NEW REPORT

## Environmental Remediation at Navy Facilities: Adaptive Site Management

*by Laura J. Ehlers*

As part of its ongoing efforts to help the Navy with its environmental cleanup program, the WSTB recently released *Environmental Remediation at Navy Facilities: Adaptive Site Management*. This report focuses on the latter stages of site cleanup. It is particularly appropriate for those sites with recalcitrant contamination where progress has stalled prior to meeting cleanup goals, thus preventing site closeout. Like other responsible parties with a large liability in hazardous waste sites, the Navy has hundreds of sites where conventional remediation technologies have been shown to be inadequate in meeting drinking-water-level cleanup standards. In many cases it is not clear how to replace or terminate remedies that have proved ineffective or how to change cleanup goals.

In response to this widespread dilemma, the report proposes a comprehensive and flexible approach, referred to as "adaptive site management," or ASM, for dealing with difficult-to-remediate hazardous waste sites. ASM borrows from the concept of adaptive management—an approach to resource management in which policies are implemented with the recognition that while the response of the system is uncertain, that this response will be monitored, interpreted, and used to adjust programs in an iterative manner, leading to ongoing improvements in knowledge and performance. Not only is ASM is consistent with the current cleanup paradigm used at federal facilities (as principally defined by Superfund), it has additional features that stress knowledge generation and transmittal and that complement more traditional cleanup objectives. The approach can accommodate different cleanup objectives, provide guidance at key decision-making points, and deal with the uncertainty inherent in many remedial strategies.

### *Adaptive Site Management Described*

The predominant paradigm for site restoration in the United States has until recently involved a unidirectional march from site investigation to remedial action and eventually to site closure. However, as sites have advanced through the restoration process, there has been a growing recognition that a more iterative approach is needed. The flexible nature of ASM is apparent in Figure 1, which is a schematic of the latter stages of ASM. The management decision periods (MDP) in the figure are designed to take advantage of the feedback loops embedded in ASM, such that uncertainties in site restoration can be addressed. These MDPs are also formal opportunities for the project managers, regulators, and interested stakeholders to evaluate data to determine if the remedial technology is meeting its objectives and, if not, to reach agreement on what additional management steps.

The purpose of MDP1 is to ensure that the remedy selected is practicable and implementable under site-specific conditions and that an appropriate, well-designed monitoring plan is developed. Subsequent to MDP1 and once the remedy is implemented, several actions can potentially occur as part of ASM. Along with operation of the remedy, there are ongoing monitoring activities—lumped under MDP2—that characterize this phase of cleanup. Denoted alongside remedy implementation in Figure 1 is evaluation and experimentation—an activity unique to ASM and one of the hallmarks of adaptive management in general. It refers to the conducting of experiments and other research activities in parallel with implementation of the chosen remedy. The evaluation and experimentation track is an opportunity to test innovative, less certain, sometimes riskier remedies that were not well enough established to be chosen as the initial remedy in the Record of Decision.

Later management decision periods give remedial project managers an opportunity to use information gained during evaluation, experimentation and routine monitoring to optimize the existing remedy, change the remedy, or even change the remedial goal. Depending on the action chosen, MDP3 may lead back to the initial steps of site management, remedy selection, or remedy redesign. MDP3 is a critical

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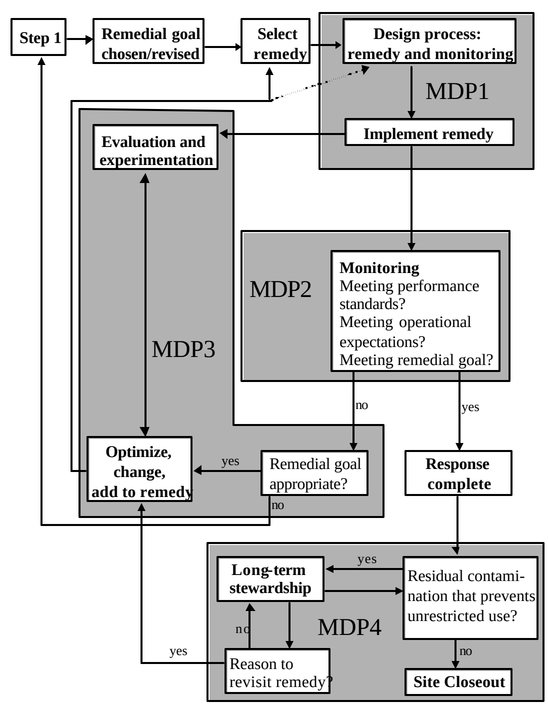


FIGURE 1 Latter stages of adaptive site management: post-remedy selection. The shaded area show the activities related to the management decision periods described in the text

CURRENT PROJECTS

### Assessment of Water Resources Research

Early in 2002, Congress mandated that the NRC conduct a study to determine the federal investment in water resources research. This activity is partly a follow up activity to the WSTB's report *Envisioning the Agenda for Water Resources Research in the Twenty-First Century*. In addition, it will determine the adequacy of the nation's investment in water resources research, given budget information that is being supplied by over 30 federal agency liaisons. The first meeting was held September 19–20 in Washington, DC, at which time the committee heard from its sponsor, USGS, as well as many of the federal liaisons and invited guests. The committee's second meeting held January 9–10, in Tucson, AZ, featured a panel of state representatives who discussed their state's water resources research needs for the next 10 years. Presentations on budget and program information from each of the federal liaisons will be the focus of the third meeting, scheduled for April 29–May 1 in Washington, DC.

Henry Vaux of the University of California is serving as committee chair. Other committee members include David Allan, University of Michigan; James Crook, consultant; Joan Ehrenfeld, Rutgers University; Konstantine Georgakakos, Hydrologic Research Center; George Hallberg, Cadmus Group; Debra Knopman, RAND; Lawrence MacDonnell, Porzak, Browning & Bushong; Thomas MacVicar, MacVicar, Federico & Lamb; Rebecca Parkin, The George Washington University; Roger Patterson, Nebraska Department of Natural Resources; Frank Schwartz, Ohio State University; and Amy Zander, Clarkson University. For more information, contact Laura Ehlers at 202-334-3422 or *lehlers@nas.edu.*

### Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems

Aquatic and related terrestrial ecosystems include lakes, rivers, streams, estuaries, wetlands, adjacent riparian systems, and upland areas, together with their associated flora and fauna. They perform environmental functions such as recycling nutrients, attenuating floods, recharging groundwater, and providing wildlife habitat. In addition, aquatic and related terrestrial ecosystems often form the basis of economic livelihoods and are used widely for recreation. But human activities have increasingly led to pollution, adverse modification, and devaluation of these natural systems. While ecosystem functions may be useful markers for studying physical, biological, and chemical processes, they are seldom experienced directly by resource users. In contrast, economists often find it helpful to envision resource "services" as things that create value for human users, which allows for the values of hydrologic, biogeochemical, and biological services to be more readily assessed.

The study will focus on identifying and assessing existing methods for defining and assigning economic values to the services of aquatic and related terrestrial ecosystems. The committee will consider the errors and biases of

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juncture at which many current sites are stalled because of lack of information about alternatives and the absence of any regulatory incentive to change course.

The final major decision of adaptive site management is MDP4, during which sites with residual contamination levels above cleanup goals are periodically assessed. Like MDP3, this decision can lead to a change in remedy if it is found that alternative technologies exist that can help achieve cleanup goals. This presents a departure from the current cleanup paradigm because the five-year review process that characterizes long-term stewardship does not support changing remedies unless the existing remedy is not protective of human health and the environment. When site managers, regulators, and the affected public have agreed that there are no unacceptable levels of contaminants left in place (i.e., the use is unrestricted), site closeout can proceed—the last step of ASM.

The report concludes by noting that there is strong support for adaptive approaches already present in recent federal guidance on monitoring and remediation. Indeed, recent Navy guidance calls for developing an alternative strategy at sites where plots of cumulative mass removed versus time exhibit "an asymptotic condition" prior to attaining the cleanup goal. ASM goes further to suggest how to interpret the monitoring data, when to consider using new technologies, and how to reach site closure for all types of sites. ASM affords a way to manage uncertainty while moving forward with the cleanup process because conventional remedies can be implemented first while additional information is gained on innovative but more risky technologies.

ASM is particularly appropriate for high-risk sites with multiple or recalcitrant contaminants, multiple stressors, and heterogeneous hydrogeology where progress has stalled prior to reaching cleanup goals and where projected large costs are at stake. Prior to widespread adoption, the Navy should consider pilot testing ASM at a limited number of sites to allow Navy managers to better understand any transactional costs and delays that may accompany ASM implementation.

The study was sponsored by the Naval Facilities Engineering Service Center. It was chaired by Edward Bouwer of Johns Hopkins University. Copies of the report are available from the WSTB office at 202-334-3422 or *lehlers@nas.edu.*

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