



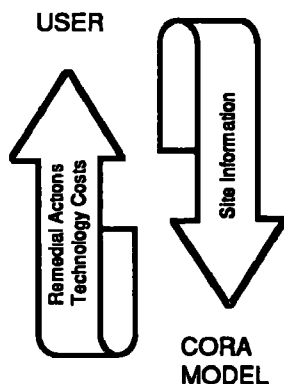
The Cost of Remedial Action Model

Office of Emergency and Remedial Response
Hazardous Site Control Division (OS-220)

Quick Reference Fact Sheet

INTRODUCTION

The Cost of Remedial Action (CORA) model is a computerized expert advisor used to select remedial actions for Superfund hazardous waste sites and estimate their costs. It may also be used for RCRA corrective actions. The model is used for both current site-specific estimates, and for program budgeting and planning.



The expert system, with its technical information and regulatory interpretations, interacts with the user to guide in the selection of a remedy and to recommend a range of remedial action technologies at a specific site. The cost system is used to develop cost estimates for the remedial action scenario. The system provides order-of-magnitude estimates for both capital and annual O&M costs. The user must manually extrapolate these costs to determine total present and future worth. The model is not currently designed to develop multiyear groundwater treatment scenarios. Both the expert system and the cost system have been validated, and the model has gained widespread use since its first release in 1987. The newest release will be available in May of 1990.

This short sheet describes the following aspects of the CORA model:

- Development
- Testing
- Structure and function
- Applications.

Finally, the short sheet provides additional sources of information on the CORA model.

DEVELOPMENT OF THE CORA MODEL

The Superfund program requires accurate cost estimates to manage current activities and develop budgets. In order to improve the accuracy and objectivity of cost estimates, EPA conducted a study in 1983 to quantitatively define pricing factors for remedial actions. A modeling approach was selected to develop pricing factors because of limited historical construction cost information. Information used to develop these early cost models included data about conditions at a sample of Superfund sites, categorizations of site types, and guidance criteria for selecting remedies. This information was aggregated to obtain budget pricing factors.

In 1985, EPA attempted to dis-aggregate early modeling results to obtain site-specific estimates. The variability of these estimates confirmed the need for different modeling tools to determine accurate site-specific costs. In addition, EPA needed a method to estimate remedial action costs in the pre-feasibility stage of analysis. The CORA model was developed in response to these needs, and is used to select remedial action technologies and estimate Superfund costs on a site-specific basis.

TESTING OF THE CORA MODEL

In order to confirm the accuracy of the CORA model, a validation exercise was performed by an independent consultant. The methodology employed by the study included examining the technology being implemented at each site, loading this data into the CORA model, and comparing CORA estimates with actual costs (either bid or construction). In May of 1987, the model was used to examine cost estimates for 12 sites. The twelve sites were either in final design, had bids established, or were in construction. Results of the analysis showed nine of the 12 were in the range of -30% to +50% of the CORA projections. Modifications were made to the model and the results obtained in June of 1988 showed all 12 sites to be within range.

The consultant also conducted a subjective evaluation of the expert system of the model. This aspect of the validation exercise sought to determine whether the CORA model recommendations conformed with good hazardous waste engineering practice, and were reasonable solutions from an engineering perspective. Results showed the model to be successful in meeting both criteria.

In a separate validation study conducted in 1990, the Department of Energy reviewed 25 RODs against the recommendations generated by the CORA model on these 25 sites. Results of this comparison revealed that 97% of the CORA model recommendations were in fact ROD alternatives.

STRUCTURE AND FUNCTION OF THE CORA MODEL

The CORA model includes two independent subsystems: an expert system and a cost system. The expert system uses site information generally accessible at the remedial investigation stage to recommend a range of remedial response actions from among 42 different technologies (see table). The cost system is used to develop estimates for the technologies selected, or may be used to independently assess remedy recommendations from other sources. The following subsections describe the expert system and the cost system more fully.

CORA SYSTEM COMPONENT DETAILS Technology Cost Modules

Containment Technologies:

Soil Cap
Asphalt Cap
Multilayered RCRA Cap
Surface Controls
Slurry Wall

Removal Technologies:

Drum Removal
Soil Excavation
Sediment Dredging
Pumping Contained Wastes
Groundwater Extraction
Active Landfill Gas Collection

Treatment Technologies:

Air Stripping
Vapor Phase Carbon
Activated Carbon
Metals Precipitation
Activated Sludge
Soil Vapor Extraction
Soil Flushing
Home Carbon Units
Offsite RCRA Treatment
Offsite RCRA Incineration
Onsite Incineration
Solidification
InSitu Biodegradation
Ion Exchange
Pressure Filtration
Flaring
Soil Slurry Bioreactor
Insitu Stabilization

Disposal Technologies:

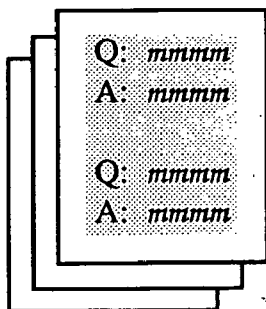
Offsite RCRA Landfill
Onsite RCRA Landfill
Below Grade
Above Grade
Offsite Solid Waste Landfill
Discharge to POTW
Discharge to Surface Water
Water Reinjection
Water Infiltration

Miscellaneous Technologies:

Transportation
Municipal Water Supply
Groundwater Monitoring
Access Restrictions
Health and Safety
Site Preparation
Site Administration

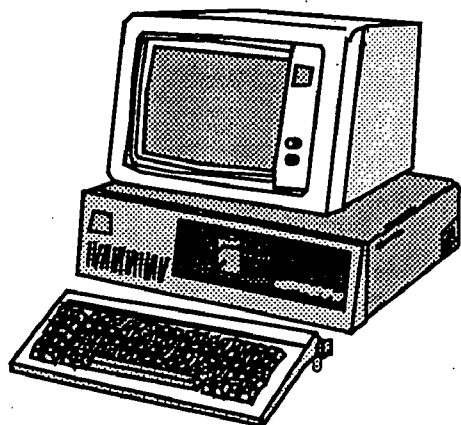
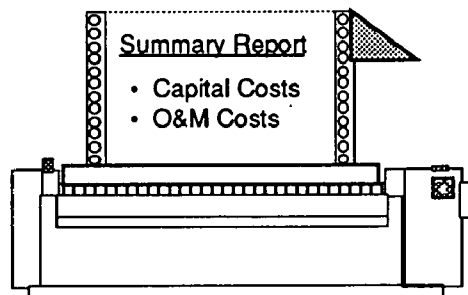
Expert System

The expert system contains the data that enables the CORA model to evaluate the information provided by the user. The user defines the site by responding to system-selected questions for waste types within a contaminated area of the site. The expert system analyzes the site based on user responses by focusing on up to 13 different types of waste matrices ranging from contaminated soils to bayous, to drums, to buildings, and offers recommendations to remedy the site. The CORA expert system's knowledge bases have approximately 670 decision rules to apply the 42 available technologies. The decision rules incorporate technology-specific engineering expertise, statute interpretations, and policy issues. The user can change responses to questions posed by the system, but cannot alter the decision rules. The system provides paper output of questions and responses to questions for future use. Thus, the system enables the user to perform sensitivity analyses by exploring alternative outcomes based on different site information.



Cost System

The CORA cost system is used to develop order-of-magnitude cost estimates (-30% to +50%) for sites after the response action scenarios are developed, using the expert system or other sources. The CORA cost system organizes cost estimates by site, operable unit, scenario, and technology. The system and the user interact to complete this information for a site previously entered into the data base or for a new site. The CORA cost system calculates capital and first-year operation and maintenance (O&M) cost estimates for each technology selected. The user may save outputs to the data base for subsequent analysis. In addition, the CORA model generates a total summary report for a site or operable unit for both capital and O&M costs. The summary report includes costs incurred by construction and operation of individual unit processes and operations, costs for items such as site preparation and administration, startup, permitting and legal services, permit and insurance renewal, services during construction, and bid and scope contingencies.



Hardware Requirements

The CORA model requires the following computer hardware specifications:

- IBM compatible PC
- MS-DOS environment
- 640K RAM
- 3 MB of hard disk space.

The CORA model is a stand-alone application, not designed for LAN use.

PRESENT AND FUTURE APPLICATIONS OF THE CORA MODEL

The CORA model is a powerful tool that saves time and increases the user's awareness of the scoping process, policy issues, technology costs, and design factors when selecting remediation schemes. Users have reported that, in particular, the expert system increases awareness of regulatory requirements and restrictions. The model also familiarizes them with basic design elements and individual technology costs. The CORA model has been used for several purposes since it was developed, tested, and approved. The CORA model was used to make cost estimates for 97 Superfund sites likely to be FY 1989 remedial action candidates. The results of the CORA expert system and cost system runs were combined with other information to develop EPA's FY 1989 budget. The model has subsequently been used to develop costs for components of FY 1991 and 1992 budgets. CORA model data has helped EPA shape the selection of remedies under SARA.

The CORA model was applied to Navy installation restoration program sites to estimate Defense Environmental Restoration Act funding for FY 1989, 1990, and 1991. In addition, the Department of Defense uses the CORA model to develop remedial action strategies and estimate their total remediation costs.

APPLICATIONS OF THE CORA MODEL		
User: EPA	Purpose: • Develop Superfund remediation budgets • Perform initial site-specific remediation scoping	Benefits: • Saves time -- 1-3 hours to scope and cost a remedial action scenario vs. 20-60 hours without the model • Increases users' awareness of scoping, policies, regulations, design factors, and technology costs
Other Federal Agencies	• Estimate outyear and total programmatic remediation budgets	
Private Industry	• Anticipate cost effects for Regulatory Impact Analyses of new environmental regulations	
States	• Estimate site-specific remediation budgeting and scoping	
All of the Above	• Screen, scope, and budget for technology of RCRA Corrective Actions and closures	

As the model is upgraded, new versions will become available. The newest version is due to be released in May 1990 and will include several new technologies, new cost algorithms, and new market prices for offsite technologies.

TO OBTAIN THE CORA MODEL OR MORE INFORMATION

Federal and State agencies may obtain a limited number of copies of the CORA model from EPA at no cost. The general public may obtain the CORA model from EPA for \$280, the cost of reproduction and support. The CORA model package consists of 8 diskettes, a comprehensive user's manual, and one hour of telephone information and assistance. The user's manual contains required information about remedial technologies, cost assumptions, design ranges, technology uses, and schematics for the technologies. The following publications provide additional detail on the CORA model:

- "A Model for Estimating the Cost of Superfund Remedial Actions," Richard K. Biggs and R. Benson Fergus, P.E., HMCRI proceedings of the 8th National Superfund Conference, Washington, D.C., November 16-18, 1987
- "The Cost of Remedial Actions Model: Practical Applications," Richard K. Biggs and Jacqueline A. Crenca, September, 1988
- "The Cost of Remedial Actions (CORA) Model: Overview and Applications," Richard K. Biggs, Kevin Klink, Jacqueline Crenca, submitted for proceedings of HAZMACON 89, Santa Clara, California, April 1989.

Information may be obtained through the following:



- The CORA Hotline - (703) 478-3566, to obtain the model and technical assistance, demonstrations, training seminars, and CORA costing services
- The Superfund Docket and Information Center (SDIC) - (202) 382-6940, to obtain publications (including those listed above) and directives
- The RCRA/Superfund Hotline - (202) 382-3000 or (800) 424-9346, for program information.