PRIORITIZING DOD HAZARDOUS WASTE SITES FOR CLEANUP

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ABSTRACT

The Defense Priority Model (DPM) ranks hazardous waste sites for remedial action priority under DoD's Installation Restoration Program. The DPM considers: the toxicity and concentration of contaminants present at the site; nearby human and ecological receptors; and ground water, surface water and air/soil as environmental transport pathways for contaminants. DoD plans to use DPM results to identify sites which present the greatest risk and therefore should receive funding priority. The DPM is a management tool that will help DoD implement its long standing worst first policy. DoD applied the DPM for the first time to sites where remedial activity was planned for fiscal year 1990. An automated version of the model was developed to facilitate scoring. DoD has coordinated DPM development efforts with the Environmental Protection Agency and States, and plans to continue to refine the model.

INTRODUCTION

For nearly 15 years, the Department of Defense has conducted an Installation Restoration Program (IRP) to assess and clean up contamination from toxic and hazardous substances on its installations. Early in the program, the Department established a policy of addressing first those sites which presented the greatest risk to public health and the environment. This policy still guides the program. To help implement this approach on a DoD wide basis, the department developed the Defense Priority Model (DPM).

BACKGROUND

The IRP is the primary element of the Defense Environmental Restoration Program (DERP) (10 USC 2701-2707 and 2810). The DERP was established by Congress in 1984 to coordinate and give emphasis to ongoing efforts by the Military Services. The IRP is DoD's program to carry out its remedial responsibilities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. It involves discovery, characterization and clean up of contamination on currently controlled DoD installations and formerly used properties in the United States and its territories. Research and development activities, community relations, risk assessment and other associated activities are also included in the program. In fiscal year 1991, DoD expects to spend over $1 billion on IRP activities.

The IRP is a self initiated program established out of concern for the health and welfare of installation personnel and communities located near military installations. In the mid-1970s DoD scientists realized that past manufacturing and production operations and waste management practices had contaminated the soil as well as surface and ground water. Of particular concern were places where contamination was moving off the installation in ground water and could result in civilian exposure.

From the start, DoD applied a worst first strategy to addressing sites. Early IRP efforts focused on industrial facilities, which had increased potential for contamination due to the nature of operations. These were primarily ammunition plants, arsenals, depots and rework facilities where large-scale manufacturing and maintenance activities which used and disposed of toxic and hazardous materials had been conducted over many years' time. The IRP has been greatly expanded and now includes all properties which have been identified as having increased potential for contamination due to past activities. This amounts to over 17,400 sites at 1,850 Army, Navy, Air Force and Defense Logistics Agency installations. Ninety-five sites are presently included on the Environmental Protection Agency's (EPA's) National Priorities List (NPL) of hazardous waste sites.

The conduct of the IRP is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300) and in coordination with EPA and state regulatory agencies. It is DoD policy to keep local communities informed of IRP activities, and at some installations, local citizens participate in the IRP process as members of technical review committees.

DoD Site Remediation Policy

DoD's site remediation policy has four facets. First, DoD takes immediate action at sites which present an imminent threat to public health or the environment. These sites are given highest priority and should be identified and the threat removed as rapidly as possible. Second, DoD cleans up sites on a worst first nationwide basis. Resources are applied first to those sites which present the greatest threat to human health and the environment. Third, the

department is committed to meeting SARA requirements at NPL sites. The SARA sets mandatory deadlines for initiation of work at NPL sites. To date, DoD has met all deadlines. Fourth, DoD must use resources efficiently and effectively. DoD takes interim actions to prevent site deterioration or arrest contaminant migration, and thereby achieves life cycle cost savings. Also, DoD may schedule work at multiple sites on one installation to save mobilization and administrative costs.

Need for a Prioritization Tool

As an element of the DERP, the IRP is centrally managed by the Deputy Assistant Secretary of Defense (Environment) (DASD(E)). The DASD(E) establishes policy and guidance for the program, including determination of activities eligible for funding and setting priorities. He also develops and defends the budget request before the Congress and allocates appropriated funds among the Military Services. The Military Services carry out the IRP at installations within their purview.

Several years ago the Department anticipated the need for a systematic prioritization approach to funding IRP activities, especially the more costly remedial activities. This recognition was based on several factors. First, the realization that many sites will be ready for cleanup at about the same time. DoD has over 4,500 sites where remedial investigations/feasibility studies (RI/FS) are underway. As these are completed, a large portion of the sites will be ready for remedial action. DoD expects cleanup efforts to peak in the mid-1990s. Second, resources, both funds and staff, are constrained. Although the Defense Environmental Restoration Account has faired relatively well in this era of Defense cuts, there is increased competition among the Services for funds. Staff resources to manage cleanup programs and oversee contractor support efforts are also severely constrained. Third, in order to maintain program integrity, DoD is developing a systematic method to assist the department in working with Congress, EPA, states and the public to accomplish work at specific sites.

Defense Priority Model Description

In response to this requirement, DoD developed what is now known as the Defense Priority Model (DPM). The DPM is a site ranking model designed to use information collected during the preliminary assessment/site inspection (PA/SI) and remedial investigation (RI) phases. It considers the characteristics and concentration of each contaminant (hazards), the presence of potential receptors (receptors) and the potential for contaminant transport through the environment (pathways). All three must be present to score a site. Figure 1 is a schematic of the model structure.

The score for each pathway-receptor combination is computed by multiplying the appropriate sub-scores for the pathway, hazard and receptor. The overall site score is computed as a root-mean-square average of the sum of these pathway-receptor combinations for the three DPM pathways: surface water, ground water and air/soil. This approach emphasizes high scoring combinations.

A description of each model component follows.

Pathway Scoring

The pathway sub-score of DPM rates the potential for contaminants from a waste site to enter surface water, ground water or air/soil. If contaminants from a site have already been detected in any medium, a maximum score of 100 is assigned to that pathway. If no contamination has been detected, the potential for contamination from the site along the pathway is calculated by inputing data about physical site characteristics. For surface water, the data inputs required are:

- Distance to nearest surface water
- Net precipitation
- Surface erosion potential
- Rainfall intensity
- Surface permeability
- Flooding potential.

Similar data are required for the ground water pathway and air/soil pathway scoring. The air/soil pathway considers both volatiles and contaminated dust.

Scores for each data factor are multiplied by a pre-established weight and all products summed. This value is then normalized. The score is modified by a waste containment factor that reflects the effectiveness of engineered barriers or clean up actions in reducing the potential for contaminant transport for each waste site type.

Hazards Scoring

Hazards scoring involves determining the potential hazard to human and ecological receptors posed by the pollutants present at the site. The hazard scores are a function of the route of exposure. For example, the human health score is based on the consumption of water or contaminated fish for the ground water and surface water pathway, and inhalation of contaminated air for the air/soil pathway. Similarly, the ecological scores are based on fish toxicity or irrigated crops *toxicity*, depending on whether the medium involved is water or air/soil.

For a site with measured contamination, health hazard scoring is based on the concept of comparing existing concentrations with an Acceptable Daily Intake (ADI). The observed concentration of each contaminant is converted to

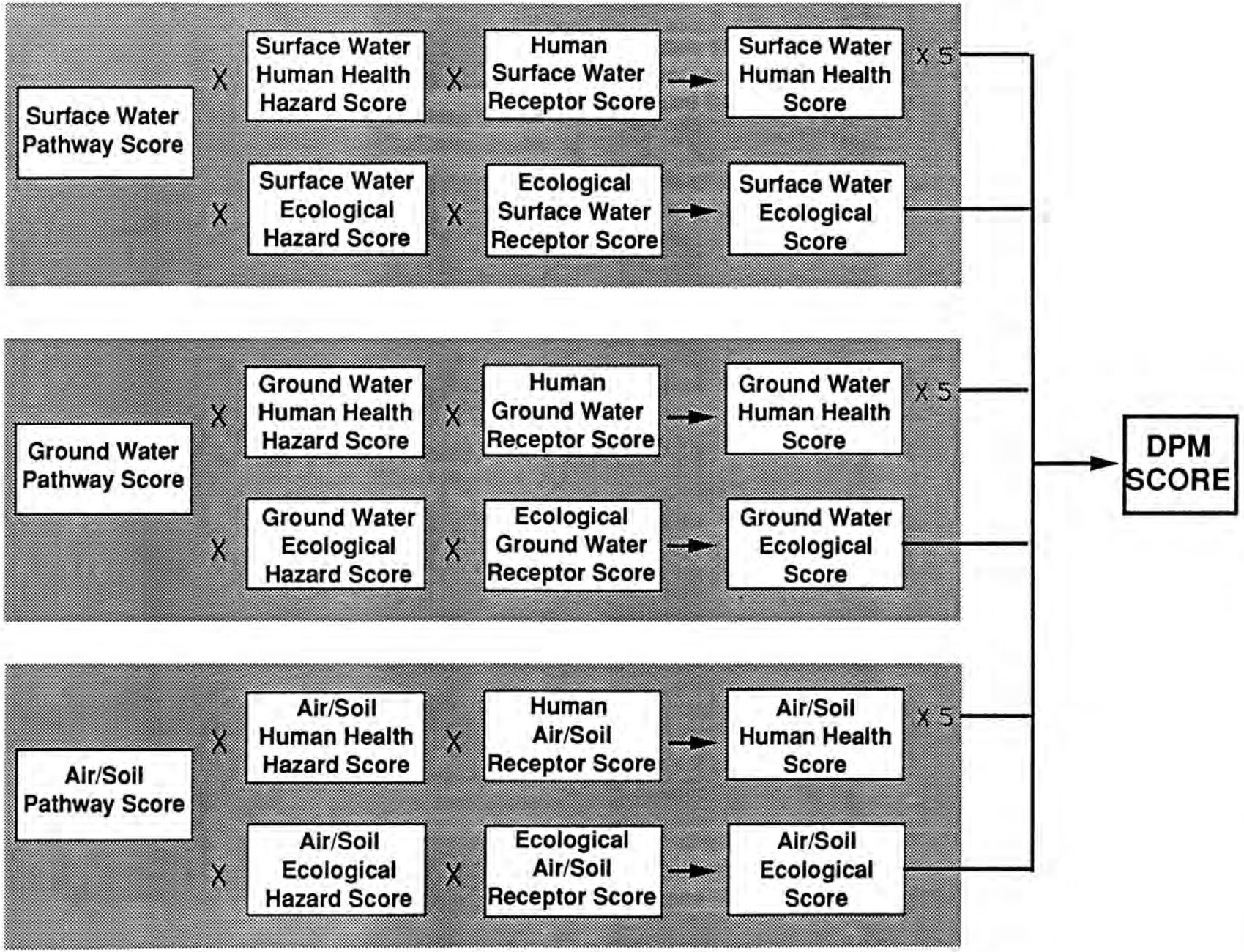

Fig. 1. Defense Priority Model Flow.

a daily ingestion or inhalation intake (micrograms/day) and then divided by a "benchmark." Benchmarks represent maximum acceptable exposure levels based on regulatory limits or, if these are not available, on toxicological information.

Human health benchmarks for the surface water and ground water pathways are derived from the following regulatory values, if they are available:

- Maximum Contaminant Levels (MCLs) for drinking water

And for the air/soil pathway:

- National Ambient Air Quality Standards (NAAQS)
- National Emission Standards for Hazardous Air Pollutants (NESHAPs)

Ecological aquatic benchmarks rely on:

- Ambient Water Quality Criteria (AWQC) for the protection of aquatic life (freshwater or saltwater)
- Ambient Aquatic Life Advisory Concentrations (AALAC)

There are no regulatory standards for terrestrial toxicity.

When standards have not been set for a chemical, toxicity data are used to establish the benchmark. Carcinogenic toxicity or non-carcinogenic chronic toxicity are preferred over acute toxicity data. For carcinogenic toxicity, both the weight of evidence (i.e., the number of species in which cancer end points have been observed) and the potency (i.e., the slope of the dose response curve) are considered. For non-carcinogenic chronic toxicity data the reference dose (RfD) is used. Toxicity is considered as a function of the route of administration: oral for surface and ground water pathways and inhalation for the air/soil pathway. Toxicity data have been obtained from: EPA's Chemical Data Management System (CDMS), Integrated Risk Information System (IRIS), and Health Effects Assessment Summary Tables (HEAST); DOE's Multi-Media Environmental Prediction and Analysis System (MEPAS); US Air Force Toxicology Profiles; and NIOSH's Registry of Toxic Effects of Chemical Substances (RTECS). Specific data on explosives and chemical agents were supplied by the Army.

If standards are not available for the aquatic exposure pathways, acute toxicity to the most sensitive fresh or saltwater species is used. For the air pathway, data on terrestrial toxicity are used, when they are available. If no data are available, the scorer inputs a small number to permit continued scoring of the pathway. Aquatic toxicity data used in the model are from EPA's CDMS; DOE's MEPAS and the AQUIRE database on the Chemical Information System (CIS) network. Terrestrial toxicity data are from the CIS database PHYTOTOX.

Radioactive materials and asbestos are considered as special cases in the model and benchmarks have been calculated.

To compute the hazard score for a site, hazard quotients are calculated for all observed contaminants (i.e., the concentration divided by the ADI). These are summed for all chemicals present at a site and a score assigned depending on the magnitude.

For sites at which contamination is suspected but not observed, the following methodology is used. The same toxicity data are used as described above, except they are combined with data on bioaccumulation and a health hazard score (from 0 to 9) is assigned. The bioaccumulation potential is considered important because it indicates that the length of time of exposure to the substance may be prolonged, if it is concentrated within living tissues. To indicate bioaccumulation potential, measured bioconcentration factors are used if they are available. If not, the log octanol/water partition coefficient or solubility in water can be used.

The chemical suspected to be present that has the highest health hazard score is used in later calculations as an indication of the potential human health risk. Similarly, the highest score for potential aquatic or terrestrial effects is used.

A consideration of pollutant mobility is currently being added to the hazards section of the DPM for the ground water pathway. This factor will take into account the tendency for the flow of certain materials to be retarded by their attraction to the soil. The retardation factor is calculated separately for organics and metals because of the different processes at work.

Receptors Scoring

The receptors portion of DPM rates the potential for humans and ecological resources to be exposed to contaminants released from a waste site. DPM evaluates six pathway/receptor combinations:

- Ground water/Human receptors
- Surface water/Human receptors
- Air/soil/Human receptors
- Ground water/Ecological receptors
- Surface water/Ecological receptors
- Air-soil/Ecological receptors.

The scoring system is designed to approximate media specific exposure, i.e., receptors are specified for each pathway; down stream or down gradient receptors have a much greater influence on the score than do upstream receptors. Human receptors are considered most critical and are weighted five times heavier than ecological receptors.

Human receptors are evaluated by site proximity to populations and use of water for drinking and other purposes. Ecological receptors are evaluated by site proximity to critical populations such as endangered species and critical habitats.

To facilitate site scoring, a computerized version of the DPM called the Automated DPM (ADPM) was developed. It operates on a PC-XT/AT platform and requires a hard disk drive and at least 640K Random Access Memory. ADPM contains all features of the model and provides additional assistance. For example, it supports units conversion, automatically computes confidence factors, applies previously input data at multiple points in the scoring process, performs lookups, and all calculations. Use of the automated version has dramatically decreased the time required to score a site and has increased scoring accuracy. The ADPM also creates a written record of the scoring which facilitates quality assurance reviews of the scores.

DPM Application

The DPM was designed so that mid-level technical personnel familiar with site conditions and basic exposure/risk concepts could score a site using information routinely available from RI reports and local agencies. This concept was initially tested in 1987. Project teams from three environmental engineering companies independently applied the DPM to 15 representative sites at three Air Force bases. Analysis of the results showed considerable variation in scores for a single site due to difficulties in applying instructions in the DPM user's manual, differences in technical judgement, and errors. Improvements in the user's manual were made to assist scorers and increase consistency in scoring.

Fiscal year 1990 was the first time the DPM was applied DoD wide. Service personnel responsible for site project management were trained in scoring using the automated DPM. These personnel scored over 275 sites where remedial activities were planned for fiscal year 1990. Scoring support was provided through a toll free telephone hotline number.

A quality assurance review was conducted on the scoring packages. Two levels of review were performed. All packages received general review for completeness of scores, internal consistency of data inputs, etc. A statistically representative group of sites plus all high scoring sites, received a comprehensive review whereby each data input was checked for reasonableness and consistency with source documents such as remedial investigation reports. Results of these reviews indicated that the primary problem facing scorers was incomplete site data. Project managers attempted to score all sites where remedial activity, including interim actions, could potentially be taken in the upcoming fiscal year. Consequently, sites for which an RI has not been performed were scored using best engineering judgement. Confidence in these scores was low. Also, there was a high degree of variation among scorers in assumptions, and pathway integrity was compromised by scorers using data from other sites on the installation. These scoring difficulties were not unanticipated since application of DPM is a relatively complicated and labor intensive process. The average site takes 4-8 hours to score, requiring between 60-70 data inputs.

Before fiscal year 1991 scoring was initiated, project managers received additional guidance and training. For example, to alleviate the problem of lack of data, project managers were instructed to score only those sites where a remedial investigation has been completed, or for which, at a minimum, critical data elements were available. Scorers were required to assign confidence values to each data input. For the fiscal year 1991 program, 290 sites were scored. A two level quality assurance review of the scoring packages, similiar to the FY90 review is now being conducted.

Use of DPM Results

The DPM was designed to use information on site characteristics, nearby environmental conditions and receptors to produce a score (0-100) indicating relative risk. Because DPM is applied after a site has been characterized, the results should be more reliable than screening tools such as EPA's Hazard Ranking System which are applied earlier in the site assessment process. The DPM is still a general management tool, however and does not attempt to predict exposure or quantify risk. The DPM's value lies in applying a standard set of criteria applicable to DoD to sites nationwide to achieve a relative indicator of risk. Incorporated in the DPM are conservative assumptions which help ensure potentially high risk sites are not overlooked.

DoD intends to use DPM scores to assist in prioritizing sites for funding. Generally, sites with higher DPM scores will be funded before sites with lower scores. Since DoD considers its NPL sites to be high priority, DoD envisions that the DPM will be most useful in ranking its non-NPL sites. DoD does not intend to establish a no action level below which remediation would not be accomplished. DoD has committed to taking action at all sites where remedial action is necessary.

DoD Commitment to DPM

DoD is strongly committed to the DPM and wants the Congress, regulatory community and the public to accept it as part of the way DoD manages its program. The DPM is included in model language for Interagency Agreements signed by DoD and EPA for NPL sites under the Superfund Amendments and Reauthorization Act, and also in model language for Defense and State Memoranda of Agreements

(DSMOA). The DSMOA program is designed to accelerate DoD clean up efforts within individual states. Under the program, states and territories may be reimbursed for technical support services they provide to DoD during the course of site investigation and clean up.

OUTREACH AND FUTURE DIRECTIONS

DoD has encouraged participation by EPA, States and the public in the DPM process. In 1987, prior to applying DPM, DoD published a Federal Register notice announcing a public comment period. DoD received comments from EPA and three States. The comments were considered and as a result, improvements were made to the model. Comments and DoD responses were summarized in a second Federal Register notice in October 1989. DoD is continuing to work with EPA and States on the DPM.

DoD will continue to refine and apply the DPM. During fiscal year 1990, DoD revised the benchmark methodology and updated the chemicals database. User friendliness of the automated DPM was improved, and a mandatory confidence factor was added for each data input. A waste quantity factor may be added to help differentiate between sites which have large quantities of waste and small quantity sites. DoD is also contemplating integrating other factors such as regulatory considerations into its prioritization process.

As DoD learns more about how the DPM performs, and gains confidence in model results, we expect to rely on it more heavily to prioritize sites. We have commissioned the National Academy of Sciences (NAS) to review the DPM. The NAS will review the DPM and other ranking methodologies for their appropriateness for intended use and their technical merit.

CONCLUSION

DoD must prioritize its sites in order to achieve its policy of worst first nationwide. The DPM is a useful tool to assist DoD decision makers in the Military Services and the Office of the Secretary of Defense. DoD expects to continue to work with EPA and States to refine the DPM to improve its usefulness.