and to learn about the site throughout the remedy selection process. Id. § 300.430(c)(2)(ii). Finally, the lead agency must establish a local information repository and inform the community of the availability of federal technical assistance grants. Id. § 300.430(c)(2)(iii)-(iv).
\item\(^{108}\) 40 C.F.R. § 300.430(f)(1), (4).
\item\(^{109}\) Id. § 300.430(f)(5).
\item\(^{110}\) Id. § 300.430(d)(1).
\item\(^{111}\) Id. § 300.430(a)(2).
\item\(^{112}\) OFFICE OF EMERGENCY AND REMEDIAL RESPONSE, U.S. ENVTL. PROTECTION AGENCY, OSWER DIRECTIVE No. 9285.701A, EPA/540/1-89/002, RISK ASSESSMENT GUIDANCE FOR SUPERFUND, VOLUME I: HUMAN HEALTH EVALUATION MANUAL PART A (INTERIM FINAL) 1-8 (1989) [hereinafter HUMAN HEALTH MANUAL].
\end{itemize}
\end{footnotesize}
tion, the lead agency conducts field studies to assess a site’s important surface features, such as soils, geology, hydrology, meteorology, and ecology.\textsuperscript{113} Samples of the soil, groundwater, and any surface water are also taken.\textsuperscript{114} Based on its sampling data and its assessment of the physical characteristics of the site, the lead agency determines the extent to which the source of the contamination at the site can be identified and characterized.\textsuperscript{115} The sample contaminants are analyzed to determine their quantity, concentrations, and physical phases, as well as their toxicity, propensity to bioaccumulate, persistence, and mobility.\textsuperscript{116}

The field investigation also includes characterizing the site’s air, surface water and groundwater,\textsuperscript{117} and identifying potential human exposure pathways to the contaminants found at the site.\textsuperscript{118} The lead agency identifies other factors relevant to the development and evaluation of remedial action alternatives, such as the presence of sensitive human populations.\textsuperscript{119} Finally, the lead agency may conduct pilot-scale treatability studies to provide further data on the engineering issues at the site.\textsuperscript{120} As will be discussed in part III.B of this comment, the site characterization process that is initiated during the field investigation phase is crucial to the success of a chosen remedy.

\textbf{b. Baseline Risk Assessment}

While the field investigation component of the RI focuses on the more technical issues surrounding the characterization of contamination, the risk assessment component is intended to educate decisionmakers about the seriousness of risks posed by contamination at a site. There are three parts of the baseline risk assessment: (1) toxicity assessment of the contaminants; (2) assessment of potential exposure to these contaminants; and (3) characterization of the risks posed by these contaminants.\textsuperscript{121} The baseline risk assessment is used to screen

\begin{itemize}
  \item \textsuperscript{113} 40 C.F.R. § 300.430(d)(1)-(2).
  \item \textsuperscript{114} \textit{HUMAN HEALTH MANUAL}, supra note 112, at 4-3. The sampling conducted during the RI is more involved than the sampling conducted during the site inspection discussed above. During the site inspection, sampling is performed only to the extent needed to determine whether a site warrants further action. \textit{See} 40 C.F.R. § 300.420(c). During the RI, the lead agency has already determined that more action at a site is needed, and performs more focused sampling of the soil and groundwater to characterize the extent and pattern of the contamination. \textit{See id.} § 300.430(d)(1).
  \item \textsuperscript{115} \textit{See} 40 C.F.R. § 300.430(d)(2)(iv).
  \item \textsuperscript{116} \textit{Id.} § 300.430(d)(2)(iii).
  \item \textsuperscript{117} \textit{Id.} § 300.430(d)(2)(ii).
  \item \textsuperscript{118} \textit{Id.} § 300.430(d)(2)(v)-(vi).
  \item \textsuperscript{119} \textit{Id.} § 300.430(d)(2)(ii).
  \item \textsuperscript{120} \textit{Id.} § 300.430(d)(2)(v)-(vi).
  \item \textsuperscript{121} \textit{See} \textit{HUMAN HEALTH MANUAL}, supra note 112, at 8-1.
\end{itemize}
out sites that do not require remediation and inform decisionmakers of the estimated risks posed by an unremedied site.\textsuperscript{122}

\textit{i. Toxicity Assessment}

EPA has performed toxicity assessments, which have undergone extensive peer review, for numerous chemicals.\textsuperscript{123} Thus, at most sites the lead agency need not perform an additional toxicity assessment, but will simply use existing data. However, the lead agency often will require an experienced toxicologist to interpret EPA's toxicity data and to determine which values are most appropriate to use when multiple estimates for a single chemical exist.\textsuperscript{124} Because toxicity assessments are crucial to the baseline risk assessment process, we briefly summarize the process that EPA applies to estimate the carcinogenic and noncarcinogenic toxic effects of contaminants.

Despite great uncertainty in extrapolating animal responses to chemicals with human responses to the same chemicals, animal bioassays are the primary tool used to evaluate a contaminant's toxicity.\textsuperscript{125} For carcinogenicity bioassays, a group of animals ingests very high doses of a chemical for virtually their entire lives.\textsuperscript{126} EPA determines what proportion of the group develops cancer. EPA must then estimate, based on the animals' carcinogenic responses at high doses, what the human carcinogenic response would be at low doses.\textsuperscript{127}

To estimate the animals' low dose response based on the high doses given in the experiment, EPA generally assumes a multistage linear dose response model, regardless of the shape of the dose response curve from the bioassay.\textsuperscript{128} In other words, in the extrapolation from the high doses ingested by animals to the low doses expected to be ingested by humans, EPA assumes the dose response


\textsuperscript{123} \textit{Human Health Manual, supra note 112, at 7-1.}

\textsuperscript{124} \textit{Id. at 7-1 to 7-3.}

\textsuperscript{125} \textit{See id. at 7-5.}


\textsuperscript{127} \textit{Id. at 287. According to Rosenthal, extrapolating the animal data, based on very high doses, to the lower doses to which humans are exposed, is "perhaps the most contentious judgment in carcinogenic risk assessment." Id.}

\textsuperscript{128} \textit{See id. EPA assumes a multistage linear model "in the absence of adequate information to the contrary." Human Health Manual, supra note 112, at 7-12. However, this requirement does not provide any guidance as to when nonlinear models should be used. See Rosenthal et al., supra note 126, at 288. Among biologically plausible models, few produce higher estimates of risk than EPA's default multistage linear model. Human Health Manual, supra note 112, at 7-12.}
follows a linear function.\textsuperscript{129} Thus, EPA generally assumes that there is no threshold dose below which there will be no risk of cancer.\textsuperscript{130} The slope of the assumed linear dose response function is called the linear slope factor for dose response.\textsuperscript{131} To estimate this slope, EPA fits its data points to a linear function and uses a conservative estimate of the slope of this linear function.\textsuperscript{132} EPA then converts the estimated slope factor to equivalent human doses to calculate carcinogenicity,\textsuperscript{133} occasionally referred to as a chemical's Cancer Potency Factor.\textsuperscript{134} The Cancer Potency Factor is expressed in terms of lifetime cancer risk per unit of concentration of the contaminant in the exposure medium.\textsuperscript{135}

In contrast to EPA's assumption that there is no safe dose of a carcinogen, the purpose of the toxicity assessment for noncarcinogenic toxicants is to estimate such a safety threshold.\textsuperscript{136} To determine the safety threshold, EPA uses animal bioassays to determine the "lowest-observed-adverse-effect-level" (LOAEL) and/or the highest "no-observed-adverse-effect-level" (NOAEL).\textsuperscript{137} EPA then converts these doses to an equivalent human dose.\textsuperscript{138} EPA divides the converted human dose NOAEL (or LOAEL) by uncertainty factors to estimate the level at which humans may be exposed to the contaminant without suffering noncarcinogenic adverse effects.\textsuperscript{139} This estimate is known as a reference dose.\textsuperscript{140}

Because they rely on animal bioassays and site-specific application of toxicity data, both carcinogenic and noncarcinogenic assessments involve great uncertainty. This uncertainty is compounded by

\textsuperscript{129} HUMAN HEALTH MANUAL, supra note 112, at 7-10.
\textsuperscript{130} Id.
\textsuperscript{131} Id. at 7-12.
\textsuperscript{132} Id.
\textsuperscript{133} Id. at 7-13. For a thorough discussion of carcinogen toxicity assessment, see Rosenthal et al., supra note 126, at 285-90.
\textsuperscript{134} HUMAN HEALTH MANUAL, supra note 112, at 7-21 n.2.
\textsuperscript{135} Id. at 7-13.
\textsuperscript{136} See id. at 7-6.
\textsuperscript{137} Id. at 7-7 to 7-10. If epidemiologic data is available to determine LOAEL or NOAEL, EPA will favor this data over animal bioassays. Id. at 7-6.
\textsuperscript{138} Id. at 7-6 to 7-7.
\textsuperscript{139} Id. at 7-7. An uncertainty factor of 10 is used to account for variation in the general population and to protect sensitive subpopulations. Id. Another uncertainty factor of 10 is used to account for uncertainty in the extrapolation of animal data to an estimate of safe doses for humans. Id. An additional uncertainty factor of 10 is used where the LOAEL is applied instead of the NOAEL because NOAEL data is not available. Id. A final uncertainty factor of 10 is used when the NOAEL (or LOAEL) is derived from a study where doses were administered subchronically (i.e., for only a portion of the study subjects' lives) rather than chronically (i.e., lifetime doses). Id. Lastly, a modifying factor of one to 10 is included to reflect EPA's qualitative judgment of additional uncertainty. See id.
\textsuperscript{140} Id. at 7-5.
the next two steps in the risk assessment process: exposure assessment and risk characterization.

ii. Exposure Assessment

To estimate human exposure at each site, the lead agency must first identify the variety of current and potential exposure pathways, such as ingestion of contaminated groundwater or soil, or inhalation of volatilizing contaminants. Evaluation of the physical characteristics of the site is a crucial element in identifying exposure pathways. Exposure pathway identification further depends on the lead agency's assumptions about the exposed population's activity patterns, which in turn will depend on the lead agency's assessment of current and potential future land uses.

After determining potential exposure pathways, the lead agency must estimate exposures for each of these pathways. To calculate exposure for a particular pathway, EPA requires the use of point estimates of the various exposure parameters. These estimates involve calculating an arithmetic mean for contamination concentration in a site's soil or groundwater, which varies greatly throughout the site. See id. at 6-9. Commentators have found EPA's identification of exposure pathways at Superfund sites to be comprehensive, except for the exclusion of the pathways of consumption of fish and exposure to surface water. Carolyn B. Doty & Curtis C. Travis, The Superfund Remedial Action Decision Process: A Review of Fifty Records of Decision, 39 JAPCA J. 1535, 1536 (1989).

The physical characteristics of a site are discovered in the field investigation phase of the RI. See supra part II.B.3.a. If EPA determines that residential development is a potential future land use in the area, then EPA will identify exposure pathways typical in a residential setting. See id. at 8-18. EPA summarizes exposure pathways separately for current land uses and potential future land uses. Id. at 6-17; see infra note 306 (concerning the difficulty of predicting future land use).

For example, EPA requires point estimates for contamination concentration in the relevant medium (i.e., soil or groundwater), the contact rate (i.e., the amount of contact per exposure event), exposure frequency (i.e., how long and how often exposure occurs), exposure duration (i.e., the time an exposed individual lives near a site), and bodyweight. Id. at 6-19 to 6-23; see Robert H. Harris & David E. Burmaster, Restoring Science to Superfund Risk Assessment, 6 Toxics L. Rep. (BNA) No. 42, at 1318, 1325-26 (Mar. 25, 1992).

EPA concluded that assuming long-term contact with the maximum concentrations of contaminants is not reasonable. See id. at 3. EPA further concluded that using high end point estimates for most of the parameters that vary among exposed individuals, but only average values for contaminant concentration, yields an exposure estimate that is conservative but not wildly conservative. See Science Advisory Bd., U.S. Envtl. Protection Agency, EPA-SAB-EHC-93-007, Review of the Office of Solid Waste
To determine the arithmetic mean of contaminant concentration, the lead agency uses sampling data taken at the site.\textsuperscript{148} EPA requires the application of a conservative estimate of the arithmetic mean of the samples to establish contaminant concentration.\textsuperscript{149}

The lead agency must use standard values for exposure frequency, exposure duration, and contact rate unless "alternate or site-specific values can be clearly justified by supporting data."\textsuperscript{150} These standard values are conservative estimates that vary according to land use.\textsuperscript{151} For example, for a residential land use exposure scenario, the lead agency must assume a soil and dust ingestion contact rate for adults of 100 mg of soil and dust per day, an exposure frequency of 350 days per year, and an exposure duration of 30 years.\textsuperscript{152} For a commercial/industrial land use exposure scenario, the lead agency must assume that an exposed person ingests 50 mg of soil and dust per day, with an exposure frequency of 250 days per year, and an exposure duration of 25 years.\textsuperscript{153} Generally, the lead agency makes two exposure estimates: one for current land use, and one for the potential land use associated with the highest level of exposure reasonably expected to occur at a site.\textsuperscript{154}

For bodyweight, the lead agency must use an average value of 70 kilograms for exposure pathways for which the contact rate to

\begin{footnotesize}
\begin{itemize}
\item[148.] \textit{See Calculating the Concentration Term}, supra note 147, at 3. When fewer than 10 samples are used to calculate the concentration mean, a poor estimate results. \textit{Id.} When 20 to 30 samples are used, a reliable estimate of the mean results. \textit{Id.}
\item[149.] \textit{Id.}
\item[151.] \textit{See id.} at 3. The classification of actual land use and potential future land use is very important to risk assessment because the standard exposure values vary greatly for each exposure scenario. \textit{See id.} at 15. EPA uses standard land use definitions for classification of actual land use and potential future land use. \textit{See id.} at 3.
\item[152.] \textit{Id.} at 15.
\item[153.] \textit{Id.}
\item[154.] \textit{Role of Baseline Risk Assessment}, \textit{supra} note 122, at 5. The estimate based on the potential future land use with the highest exposure that is reasonably expected to occur at a site forms the basis of the estimate of reasonable maximum exposure (RME). \textit{Human Health Manual}, supra note 112, at 6-4 to 6-5. The goal of the RME is to combine upper bound and mid-range exposure factors so that the RME is a reasonable and protective estimate, but not the worst possible scenario. \textit{Standard Default Exposure Factors}, \textit{supra} note 150, at 2.
\end{itemize}
\end{footnotesize}
bodyweight ratios are fairly constant, such as ingestion of drinking water.\textsuperscript{155} For exposure pathways that vary over a lifetime, such as soil ingestion, the lead agency establishes exposure by using age group data for exposure frequency, contact rates, and bodyweight.\textsuperscript{156} To determine lifetime exposure through such variable exposure pathways for cancer risk assessments, the lead agency calculates a time-weighted average of the age group data.\textsuperscript{157}

After the lead agency has determined the point estimates for all of the exposure parameters, it is ready to calculate its exposure estimates. The lead agency multiplies the point estimates of contaminant concentration, contact rate, exposure frequency, and exposure duration together. This figure is divided by bodyweight and an averaging time factor,\textsuperscript{158} which results in an estimate of daily exposure.\textsuperscript{159} During each of these steps, inaccurate, unavailable, or invariably uncertain information injects considerable uncertainty into the risk assessment process.\textsuperscript{160}

\textit{iii. Characterization of Risk}

Once the lead agency has assessed a contaminant's toxicity and estimated exposure pathways, it characterizes the baseline risk posed by each exposure pathway.\textsuperscript{161} This step may involve the highest degree of uncertainty.\textsuperscript{162} To determine the carcinogenic risk of a particular contaminant exposure, the lead agency multiplies the Cancer Potency Factor by the estimated daily intake of each carcinogen prorated over 70 years to arrive at a baseline estimate of increased life-

\textsuperscript{155} \textit{Human Health Manual, supra} note 112, at 6-22.
\textsuperscript{156} \textit{Id.} at 6-22 to 6-23.
\textsuperscript{157} \textit{Id.} at 6-23.
\textsuperscript{158} The averaging time factor is included to average the exposure over a relevant period for certain adverse affects. \textit{Id.} Thus, this factor varies according to whether EPA is assessing carcinogenic or noncarcinogenic adverse health effects of a contaminant. \textit{Id.} For example, for carcinogenic effects, EPA assesses increased lifetime cancer risk, and therefore uses a lifetime averaging time that prorates intakes over the exposure period to intakes over a lifetime. \textit{Id.} For acute toxicants, intakes are averaged over the shortest exposure period that could produce an adverse health effect. \textit{Id.}
\textsuperscript{159} \textit{Id.} at 6-21.
\textsuperscript{161} \textit{Human Health Manual, supra} note 112, at 8-3. Where EPA is using toxicity data based on intake and not on exposure, it must adjust the RME estimate to reflect the amount absorbed per exposure. \textit{Id.} at 8-5.
\textsuperscript{162} This is because "the analyst must synthesize a characterization of overall risk out of the diverse, uncertain, and sometimes conflicting estimates derived from the previous three steps." Andrews, \textit{supra} note 160, at 215. Moreover, the characterization itself involves "weighing the quality, persuasiveness, and applicability of differing bodies of evidence; deciding how to estimate and adjust for statistical uncertainties; and even choosing which of various possible estimates to present ('best estimate' or 'upperbound,' for instance)." \textit{Id.}
time cancer risk. For sites with multiple carcinogenic contaminants, the lead agency assumes that the risks posed by each contaminant are additive, and simply sums all of the increased cancer risks of individual contaminants to arrive at a baseline estimate of total lifetime cancer risk posed by an exposure pathway. As discussed in part III.A of this comment, merely adding the risks of multiple contaminants may not accurately reflect risk because of synergistic effects.

The meaning of the baseline cancer risk assessment is commonly misunderstood. A baseline cancer risk of $10^{-4}$ does not mean that for a population of 10,000 exposed to an unremedied site, one person will get cancer. Rather, a $10^{-4}$ risk means that a member of the exposed population that meets the conservative exposure criteria used in the estimation of the cancer risk will experience an estimated increase of .0001 of the risk of getting cancer over a lifetime from an unremedied site. Thus, the vast majority of the population who have exposure levels far below the conservative exposure estimate will have an estimated increased lifetime cancer risk of much less than $10^{-4}$. Those rare individuals who have exposures larger than the exposure estimate will have an estimated increased lifetime cancer risk in excess of $10^{-4}$.

For noncarcinogens, the lead agency characterizes the baseline risk by identifying whether the reference dose or safety threshold will be exceeded for any of the exposure pathways. The lead agency calculates a noncancer hazard quotient for every toxicant exposure pathway. A noncancer hazard quotient is the exposure estimate for the exposure pathway divided by the reference dose. The noncancer hazard quotients for each contaminant are summed to produce a noncancer hazard index for an exposure pathway. When the hazard index exceeds one, EPA assumes there may be adverse health effects at the site. Thus, the noncancer hazard index approach is based on the assumption that simultaneous exposures to multiple contaminants at doses below the reference dose for each of the contaminants could result in an adverse health effect.

164. Id. at 8-12.
165. Before conducting research for this comment, the authors misunderstood the meaning of a cancer risk assessment. We believe that this misperception is common.
166. See Doty & Travis, supra note 141, at 1536.
167. See Human Health Manual, supra note 112, at 8-6, 8-11.
168. Id. at 8-11. The reference dose is an estimate of the maximum daily exposure that is expected to be without adverse health effects. Id. at 7-5 to 7-6.
169. Id. at 8-13. Separate hazard indices are calculated for chronic (seven years to lifetime), subchronic (two weeks to seven years), and shorter-term (less than two weeks) exposures. Id.
170. Id.
171. Id.
After calculating baseline cancer risks and hazard indices for each exposure pathway, the lead agency then considers whether any of the exposure pathway risks should be combined to estimate risk for a single exposed individual. The lead agency combines exposure pathway risks where it finds that some individuals may consistently face multiple exposure pathways. For example, where it is likely that populations near a site will ingest both contaminated soil and water from the site, the lead agency adds the risks posed by both exposure pathways. In some situations, the lead agency combines one pathway's risk according to conservative exposure estimates with another pathway's risk according to average exposure. When the lead agency determines that it is appropriate to combine risks from exposure pathways, the agency simply sums the cancer risks and the hazard indices from each of the exposure pathways.

Finally, the lead agency presents a summary of its cancer risks and noncancer hazard indices in tables for all exposure pathways. For each baseline risk assessment, at least two summary tables are provided: one based on exposures under current land use, and one based on exposures under the potential future land use with the highest exposure pathways, such as residential use. EPA requires explanatory text to accompany the risk tables, including a description of the types of health risks posed by the site, the assumptions that went into the quantified risk estimates, and the uncertainties associated with these estimates. The purpose of the risk tables is to screen out sites that do not require remediation and to inform the lead agency about the potential risks to human health posed by a site. However, as will be discussed in part III.A, the role that baseline risk assessments play in remedy selection is often exaggerated.

4. Feasibility Study

After the remedial investigation, the lead agency performs a feasibility study. The primary purpose of the FS is to determine the range of remedial alternatives, to assess the strengths and weaknesses

172. Id. at 8-15.
173. Id.
174. Id. at 8-15 to 8-16.
175. Id. at 8-16 to 8-17. However, if the combination of exposure pathways has resulted in a hazard index based on different chemicals, the contribution of individual chemicals may need to be segregated. Id.
176. Id. at 8-26. For example tables of cancer and noncancer risks for a variety of exposure pathways, see id. at 8-7 to 8-9.
177. See id. at 8-10.
178. Id. at 8-25 to 8-26.
179. Role of Baseline Risk Assessment, supra note 122, at 3-5. For a discussion of the screening function of the baseline risk assessment, see infra notes 245-47, 323-29 and accompanying text.
of various alternatives, and to identify the tradeoffs of choosing one remedy over another. The first step of the FS is the development of preliminary remediation goals (PRGs). Next, the lead agency identifies and screens various remedial technologies. Finally, the lead agency closely evaluates remedial alternatives and selects a preferred remedy. This process of identifying and evaluating remedial alternatives is largely left to the lead agency’s discretion.

a. Development of Preliminary Remediation Goals

Toward the beginning of the FS, the lead agency develops preliminary remediation goals for all contaminants of potential concern in all media of potential concern. PRGs are expressed as contaminant concentration levels and provide guidance to the lead agency in developing and selecting remedial alternatives. There are two types of PRGs: ARAR-based PRGs and risk-based PRGs.

ARAR-based PRGs are the levels of concentrations permitted by ARARs for contaminants found at a site. Thus, there is no risk evaluation of ARAR-based PRGs. They are dependent only on statutorily defined maximum concentration levels. In deciding whether a particular requirement is “relevant and appropriate,” the lead agency must consider the following eight factors:

(i) The purpose of the requirement and the purpose of the CERCLA action;
(ii) The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site;
(iii) The substances regulated by the requirement and the substances found at the CERCLA site;
(iv) The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site;

180. 40 C.F.R. § 300.430(e)(1).
181. Id. § 300.430(e)(2)(i).
182. Id. § 300.430(e)(1).
183. Id. § 300.430(e)(9), (f).
184. OFFICE OF EMERGENCY AND REMEDIAL RESPONSE, U.S. ENVTL. PROTECTION AGENCY, OSWER DIRECTIVE No. 9285.7-01B, EPA/540/1-89/002, RISK ASSESSMENT GUIDANCE FOR SUPERFUND, VOLUME I: HUMAN HEALTH EVALUATION MANUAL PART B, DEVELOPMENT OF RISK-BASED PRELIMINARY REMEDIATION GOALS vii (1991) [hereinafter DEVELOPMENT OF PRGs]. Chemicals of potential concern include all important chemicals previously detected at a site during prior investigation and chemicals that the site history indicates are likely to be present in significant quantities, even though they have not yet been detected. Id. at 8. Media of potential concern could be either all contaminated media to which individuals may be exposed, and/or uncontaminated media that may become contaminated in the future due to chemical migration. Id.
185. See id. at 1.
186. Id.
187. Id. at 10.
188. In contrast, a risk evaluation is necessary for a risk-based PRG. See infra notes 193-214 and accompanying text.
(v) Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site;
(vi) The type of place regulated and the type of place affected by the release or CERCLA action;
(vii) The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and
(viii) Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site. 189

For groundwater and surface water that serve as current or potential sources of drinking water, the lead agency commonly uses “non-zero maximum contaminant level goals” and “maximum contaminant levels” from the Safe Drinking Water Act as ARAR-based PRGs. 190 This is consistent with the preamble to the NCP, which provides that where contaminated groundwater is within a class I or class II aquifer, preliminary remedial goals are generally based on drinking water standards. 191 For surface water, the lead agency may use standards from the Clean Water Act or any applicable state water quality standard as the PRG. 192

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189. 40 C.F.R. § 300.400(g)(2).
190. Development of PRGs, supra note 184, at 10-11. The Safe Drinking Water Act is codified at 42 U.S.C. §§ 300f-300j (1988). A Maximum Contaminant Level Goal (MCLG) is defined as the level at which no known or anticipated adverse human health effects will occur. Id. § 300g-1(b)(4). Maximum Contaminant Levels (MCLs) are set as close as feasible to an MCLG and represent the maximum permissible concentration in water that may be delivered to any user of a public water system. Id. §§ 300f(3), 300g-1(b)(4). Thus, an MCLG is a pure health-based drinking water goal, while an MCL is a technology-based standard. Using drinking water standards as PRGs is consistent with the NCP, which provides that, for groundwater and surface waters that are current or potential sources of drinking water, the cleanup must attain any applicable nonzero MCLG if EPA finds that the MCLG is relevant and appropriate. 40 C.F.R. § 300.430(e)(2)(i)(B). The NCP further provides that where the MCLG has been set at zero for an applicable groundwater or surface water contaminant, the cleanup standard will be set at the MCL where EPA finds that the MCL is relevant and appropriate. Id. § 300.430(e)(2)(i)(C).
191. Preamble to National Oil and Hazardous Substance Pollution Contingency Plan (NCP), 55 Fed. Reg. 8666, 8732 (1990). A class I aquifer is an aquifer of unusually high value that is highly vulnerable to contamination because it is an irreplaceable source of drinking water and/or ecologically vital. Office of Groundwater Protection, U.S. Env'tl. Protection Agency, PD-426-G843, Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy 16 (1986) [hereinafter Ground-Water Classification]. A class II aquifer is any non-class I aquifer that is a current or potential future source of drinking water or other beneficial use. Id. at 20. However, where EPA finds that contaminated groundwater and surface water are not current or potential sources of drinking water, such as with a class III aquifer, it will not use drinking water standards from the Safe Drinking Water Act. See Development of PRGs, supra note 184, at 10; 55 Fed. Reg. 8666, 8732. A class III aquifer is an aquifer that is saline or otherwise contaminated beyond levels that would allow for drinking or other beneficial uses. Ground-Water Classification, supra, at 21.
192. See Development of PRGs, supra note 184, at 11. Because surface waters maintain high potential for many uses, including drinking water, several ARARs may be identi-
Where no ARAR exists for a chemical of potential concern in a medium of potential concern, the lead agency develops site-specific risk-based PRGs. Generally, the lead agency produces risk-based PRGs for soils since no federal standards currently exist for soils. The lead agency also develops risk-based PRGs for any groundwater or surface water contaminants for which there are no applicable standards under federal or state law. For a carcinogenic contaminant, a risk-based PRG is set at the concentration that will limit an exposed individual’s incremental lifetime risk of cancer to $10^{-6}$. The risk-based PRG for a contaminant with noncarcinogenic adverse health effects is set at a concentration level that will limit the hazard index to one. For chemicals with both carcinogenic and noncarcinogenic toxic effects, the lead agency calculates separate concentrations to meet both target risk levels and uses the lower of the two values as the risk-based PRG.

The methodology for calculating risk-based PRGs is similar to the methodology for assessing baseline risk. The lead agency uses the same toxicity assessments employed in the baseline risk assessment. In addition, the lead agency characterizes exposure pathways and parameters for calculation of risk-based PRGs on exposures that will occur with the most appropriate future land use for a site. In general, residential areas are assumed to remain residential, and industrial areas are assumed to remain industrial unless land use regulations or trends indicate that this is not appropriate. If the lead agency lacks site-specific information to characterize land use, the lead agency is supposed to assume future residential land use.

In certain circumstances, the lead agency may find it necessary to use multiple or mixed land use assumptions for exposure estimates. First, if insufficient site-specific information is readily available to select one future land use over another, the agency may develop a separate set of risk-based PRGs for each possible land use. Second,
where waste is to be managed onsite, the assumptions for the site itself may be different from the land use in the surrounding area.\textsuperscript{206} For example, if the site is located in a residential area, the lead agency may assume residential land use exposures for the groundwater beneath the site, while assuming industrial land use exposures for site soils if institutional controls and management will preclude residential exposure.\textsuperscript{207} In any event, the assumptions used to classify land uses invariably inject uncertainty into the exposure assessment.\textsuperscript{208}

Based on the land use characterization of a site, the lead agency identifies exposure pathways and parameters for each chemical of concern in each medium of concern, using the standard default exposure factors for the relevant land use.\textsuperscript{209} As with the baseline risk assessment, the lead agency develops the PRGs by combining risks from exposure pathways only where there is a strong relationship between exposure pathways.\textsuperscript{210} The lead agency may combine a conservative estimate of exposure for one pathway with average estimates from other exposure pathways.\textsuperscript{211} Using the toxicity assessment and the exposure assessment for all identified exposure pathways, and combined exposure factors if appropriate, the lead agency calculates a PRG for each contaminant.\textsuperscript{212}

Although the methodology for calculating risk-based PRGs is similar to the methodology applied in the baseline risk assessment, there is one key difference. As discussed above, baseline risk assessments account for exposure to multiple contaminants by summing the risks.\textsuperscript{213} However, a risk-based PRG is based on the risks posed by a single contaminant.\textsuperscript{214} Thus, PRGs do not account for any level of synergistic risks posed by a combination of contaminants at a site.

Most importantly, both ARAR-based PRGs and risk-based PRGs are only initial guidelines and do not establish final cleanup standards.\textsuperscript{215} The lead agency continually evaluates and modifies PRGs throughout the remedy selection process as more information

\textsuperscript{206} Id.
\textsuperscript{207} Id.
\textsuperscript{208} See infra note 306 and accompanying text for a discussion of uncertainty in predicting future land use.
\textsuperscript{209} See Development of PRGs, supra note 184, at 19. As with the baseline risk assessment, the standard exposure parameters are drawn from Standard Default Exposure Factors, supra note 150, at 1.
\textsuperscript{210} Development of PRGs, supra note 184, at 19-20.
\textsuperscript{211} Id.
\textsuperscript{212} See id. at 30-31 (presenting sample case study calculations to illustrate which inputs are considered).
\textsuperscript{213} See supra note 175 and accompanying text.
\textsuperscript{214} See Development of PRGs, supra note 184, at 31 (presenting a sample calculation of a risk-based PRG, which uses the carcinogenic dose meeting the target risk level for a single contaminant).
\textsuperscript{215} Id. at 4.
becomes available about land use assumptions, exposure assumptions, and technological feasibility. The lead agency does not propose final remedial goals until it selects a preferred remedy.

b. Identification and Screening of Alternatives

The lead agency uses the PRGs and information gathered during the field studies to develop a number of remedial action alternatives. The development of the remedial action alternatives must be "fully integrated with the site characterization activities" of the remedial investigation. In addition, during the feasibility study, the lead agency must perform an evaluation of a site's potential threat to the environment, paying careful attention to any sensitive and critical habitats of species protected by the Endangered Species Act. This information must be factored into the development of alternatives and final remediation goals. In the end, the number and type of alternatives identified is left to the lead agency's discretion based on its assessment of the scope, characteristics, and complexity of a site's contamination.

The lead agency also has discretion to modify the PRGs as it deems appropriate. Thus, the lead agency is not limited to the existing alternatives that achieve the original risk-based or ARAR-based PRGs. In fact, the NCP requires the lead agency to consider a no-action alternative. The NCP favors the use of innovative remedial technologies by directing the lead agency to include innovative alternatives when, relative to demonstrated technologies, such innovations have the potential for comparable or superior performance, fewer adverse impacts, or lower cost for similar performance.

For sites with multiple contaminated media, the lead agency develops alternatives for each contaminated medium separately. Thus, for cleaning up contaminated soil, termed "source control,"

216. Id. at 5-6.
217. Id. at 6.
218. See 40 C.F.R. § 300.430(e)(2).
219. Id. § 300.430(e)(1).
220. Id. § 300.430(e)(2)(i)(G).
221. Id. § 300.430(e)(2).
222. Id. Thus, the number of alternatives for a particular site should be generally proportional to the degree of a site's contamination problems. See id. § 300.430(e)(1).
223. Id. § 300.430(e)(2)(i).
224. Id. § 300.430(e)(6). If removal or remedial action has already been taken at a site, the lead agency must consider a no further action alternative. Id.
225. Id. § 300.430(e)(5).
226. See id. § 300.430(e)(3)-(4) (providing specific guidance for development of alternatives for source control and groundwater remediation, respectively).
227. Id. § 300.5 (defining "source control").
the lead agency develops alternatives apart from those developed for cleaning up contaminated groundwater or surface water.

For contaminated soil, the NCP has specific provisions addressing remedial alternatives. The lead agency must develop a range of alternatives for source control remediation that reduces the toxicity, mobility, and/or volume of the contaminants in the soil.228 These alternatives must include the option of removing or destroying the contaminants in the soil to the maximum extent feasible.229 The NCP also directs the lead agency to develop other alternatives that, at a minimum, address only the principal threats posed by the soil contamination,230 which may include removal or destruction of only certain contaminants.231 These alternatives may also involve immobilization treatments, which keep contaminants that remain in the soil from moving into the groundwater or other areas where humans could potentially be exposed.232 Finally, the NCP directs the lead agency to evaluate one or more source control alternatives that include little or no treatment, but protect human health and the environment.233 These alternatives may consist of engineering controls, such as immobilizing soil contaminants or constructing clay barriers or caps on top of contaminated soils to eliminate exposure.234 In addition, institutional controls, such as site access restrictions and land use deed restrictions, may be used to supplement engineering controls in preventing exposure to contaminants.235

For contaminated groundwater, the NCP provides that the lead agency must develop a limited number of remedial alternatives that attain site-specific remediation goals.236 EPA expects complete restoration of usable aquifers wherever the lead agency finds that restoration is practicable.237 The development of alternatives for

228. Id. § 300.430(e)(3)(i).
229. Id. Removal technologies, which remove contaminants from the soil for proper treatment and disposal, include air stripping and various methods of soil washing. See Melvyn Kopstein, Science for Superfund Lawyers, 19 Envtl. L. Rep. (Envtl. L. Inst.) 10,388, 10,390-91 (Sept. 1989) (giving a good basic description of these processes). Destruction technologies, which detoxify or destroy soil contaminants, include various types of thermal or incineration treatments, as well as chemical and biological treatments. See id. at 10,389-92.
230. 40 C.F.R. § 300.430(e)(3)(i).
231. See, e.g., Doty & Travis, supra note 141, at 1537 (table VII), 1540-42.
232. See Kopstein, supra note 229, at 10,390.
233. 40 C.F.R. § 300.430(e)(3)(ii).
234. See, e.g., Doty & Travis, supra note 141, at 1540-42.
235. See 40 C.F.R. § 300.430(a)(1)(iii)(D).
236. Id. § 300.430(e)(4).
237. Id. § 300.430(a)(1)(iii)(F); see infra note 335 and accompanying text (noting that aquifer restoration to human health standards is the remedial goal at approximately 93% of the sites with nonaqueous phase liquids (NAPL) contamination). The lead agency will not attempt to attain drinking water standards from the Safe Drinking Water Act where it
groundwater remediation is focused on schemes that will most effectively pump contaminants from the aquifer or treat them in situ.\(^{238}\) However, where the lead agency finds that restoration of a usable aquifer is not practicable, groundwater treatment is designed to contain the contaminant plume and prevent human exposure to contaminated groundwater, rather than achieve restoration of the aquifer.\(^{239}\)

The lead agency also has discretion to develop alternative groundwater cleanup standards, or alternate concentration limits, for a site.\(^{240}\) CERCLA provides that where there are known and projected points of entry of the groundwater into the surface water, where the contaminated groundwater will not significantly degrade the surface water, and where the remedial action includes measures preventing exposure to the groundwater, the lead agency may base its cleanup standards on human exposure at the point of entry of the groundwater into the surface water.\(^{241}\) Thus, the lead agency may develop a remedial alternative that precludes exposure to the groundwater and only minimally treats the groundwater to prevent deterioration of nearby surface waters.\(^{242}\)

The final step of identifying and screening alternatives involves eliminating remedial alternatives that the lead agency finds unfavorable because they are ineffective in eliminating risk, problematic in implementation, or excessive in cost.\(^{243}\) This step provides substantial discretion to the lead agency because the agency may eliminate some remedial alternatives from further consideration based on subjective criteria. Those alternatives that survive this subjective screen are slated for detailed evaluation.\(^{244}\)

finds that the contaminated groundwater is not a current or potential source of drinking water. Development of PRGs, supra note 184, at 10-11.

238. There are proven technologies for treatment of contaminated water once it is pumped out of the aquifer. Carolyn B. Doty & Curtis C. Travis, Oak Ridge Nat’l Lab., The Effectiveness of Groundwater Pumping as a Restoration Technology 4 (1991) [hereinafter Groundwater Pumping]. Such treatments of contaminated water include air stripping of volatile organic contaminants, activated carbon absorption, filtration, phase separation, and chemical treatments. Kopstein, supra note 229, at 10,390-92. However, the problem, as discussed infra part III.B.2, is that groundwater extraction and treatment (e.g., pump and treat) is not effective for aquifer restoration.

239. 40 C.F.R. § 300.430(a)(1)(iii)(F).

240. Id. § 300.430(e)(2)(i)(F); see supra note 49 for a description of alternative concentration limits.


242. Such an alternative concentration limit would fulfill the ARAR requirement. See id. (defining an ACL as applicable in lieu of other ARARs).


244. See id. at 3, 5.
c. Detailed Evaluation of Alternatives and Selection of a Preferred Remedial Alternative

After the lead agency has identified a number of viable alternatives, it must evaluate these alternatives in detail and select one of them as the preferred remedy. The lead agency will generally select the no-action alternative as the preferred alternative if the baseline risk assessment indicates a baseline cancer risk of less than $10^4$ and a baseline hazard index of less than one. However, the lead agency retains discretion to take action where the baseline risks are below these thresholds if it finds that taking no action would result in adverse environmental impacts or that action is warranted for site-specific reasons. Further, the lead agency will generally take action even if the baseline risk assessment indicates risks below the thresholds if no action would eventually result in contamination of groundwater in excess of maximum contaminant levels or maximum contaminant level goals in the Safe Drinking Water Act.

If the baseline risk assessment shows a risk in excess of the thresholds or action is otherwise warranted, the lead agency will evaluate all of the action alternatives according to the nine criteria established in the NCP. The first two criteria from the NCP are: (1) overall protection of human health and the environment; and (2) compliance with federal or state ARARs, or the appropriateness of a waiver. These two criteria are threshold criteria that every remedial alternative must meet to be selected. The lead agency generally considers a remedy protective of human health and the environment if it will reduce the increased cancer risk caused by a site to $10^4$. In cases where the achievement of ARARs would still result in cumulative cancer risks above $10^4$, the lead agency may choose a remedy that will attain cleanup standards more stringent than the ARARs. For chemicals that cause noncarcinogenic adverse health

245. Role of Baseline Risk Assessment, supra note 122, at 3-5.
246. Id. at 1. Such site-specific reasons justifying remedial action may include a situation where the lead agency finds that there is great uncertainty in the baseline risk assessment, or that action is necessary to prevent a potential future release. See id. at 4-5.
247. Id. at 4.
249. 40 C.F.R. § 300.430(e)(9)(iii)(A)-(B).
250. Id. § 300.430(f)(1)(i)(A).
251. See id. § 300.430(e)(2)(i)(A)(2), (D). An increased cancer risk of $10^6$ is termed EPA's point of departure. Id. However, cancer risks of up to $10^4$ are considered generally acceptable. Id.
252. See id. § 300.430(e)(2)(i)(D). However, EPA considers compliance with a chemical-specific ARAR to be generally protective even if it is outside the usually acceptable risk ranges. Role of Baseline Risk Assessment, supra note 122, at 2.
effects, the remedy must achieve exposure levels that will not cause adverse effects to sensitive subgroups of the exposed population.\textsuperscript{253}

However, the lead agency need not adhere strictly to the above criteria in selecting an appropriate remedy. EPA does not apply the $10^4$ increased cancer risk upper boundary as an absolute requirement for a selected remedy.\textsuperscript{254} The lead agency may consider a remedial alternative acceptable if the alternative results in an estimated increased cancer risk of "around $10^4."\textsuperscript{255} In addition, although EPA has concluded that a hazard index greater than one creates cause for concern,\textsuperscript{256} there is no established requirement that a remedial action must reduce all hazard indices below one.

Furthermore, closely following the statute, EPA regulations allow the lead agency to waive attainment of ARARs under the following six conditions:

(1) The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;

(2) Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;

(3) Compliance with the requirement is technically impracticable from an engineering perspective;

(4) The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach;

(5) With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or

(6) For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment.\textsuperscript{257}

These criteria give the lead agency substantial flexibility to determine whether an applicable statutory provision is either not relevant and appropriate or should be waived. Thus, despite the threshold criteria requiring compliance with ARARs, the lead agency retains substantial flexibility to select a less protective remedy.

\textsuperscript{253} 40 C.F.R. § 300.430(e)(2)(i)(A)(1).
\textsuperscript{254} ROLE OF BASELINE RISK ASSESSMENT, supra note 122, at 2.
\textsuperscript{255} Id.
\textsuperscript{256} HUMAN HEALTH MANUAL, supra note 112, at 8-13.
\textsuperscript{257} 40 C.F.R. § 300.430(f)(1)(ii)(C).
Those remedial alternatives that meet the first two threshold criteria are evaluated under additional criteria that the lead agency balances to decide which remedial alternative is most appropriate.\textsuperscript{258} These criteria are: (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; and (7) cost-effectiveness.\textsuperscript{259}

To compare long-term effectiveness of remedial alternatives, the lead agency evaluates the long-term human health risks associated with each alternative.\textsuperscript{260} To compare short-term effectiveness, the lead agency evaluates the risks that will be present during the implementation of the remedial alternative.\textsuperscript{261} The lead agency may determine that quantification of the short-term and long-term risks of all of the alternatives is necessary to address the concerns of site engineers and the exposed population.\textsuperscript{262} Alternatively, the lead agency may decide to compare short-term risks of alternatives qualitatively and indicate which of these alternatives will attain the PRGs.\textsuperscript{263} Whether the comparison of long-term and short-term risks should be quantitative or qualitative depends on whether the relative short-term or long-term effectiveness of the alternative is an important consideration in selecting the alternative, and on the "perceived risk" associated with the alternative.\textsuperscript{264} Evaluating the perceived risk implicates the agency's professional judgment and the concerns of the neighboring communities.\textsuperscript{265}

\begin{itemize}
\item \textsuperscript{258} Id. § 300.430(f)(1)(i)(B).
\item \textsuperscript{259} Id. § 300.430(e)(9)(iii), (f)(1)(i)(B). These are known as the primary balancing criteria. Id. § 300.430(f)(1)(i)(B).
\item \textsuperscript{260} See Risk Evaluation of Remedial Alternatives, supra note 243, at 11 (discussing the consideration of long-term human health risks during the feasibility study). For a more thorough discussion of the evaluation of long-term human health risks during the detailed analysis of remedial alternatives in the feasibility study, see id. at 14-15.
\item \textsuperscript{261} Id. at 11. This includes short-term risks to nearby residents and to remedial construction workers during implementation of the remedy. Id. For a more detailed discussion of the evaluation of short-term human health risks during the detailed analysis of remedial alternatives in the feasibility study, see id. at 15-20.
\item \textsuperscript{262} Id. at 14.
\item \textsuperscript{263} Id. Quantification of the long-term risks of alternatives is conducted in a manner similar to the baseline risk assessment. Id. at 12. This measure of residual risk requires for every alternative: (1) an assessment of postremedy exposure to contaminants remaining at a site; (2) an assessment of the toxicity of these contaminants; and (3) use of these assessments to characterize the residual risk. Id. Quantification of the short-term risks requires a similar analysis for exposure estimates during the implementation of each alternative. See id. at 15-19. However, the estimation of short-term risks is complicated because it requires the assessment of exposure from releases caused by the remedial activities. See id. at 16-17.
\item \textsuperscript{264} See id. at 14.
\item \textsuperscript{265} Id. Factors leading to a higher perceived risk include:
\begin{itemize}
\item Close proximity of populations; presence of highly or acutely toxic chemicals; technologies with high release potential, either planned or "accidental"; high uncertainties in the nature of releases (e.g., amount or identity of contaminants re-
The lead agency must also consider the permanence of the remedial alternatives. This consideration is especially significant for remedial alternatives that include engineering or institutional controls to reduce or eliminate exposure. For such alternatives, the lead agency must consider whether the controls will be able to protect human health over time and whether there is a significant risk that the controls will fail.

To implement CERCLA's preference for remedial alternatives that encompass treatment of contaminants, EPA includes treatment as a balancing factor. Under this factor, the lead agency must weigh the degree to which each alternative reduces the toxicity, mobility, and volume of contaminants through treatment. The lead agency generally considers a remedial alternative to consist of treatment if the alternative will achieve reductions of 90% to 99% in the concentrations or mobility of contaminants.

To compare the implementability of alternatives, the lead agency must assess the ease or difficulty of executing each alternative. This requires weighing the technical feasibility of each alternative, including the level of confidence that a given alternative will achieve pre-

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266. Id. at 15. But see infra part IV.B where we discuss the Clinton Administration proposal. The Clinton plan calls for "long-term reliability" as a substitute for "permanence." Clinton Summaries, supra note 21, at 4.

267. RISK EVALUATION OF REMEDIAL ALTERNATIVES, supra note 243, at 15.

268. Id.

269. See 42 U.S.C. § 9621(b).


271. 40 C.F.R. § 300.430(e)(9)(iii)(D). In weighing this criterion, the lead agency must consider the following factors:
(1) The treatment or recycling processes the alternatives employ and materials they will treat;
(2) The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled;
(3) The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reduction(s) are occurring;
(4) The degree to which the treatment is irreversible;
(5) The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and
(6) The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

272. 55 Fed. Reg. 8666, 8721. However, where the remedial alternative would achieve health-based or site-specific remediation goals, the lead agency should consider reductions outside the 90% to 99% range to be treatment. Id.

273. 40 C.F.R. § 300.430(e)(9)(iii)(F).
dicted performance levels.\textsuperscript{274} In addition, the lead agency must consider administrative feasibility, such as the need for permits to implement various remedial activities.\textsuperscript{275} The lead agency must also assess the availability of services and materials necessary for each alternative, including the adequacy of disposal capacity for any waste generated by the remedial activities.\textsuperscript{276} Finally, the lead agency must consider the cost effectiveness of each alternative,\textsuperscript{277} including direct and indirect capital costs, as well as the present value of annual operations and maintenance costs.\textsuperscript{278} The lead agency then compares the overall effectiveness with the cost of each alternative to determine if it is cost effective, or whether its costs are proportional to its overall effectiveness.\textsuperscript{279}

Based on the application of the threshold criteria and the weighing of all of the balancing factors, the lead agency selects a preferred alternative to present to the public in a proposed plan for review and public comment.\textsuperscript{280} At this point, the lead agency must consider the final two remedy selection criteria: (8) state acceptance;\textsuperscript{281} and (9) community acceptance.\textsuperscript{282} After a review and comment period, the lead agency, in conjunction with the state, determines whether, in light of the comments received, the preferred remedy is still the most appropriate.\textsuperscript{283} The lead agency may reassess its initial determination that the preferred alternative provides the best balancing of all of the tradeoffs by considering information from or opinions voiced by the state or the community.\textsuperscript{284} The lead agency then makes a final remedy selection and publishes the Record of Decision.\textsuperscript{285} In addition to the final remedy, the ROD includes all facts, analyses of facts, and site-specific policy determinations considered in the course of select-

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{274} Id. § 300.430(e)(9)(iii)(F)(1).
\item \textsuperscript{275} Id. § 300.430(e)(9)(iii)(F)(2).
\item \textsuperscript{276} Id. § 300.430(e)(9)(iii)(F)(3).
\item \textsuperscript{277} Id. § 300.430(f)(1)(ii)(D).
\item \textsuperscript{278} Id. § 300.430(e)(9)(iii)(G).
\item \textsuperscript{279} Id. § 300.430(f)(1)(ii)(D). The overall effectiveness of an alternative is determined with respect to its effectiveness and permanence in eliminating long-term risks, its effectiveness in reducing toxicity, mobility, and volume, and the short-term risks posed by the alternative. Id.
\item \textsuperscript{280} Id. § 300.430(f)(1)(ii).
\item \textsuperscript{281} Id. § 300.430(e)(9)(iii)(H).
\item \textsuperscript{282} Id. § 300.430(e)(9)(iii)(I). For a discussion of the role of community relations in the selection of a remedy, see supra notes 55-57 and accompanying text.
\item \textsuperscript{283} 40 C.F.R. § 300.430(f)(1)(ii). If a state is the lead agency, then the state will consult with other state support agencies. Id.
\item \textsuperscript{284} Id. § 300.430(f)(4).
\item \textsuperscript{285} Id. § 300.430(f)(1)(ii). A ROD may address only a portion of a site's cleanup, thus necessitating EPA to go through the RI/FS process a number of times for one site. Are WE CLEANING Up?, supra note 82, at 3 (box 1).
\end{itemize}
\end{footnotesize}
The ROD also establishes the final remediation goals for a site.\textsuperscript{287}

5. **Remedial Design, Remedial Action, and Operation and Maintenance**

After the lead agency has selected a remedial alternative for a site, the remedial design and action (RD/RA) phase begins. During the RD/RA, the actual design and construction of the remedy is accomplished.\textsuperscript{288} The RD/RA may be initially financed by the Superfund and performed by the lead agency, or it may be financed and performed by responsible private parties pursuant to a consent decree.\textsuperscript{289} In either case, it remains the responsibility of the lead agency to ensure that all RD/RA activities conform to the selected remedy as specified in the ROD.\textsuperscript{290} The lead agency must also ensure that the implementation of the selected remedy will attain the ARARs identified in the ROD,\textsuperscript{291} and that all conditions for any waivers of ARARs included in the ROD are met.\textsuperscript{292}

The lead agency may decide during the RD/RA that remedial activities should differ significantly from the remedy selected in the ROD.\textsuperscript{293} If the lead agency determines that such a change is appropriate, it must consult with supporting agencies to evaluate whether the difference "fundamentally alters" the remedy selected in the ROD in terms of scope, performance, and cost.\textsuperscript{294} If the lead agency decides that the change fundamentally alters the selected remedy, the lead agency must prepare an amendment to the ROD with a new opportu-

\textsuperscript{286} 40 C.F.R. § 300.430(f)(5)(i).
\textsuperscript{287} Id. § 300.430(f)(5)(iii)(A).
\textsuperscript{288} Id. § 300.435(a).
\textsuperscript{289} EPA's Model Superfund Consent Decree Presents Major Risk For Settling Party, 22 Env't Rep. (BNA) No. 40, at 2314 (Jan. 31, 1992); Fiscal 1986 Superfund Enforcement Figures Reflect Program's Disruption, Official Says, 17 Env't Rep. (BNA) No. 30, at 1220-21 (Nov. 21, 1986) (stating that, of 100 sites progressed through the RI/FS, 66 were financed by Superfund, 52 were financed by potentially responsible parties, 3 were financed through mixture of both, and 1 is a federal facility). Regardless of whether the lead agency or responsible parties undertakes the cleanup, the actual design and construction will likely be performed by contractors. See, e.g., Congress Continues Criticism of Superfund; OTA Questions EPA's Extensive Contractor Use, 19 Env't Rep. (BNA) No. 40, at 2054-55 (Feb. 3, 1989). If the lead agency is responsible for the cleanup, it must comply with public contracting requirements included in the NCP. See id.
\textsuperscript{290} 40 C.F.R. § 300.435(b)(1).
\textsuperscript{291} Id. § 300.435(b)(2).
\textsuperscript{292} Id.
\textsuperscript{293} Id. § 300.435(c)(2). The lead agency may decide on such a change as a result of negotiation and settlement with responsible parties. Id. Presumably, such a change may also occur when it becomes apparent that certain remedial technologies are not performing as predicted.
\textsuperscript{294} Id.
nity for public review and comment. If, however, the lead agency
determines that the difference does not fundamentally alter the se-
lected remedy, the lead agency need only publish a notice in a local
newspaper and make an explanation of the change available to the
public through the administrative record.

The remedy becomes "operational and functional" either one
year after construction of the remedy is complete, or when EPA and
the state decide that the remedial action is functioning properly,
whichever occurs later. At this point, operation and maintenance
of the remedy begins, and the state must assume responsibility for
overseeing the remedial action. However, for Fund-financed reme-
dial actions that include restoration of groundwater or surface water,
the lead agency will remain responsible for the treatment of the con-
taminated groundwater or surface water for up to ten years.
Furthermore, if the remedial action selected will not eliminate all
hazardous substances at a site to levels that allow for unlimited use
and exposure at the site, the lead agency must conduct a review of the
remedial action at least every five years.

During all of the stages in the remedy selection process, the lead
agency has the opportunity to exercise considerable discretion. While
the statute and its regulations provide thousands of pages of guidance,
they contain so many subjective considerations that the lead agency
can justify nearly any remedy it selects. Although broad discretion is
important for the site-specific application of a remedy, there are coun-
tervailing concerns of uniformity and efficiency. In an attempt to
strike a balance between these concerns, the next part of this com-
ment assesses the remedy selection process and suggests some changes
to make the process more effective, equitable, and efficient.

III ASSESSMENT OF THE REMEDY SELECTION PROCESS

Selecting a remedy for a site with complex subsurface contamina-
tion, with great uncertainty in the risks posed by the contaminants and
in the fate of the contaminants in the subsurface, is no easy task. Re-
gardless of how EPA administers the regulations detailed in part II of

295. Id. § 300.435(c)(2)(ii).
296. Id. § 300.435(c)(2)(i).
297. Id. § 300.435(f)(2).
298. Id. § 300.435(f)(1).
299. Id. § 300.435(f)(3). At most sites, operation and maintenance of the remedy may
go on for years, especially if the remedy includes restoring contaminated groundwater.
GROUNDWATER PUMPING, supra note 238, at ix (stating that lead agencies have predicted
remedial timeframes for restoration of an aquifer between two and 30 years, but that actual
restoration of an aquifer may take 100 years or more).
300. 40 C.F.R. § 300.430(f)(4)(ii).
this comment, it will inevitably displease powerful constituencies. Indeed, industry often accuses EPA of selecting excessively expensive remedies to address trivial risks, which undermines the competitiveness of our economy and causes job losses. At the same time, environmental organizations often see EPA as compromising community health by selecting below standard remedies. While recognizing the difficulty of EPA's job, we suggest that the remedy selection process can be improved in the following areas: The risk assessment process; the technical feasibility of remediating contaminated groundwater; agency discretion in remedy selection; and identification of uncontrolled hazardous waste sites currently left out of the Superfund program.

A. Risk Assessment

The remedy selection process can be improved by increasing the accuracy of the risk assessment process. Because of the great uncertainty inherent in estimating risks, the risk assessment process has been criticized as being both over and under conservative. Critics have argued that EPA's risk assessment process is often based on exaggerated potential exposure pathways. As previously mentioned, EPA's baseline risk assessment includes assumptions about current and future land use conditions. For example, EPA may assume that the exposed population will have unrestricted future access to a site to ingest soil, even if this is not currently the case. Because land uses change over time, it is often difficult to accurately predict future exposure pathways.

301. See, e.g., HAZARDOUS WASTE CLEANUP PROJECT, STICKER SHOCK: RECOGNIZING THE FULL COST OF SUPERFUND CLEANUPS 1 (1993). The Hazardous Waste Cleanup Project is a coalition of trade associations in the industrial sector that focuses on reforming Superfund and other hazardous waste laws. Id. at i.


304. See supra notes 154, 177 and accompanying text.

305. EPA now requires the use of standardized exposure factors so that certain exposure pathways are assumed under certain land use conditions unless site-specific values can be "clearly justified by supporting data." STANDARD DEFAULT EXPOSURE FACTORS, supra note 150, at 1. The lead agency must use residential land use assumptions for the assessment of risks under future land use conditions when the lead agency finds that residential land use at and near a site is a reasonable future land use, even if the site is currently in industrial use. Id. at 5.

Critics of over conservatism in risk assessment also argue that EPA's conservative point estimates for multiple exposure factors result in an unreasonably conservative exposure estimate. For example, exposure calculations that combine 95th percentile exposure factors for intake/contact rate, exposure frequency, and exposure duration, yield a 99.875 percentile exposure factor.

To avoid compounding conservatism in the calculation of baseline risk assessment, some commentators recommend using the Monte Carlo simulation, which allows an assessment of the full risk distribution and places conservative point estimates in context. Under the Monte Carlo simulation, each input variable in the calculation of baseline risk becomes a random variable with a known or estimated probability distribution. These probability distributions become the basis for a weighted pool of each variable. The analyst must account for correlations between variables and factor this into the probability distributions. Random selections from each weighted pool are then used to calculate a single potential risk data point. Computers repeat this random drawing and calculation of data points thousands of times, resulting in thousands of potential exposure data points. These data points can then be analyzed to determine what level of exposure in the simulated exposure population represents the 95th percentile or any other selected exposure factor.

While the current EPA method estimates exposure based on the rare individual in the 95th percentile for all of the exposure parameters, land use scheme can anticipate changes in technology, demographics, and economics. As with drafters of zoning schemes, an agency in charge of predicting future land use cannot be "error free in elevating past trends, present capabilities, and future needs." The math for this outcome is fairly simple. Multiplying 0.05 by 0.05 by 0.05 produces 0.00125, or .125%, a number representing the probability that any single person has all 95th percentile exposure factors. Thus, the result is a person in the 99.875 percentile of exposure.


This can be envisioned as a pool full of ping pong balls, each with different assigned variable values. The number of ping pong balls with a particular value depends on the probability of that value. If 3% of the population is estimated to have a certain exposure level, then 3% of the ping pong balls will be assigned that exposure level. Telephone Interview with Dr. David E. Burmaster, Alceon Corp., Cambridge Mass. (Nov. 19, 1993).

If the computer created 1000 data points, the data point that is the 50th highest exposure level would be the 95th percentile. The data point that is the 500th highest exposure level would be the 50th percentile. Telephone Interview with David E. Burmaster, supra note 311.
ters, the Monte Carlo simulation avoids the obscured conservatism that results from multiplying conservative point estimates. Rather, Monte Carlo simulation allows decisionmakers to estimate, based on all of the exposure factors, the level of exposure that corresponds to the 95th percentile, or any other percentile, of the exposed population.

Other commentators argue that the embedded conservatism in EPA's quantitative risk assessments is warranted to protect human health and the environment. These commentators suggest that it is sensible for risk assessment to be conservative because risk estimates involve huge uncertainties and underestimating risk can result in cancer clusters and other extremely undesirable consequences. In addition, planned conservatism in some areas helps to offset nonconservative assumptions in other parts of the risk assessment process, such as the exclusion of synergistic effects from exposure to multiple carcinogens that can elevate the risk of cancer beyond the summation of the individual risks. For instance, research shows that the cancer rate among asbestos workers who smoked is more than three times higher than the added risks of smoking and exposure to asbestos. In the baseline risk assessment, the risk from exposure to multiple chemicals is additive rather than multiplicative. Further, risk-based preliminary remediation goals do not account at all for additive effects, much less for synergistic effects. Others suggest the baseline risk assessment is under conservative because it fails to adequately account for risks posed to the environment. Taken together, these arguments suggest that conservatism in EPA's risk assessment process is both appropriate and necessary.

Although many of the arguments for and against conservatism in risk assessment are valid, we believe the debate exaggerates the role that risk assessment actually plays in remedy selection. The only sub-

318. Finkel, *supra* note 316, at 445. This is especially significant for Superfund risk assessment because most Superfund sites include a variety of chemical contaminants. See, e.g., Kopstein, *supra* note 229, at 10,388.
319. *Id.* at 447.
320. *Human Health Manual, supra* note 112, at 8-12 to 8-13; *supra* note 175 and accompanying text.
321. See *Development of PRGs, supra* note 184, at 31 (presenting a sample calculation of a risk-based PRG, which uses the carcinogenic dose meeting the target risk level for a single contaminant).
322. Andrews, *supra* note 160, at 217. In practice, risk assessment, if it takes environmental harms into account at all, oversimplifies such risks and focuses on only a few human health effects. *Id.*
stantive use of the baseline risk assessment in the remedy selection process is as a screening device. If the baseline risk assessment indicates a cancer risk below $10^4$ or a hazard index of less than one, then generally no remedial work is warranted at the site at all. By this screening function, the baseline risk assessment’s role in remedy selection is limited to providing guidance to the lead agency by giving it a rough estimate of the risks posed by all contaminants at the un-remedied site under current and potential future land use conditions. Thus, while the baseline risk assessment may be politically important in the selection of a remedy, it never mandates a particular level of cleanup.

Risk assessment plays a more substantive role in the establishment of risk-based PRGs. PRGs are set at concentration levels that reduce the risks posed by a site to target levels, assuming the highest exposures from reasonably anticipated future land uses. However, risk-based PRGs are only initial guidelines and do not require cleanup to meet their goals. The lead agency has discretion to weaken the initial risk-based PRGs substantially if it finds that attaining the initial PRGs would be too costly and uncertain.

Given the screening function of the baseline risk assessment, it is reasonable to use conservative estimates, including a potential future exposure scenario based on the highest exposure from reasonably possible future land uses. Anything less than an assessment of the most dangerous future land use would be inappropriate if the result was that remediation would not occur at a site at all because the established risk thresholds are not exceeded. Furthermore, the lead agency retains the discretion to correct improper assumptions used to establish risk-based PRGs.

Even though the role of risk assessment in selecting a final remedy is less important than the heated debate surrounding it suggests, risk assessment’s functions in screening sites and establishing PRGs is important enough to merit improvement. To avoid hidden conservatism, EPA should require the use of the Monte Carlo method in the risk assessment process. We believe that using the Monte Carlo simu-

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323. See Role of Baseline Risk Assessment, supra note 122, at 3-5; see also supra notes 245-47 and accompanying text.
324. See Role of Baseline Risk Assessment, supra note 122, at 3-5.
325. See supra part II.B.4.c.
326. Development of PRGs, supra note 184, at 14-15.
327. Id. at 4.
328. Id. at 6.
329. The Clinton Administration has proposed that EPA establish a national risk protocol for risk assessments that would standardize risk assessment at all sites based on “reasonable assumptions.” See Clinton Summaries, supra note 21, at 3. EPA has already developed standard risk assessment procedures. See supra part II.B.3.b. Thus, the effect of the Administration’s proposal is unclear.
lation to estimate the ninety-fifth percentile of exposure results in sufficiently conservative exposure estimates. At the same time, to account for the uncertainty associated with increased synergistic risks at sites with multiple contaminants, EPA should include uncertainty factors in the toxicity assessment. These steps should make risk assessment a more valuable tool for use in its appropriately limited role of establishing a regulatory threshold and providing guidance to decisionmakers.

B. Groundwater Remediation Issues

The remedy selection process can also be improved through the way EPA handles groundwater contamination. Cleaning up contaminated groundwater is undoubtedly one of the most serious problems EPA faces. EPA expects to restore contaminated groundwater to its beneficial uses wherever practicable. However, research at Superfund sites indicates that certain groundwater contaminants, most notably nonaqueous phase liquids (NAPLs), cannot be pumped out of groundwater aquifers. This inability to remove NAPLs is problematic because EPA estimates that up to 60% of NPL sites may be contaminated with NAPLs. At 93% of these NAPL-contaminated sites, EPA plans to restore the aquifer to human health standards. This lofty goal, however, is probably unrealistic, particularly consider-
ing that at least one expert believes that not a single contaminated aquifer to date has been fully restored.\textsuperscript{336} To provide background on this difficult issue, we first discuss NAPL science and the technical aspects of cleaning up NAPLs. Then we discuss EPA's response to the problem and what can be done to address groundwater contamination more effectively.

1. The Nonaqueous Phase Liquids Problem

When NAPLs are released into the soil, they travel vertically through soil pores toward the water table.\textsuperscript{337} Generally, the movement of NAPLs in the subsurface is determined by gravity, viscous forces, capillary forces, and geologic conduits and barriers.\textsuperscript{338} A variety of factors influences the mobility of NAPLs, including properties of the liquid, such as viscosity and density, and properties of the subsurface, such as soil heterogeneity, intrinsic permeability, structural and stratigraphic geology features, mineralogy, pore size, and pore geometry.\textsuperscript{339} If NAPLs encounter a layer of low permeability, such as rock or clay, on their way to the water table, they may form a suspended pool.\textsuperscript{340}

When NAPLs reach the water table, some amount will dissolve into the groundwater. The term "nonaqueous phase liquid" refers not to this portion of the contaminants dissolved in the groundwater, but to the liquid, nondissolved phase of the contaminants.\textsuperscript{341} Certain light NAPLs (LNAPLs), such as benzene, xylene, and toluene, are less dense than water and, upon reaching the saturated zone, float on top of the water table as free product.\textsuperscript{342} Actions to remediate LNAPLs

\textsuperscript{336} Telephone Interview with Carolyn B. Doty, Office of Risk Analysis, Oak Ridge National Laboratory (Sept. 13, 1993). Of the 166 deletions from the NPL, none have yet achieved restoration of an aquifer with significant NAPL contamination. Id.

\textsuperscript{337} DNAPL PRESENCE AT NPL SITES, supra note 333, at viii.

\textsuperscript{338} OFFICE OF RESEARCH AND DEV., U.S. ENVTL. PROTECTION AGENCY, PUB. NO. 600/R-92/030, DENSE NONAQUEOUS PHASE LIQUIDS—A WORKSHOP SUMMARY 3 (1991) [hereinafter DNAPL WORKSHOP].

\textsuperscript{339} Id. For example, the nonaqueous phase of coal tar and creosote is less mobile and less gravity dominated than the nonaqueous phase of chlorinated solvents because the viscosity of coal tar and creosote is 10 to 20 times greater than water. Id.

\textsuperscript{340} In addition, as they move through the unsaturated zone, NAPLs release vapor phase contaminants to the spaces between soil molecules. Over time, vapor phase contaminants can migrate downward to contaminate the water table. See IMPRACTICABILITY GUIDANCE, supra note 331, at 7. The unsaturated zone is the subsurface zone above the water table, while the saturated zone is the region where the groundwater and NAPLs intermix. GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 3.

\textsuperscript{341} GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 3. The degree to which NAPLs dissolve in groundwater varies among compounds. Id.

\textsuperscript{342} GROUNDWATER PUMPING, supra note 238, at 27.
have been somewhat successful because current technology is able to locate and remove at least a portion of the floating free product.\textsuperscript{343}

Remedial actions aimed at locating, much less removing, dense NAPLs (DNAPLs) from the water table have been almost wholly unsuccessful.\textsuperscript{344} Unlike LNAPLs, DNAPLs are denser than water\textsuperscript{345} so they sink to the bottom of groundwater aquifers, “leaving behind ganglia of residual contamination and becoming trapped in pore spaces by capillary action.”\textsuperscript{346} A site has a “high probability” of being contaminated by DNAPLs if “chemical usage was appreciable, and usage and disposal were consistent with industry practices common more than several years ago.”\textsuperscript{347} Many researchers believe that current technology is incapable of removing trapped DNAPLs from the subsurface. If left unaddressed, DNAPLs may dissolve slowly, producing plumes of aqueous phase contamination.\textsuperscript{348}

One of the primary difficulties in remediating DNAPLs is determining where these contaminants are in the subsurface.\textsuperscript{349} Characterization of the movement of contaminants at CERCLA sites often relies on the direction of groundwater flow. However, since DNAPLs move preferentially through permeable layers and rock fractures, groundwater flow is not a reliable indicator of DNAPL movement. For example, DNAPLs may flow along rock bed planes, opposite the direction of groundwater flow.\textsuperscript{350} Clay layers are effective in limiting vertical water movement but may not retard downward movement by DNAPLs through small fractures and pores.\textsuperscript{351} Thus, DNAPLs may migrate downward from the top aquifer to contaminate lower aqui-

\textsuperscript{343} GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 7; see GROUNDWATER PUMPING, supra note 238, at 37.
\textsuperscript{344} GROUNDWATER PUMPING, supra note 238, at 37.
\textsuperscript{345} GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 3.
\textsuperscript{346} GROUNDWATER PUMPING, supra note 238, at 37. The most commonly detected DNAPLs at CERCLA sites are chlorinated organic solvents, such as trichloroethylene (TCE) and tetrachloroethylene (PCE), polychlorinated biphenyls (PCBs), creosote, and coal tar. IMPRACTICABILITY GUIDANCE, supra note 331, at 6.
\textsuperscript{347} DNAPL WORKSHOP, supra note 338, at 4. Industries associated with DNAPL contamination include: wood treatment operations (creosote); manufactured gas plants (coal tar); transformer oil production, reprocessing, and disposal facilities (PCBs and chlorinated solvents); chemical industry facilities (chlorinated solvents, pesticides, herbicides, and other dense organic compounds); steel industry coking operations (coal tar); dry cleaners (chlorinated solvents); electronic instrument manufacturers (chlorinated solvents); machine shops (chlorinated solvents); print shops (chlorinated solvents); metal works (chlorinated solvents); and waste disposal facilities (all types). Id. at 2-3.
\textsuperscript{348} IMPRACTICABILITY GUIDANCE, supra note 331, at 7.
\textsuperscript{349} See DNAPL WORKSHOP, supra note 338, at 5-6. Furthermore, drilling to find the extent of DNAPL contamination may actually worsen the problem by opening conduits through which DNAPLs can move to other aquifers. Id. at 6.
\textsuperscript{350} Id. at 3.
\textsuperscript{351} Id. at 4.
fiers. Because of these characterization problems and the tendency of DNAPLs to move vertically beneath the water table through bedrock fractures and pores, traditional technologies have been ineffective in locating and extracting DNAPLs from the subsurface.

2. Available Technology

The following section, while not a comprehensive presentation of available technologies for groundwater remediation, outlines the range of options that decisionmakers possess to determine how to approach groundwater remediation. We hope to provide enough background for the reader to evaluate EPA's selection of remedies at DNAPL contaminated sites.

Pump and treat technology is one of the most common restoration and containment remediation methods. This technology involves pumping large volumes of water from the subsurface through wells or drains, treating the recovered water, and either injecting the treated water back into the aquifer or disposing of it into the wastewater system or a stream. Although existing treatment technologies are generally effective at removing contaminants from water once it is pumped out of an aquifer, it has proven to be very difficult to locate and remove DNAPLs from the subsurface in the first place. Nonetheless, pump and treat technology is still used at DNAPL-contaminated sites, and in some instances, it has been effective in containing DNAPL plumes by creating an artificial hydraulic gradient toward the pumps and wells, rather than allowing the contamination to flow outward.

Generally, pumping and treating alone is not sufficient to remove residual DNAPL contamination from the subsurface. DNAPL recovery can be enhanced by injecting fluids into the DNAPL zone, which increases hydraulic gradients and DNAPL solubility while reducing interfacial tension and DNAPL viscosity. However, the success of enhanced DNAPL recovery is limited by geologic

352. Investigating DNAPLs in the subsurface also carries a risk of contaminating lower aquifers by creating pathways of DNAPL migration through exploratory drilling. Id. at 6.
353. Pump and treat technology has been the specified remedy in hundreds of Records of Decision (RODs). GROUNDWATER PUMPING, supra note 238, at 2.
354. Telephone Interview with Carolyn B. Doty, supra note 336.
355. GROUNDWATER PUMPING, supra note 238, at 4; see Kopstein, supra note 229, at 10,390-91 (describing various treatment technologies).
356. GROUNDWATER PUMPING, supra note 238, at viii, 27-37.
357. Id. at 27; DNAPL WORKSHOP, supra note 338, at 10. However, pump and treat technology is not always an effective containment tool. See infra notes 381-86 and accompanying text.
358. DNAPL WORKSHOP, supra note 338, at 10.
359. Id. Methods of enhanced DNAPL recovery include induced gradient/water flooding, steam and hot water displacement, and chemically enhanced recovery. Id. at 10-11.
heterogeneity. Low permeability zones such as clay, into which DNAPLs can migrate through minute fractures, can prevent injected liquids from ever reaching DNAPLs.\textsuperscript{360}

Another method of DNAPL recovery is in situ vacuum extraction or soil vapor extraction (SVE). This method applies a vacuum to the unsaturated zone (i.e., the soil area above the water table), which induces air flow and removal of volatile organic compounds (VOCs) through a network of underground pipes.\textsuperscript{361} This treatment is effective in removing VOCs from the soil, thus preventing these contaminants from migrating into the groundwater.\textsuperscript{362} However, SVE technology is not effective in removing DNAPLs from the saturated zone because low mass transfer rates limit the amount of VOCs that can be removed from the groundwater.\textsuperscript{363}

Another in situ technology, bioremediation, seems promising, but also has limited effectiveness.\textsuperscript{364} First, the microorganisms used in bioremediation cannot consume many DNAPLs.\textsuperscript{365} Bioremediation is effective at biodegrading nonchlorinated low molecular weight contaminants, but is limited in cases of contaminants with high molecular weights, such as polychlorinated biphenyls (PCBs), chlorinated solvents, and the polyaromatic hydrocarbons in creosote.\textsuperscript{366} Second, bioremediation is restricted by subsurface conditions that prevent the microorganisms from thriving.\textsuperscript{367} Despite its limitations, bioremediation may be an effective "polishing step" to remove remaining DNAPLs after the majority have been removed with other technologies.\textsuperscript{368}

Many believe that, while current technologies can contain DNAPLs with some degree of success, none of the current technologies is capable of restoring a DNAPL-contaminated aquifer.\textsuperscript{369} Yet despite a lack of proven technology, restoration of aquifers remains a

\textsuperscript{360} Id. at 10.
\textsuperscript{361} Id. at 12, 19 (table 1).
\textsuperscript{362} Id.
\textsuperscript{363} Id.
\textsuperscript{364} Id.
\textsuperscript{365} Bioremediation is the use of microorganisms in situ to degrade soil and groundwater contaminants. Id. at 12, 20 (table 1); see Eugene L. Madsen, Determining In Situ Biodegradation, Facts and Challenges, 25 ENV'T, SCI. & TECH. 1663, 1663 (1991).
\textsuperscript{366} DNAPL WORKSHOP, supra note 338, at 12.
\textsuperscript{367} Id.
\textsuperscript{368} Id. “Due to the toxicity of most DNAPLs, and the lack of essential nutrients, electron acceptors, and other requirements for life in the NAPL pool itself, the potential for biologically-mediated degradation of DNAPLs is limited.” Id.
\textsuperscript{369} Id.
goal at a majority of CERCLA sites. More specifically, despite its questionable effectiveness, pump and treat technology has essentially remained “the only available option for aquifer restoration.”

The primary indicator of the effectiveness of pumping and treating is a reduction in contaminant concentrations over time. Although pump and treat technology is effective at reducing concentrations initially, the reductions are likely to level off with little or no further decrease. In a recent study of Superfund sites, leveling off occurred at thirteen of sixteen sites that were studied. The study concluded that meeting the cleanup goals at any of the sixteen sites by the pump and treat method is unlikely, even where cleanup goals are significantly less protective than drinking water standards. Thus, groundwater pumping is ineffective at restoring groundwater to health-based standards, and it was estimated that it would take as much as 100 to 1000 years to restore an aquifer through pumping and treating. In short, the study found that pumping and treating is only effective for containment, contaminant mass reduction, and wellhead treatment.

The study cited several reasons for the ineffectiveness of pump and treat technology in restoring aquifers with DNAPL contamination. First, pumping and treating fails to remediate contaminated soil, which remains a continuing source of groundwater contamination. Second, although success has been achieved in removing a portion of

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370. See supra note 335 and accompanying text.
371. As discussed below, a study of 16 CERCLA sites where restoration was the remediation goal found that, while pump and treat technology was generally effective at containment and reduction of containment mass, it was ineffective at aquifer restoration. See infra notes 373-78 and accompanying text.
372. GROUNDWATER PUMPING, supra note 238, at 2-3. In one study, 28 out of 37 RODs specified pump and treat technology, some for purposes of restoration, some for purposes of containment. Doty & Travis, supra note 141, at 1542.
373. GROUNDWATER PUMPING, supra note 238, at 18.
374. Id.
375. Id. at 24. Because DNAPLs hide out in subsurface capillary fringes and rock fractures, once pumping and treating ceases, concentrations in groundwater increase significantly. See id. at 27.
376. Id. at 32.
377. Id. at 43-44.
378. Id.
379. Id. at 35. Even with completion of soil remediation, contaminants sorbed onto aquifer material, trapped in low permeability zones such as clay layers, or gathered in nonaqueous phase pools cannot be pulled out by the pumping method and remain a continuing source of groundwater contamination. Id. Organic contaminants sorb to aquifer material such as rock or soil molecules in the saturated zone; this reduces their mobility and increases their resistance to induced hydraulic flow. Id. This causes pumping to be ineffective for two reasons. First, the mass of contaminant sorbed to aquifer material is greater than the mass in solution. Second, over time, organic contaminants become more resistant to desorption. Thus even with years of pumping, significant amounts of organic contaminants will remain in the saturated zone. Id. at 35-36.
floating LNAPLs, simply locating DNAPLs has seen little success. Finally, even if restoration is theoretically possible through pumping and treating, it is impossible to estimate how many years extraction wells would have to operate to restore a DNAPL-contaminated aquifer. 380

At some sites, pumping and treating may not even be able to achieve the lesser goal of containment. 381 In the above study, four of the sixteen sites studied (25%) had not achieved containment through pump and treat remediation. 382 Two principle reasons may explain why attempts to contain DNAPLs may fail. First, current technologies are unable to overcome the physical properties of DNAPLs. DNAPLs can move vertically downward despite the artificial upward hydraulic flow created by pumping. 383 For example, the high density and low viscosity of chlorinated solvents make them highly mobile and impossible to contain under certain conditions. 384 Second, unless remediation designers know exactly where DNAPLs are located, physical containment cannot be fully successful. 385 Current site characterization methods cannot accurately locate chlorinated solvents in the subsurface or demonstrate that containment has been achieved. 386 However, as site characterization methods improve, and scientists learn more about the fate of DNAPLs in the subsurface, containment of DNAPL plumes may become more feasible.

A final problem with the pump and treat method is that it can be ecologically damaging. 387 Large volumes of water must be pumped out of the subsurface to extract a small mass of organic contaminants. 388 At one site, two wells pumped more than five billion gallons of groundwater over four years, yet fewer than 800 pounds of contaminants were recovered. 389 Pumping such huge volumes of water can cause surface subsidence and loss of habitat unless the treated water is reinjected into the aquifer. 390 Given the ecological problems associated with the pump and treat method, as well as the mounting

380. Id.
381. Containment means "physical control of the aqueous and nonaqueous phases in the subsurface." DNAPL WORKSHOP, supra note 338, at 10.
382. GROUNDWATER PUMPING, supra note 238, at 27.
383. DNAPL WORKSHOP, supra note 338, at 10.
384. Id. Highly viscous DNAPLs, such as coal tar and creosote, are less mobile and may be more easily contained. Id.
385. Id. at 7.
386. Id.
387. GROUNDWATER PUMPING, supra note 238, at 41.
388. Id. at 30.
389. Id. at 36.
390. Id. at 41-42. Possibly even more damaging is drilling through pooled DNAPLs and creating a conduit through which contamination can spread to lower aquifers. Id. at 41.
evidence that the method is ineffective at restoring aquifers, EPA’s goal of restoration demands serious reevaluation.

3. EPA’s Response

EPA recognized the problems with pump and treat technology years ago. In 1988, a senior EPA official said:

[A] recent analysis by EPA’s own Office of Research and Development strongly indicates that the groundwater pump and treat systems, which the agency has been selecting to control groundwater contamination, will not achieve the levels of cleanup required by agency standards in less than tens, perhaps hundreds of years.391 Yet only in 1992 did EPA respond to the convincing evidence that current remedial technologies cannot restore NAPL-contaminated aquifers; it issued a directive addressing remediation of contaminated groundwater.392 This directive outlines five remedy implementation guidelines.

First, remedial action for contaminated groundwater should be implemented in phases.393 The phased approach is considered to be appropriate where DNAPL contamination is suspected or where there is complex hydrology, and thus the possibility of meeting cleanup standards is uncertain.394 The initial phases should be implemented as early as possible and should include containment and/or source control measures.395

Second, groundwater remedies should include monitoring as well as provisions for modifying monitoring to improve effectiveness and efficiency.396 Third, after implementation of a groundwater remedy, “modification of remedial action objectives may be warranted where cleanup standards cannot be achieved, due to technical impracticability from an engineering perspective.”397 The directive provides three requirements before such a modification may be made:

(a) demonstration of technical impracticability to the satisfaction of EPA (or other entity responsible for making decisions at the site);
(b) EPA issuance of a technical impracticability waiver (40 C.F.R. [§ ] 300.430 (f)(1)(ii)(C)(3)) for Superfund sites . . . ; and
(c) EPA determination of alternative remedial action objectives.398

391. COMING CLEAN, supra note 61, at 47.
392. See GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 1-4.
393. Id. at 9. Thus, in the phased approach, the remedial action is modified or succeeded by different, but compatible or more comprehensive, actions. Id.
394. Id.
395. Id.
396. Id.
397. Id. at 10.
398. Id. If a modification of the remedial decision is made, then either an Explanation of Significant Differences (ESD) or a ROD amendment will be required. Id. If the modification is fundamentally different from the remedy selected in the ROD, a ROD amend-
Fourth, EPA should use EPA-approved data, supporting analysis, and site characterization to decide whether aquifer restoration is impracticable, instead of using industry-sponsored studies. The data should include contaminant characteristics, hydrological conditions, contaminant distribution and subsurface migration, any response actions undertaken or attempted, alternative remedial technologies, and estimation of the likely level of achievable restoration.

Finally, if EPA makes a finding of technical impracticability, it must identify alternative remedial actions to protect human health and the environment. The directive suggests the use of a number of the technologies discussed above, including in situ soil treatment and enhanced recovery. The recommendation also promotes use of new technologies to enhance recovery of residual LNAPLs and DNAPLs. Perhaps most importantly, lead agencies are advised to include the following alternative remedial action objectives: Containment, reduction of the areal extent of the dissolved contaminant plume, removal of subsurface NAPLs, and removal of free phase NAPLs.

In 1993, EPA issued a second directive that expanded on the first and dealt directly with the evaluation of the technical impracticability of groundwater restoration. The directive clarifies how the decision of technical impracticability should be made and supported, and carefully notes that: "This guidance does not signal a scaling back of EPA’s efforts to restore contaminated groundwaters at Superfund sites." The discussion of impracticability centers around three factors that may inhibit groundwater restoration: Hydrologic factors, properties of the contaminants, and remediation design inadequacies. While the first two factors may legitimately limit restoration potential, the lead agency should not consider design inadequacies, such as incomplete site characterization leading to too few extraction

399. GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 10.
400. Id. Other requirements and issues related to impracticability were presented in a second OSWER directive. IMPRACTICABILITY GUIDANCE, supra note 331, at 13-19; see infra notes 405-11 and accompanying text (discussing the directive).
401. GROUND-WATER REMEDIATION CONSIDERATIONS, supra note 331, at 11.
402. Id. at 11-12.
403. Id. at 12.
404. Id. at 11-12.
405. IMPRACTICABILITY GUIDANCE, supra note 331.
406. Id. at 2.
407. Id. at 1-2.
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wells or improperly placed wells, as sufficient bases for determination of impracticability. The directive recognizes that characterization of DNAPL contamination at groundwater entry locations, in DNAPL zones (i.e., subsurface areas containing residual and/or free phase DNAPLs), and in aqueous contaminant plumes that contain dissolved DNAPL is crucial to the selection of effective remedies because each site component is likely to require a different remediation strategy. Accordingly, the long-term objectives at DNAPL-contaminated sites should be to remove free phase, residual, and vapor phase DNAPLs to the extent practicable and to contain DNAPL sources that cannot be removed. Where long-term sources of contamination can be contained, restoration of the contaminated groundwater plume outside the DNAPL-contaminated area is expected.

Both directives emphasize a phased approach as the foundation of EPA's groundwater cleanup program. EPA advocates consideration of a phased approach whenever "there is uncertainty regarding the ultimate restoration potential of the site but also a need to quickly control risk of exposure to, or limit further migration of, the contamination." In this context, the lead agency should act quickly to contain DNAPL contamination in an interim remedial action and use what it learns about the site to inform later remedial actions.

When it is highly certain that ARARs cannot be attained, the lead agency may invoke a technical impracticability (TI) ARAR waiver in the final ROD as long as the agency establishes an alternative remedial strategy. Although this TI ARAR waiver has been available to the lead agency since 1980, the 1993 directive demonstrates EPA's recognition that the waiver may be especially applicable to sites with DNAPL contamination. To waive an ARAR based on technical impracticability, the lead agency must make a finding that focuses on technological infeasibility, rather than on cost.

The technical impracticability process begins when a potentially responsible party or the lead agency performs a TI evaluation. Based on the evaluation, the lead agency will make the TI determina-

408. Id. at 2.
409. Id. at 7.
410. Id. at 8.
411. Id.
412. Id. at 4.
413. Id. at 5.
414. Id. at 10. Cost is only a factor if meeting ARARs would be "inordinately costly."
415. The evaluation should include:
   (1) Specific ARARs or media cleanup standards for which TI determinations are sought;
   (2) Spatial area over which the TI decision will apply;
If the lead agency decides that restoration is impracticable, it will select an alternative remedial strategy. The alternative strategy must include three basic goals: Preventing exposure to contaminated groundwater, remediating contamination sources, and remediating aqueous contaminant plumes.

The 1993 directive suggests that consideration of the aggressiveness of the containment remedy is appropriate. Less aggressive strategies, such as natural gradient flushing and natural attenuation, cost less than more aggressive strategies, such as active pumping and treating throughout the contaminated plume. However, more aggressive strategies take less time to restore the plume outside the containment area and are likely to decrease the potential risk of exposure. The directive states that, where circumstances warrant, the lead agency should use more aggressive strategies, but that otherwise the lead agency may choose a less aggressive strategy. Thus, EPA implicitly allows cost effectiveness to be a consideration.

(3) Conceptual model that describes site geology, hydrology, ground-water contamination sources, transport, and fate;
(4) An evaluation of the restoration potential of the site [including] . . . .
(a) A demonstration that contamination sources have been identified and have been, or will be, removed to the extent practicable;
(b) An analysis of performance of any ongoing or completed remedial actions;
(c) Predictive analyses of the time frames to attain required cleanup levels using available technology; and
(d) A demonstration that no other remedial technologies (conventional or innovative) could reliably, logically, or feasibly attain the cleanup levels at the site within a reasonable time frame.
(5) Estimates of the cost of the existing or proposed remedy options, including construction, operation, and maintenance costs; [and]
(6) Any additional information or analyses that EPA deems necessary for the TI evaluation.

IMPRACTICABILITY GUIDANCE, supra note 331, at 11.
416. Id. at 11 n.12. Findings of TI can be made either as part of the final ROD or after the remedy has been implemented and found to be ineffective. Id. at 10. EPA believes that most cases will fall into the latter category since it is difficult to predict the effectiveness of a remedy based on limited site characterization data. Id. “Front end” determinations of technical impracticability require a detailed set of data. In some cases, where there is detailed site characterization and data analysis that define the most critical limitations to groundwater restoration, it may be appropriate to make a technological infeasibility finding prior to remedy implementation. Id.
417. All remedies must first meet the threshold remedy selection criteria: they must protect human health and the environment and comply with all ARARs that have not been waived. See supra part II.B.4.c. The lead agency must then use the balancing factors and evaluate whether an alternative is cost effective and utilizes permanent solutions and treatment “to the maximum extent practicable” as compared to other alternatives. IMPRACTICABILITY GUIDANCE, supra note 331, at 21. The remedy selection process provided in the NCP mandates these requirements. 40 C.F.R. § 300.430(f).
418. IMPRACTICABILITY GUIDANCE, supra note 331, at 19.
419. Id. at 22.
420. Id.
421. Id.
While the EPA directive goes into great detail in defining what data must support a finding of technical impracticability, EPA has discretion in deciding whether to waive ARARs or to insist on groundwater restoration. Nothing in the guidelines forces EPA to waive ARARs, because the guidelines do not establish any threshold that mandates a TI finding. This discretion increases inconsistency among EPA regions. Moreover, the discretion to proceed with restoration despite impracticability means that resources may be wasted on sites for which restorative technology does not yet exist while other sites will remain unaddressed. EPA seems to believe that it is appropriate to allow lead agencies to push for the highest level of cleanup since responsible parties will be footing the bill. Although EPA understandably wants to retain the technology-forcing aspects of its regulatory program by selecting stringent remedies, it may be losing credibility with both the public and industry by making promises on which it cannot deliver and by requiring industry to pay for ineffective and inefficient remedies.

A uniform policy should be developed for dealing with DNAPL groundwater contamination. At a minimum, containment technology should be implemented at all DNAPL sites. However, the lead agency should not be permitted to require restoration of a DNAPL-contaminated aquifer where the TI analysis shows that it would be technically infeasible, extremely costly, and environmentally damaging. Whenever restoration of an aquifer is possible in a short timeframe at reasonable cost, CERCLA mandates that the lead agency strive toward restoration. However, where the agency faces technical infeasibility, high costs, and increased environmental harm, the agency should look for alternative ways of dealing with groundwater contamination problems.

Instead of performing ineffective restoration activities, EPA should implement a systematic research and development program for cleaning up DNAPLs. Specifically, EPA should require responsible parties to directly subsidize research on the effective cleanup of DNAPLs.

C. Uncontrolled Discretion

The remedy selection process illustrates the tension between site-specific decisions requiring expert judgement and the inequities and inefficiencies of uncontrolled discretion. The remedy selection process is complex, requiring the lead agency to accomplish many difficult

423. See infra part IV.C where we propose that PRPs fund remedial technology innovation research.
tasks when choosing a remedy for each unique site. Our research has shown that the remedy selection process is largely an exercise of case-by-case discretion.\textsuperscript{424} For example, the lead agency exercises broad discretion in identifying remedial alternatives; when many alternatives exist, the lead agency may select a reasonable number to consider. Most importantly, the remedy selection criteria are broad enough that the lead agency can justify nearly any remedy at any site.

The lead agency for a particular site could conclude that extensive remedial treatment of contaminated soils and groundwater is required to protect human health because the site may support residential use in the future, and the groundwater is a potential source of drinking water. At the same site, the lead agency could decide that institutional and engineering controls, such as deed use restrictions and clay barriers, will eliminate exposure to contaminated soil and water, thus removing the need for treatment.\textsuperscript{425} Further, the lead agency could determine that alternative concentration limits should be used in lieu of drinking water standards because the remedial action will include measures to prevent exposure to the contaminated groundwater and there are known and projected points of entry of the groundwater into surface waters.\textsuperscript{426} In such a case, the lead agency need only ensure that the groundwater is remediated enough to prevent deterioration of the surface water, which may require minimal or no treatment.\textsuperscript{427} Overall, the lead agency could conclude that a remedy consisting of soil treatment, institutional and engineering controls, and little or no treatment of the contaminated groundwater achieves the best balance.

The broad discretion vested in the lead agency allows for the selection of a wide range of remedies. Variation in remedies among

\textsuperscript{424} EPA also has practically unlimited discretion in choosing which sites to remediate. \textit{See supra} part II.B.2.

\textsuperscript{425} \textit{See} 40 C.F.R. § 300.430(e)(9)(iii).

\textsuperscript{426} \textit{See supra} note 49 and accompanying text. The lead agency could also conclude that attainment of any ARARs, such as drinking water standards, should be waived because the lead agency determines that achievement of the ARARs is technically impracticable from an engineering perspective. \textit{See} 40 C.F.R. § 300.430(f)(1)(ii)(C)(3); 42 U.S.C. § 9621(d)(4)(C). However, one commentator has concluded that EPA prefers to use alternative concentration limits to justify remedies with little or no treatment of the groundwater. Brown, \textit{supra} note 49, at 336. This commentator believes that EPA is reluctant to use the ARAR waiver because this would "be tantamount to an admission by EPA that the remedy selected was less than adequate and that the groundwater beneath the site was being written-off for the time being because of cost considerations." \textit{Id.} However, as discussed \textit{supra} part III.B.3, EPA has acknowledged that there are serious questions about whether it is ever feasible to remediate an aquifer contaminated with DNAPLS. Thus, a technical impracticability waiver for attainment of MCLs or MCLGs may be more common in the future.

\textsuperscript{427} \textit{See} 42 U.S.C. § 9621(d)(2)(B)(ii). In one case, EPA used ACLs that were 400 to 600 times less protective than the applicable drinking water standards. \textit{See} Brown, \textit{supra} note 49, at 333.
sites fuels criticism that selected remedies are unjustifiably expensive and disruptive, not protective of human health and the environment, or inconsistent with the law. One commentator describes a case where EPA's efforts to restore an unused aquifer actually created a significant risk to public health and safety by disturbing an extensive fuel-piping system.\textsuperscript{428} Meanwhile, another commentator describes a case where EPA chose a remedy that "dramatically demonstrates how pressures to keep costs of cleanup to 'reasonable' levels have driven EPA to ignore the prescriptive commands of the Superfund law."\textsuperscript{429}

Of course, variance among site cleanups should be expected since contamination problems at each site are unique, the availability of different treatments varies among geographic regions, and local communities have differing values about the desirable level of cleanup. As EPA Administrator Carol Browner recently testified, EPA is committed to ensuring that lead agencies have adequate flexibility to meet the needs of the sites and the affected communities.\textsuperscript{430} However, some of the variance in remedies is caused by factors other than site-specific technical issues. For example, the selection of a remedy depends in large part on the balancing of the NCP criteria. Because of uncertainty about the risks posed by chemical contamination and the efficacy of various ways to address those risks, remedy selection may be substantially influenced by the remedial project manager's ideological beliefs and values.

Moreover, the ability of responsible parties to lobby the lead agency for less expensive remedial alternatives may have a significant effect on which remedy is selected. For instance, in an effort to expedite cleanups, EPA often settles rather than litigates the responsible parties' cleanup liability.\textsuperscript{431} The lead agency may strongly desire to settle with the responsible parties so that the private parties will conduct the cleanup\textsuperscript{432} rather than reimburse the lead agency for its

\textsuperscript{428} Elizabeth Temkin, \textit{Cleaning Up ARARs: Reflections from the Field}, 6 WATER, NAT. RESOURCES & ENV'T 18, 23 (1992).

\textsuperscript{429} Brown, \textit{supra} note 49, at 336. In this article, the author describes in detail the remedy selected for a site in Berks County, Pennsylvania. \textit{Id.} at 328-37. For this site EPA chose a remedy that will leave most of the soil contamination in place and will leave the groundwater so contaminated that drinking it will result in an increased lifetime cancer risk of $1.9 \times 10^3$. \textit{Id.} at 332-33.

\textsuperscript{430} Browner Statement, \textit{supra} note 11, at 470.


\textsuperscript{432} The lead agency's desire to have the responsible parties conduct the cleanup may result from strains on the lead agency's staffing or limits on the availability of money from the Superfund to finance the cleanup. \textit{See id.} (stating that "[f]und financed cleanups and litigation under CERCLA will not in themselves be sufficient to assure the success of this cleanup effort").
cleanup actions.\textsuperscript{433} This gives the responsible parties significant leverage in the remedy selection process.\textsuperscript{434} In addition, the NCP includes a provision allowing changes to a remedy already selected and documented in a ROD when such modifications become necessary as a result of negotiation and settlement with responsible parties.\textsuperscript{435}

One of the problems with uncontrolled discretion and variation in site cleanup is that poor and minority communities often are left with the most contaminated sites. The NCP requires the lead agency to involve the community in the remedy selection process.\textsuperscript{436} Because the selection of a remedy is ultimately a balancing process, it is influenced by the political clout of the affected community surrounding a site.\textsuperscript{437} Unfortunately, in the United States, the relatively greater political clout of predominantly White communities has generally resulted in more stringent remedies in these neighborhoods than in predominantly minority neighborhoods. A recent study by the National Law Journal found that at sites in largely White communities lead agencies decided to remediate the contamination 22\% percent more often than to contain the contamination.\textsuperscript{438} However, for sites

\textsuperscript{433} Id. In fact, the Hazardous Waste Enforcement Policy states that because cleanup can be started more quickly when private parties perform the work, it is “preferable for private parties to conduct the cleanup themselves.” Id.

\textsuperscript{434} It is interesting to speculate how the remedy selection process would be affected by replacing the litigation-based cost recovery scheme with a higher broad-based tax to completely fund cleanups. Such a proposal has been strongly advocated by the American International Group, Inc., which is the largest underwriter of commercial and industrial insurance in the United States. \textit{Why It’s Important To Put Cleanup First and Establish a National Environmental Trust Fund}, N.Y. TIMES, May 15, 1990, at C4 (special advertising section). For a detailed argument in favor of such a proposal, see Peter S. Menell, \textit{The Limitations of Legal Institutions for Addressing Environmental Risks}, 5 J. ECON. PERSP. 93, 105-10 (1991).

\textsuperscript{435} 40 C.F.R. § 300.435(c)(2). Responsible parties are often quite effective at advocating for or against certain technologies because many responsible parties have significant CERCLA litigation experience or the resources to hire attorneys with CERCLA expertise. See supra notes 293-96 and accompanying text (discussing changes to a remedy previously selected in a ROD).

\textsuperscript{436} See 40 C.F.R. § 300.430(c) (establishing community relations activities that the lead agency must conduct); id. § 300.430(f)(1)(ii) (requiring public review and comment on the lead agency’s proposed remedy).

\textsuperscript{437} Luke Cole, \textit{Empowerment As the Key to Environmental Protection: The Need for Environmental Poverty Law}, 19 ECOLOGY L.Q. 619, 646 (1992). Remedies tend to be more treatment intensive in White communities because “it is those with the political clout who win in the administrative process,” such as the selection of a Superfund remedy. Id.

\textsuperscript{438} Lavelle & Coyle, supra note 87, at 56. EPA characterizes selected remedies as either treatment or containment for the purpose of implementing the statutory preference for remedial actions that treat contamination. Id. The statutory preference for treatment is established by 42 U.S.C. § 9621(b)(1). As a guideline, EPA generally considers a remedial alternative to be a treatment alternative if the alternative would achieve reductions of 90\% to 99\% in the concentrations or mobility of contaminants of concern. See 55 Fed. Reg. 8666, 8721.
in minority communities, lead agencies decided to contain the contamination 7% more often than to remediate it.439

The disparity in remedy selection is likely a reflection of racism and differential power in society.440 People of color tend to have fewer resources to participate in political and administrative processes and tend to be underrepresented in decisionmaking bodies.441 Further, people of color often have a deeper skepticism about participating in legal processes, because the law has historically been used to oppress them.442 However, awareness of environmental injustice is on the rise, and a significant grassroots movement is attacking environmental racism.443 In the future, grassroots community organizations may prevent lead agencies from selecting less stringent remedies for sites in minority communities.444

The Clinton Administration has indicated a commitment to addressing the racial disparity in environmental protection. President Clinton recently signed an Executive Order creating an interagency task force on environmental justice to develop policies to ensure that poor and minority communities are protected from environmental harm.445 In addition, Clinton's proposed CERCLA amendments include provisions intended to address disparities in remedies selected for sites in disadvantaged communities.446 The proposal would require EPA to consider, in the Hazard Ranking System and the remedy selection process, the cumulative toxic risk faced by a site's affected community, and not just the risks posed by a site.447 The Clinton proposal would also establish Community Work Groups (CWGs) of community representatives to make remedy selection recommendations to EPA. These CWGs could give poor and minority communities a direct voice in the remedy selection process. We support these environmental justice provisions of the Clinton proposal. However, the Clinton proposal does not sufficiently limit the case-by-case discretion of site decisionmakers.

To avoid inequitable and inefficient variation in the methods and degree of site cleanup, the remedy selection process must be changed to curtail the lead agency's discretion. We recognize that the lead

440. Id.; see Paul Mohai & Bunyan Bryant, Race, Poverty & the Distribution of Environmental Hazards: Reviewing the Evidence, 2 Race, Poverty & Env't 3, 24-26 (1992).
441. See Mohai & Bryant, supra note 440, at 24-25.
446. Clinton Summaries, supra note 21, at 6.
447. Id.
agency must have flexibility to tailor remedies to meet the unique technical issues posed by each site and to address the concerns of the affected community. Yet the process must be changed so that the remedy selection decision does not simply emerge from a black box as the lead agency's balancing of the NCP criteria. This form of decision-making creates the danger that improper factors, such as the remedial project manager's ideological beliefs, the influence of responsible parties, and the race of the exposed community, will affect remedy selection.

D. Unaddressed Sites

In our view, the most serious problem with the current Superfund program is that EPA seems incapable of making progress in completing remediations and clearing the backlog of sites currently on the NPL. EPA's difficulty in addressing currently listed sites makes it resistant to identifying new sites and adding sites to the NPL. For example, the Congressional Office of Technology Assessment estimated that from 1980 to 1989 there were 240 to 2000 sites that EPA evaluated and should have added to the NPL, but did not. Thus, many sites that may be posing serious health risks are not eligible for Superfund-financed remedial actions. Perhaps more importantly, EPA has abandoned any systematic effort to identify new sites, despite the fact that EPA is aware that many unidentified and uncontrolled hazardous waste sites exist. Such sites are likely posing serious risks to human health and the environment. The contaminants at these uncontrolled and unidentified sites may continue to migrate. The longer EPA waits to identify and remediate these sites, the more expensive and difficult cleanup will be.

IV

PROPOSED REVISIONS TO THE REMEDY SELECTION PROCESS

We propose specific provisions for CERCLA reform to guide the lead agency more effectively in selecting a remedy and to create wiser allocation of resources at a greater number of sites. Our proposal contains five basic concepts. First, the lead agency, with input from the local community, must decide upon appropriate future uses of a site before conducting any other analysis. The lead agency must select a remedy that attains uniform cleanup standards for these appropriate

448. Over the past 14 years, work has been completed at only about 200 sites. Cushman, supra note 15, at A1.
449. COMING CLEAN, supra note 61, at 86.
450. Id. at 88 (stating that EPA officials believe that many unidentified hazardous waste sites exist, but that addressing currently identified sites is a higher priority).
future uses. Second, our proposal establishes a ceiling for costs that the lead agency may incur or require liable parties to incur in fully remediating a site. Third, our proposal requires minimum treatment at all sites, regardless of subsequent use, to prevent further migration of contaminants. Fourth, at sites where contaminants will remain on-site after remediation, responsible parties must pay a fee proportional to the amount of remaining contaminants. The proceeds from this fee will be used to pay for research and development of new remediation technologies. Finally, EPA must establish a systematic national site identification program in cooperation with the states.

A. Appropriate Uses

The first aspect of our proposal involves determining the appropriate uses for a site prior to setting cleanup standards. This proposal is similar to provisions in the Clinton Administration’s proposed CERCLA amendments. The Clinton proposal would require EPA to develop uniform standards for various land use scenarios. The lead agency at a particular site would then apply the appropriate standard for the reasonably anticipated land use. Under our proposal, the lead agency must decide upon appropriate postremedial uses of a site early in the remedy selection process and separately from other decisions. Thus, we agree with the Clinton Administration that the lead agency should make a separate and explicit determination of which future uses may be possible after completion of the site remedy and tailor the remedy to these uses.

The concept of tailoring cleanup to a realistic assessment of a site’s future land uses is hardly revolutionary. Many states take such an approach in state-administered cleanup programs. Furthermore, the idea has been endorsed by industry as well as the Natural Resources Defense Council. Thus, a broad consensus exists that cleanup resources need to be allocated more wisely by requiring stringent cleanups only where the high cost can be justified by a realistic assessment of the future use of a site.

452. Id. at 3.
453. Id.
To decide the most appropriate future uses for a site, the Clinton proposal would rely on Community Work Groups. Where a CWG reaches a consensus on future land use, the lead agency would be required to give this recommendation substantial weight. If a CWG does not reach a consensus, the lead agency would attempt to reconcile the differences and give substantial weight to the views of the CWG members who are residents of the affected community.

We support allowing CWGs significant input into the future uses decision. However, we would also require the lead agency to consider present and past uses of a site, current land use regulation of a site, whether a public water system is currently in use, and whether there is a realistic possibility that the community surrounding a site will need to use the contaminated groundwater as a source of drinking water in the future. In addition, we believe the lead agency should be required to consult the local land use jurisdiction and consider current land uses and trends in the surrounding area.

Furthermore, to allow the public to participate effectively, the lead agency should be required to provide information about the importance of the future uses decision in the remedy selection process. Moreover, the lead agency should be required to inform the public about potential disruptions and short-term risks caused by more intensive treatments that may be necessary to make a site available for residential use. Finally, for sites in poor and minority communities, the lead agency should ensure that CWG members are representative of the community. The lead agency should pay particular attention to the concerns of communities that have high concentrations of toxics to ensure they do not continue to be disproportionately affected by environmental problems. Thus, under our proposal, the lead agency must consider certain factors, including input from an informed and well-represented community, the cumulative toxic load the community is bearing, and the most appropriate future land uses and future uses of any contaminated groundwater.

Under our proposal, after the lead agency decides what subsequent uses of a site are appropriate, the agency assesses the technical constraints of the site. If the lead agency decides that the remedy should allow for residential or agricultural use of the site, and use of contaminated soil. See Standard Default Exposure Factors, supra note 150, at 15.
the contaminated groundwater as a source of drinking water, the lead agency should develop remedial alternatives that allow for such uses. For sites that will not be used in the future for residences or agriculture, or for contaminated groundwater that will not be used as drinking water, the lead agency should maintain discretion to select a remedy appropriate to the planned uses. Where appropriate, the remedial actions must include use restrictions that prevent residential or agricultural use of the site, use of the contaminated groundwater as drinking water, or both. Consistent with the Clinton proposal, we would require EPA to develop uniform soil and groundwater cleanup standards for various potential uses of land and groundwater.\textsuperscript{462} These uniform national cleanup standards would help eliminate the inconsistency, inequality, and wastefulness caused by site-by-site determinations of ARARs and calculation of risk-based remediation goals.

\textbf{B. Spending Limits}

In contrast to the Clinton plan, which would simply elevate the importance of the cost of a remedy, we propose spending caps on site cleanups. The Clinton proposal would change the factors that must be balanced in the lead agency’s selection of a remedy in ways that improve efficiency. For example, the proposal would eliminate the current statutory preference for treatment. However, the preference for treatment is retained for hot spots, which are sites with hazardous waste contamination that is highly toxic, cannot be reliably contained, and would present a significant risk to human health or the environment should exposure occur.\textsuperscript{463} In addition, the proposal would establish the following five factors to be weighed by the lead agency: (1) effectiveness; (2) long-term reliability, or the remedy’s ability to achieve long-term protectiveness; (3) implementation risk; (4) acceptability to the affected community; and (5) cost in relation to the preceding factors.\textsuperscript{464} Finally, the Administration’s proposal would direct EPA to develop “generic” remedies for categories of sites, which are intended to provide guidance to the lead agencies.\textsuperscript{465}

Although the Clinton proposal upgrades the lead agency’s consideration of cost and provides more guidance, the lead agency still retains a great deal of discretion at a particular site. We believe that further constraints on the lead agency’s discretion are necessary. Most importantly, we do not feel it is appropriate to require full remediation of a site at any cost. Giving the lead agency a blank

\textsuperscript{462} Clinton Summaries, supra note 21, at 21.
\textsuperscript{463} Id. at 22.
\textsuperscript{464} Id.
\textsuperscript{465} Id. at 22-23.
check at a site creates the danger that resources will be wasted on infeasible and costly remediation techniques while other sites remain unaddressed. Therefore, under our proposal, even if the lead agency determines that future residential or agricultural use of the site and/or use of the groundwater as a source of drinking water are appropriate, the lead agency may not select a remedy that allows for such uses if the remedy would be impracticable. Rather than leaving the meaning of impracticability to the discretion of the lead agency, our proposal requires a finding of impracticability when it is literally infeasible to achieve the necessary level of cleanup, or where it would either cost more than specified amounts or take longer than a specified number of years.

Under our proposal, soil remediation that allows for residential or agricultural use would be impracticable where it would cost more than ten million present value dollars or take longer than ten years to accomplish. Groundwater remediation that allows for use of the contaminated aquifer as a source of drinking water would be impracticable if it would cost more than twenty million present value dollars, or the time necessary to complete remediation would exceed thirty years or is entirely indeterminable. Naturally, the limits we propose are somewhat arbitrary, reflecting our subjective valuation of clean soil and water. Ultimately, these limits should be subjected to the political process, where voters can decide how much to spend to remediate contaminated sites. Where the lead agency must make a finding that restoration is impracticable, the lead agency should still have discretion to determine appropriate remedies, within the established cost limits, that are protective of human health and the environment.

It is likely, under our proposal, that the lead agency would have to invoke impracticability waivers for restoration of an aquifer where there is DNAPL groundwater contamination. As discussed above, there is strong evidence that attainment of drinking water standards at sites with DNAPL groundwater contamination is infeasible.466 Thus, we argue that EPA should not be allowed to require restoration of a DNAPL-contaminated aquifer if the only available remediation technologies are ineffective, costly, and possibly environmentally damaging.

C. Technological Innovation Fees

One possible criticism of our proposal is that capping the amount spent on remediating a site would undermine the impetus toward development of new and improved remedial technology. For this reason, we believe that there must be a mechanism to force responsible

466. See supra part III.B.2.
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parties to directly fund technological research. We propose that the lead agency assess a technological innovation fee on the responsible parties at sites where use restrictions are necessary due to remaining contamination.\textsuperscript{467} This fee would fund research and development of new remedial technology, including experiments conducted at government-operated contaminated sites.\textsuperscript{468} Such a fee should be substantial enough to fund significant research and proportional to the amount of contamination remaining onsite after completion of the remedial action. This fee will ensure that development of better remedial technology will continue so that perhaps one day, full remediation of all contaminated sites will be practicable.

\textbf{D. Minimum Remedies}

In addition to the above measures, we believe that the revised CERCLA statute should require a minimum amount of remediation at all sites. The lead agency should never simply construct a fence and post a no trespassing sign.\textsuperscript{469} Although many experts believe that uncontrolled hazardous waste sites are not a big problem,\textsuperscript{470} the public still perceives such risks as serious.\textsuperscript{471} Further, the public's perception of risks posed by uncontrolled hazardous waste sites goes beyond the "expected number of fatalities."\textsuperscript{472} Because these types of risks are artificial, latent, and involuntary, the public places an especially high value on them.\textsuperscript{473} Finally, and most importantly, despite the best efforts of scientists to understand the effects of chemical contaminants,
the long-term effects of chemical contamination are uncertain. EPA can only crudely estimate potential health effects of chemical exposures with animal bioassays.\textsuperscript{474} Moreover, scientists do not know what such contaminants may be doing to the ecosystems critical to our survival.\textsuperscript{475} In the face of such uncertainty, we believe that it is only prudent to minimize the extent of hazardous waste contamination problems at Superfund sites. Thus, CERCLA should be amended to require, at a minimum, remedies that include treatment to immobilize soil contamination and contain groundwater contamination, as well as measures that prevent human exposure to the contamination, such as clay barriers and institutional controls.\textsuperscript{476} We would require that every site receive a remedy that ensures contamination problems do not worsen with time.

\textit{E. Comprehensive Site Identification}

We believe our proposals would lead to more sensible remedy selection. By limiting the amount that can be spent on each site, more resources would be available to spend on unaddressed sites. Since there may be numerous unaddressed sites with serious contamination problems, we believe that it is essential that EPA establish a comprehensive national site identification program. EPA should work with local and state officials, who are currently responsible for site identification by default, to develop such a program. One starting point would be to use historical aerial photos to identify abandoned hazardous waste sites.\textsuperscript{477} Only after EPA identifies the bulk of the nation's uncontrolled hazardous waste sites can it begin to properly allocate cleanup resources and adequately address the uncontrolled hazardous waste disposal problem.

\textbf{CONCLUSION}

If anything is clear about the Superfund program, it is that the quick fix envisioned by Congress to clean up contaminated sites is not feasible. Since Congress first enacted CERCLA in 1980, many com-

\textsuperscript{474} See \textit{supra} note 125 and accompanying text.
\textsuperscript{475} See Doty & Travis, \textit{supra} note 141, at 1539 (finding that, although ecological risks at contaminated sites were acknowledged and assessed qualitatively, no extensive or quantitative assessments of ecological risks were prepared in 50 remedial action decisions).
\textsuperscript{476} The cap that we propose for technical infeasibility findings would not apply to these minimum remedial requirements. This cap would only apply to a finding that remediation allowing residential use or use of the groundwater as drinking water is not feasible.
\textsuperscript{477} Early in the Superfund program's history, EPA staff did begin work on the 200 Cities Hazardous Waste Site Discovery Plan, which included the use of historical aerial photographs to discover sites. \textit{Coming Clean}, \textit{supra} note 61, at 89. However, this program was summarily cut out of EPA's budget in 1982. \textit{Id}. 
plex technical and policy issues surrounding the clean up of hazardous wastes have emerged. These problems require significant time and resources to resolve. With Superfund reauthorization in high gear, we hope that our comprehensive presentation of EPA's remedy selection process will better inform participants in the debate by helping them to understand this process. We also hope that our proposals help to construct a more effective, efficient, and equitable law.

After reading pages and pages of statutes, regulations, and directives addressing the remedy selection process, we were struck by just how much is left to the case-by-case discretion of the lead agency. We were also struck by the amount of criticism that EPA's risk assessment process has engendered even though, as we demonstrate, its role in the remedy selection process is not as important as it may seem. We do, however, recommend some changes to the risk assessment process, which we believe will improve this guidance tool.

In addition, we believe that EPA should change its approach to groundwater remediation issues. There is a growing consensus that, under current technology, it is not feasible to remediate groundwater that is contaminated with dense nonaqueous phase liquids. Accordingly, we believe that full remediation of DNAPL-contaminated groundwater should not be required when the only available technologies are costly, ineffective, and possibly harmful. Instead, costs should be limited to reasonable levels, and remediation and containment strategies should be carried out as best they can. To ensure development of new technologies, we propose that a fee be imposed on responsible parties at sites where contamination will remain. Proceeds of this fee should be used to fund research and development of newer, more effective remedial technologies.

Finally, and perhaps most importantly, we urge EPA to establish a national site identification program. Only when EPA can conclude that it has identified most of the uncontrolled hazardous waste sites, can it properly allocate cleanup resources and begin to truly address our hazardous waste contamination problems.