NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 310

DEALING WITH HAZARDOUS WASTE SITES
A COMPENDIUM FOR HIGHWAY AGENCIES

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Staff
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Many state highway agencies are beginning to encounter problems caused by the discovery of hazardous waste on existing or soon to be acquired rights-of-way. Because these problems affect highway agencies in many ways, the information assembled in this report will be of interest to professionals in a variety of disciplines. Environmental specialists, right-of-way officials, project development engineers, construction contract administrators and engineers, and legal counsels can all be involved, depending on the agency's organizational structure and the particular point at which the problems associated with hazardous waste are encountered.

Improper disposal and management of hazardous wastes, hazardous substances, and toxic chemicals have created substantial problems for state highway and transportation agencies in the planning, design, construction, and operation of highway facilities. For example, parcels purchased or considered for purchase by state highway agencies are sometimes contaminated by hazardous waste. Such sites, in addition to having been used as dumps, frequently reflect improper management of hazardous materials by former businesses. Federal and state regulations require that state highway agencies develop and implement plans for resolving these problems. Hazardous waste problems and their solutions have far reaching impacts on highway programs by increasing costs, creating time delays, and providing greater opportunities for litigation.

Under NCHRP Project 20-22, "Factors to be Considered by Highway Agencies in the Identification and Remediation of Hazardous Waste Sites," HMM Associates, Inc., Concord, Mass., and Eastern Research Group, Inc., Arlington, Mass., synthesized existing information to prepare a resource document that will assist highway agencies in the development of their own guidelines. The research was specifically directed at problems related to hazardous waste sites, and not to the storage and disposal of agency-generated hazardous waste or to the immediate response to accidents involving hazardous materials.

Problems associated with hazardous wastes are critical, yet fairly new for many highway agencies. The presence or suspected presence of hazardous waste sites creates a multitude of problems affecting right-of-way acquisition, project development, and construction. Solutions to these concerns involve an intricate array of regulations, and require interactions with other agencies and individuals as well as with the general public. A complete treatise on the issue of hazardous waste sites would be a monumental effort beyond the resources available to an NCHRP project. Therefore, the ojective of the research documented in this report was to compile the principal, relevant information describing the administrative, technical, and legal considerations that highway agency officials must be sensitive to when developing and implementing

highway programs. The information provided will be a useful resource in the challenging, complex process of dealing with hazardous waste sites.

The possibility of encountering hazardous waste sites is not to be ignored. This NCHRP report will assist state highway agencies, and others with similar concerns, prepare for dealing with these potentially serious problems. Indeed, some problems can be avoided, and for others, more rational remediation approaches can be developed than might be possible under the pressures to act quickly once a hazardous waste site is discovered. However, no matter what preparations are made, they must continually be reexamined. The complexities and uncertainties caused by changes in the technological, legislative, regulatory, and legal environments require that information on hazardous waste be reviewed and updated.

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ACKNOWLEDGMENTS

This report was developed under NCHRP Project 20-22 by HMM Associates Inc., Concord, MA, and Eastern Research Group, Inc., Arlington, MA. HMM Associates was the contractor for this study. The work undertaken by Eastern Research Group was under subcontract to HMM Associates.

David J. Friend, HMM Associates, and Jan Connery, Eastern Research Group, were co-principal investigators. Legal advice was provided by the law firm of McGregor, Shea and Doliner. Other contributors to the report included C. George Bower, HMM Associates; and Brana Lobel, Heidi Schultz, and Linda Saunders, Eastern Research Group.

DEALING WITH HAZARDOUS WASTE SITES
A COMPENDIUM FOR HIGHWAY AGENCIES

SUMMARY

Hazardous waste sites can pose a myriad of legal, regulatory, financial, and technical problems to a highway agency and its officials. An agency becomes exposed to substantial liability when it purchases a contaminated parcel of land or if it owned property when wastes were placed there (either by past agency practices, by third-party illegal disposal practices, or by the activities of tenants). Under a number of federal and state statutes, claims can be made against the agency for a variety of cleanup costs, as well as for personal or property damages. In addition to these costs, the additional time delay that results from cleaning up a contaminated site can add significantly to overall project costs. And, highway agency personnel—unfamiliar with the signs and properties of hazardous wastes—can expose themselves to considerable safety and health risks.

The research project documented in this report was initiated in response to highway agency concerns over hazardous wastes discoveries. The principal objective of this project was to develop a compendium of information that highway officials can use: (a) to understand the liabilities and risks they face; and (b) to develop internal policies and procedures that, if implemented properly, will avoid or minimize agency liability. It was also intended to provide highway staff with a basic understanding of the techniques, technologies, and terminology associated with the identification and remediation of a hazardous waste site.

The report is divided into two parts. The first part, the research report, provides background information and describes the research approach. The problems and practices of highway agencies described in this part were determined from a telephone survey of highway agency staff and the results of a mail survey conducted by the Federal Highway Administration (FHWA). The state of the art in hazardous waste technology was assessed from the results of a telephone survey of federal and state agencies, trade associations, university research centers, and an extensive literature review. The findings of the research are also summarized in this part, and several areas worthy of further study are identified.

The second part of the report, the compendium, consists of information that highway officials are urged to consider in developing operational plans to deal with the problem of hazardous waste sites. This compendium of information provides the reader with:

- Summarized experiences of state highway agencies with hazardous waste sites to date.
- Applicable provisions and liabilities imposed by federal, state, and common law on highway agency real estate transactions.
- Advice which highway officials should consider when formulating policies and procedures to minimize agency hazardous waste liability.

- A description of how highway agencies can organize and staff to integrate hazardous waste considerations into agency decision-making.
- A description of the role of hazardous waste contractors and how highway officials can effectively identify, evaluate, and select contractors to perform hazardous waste site investigations and remediation activities.
- Guidance on how to develop a community relations plan—an essential activity whenever hazardous wastes are suspected or found on highway agency property or rights-of-way.
- A description of the preliminary activities that can be performed by highway agency staff or contractors to determine the potential for hazardous waste contamination on a site.
- A description of the on-site activities that can be performed by trained personnel to confirm or deny the findings of a preliminary hazardous waste site evaluation.
- A description and comparison of the hazardous waste remediation technologies that are presently available and the conditions suitable for their application.

There can be no prescription for how a highway agency should manage its real estate holdings to minimize liability. Every agency is different in its organizational structure, political environment, financial resources, and environmental issues of importance. However, every highway agency should review the compendium with the intent of modifying and adapting the information it provides to the agency's unique conditions.

Part I—Research Report

Chapter 1

INTRODUCTION

PROBLEM STATEMENT

Statistics on the quantities of hazardous wastes generated each year in the United States are intimidating. The U.S. Environmental Protection Agency (EPA) estimates that more than 275 million metric tons of hazardous wastes are generated each year. These wastes consist of chemical products, biological products, fuels, petroleum products, explosives, acids, fertilizers, gaseous substances, and various industrial wastes.

Radioactive materials are another form of hazardous wastes. More than 20,000 medical and academic institutions, laboratories, government agencies, industrial enterprises, and nuclear power plants generate low-level radioactive waste. A recent Department of Energy study projects that the volume produced by these organizations could double by 1990.

Despite the threat of civil and criminal penalties, significant quantities of hazardous wastes are being disposed of improperly. Because of economic conditions, changing regulations, and the limited number of approved disposal sites, some hazardous waste generators and transporters continue to dispose of their wastes illegally.

More than 16,000 hazardous waste sites have already been identified nationwide. Moreover, the U.S. General Accounting Office estimates that the improper disposal of commercial, industrial, and municipal hazardous wastes during the past several decades has probably produced over 235,000 sites where ground water, surface water, soils, and air are contaminated. Newspaper and other media accounts are daily reminders of the extent and seriousness of hazardous waste sites.

State highway agencies are not isolated from the problems that result from the improper disposal and management of hazardous wastes. State highway officials have purchased or considered for purchase contaminated parcels of land. Hazardous waste problems have been uncovered during the evaluation of alternative highway corridors or alignments and during the excavation and construction phases of projects. Highway officials have also had to deal with hazardous wastes dumped illegally on existing rights-of-way.

The discovery of hazardous waste sites can have enormous impacts on highway project planning, budgeting, and programming. Therefore, highway officials must be familiar with federal and state hazardous waste regulations and have up-to-date knowledge of the procedures and techniques approved for hazardous waste site assessment, investigation, and remediation. In the absence of this guidance, highway agency staff can expose themselves and the agency to considerable liability and risk.

RESEARCH OBJECTIVE AND SCOPE

The overall objective of this research project was to develop a guidance document that describes an approach for systematically integrating hazardous waste considerations into highway planning and decision-making. To be comprehensive in its coverage, the document identifies the liabilities associated with the ownership of contaminated property; the steps an agency can take to reduce the chances of acquiring contaminated property in the future; and the ways to minimize the risks associated with uncovering hazardous wastes during construction. It also suggests activities an agency can engage in to improve its management of existing property so that hazardous waste liabilities are minimized. The objective was not to conduct new research in the area, but rather to synthesize and present existing information in a clear and concise manner.

The focus of this research project was on hazardous waste sites and the management of highway agency real estate. It does *not* address the requirements of properly storing and disposing of hazardous wastes associated with agency activities and stored at agency facilities.

This research project was intended to fill a gap in information that highway officials should have at their disposal, especially those officials involved in project development, environmental aspects, rights-of-way, construction, maintenance, and legal issues. If used wisely, the information presented in the compendium will:

1. Minimize the likelihood of highway and other agency personnel being exposed to potentially harmful hazardous chemicals in the course of their day-to-day activities.
2. Reduce or eliminate litigation against the highway agency or individual staff.
3. Realize significant cost savings through improved highway agency decision-making and pre-acquisition site assessment.
4. Minimize the need for highway redesign and other costly construction delays.

RESEARCH APPROACH

The research approach for this project consisted of five basic tasks: (1) describe the procedures currently being used by state highway agencies to avoid or minimize the liability incurred with the discovery of a hazardous waste site; (2) describe the procedures being used by others (e.g., federal and state environmental agencies, hazardous waste contractors, construction contractors, professional trade associations, and unions) to assess and evaluate parcels of land for potential hazardous waste; (3) describe currently available remediation technologies; (4) prepare a compendium summarizing the results of the foregoing tasks; and (5) prepare a report of the research project findings (including the compendium).

Survey of Highway Agency Problems and Needs

To develop an understanding of how the issue of hazardous waste sites is addressed by state highway agencies, a series of telephone interviews was conducted with selected state government officials in every state. These interviews were followed by site visits to Florida and Pennsylvania for the purpose of gathering more detailed information on activities being undertaken there.

Individuals to contact within each state highway agency were identified from the most recent *ASSHTO Reference Book of Member Department Personnel and Committees.* To cover the entire range of potential agency involvement, contacts were directed initially towards personnel in the divisions involved in highway planning, rights-of-way appraisal and acquisition, and maintenance. Agency legal counsels and State Attorney General staffs were contacted independently by the legal staff of the project team.

The principal purpose of the telephone interviews was to identify the full range of agency hazardous waste concerns. Series of questions were posed to uncover as much information as possible about each hazardous waste situation encountered by the agency. For each hazardous waste site encounter, those interviewed were asked to provide the following information:

1. Describe the highway project or activity that was affected by the discovery of a hazardous waste site.
2. Describe the impact of the discovery on the project's design, schedule, and budget.
3. How was the waste site discovered? Was there any warning that the site may have been contaminated? Were any special techniques used to detect the presence of the wastes? Was the discovery by accident?
4. What type of hazardous waste was involved?
5. What kind of site was involved? What type of contamination was involved?
6. Who discovered and reported the site? Did any personal injury or property damage result?
7. Where was the site and who owned it? Did the highway agency contribute in any way to the contamination? Were activities of the highway agency the primary source of the wastes?
8. What was done immediately after the discovery to assess the extent of contamination? Was assessment of site conditions undertaken by agency personnel or private contractors? What was the nature and extent of hazardous waste contractor involvement? What did the site assessment (sampling, etc.) involve?
9. What was done to remedy the situation? What legal issues surfaced and how were they dealt with? What interaction and coordination took place with other agencies? What process was employed for selecting and managing a cleanup contractor?

Agency staff were requested to provide written copies of available correspondence describing the activities that surrounded each site.

In addition, interviewed highway agency staff were asked to provide the following, more general, information regarding administrative policies and procedures:

1. What policies and procedures are in place to deal with the problems posed by hazardous waste sites? Are there policies and procedures: to define what should be done during project planning and preacquisition to avoid the purchase of contaminated property; to cover agency practices during property appraisal and acquisition; to deal with the discovery of hazardous waste during construction; to cover other agency activities?
2. Are there any training programs in place or research being conducted by highway agency staff aimed at improving the

agency's ability to deal with hazardous waste sites?

3. How has the agency organized (or reorganized) itself to cope with the problems being faced?

4. What kind of technical or legal assistance would the agency find helpful?

The results of the telephone interviews were supplemented by information obtained from a mail survey conducted by the Federal Highway Administration (FHWA). Based on the issues covered during this survey, the legal issues of importance to highway officials were formed and research was initiated. This involved a literature search of legal periodicals, newsletters, conference proceedings, law and real estate journals, as well as a limited review of case work.

Inventory of Hazardous Waste Site Assessment and Remediation Technologies

Hazardous waste site investigation and remediation activities are usually performed or managed by the U.S. EPA, state environmental agency personnel, or private contractors. University research organizations have recently played an important role in developing new and cost-effective detection and treatment techniques. Trade associations have been active in compiling information to assist their members in dealing with hazardous waste problems. To understand the state of the art in hazardous waste technology, a telephone survey of federal and state agencies, trade associations, and university research centers was conducted, followed by an extensive literature review.

The purpose of the telephone survey was to identify case studies that would be of interest to highway officials, to obtain guidance documents, and to determine how others were identifying and remediating certain kinds of hazardous waste problems. Contacts were made with staff in various EPA offices (Office of Environmental Engineering and Technology, Office of Research and Development, Office of Solid Waste, Office of Emergency and Remedial Response (Superfund), and the Environmental Monitoring and Support Lab (Las Vegas); the Occupational Safety and Health Administration (OSHA); the National Institute for Occupational Safety and Health (NIOSH); the U.S. Coast Guard (USCG); the U.S. Army Corps of Engineers; the National Institute of Environmental Health Services (NIEHS); and the Office of Technology Assessment. Selected university research groups and state environmental agencies were also solicited for information. In addition, contacts were made with representatives of each of the following organizations:

- American Academy of Environmental Engineers
- American Association of Railroads
- American Consulting Engineers Council
- American Industrial Real Estate Association
- American Land Title Association
- American Petroleum Institute
- American Right-of-Way Association
- American Road and Transportation Builders Association
- Association of General Contractors
- Association of Soil and Foundation Engineers
- Building Owners and Managers Association International
- Chemical Manufacturers Association
- International Bridge, Tunnel, and Turnpike Association
- International Right-of-Way Association
- National Association of Counties
- National Association of Demolition Contractors
- National Association of Dredging Contractors
- National Association of Homebuilders
- National Association of Industrial and Office Parks
- National Association of Realtors
- National Conference of Commissioners on Uniform State Laws
- National Conference of State Legislatures
- National League of Cities
- National Solid Waste Management Association
- National Science Foundation
- MOLES (Association of Excavating Contractors)
- Urban Land Institute

The literature review, conducted concurrent with the telephone survey, was accomplished using the resources of the agencies and groups listed previously, the MIT Library System, and the DIALOG Information Retrieval Service from DIALOG Information Services, Inc. (Palo Alto, California). The results of both the telephone survey and the literature search are reflected in the contents and reference sections of the compendium.

Chapter 2

FINDINGS

CONCERNS AND INFORMATIONAL NEEDS

From the telephone survey, the research team discovered a range of different concerns and informational needs. These concerns varied from state to state, and between different functional units of an agency. In summary, the following general problem areas and corresponding informational needs were identified:

Problem	Need
Agency Liability	
• Complex and constantly changing regulations make it difficult to understand limits of agency liability.	• Synthesis of existing statutes and regulations pertaining to hazardous waste and highway agency real estate.

Problem	Need
• Unavailability of guidance on how to minimize agency liability.	• Synthesis of guidance on how to avoid or minimize agency hazardous waste liability.
• Unavailability of liability insurance for hazardous waste contractors.	• Guidance on how to identify, select, and contract with hazardous waste contractors.
Policies and Procedures	
• Lack of internal policies and procedures identifying how different units of the agency should deal with the prospect of hazardous waste sites.	• Guidance on factors to be considered when developing agency hazardous waste procedures. • Samples of policies and procedure being used by other highway agencies. • Information on how other agencies are organizing and staffing to address this issue.
Technical Approaches and Techniques	
• Unfamiliarity with site assessment and appraisal techniques and technologies.	• Synthesis of information on state-of-the-art techniques and technologies.
• Unfamiliarity with alternative site remediation technologies.	• Synthesis of information on tested remediation technologies.
• High costs of site evaluation and remediation.	• Guidance on evaluation and selection of hazardous waste contractors.

On the basis of this input, subsequent research, and discussions with the Advisory Panel for this project, it was decided to emphasize the following issues in developing the compendium.

HAZARDOUS WASTE POLICIES AND PROCEDURES

Policies and procedures for dealing with hazardous wastes should be in place for every stage in the highway development process.

During *project planning,* agency policy and procedure should: (1) specify the agency unit responsible for conducting a preliminary hazardous waste evaluation; (2) indicate whether the evaluation will be conducted by agency personnel or by contractors; (3) define hazardous waste; (4) describe the types of properties that are most likely to contain hazardous wastes; (5) list potential sources of information; (6) define the scope of the evaluation; and (7) specify what form the evaluation report should take, and how its findings are to be incorporated into environmental documents.

Prior to, or as part of *right-of-way appraisal and acquisition,* policies and procedures will need to: (1) specify the agency unit responsible for determining when a detailed site investigation is warranted; (2) determine what parts of the site investigation will be conducted by agency personnel and which will be conducted by a contractor; (3) establish guidelines for identifying and hiring a qualified contractor; (4) provide guidance for obtaining right-of-entry to the property if it is not owned by the highway agency; (5) set up liaison with federal and state regulatory officials; (6) provide guidance on estimating the value of a property with hazardous wastes, notifying the owner about the problem, deciding whether to purchase a property, and negotiating a settlement; (7) establish guidelines for informing design personnel of the site assessment—the presence of hazardous wastes on a right-of-way may require design modifications; and (8) establish record-keeping procedures.

For *construction* on sites where hazardous waste may be encountered, policy and procedures will need to developed to describe what to do and whom to contact if hazardous conditions are encountered at any time during construction operations.

Finally, if involved in the *cleanup of a hazardous waste site,* policies and procedures will need to: (1) specify which agency unit is responsible for this phase; (2) establish guidelines for identifying, hiring, and managing a qualified contractor; and (3) provide guidance on developing a plan for remediation.

DEFINITION OF HAZARDOUS WASTE

In order to have a policy about hazardous wastes, agency personnel must understand what is meant by the term "hazardous waste." The term has been defined in different ways. From the point of view of personnel safety, a hazardous waste is any waste substance that may endanger human life or health. Flammable, corrosive, toxic, and reactive wastes are all hazardous by this definition. There are also legal definitions established under federal and state statutes and regulations that must be known. In-house training of agency personnel in the risks associated with hazardous wastes is essential.

MINIMIZING HEALTH AND SAFETY RISKS

The highway agency must develop specific policies and procedures for minimizing risk to agency personnel who may encounter hazardous wastes. The safest policy is to prohibit personnel from handling any actual or suspected hazardous wastes, and to require that immediate notification regarding any suspected wastes be made to the appropriate authorities. Contractors can then be hired to investigate and manage the waste cleanup.

TRAINING AND INFORMATION

All personnel should be given basic training in hazardous waste awareness, so that they understand agency policy regarding hazardous waste and know how to protect themselves. It is unlikely that a highway agency will experience hazardous waste problems frequently enough to justify more specialized training. If personnel do receive specialized training, it must be updated periodically, and the agency must commit resources to keeping current with changes in technology, regulations, and field experiences. The agency may wish to designate a hazardous waste

coordinator, whose responsibility it is to keep as current as possible on pertinent developments in the field. Use of expert consultants may also be necessary.

REGULATORY COMPLIANCE

Management of a waste problem requires familiarity with a multitude of federal laws and regulations, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments (HSWA), and the Occupational Safety and Health Administration (OSHA) worker protection requirements. Regulation of hazardous wastes is further complicated by the existence of state statutes and regulation comparable to federal requirements, but which may differ in important ways. An organizational plan must ensure that all procedures are in compliance with applicable federal and state regulations.

LEGAL ISSUES

In dealing with hazardous wastes, the highway agency may be subject to many kinds of liabilities. The agency should be thoroughly familiar with the legal aspects of hazardous waste management and incorporate liability considerations into all relevant aspects of its policy and procedures. For example, owners of contaminated property are generally liable for the costs of cleanup and any personal or property damage claims that may arise. There are circumstances under which certain liabilities can be avoided. Legal provisions can also be included in purchase agreements and deed to limit potential liabilities, to some extent. The policies and procedures developed should be based on a sound understanding of the highway agency's legal ability to recover cleanup costs and protect itself from other claims.

There are also liabilities associated with the conduct of hazardous waste site investigations. Worker protection safeguards must be in place. Proper legal steps must be taken to gain access to property. Contractors involved in site assessments or remediation will want their legal rights protected by the highway agency. Thus, contract provisions need to be carefully written to ensure that the interests of the agency are protected.

HIRING HAZARDOUS WASTE CONTRACTORS

Contractors may be an important resource to the highway agency. The highway agency may want to consider using private contractors for many aspects of site investigation and response. They are familiar with existing regulatory requirements, trained in the protection of health and safety and emergency response, and familiar with the design and implementation of remediation technologies. They are also, through experience, proficient in cost estimation. The role played by private contractors and consultants will be a function of an agency's needs, and of the time and other requirements of the contract procurement process.

TIME FRAMES

Time is an important issue that affects many aspects of hazardous waste management. Highway officials are often under pressure to acquire property and get a project under contract as soon as possible. Detailed information on the condition of the property may be sacrificed to get the acquisition process underway. An operational plan should ensure that personnel have adequate time and resources to reasonably determine if a potential hazardous waste problem is present.

Discovery of unanticipated wastes during property acquisition or construction can add months to a project's lifetime. Therefore, the operational plan should include a mechanism for reorganizing priorities, if necessary. In general, the goal should be to obtain adequate information to make a decision as quickly as possible. Sometimes, a delay in decision-making can reduce the options available to the agency. While a decision is pending, regulations may change to prohibit an attractive disposal method; competition for landfill space may increase requiring the agency to find another site; or an alternative parcel of land may be sold, forcing the agency to acquire the contaminated parcel. In some cases, the agency may decide to purchase a contaminated property because the cleanup costs less than delays that would otherwise result.

LIAISON WITH FEDERAL, STATE, AND LOCAL REGULATORY OFFICIALS

Most hazardous waste problems involve some degree of interaction with environmental agency officials. These individuals can be an important source of information and advice, and they may be involved in the permitting and regulatory compliance process. The highway agency should identify and establish relationships with key officials in the relevant agencies, particularly the regional EPA office and the state environmental agency. One way to do this is to consult key personnel on establishing the operational plan for hazardous wastes. The highway agency should also consider negotiating an interagency agreement with the state environmental agency establishing a formal role for state and EPA personnel if a waste problem is discovered.

STAFFING AND ORGANIZATIONAL STRUCTURE

Every highway agency is unique in terms of its priorities, its internal organization, its staff capabilities, and its resources. Highway agencies must examine their unique situations and take appropriate steps to train and hire needed in-house staff, coordinate with other agencies, and establish relationships with qualified contractors and consultants.

APPLICATION OF FINDINGS

This research project was initiated in response to growing concerns from highway officials about the impact unknown hazardous waste sites were having, or could have, on highway planning and property. The liability assumed by highway officials as owners of contaminated property argues strongly for the development of a comprehensive operational plan in every

highway agency to deal with this problem before a costly encounter with hazardous waste occurs.

The information presented in the following compendium is intended to provide a framework by which highway officials can evaluate existing agency procedures and develop or rectify their programs to address hazardous waste concerns. Highway agency managers are encouraged to take the lead in the development (or modification) of the agency's operational plans. Although no prescriptions can be offered on the course of action that should be taken by an agency in every instance, it is important that this procedural evaluation take place. ***Do not wait until hazardous wastes are discovered on agency property to take action—it may be too late.***

Chapter 3

CONCLUSION AND RECOMMENDED FURTHER RESEARCH

The information gathered by this research project and contained in the compendium is already being used by highway officials in a number of states. Several highway agencies have also developed and made operational hazardous waste-related policies and procedures designed to avoid the acquisition of contaminated property, where possible, and minimize agency liability when acquisition is necessary or unavoidable. However, because highway agency experience in this area is rather limited, several areas worthy of further research do exist.

First, various organizational and staffing approaches have been used by different agencies to deal with their particular concerns. More detailed information might be gathered and more definitive guidance provided on the impacts associated with different courses of action as agency experience with hazardous wastes grows, and record-keeping procedures improve. At some future date, it may also be useful to evaluate more closely the conditions under which different staffing and organizational changes are working or not working effectively.

Second, agencies have little practical experience with many hazardous waste detection and site remediation techniques. Additional testing to determine the effectiveness and applicability of alternative hazardous waste technologies is needed. While this research is most appropriately done by environmental professionals, results should be disseminated to highway officials for incorporation in in-house agency training courses, for use in evaluating hazardous waste contractors, and for use by policymakers in deciding how to approach the particular waste problems they encounter.

Third, highway officials need information on how to obtain preliminary estimates of the costs of cleanup. The uniqueness of a site may make the development of general cost guidelines difficult. However, further research in this area could produce substantial time and money savings to an agency.

Although research in each of the foregoing areas is desirable, it is important to note that its absence does not limit the usefulness of the following compendium, or lessen the importance to highway officials of developing operational plans to better manage agency real estate.

Part II—Compendium

Chapter 1

INTRODUCTION

PURPOSE OF THE COMPENDIUM

Highway officials currently devote considerable resources to incorporating environmental concerns about air, noise, water, terrestrial and ecological impacts into highway planning, design, and construction. In recent years, another environmental concern—hazardous wastes—has begun to affect the operations of many organizations across the country, including highway agencies. Highway agencies, especially those with extensive highway expansion programs and active construction agendas, must be acutely aware of the costs and risks associated with the discovery of hazardous waste on highway agency property or rights-of-way.

The contents of this compendium describe an approach for systematically integrating hazardous waste considerations into

highway project development and decision-making. They identify steps an agency can take to significantly reduce the chances of acquiring contaminated property in the future, and to minimize the risks associated with uncovering wastes during construction. They also suggest activities a highway agency can pursue to improve its management of existing rights-of-way so that hazardous waste liabilities are minimized.

Because highway development is conducted in a variety of institutional and environmental settings, the discussion focuses on procedures, alternative strategies, and ways of viewing hazardous waste site involvement that are generally applicable to all state highway agencies. Some of the procedures for dealing with different hazardous waste site situations are already in place in some highway agencies. Others resulted from discussions with federal and state highway officials and observations of the problems highway agencies are actually facing.

The compendium also provides highway officials with a range of legal, regulatory, and technical information on the issues they must address in handling different hazardous waste situations. Specifically, it contains useful information on: (1) laws and regulations under which highway officials must work to deal with hazardous waste sites; (2) liability of a highway agency under different conditions and how highway officials can protect themselves from potential legal suits and high settlements; (3) techniques for identifying hazardous waste sites; (4) techniques for taking remedial action at confirmed hazardous waste sites; and (5) relative costs, effectiveness, and other impacts associated with alternative detection and disposal techniques.

The reader should keep in mind that this type of information changes frequently. No liability can be assumed from the use by highway officials of the information in this document. Highway officials who manage hazardous waste-related problems should use the information provided here as a basis from which to identify and continually bring themselves up to date on the most recent applicable regulatory and technological information.

USE OF THE COMPENDIUM

This compendium is intended to satisfy the needs and interests of highway administrators, engineers, planners, environmental and right-of-way staff, and other personnel involved in highway decision-making. It is intended for highway officials, or their contractors, involved in highway location or corridor studies; project planning; environmental studies; right-of-way appraisal and acquisition; highway design; construction; right-of-way maintenance; contracts management; or legal counsel.

The approach to highway decision-making and the procedures discussed here are not intended to be adopted by highway agencies as a whole. Every highway agency is different in organizational structure, political environment, financial resources, and social and environmental issues of importance. Therefore, each highway agency should review this compendium with the intent of modifying and adapting the material to its unique conditions. In some instances, this may require changes in agency policies and institutional arrangements.

Similarly, every hazardous waste site is unique and requires tailored solutions. The technologies appropriate for identifying and remediating a site depend on site-specific conditions, such as the type and form of contamination present and the geohydrologic environment. This document provides general guidance and should be used as a preliminary basis for developing a course of remedial action or directing contractors.

This document does *not* address the requirements faced by highway agencies in properly storing and disposing of the hazardous wastes generated or associated with activities such as vehicle use and maintenance (e.g., fuels, oils, battery acid, asbestos brake parts); painting (e.g., paints, solvents, chemical cleaners); and roadside vegetation control and maintenance (e.g., herbicides, insecticides). The management of hazardous wastes produced by a highway agency requires compliance with a distinct set of laws, regulations, and policies. Highway officials are urged to familiarize themselves with these requirements and develop hazardous waste management programs necessary to address their internally generated hazardous waste problems. However, the compendium does provide limited guidance and information that will be useful in cleaning up hazardous waste sites created at highway facilities as the result of past practices.

The remainder of this report is divided into four chapters and four appendixes. Chapter 2 begins by describing the kinds of hazardous waste problems that highway officials are confronting. It then outlines the risks and liabilities associated with the ownership of contaminated property under current federal and state law. The risks associated with hazardous waste site activities are also described. This chapter also provides a description of how hazardous wastes can complicate highway agency real estate transactions, and gives a compelling argument for why highway officials should incorporate hazardous waste considerations into their decision-making process and procedures. It should be read by all highway officials.

Chapter 3 offers guidance on how a highway agency can modify its project planning, property appraisal and acquisition, construction, and property management practices to minimize the risks associated with discovering and cleaning up a hazardous waste site. It also describes how highway agencies are modifying their decision-making process and organizational structures to respond to this problem. Finally, it examines the role of hazardous waste contractors, and how to develop a community relations program should hazardous wastes be found. A number of different highway agency personnel will find this part of the compendium useful.

Chapter 4 has a more technical focus. It describes specific techniques and technologies available and used by experts to identify and remediate hazardous waste sites. This section will be of interest to highway agency staff actively involved in selected hazardous waste site investigation or cleanup activities, or personnel involved in the selection and management of contractors assigned those responsibilities.

The conclusions drawn from the research are summarized in Chapter 5.

The material provided in the appendixes consists of legal definitions of hazardous waste (Appendix A) and a sample (EPA) hazardous waste site evaluation form including general information and instructions pertaining to the form (Appendix B). Appendix C covers remedial action technologies including tables summarizing control methods, treatment methods, and disposal methods. A glossary of terms is contained in Appendix D. Acronyms and terminology that appear frequently throughout the compendium are identified in this appendix. Becoming familiar with these terms at the outset will enhance the reader's comprehension of the compendium.

Chapter 2

LIABILITIES AND RISKS ASSOCIATED WITH CONTAMINATED RIGHTS-OF-WAY

It is important that highway officials understand the nature and extent of the liabilities and risks they face as participants in various real estate transactions, as managers of large tracts of property, and as potential managers or participants in hazardous waste site cleanups. The liability faced by a highway agency will depend upon what hazardous wastes are found, when they are found, and how they are handled by the agency. ■ *Section 1 describes the kinds of hazardous wastes and waste sites being discovered by highway agencies across the United States; when during the highway development process these discoveries are being made; and the impact such discoveries are having on agency operations.* ■ *Section 2 identifies and summaries the key provisions of federal and state law that highway officials should be aware of when responding to particular hazardous waste situations—real or potential.* ■ *Section 3 contains bibliographic references used in developing the material presented in this chapter.*

1. HIGHWAY DEVELOPMENT AND THE DISCOVERY OF HAZARDOUS WASTE SITES

The Problem of Uncontrolled and Abandoned Hazardous Waste Sites

There are no reliable estimates of the quantities of hazardous wastes generated annually in the United States. The most comprehensive survey performed to date estimated that U.S. industry generated approximately 264 million metric tons of hazardous wastes in 1981. The chemical industry generates the greatest percentage of the total waste, with 68 percent, while metal-related industries account for roughly 22 percent of the total. Petroleum industries, including motor freight and refining activities, are the sources of most of the remaining wastes.

A relatively small percentage of the hazardous wastes produced at industrial plants is shipped to commercial management facilities for storage, treatment, and disposal. The vast majority of these wastes is stored or disposed of on-site. Surface impoundment in pits, ponds, and lagoons is used to store or treat the largest quantity of hazardous wastes. Tanks, waste piles, drums, and other containers are the repositories for the remainder. When improperly handled, these wastes can contaminate ground water, soils, surface waters, or the air.

Although federal and state regulations encourage the proper handling of hazardous wastes, mismanagement and resulting contamination still exist at many locations. These "uncontrolled or abandoned" hazardous waste sites can be found on public lands, such as those created by former municipal, county, or state landfills where illegal or badly managed waste disposal has taken place. Other uncontrolled sites can be found on private property belonging to companies that currently generate, or historically produced, hazardous wastes during manufacturing or other industrial processes. The Congressional Office of Technology Assessment estimated in 1985 that there are some 10,000 hazardous waste sites nationwide requiring remedial action at a potential cost of up to $100 billion. More recent estimates place the cost of cleanup at $30 to $40 million per site.

Underground storage tanks (UST) present another important source of potential contamination. The U.S. Environmental Protection Agency (EPA) has estimated that there are approximately 1.4 million underground storage tank systems in the United States at more that 500,000 facilities. More than 95 percent of these systems are used to store petroleum products, with the remainder used to store various other chemicals. Many existing USTs are constructed of unprotected steel, and are over 10 years old. Consequently, a significant percentage of existing USTs have been found to be leaking. And, nearly half of such tanks are located below the water table, thereby contributing to the contamination of the nation's valuable ground-water supplies. Abandoned underground tanks present a significant unseen risk and liability for everyone involved in real estate transactions.

Highway Development and Hazardous Waste Sites—Summary of State Experiences

Like all organizations involved in real estate transactions, highway agencies cannot escape the spectre of discovering unexpected hazardous wastes. A questionnaire survey of state officials was conducted by the Federal Highway Administration (FHWA) in early 1987 to characterize the kinds of hazardous waste problems facing state officials and to clarify highway agency needs in this area. A telephone survey of selected highway agency staff was conducted by the research project staff during this same period.

The findings of the surveys are summarized in Tables 1 and 2. Table 1 identifies, by state, highway projects that have been affected by the discovery of hazardous substances. It also identifies the kind of wastes encountered and the action taken by the highway agency to deal with the problem. This list is representative of the kinds of hazardous waste problems that face highway officials involved in real estate acquisition and property management. It is not an exhaustive list; additional or different hazardous waste situations have, in all likelihood, occurred since the states were surveyed. Table 2 describes in greater detail the experiences of selected states. Accounts of other highway agency experiences are dispersed throughout the guide.

The surveys revealed the following about the pattern and nature of hazardous waste problems faced by highway officials:

1. *No geographic area of the United States is insulated from the problems presented by the unexpected discovery of hazardous waste sites.* State highway agencies across the United States from Florida to Alaska have encountered hazardous wastes during highway development activities. While several highway agencies reported having had no unfortunate experiences with hazardous wastes to date, this appears to be the exception rather than the norm.

2. *Highway projects most commonly impacted by the discovery of hazardous wastes can be found in urban areas.* Highway

Table 1. Summary of state highway agency experiences with hazardous waste sites.

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Alaska	South Fairbanks Expressway	Lead	• Excavation and capping under roadway	- planning] - coordination] - treatment] $150,000
	Peger to College Connector	Waste oils, PCBs	-	-
California	Hazardous waste discovered on a variety of highway projects in the state, including the Century Freeway (I-105) in Los Angeles and Meeker Avenue on the John T. Knox Freeway	Landfills, soil contaminants, asbestos, PCBs, fuel, and chemical containers and drums	• Total removal and disposal at approved landfill	$100 - 300/ton
			• Recycling	-
			• Bury materials in embankment	$8-20/cubic yards (cy)
			• Spray aeration & microbial degradation	-
			• Tank removal & decontamination	$2,000-15,000 each
			• On-site treatment:	
			batch plant incineration	$100/cy
			mobile on-site infrared incinerator	$150-300/ton
			mobile on-site incinerator	$200-400/ton
			chemical stabilization of soil	$ 20-100/cy
			chemical oxidation of soil	$ 50-200/cy
			vacuum extraction & surface treatment	$200/cy
			steam injection & surface treatment	$100-300/cy
Colorado	I-76 (Denver)	Unknown waste deposits	• Removal of landfill deposits • Water quality monitoring • Use of geofabrics and geogrids • Dynamic compaction	-
	SH 145 (Placerville)	Uranium milling deposits	• Fencing	-
	SH 141 (Uravan)	Uranium milling deposits	-	-
Connecticut	Unspecified	Buried paint drums, leaking UST's, asbestos, PCBs	• Removal, transport, and disposal • Aquifer pumping and soil venting	- -

Table 1. Continued

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Delaware	Widening of Terminal Avenue (Port of Wilmington)	Lead, mercury (existing RCW), zinc, arsenic	• Undecided	- Testing: $18,000 (to date)
Florida	I-595 Broward County (21 haz. waste sites; 40 underground storage tanks)	Petroleum products, paint residuals, metal finishing wastes, commercial solvents	-	- Site assessment: $1,000 to $90,000/site
Idaho	Orchard Extension (Boise)	Heavy metals PCBs	• Shifted alignment to avoid Wallace Plating Company	-
Illinois	Division Street Bridge Replacement (Chicago)	PCB in dredge material	• Changed project "concept" from replacement to rehabilitate	- Cost to treat and transport contaminated material estimated at $100 million - Cost of redesign = $450,000 plus 2 yrs delay in letting project for construction
	Viaduct Avenue (Illinois Rt 84) (Savannah)	Slough area contained material contaminated with oil, grease, and small amounts of cyanide, barium, and cadmium	-	- Treatment $135,000 - Testing $ 16,000
Indiana	I-164 (Evansville) Connector	Landfill	• Bridged landfill using dynamic deep compaction of crushed stone.	-
	Division Street (Evansville) Segment of I-164 project	Asbestos found in Old Evansville City Garage	• Removal and disposal	$12,000
	SR-912 (Lake County) Bridge construction over Indiana Harbor Canal	Heavy metals, PCBs	-	-

Table 1. Continued

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Iowa	A.Y. McDonald Property (Dubuque)	Lead in soil	-	-
	Carroll - Kloser Feed Store	DDT in soil	-	-
	Waterloo - Weissman Industries (US 218)	PCBs, heavy metals	-	-
	Million Dollar Station	Gasoline in ground water	-	-
Kansas	Bridge project over Spring River	Above normal concentrations of heavy metal (lead)	• Placed in fill and covered with acceptable materials (required 404 permit)	Cost of handling and delay of 6 months estimated at $87,500 (Total project $3.5 million)
Maine	Rt 150 (Cambridge - Harmony)	Old gasoline storage tank	• Pumped out by private countractor; tank crushed and buried	-
	Rt 9 (Crawford)	DDT, dieldrin, other agricultural pesticides	• Removed contaminated soil and disposed in landfill	-
	Biddeford Connector	"Unidentified" barrels	• None necessary	-
	Rt 17 (in vicinity of F.O'Connor Site on EPA NPL)	PCBs	• No action; project in PE stage	-
	Mechanic Street (Holden)	PCBs	-	-
Maryland	Expansion of MDOT Rosedale Landscape Depot	Herbicides, pesticides	• Removal • Construction of storage "mausoleum"	$250,000 $250,000

Table 1. Continued

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Massachusetts	I-95/Rt 1 Interchange (Peabody)	Gasoline-saturated soil	• Removal and disposal (550 cy)	$100,000
	Water Street (Fall River)	Oil/grease material	• Removal and disposal (28 ± cy)	$13,000
	Bridge reconstruction (New Bedford Harbor)	PCBs	-	-
Michigan	Zilwaukee Bridge	Sand with high arsenic levels used for embankment	• Clay blanket required in fill to contain arsenic	$23,700 (net cost)
	I-696 (Oakland County) [Howard Plating Company]	Zinc, chrome, cadmium, copper, alkalis, acids, cyanides	• Decontamination/treatment/ disposal of tank plating equipment • Decontamination/treatment of interior walls & floors • Removal and disposal of building • Removal and disposal of soils • Soil sampling • 24-hour surveillance • Liability insurance • Access/staging/truck cleaning	$1.44 million
	Rt 131/Michigan Street at DOT Highway Garage (Kalamazoo)	UST leak/groundwater contamination	-	$500,000 cleanup $26,000 EPA fine
	Anne Arbor - DOT sign shop	Solvents	• Ground-water monitoring wells	$26,000 EPA fine
Minnesota	I-335 ROW at 120 Plymouth Avenue leased to Union-Scrap Iron and Metal Corporation (battery recycling)	Lead	• Placed on EPA Nat. Priority List; under evaluation	Union Scrap filed for bankruptcy; Mn/DOT identified as Responsible Party.
	I-494/Hardman interchange	Heavy metals	-	-
	Central Minnesota Rest Area	PAH compounds in surface waters	• No action necessary	-

Table 1. Continued

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Minnesota (continued)	T.H. 3 Lafayette Freeway	Lead pellets	• Reclaim and recycle pellets	$109,000
	I-94 (Minneapolis)	Calcium hydroxide	-	-
	Purham Truck Station	Arsenic	-	-
	TH 169 (Milaca to Onamia)	Tires, batteries, volatile organics	-	-
	TH 33/US 2 (Savage)	Hydrocarbons	-	-
	I35 (Duluth)	Hydrocarbons	-	-
	TH 212/TH 5 (Oakdale)	Volatile organics, PAH, phenols	-	-
	I-35W (N. Minneapolis)	Methane	-	-
Montana	I-15 (Basin)	Old mine tailings	• Material moved and buried under Interstate embankment.	-
	Urban highway project (Butte)	Old mine tailings	• Superfund site; discussions still very preliminary	-
Nebraska	Unspecified	Leaking fuel tanks	-	-
		Trichlorethylene UN-710	-	-
		Waste toluene flammable liquid UN-1294	-	-
		Waste flammable UN-1993	-	-
		Waste xylene flammable liquid UN-1307	-	-
New Hampshire	Urban reconstruction project (Hudson)	Asbestos	• Contaminated soil wet down; excavated and removed	$50,000
	Bridge replacement over Connecticut River between Hinsdale, NH and Brattleboro, VT.	Coal tar	• Site safety plan developed, but not yet employed; project never advertised	$177,000 to date
	Bridge replacement (Concord)	Coal tar or asbestos	• Discovery from borings data; clean up plan being prepared	-

Table 1. Continued

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	PROJECT IMPACT
New Jersey	Rt I-280, Kearney	Oil	-	Cleanup: $5,000,000
	Rt 129, Bayonne	-	-	-
	Rt 185, Jersey City	Chromium, heavy metals	-	-
	Rts 1&9, Newark	-	-	-
New York	SW Lockport Bypass (Rt 31) Niagara Materials Company	Metals and phenols	• Analysis indicated no problem	-
North Carolina	I-277 (Charlotte) Rowe-Bouligny Corp.	Chromium, cadmium, lead	• Recommendation to install drainage system	RI/FS $35,000 Closed drainage system: $200,000
	Urban systems project (Gastonia)	Underground storage tanks	-	-
Oregon	Corvallis Bypass	Landfill still under study, substances unknown at this time	-	-
	North Union Ave (Portland) Allied Plating Company	Chromium	• Contaminated soil from tailings pond found on Highway Division properties; consultant studying	- Sampling, testing, closure plan: $300,000 - Actual closure may cost $2-4 million
Pennsylvania	I-476, Philadelphia	Asbestos	-	-
	(a) Paper Products Site	-	-	-
	(b) Mayer landfill	-	-	-
	(c) Incinerator	Incinerator ash	-	-
	Vine Street Xway (Philadelphia)	PCBs	• Remove PCB contaminated ballast	-

STATE	PROJECT	HAZARDOUS WASTE(S) ENCOUNTERED	TREATMENT	COST
Rhode Island	Unspecified highway projects.	Creosote, oily soils, PCBs	-	-
	Demolition of 4 buildings			
	(a) Furniture Store	Asbestos	Removal	- $131,500
	(b) Fruit and Produce Building			- $ 3,520
	(c) Fix Communication Building			- $210,900
	(d) Single Family Residence			- $ 3,700
South Carolina	Twin underpasses at SC 768 overpass at S-1534 and section of freeway near Gills Creek (Columbia)	Landfill wastes	• Preliminary investigation has indicated no hazardous wastes	-
	Ramps/bridge construction over Cooper River and Clouter Creek	Asbestos	• Removal and disposal	$600,000
Tennessee	Bridge replacement	Contaminated sediments in stream bed	-	-
Vermont	Burlington Southern Connector (Barge Canal site)	Coal tar Oily residue Pesticides	• Superfund site, evaluation still underway; RI/FS being done by EPA	- $600,000 to date - RI/FS estimated at $750,000
	Unspecified	Leaky UST	• Aeration; then soil used as surfacing for parking lot	-
Washington	I-705, Tacoma Spur	Tar: PAH - toluene napthalene xylene benzene	• Removal to licensed disposal facility	$4.8 million
		Oily sand and silt	• Contained on-site within ROW	-
			• On-site water filtration	$320,000
			• Groundwater monitoring program	$350,000
		Copper ore (copper, lead, arsenic)	• Recycled	$560,000

Table 2. Selected highway agency experiences with hazardous waste sites.

Minnesota

In the early 1970's, the Minnesota Department of Transportation (MnDOT) purchased a parcel of land on Plymouth Avenue in Minneapolis for the construction of I-335. The agency leased the property to Union Scrap Iron and Metal Corporation which operated a battery recycling business. Following eight years of operation, the facility was shut down in 1981, but only after significant lead and acid contamination had occurred on-site. When the site was placed on the National Priority List (NPL) by the EPA, the company filed for bankruptcy and the Minnesota DOT was identified as a responsible party under the Superfund regulations. MnDOT will proceed with the cleanup of the site with costs that could reach into the millions of dollars.

Also in Minnesota, the Department of Transportation was able to avoid a hazardous waste site on the I-494/Hardman Avenue interchange project by conducting a thorough title search prior to acquisition. The title search revealed the presence of a demolition landfill, and testing ultimately indicated the presence of heavy metals in the soils.

Texas

During right-of-way acquisition for the construction of an interchange for State Highway 548 in Houston, the Texas State Department of Transportation encountered a heavily contaminated hazardous waste site owned by Kopper Company, Inc. High concentrations of pentachlorophenols and other wood processing chemicals were found in the soils, water, and structures of a large creosote plant. Texas DOT negotiated an easement to cross the property rather than proceed with a taking. Creosote contamination of the soils at the EPA Superfund site was found in pockets as deep as 70 feet. Environmental assessment costs alone exceeded $500,000, and the removal of contaminated equipment cost approximately $800,000. Other clean-up costs are still being determined.

Colorado

The Colorado Department of Highways encountered a closed municipal landfill in the construction of I-76 in Denver. Ultimately, it was necessary to remove substantial landfill materials, conduct water quality monitoring, and employ embankment stabilization through dynamic compaction and preloading at considerable cost to the Department.

Michigan

Under an agreement established with Michigan DOT in the 1960's, General Motors disposed of foundry casting sand on the state's right-of-way on I-75 in Saginaw County. The sand was used for fill in the construction of the embankments of the Zilwaukee Bridge. Subsequently, high levels of arsenic were found in the sand by the Michigan Department of Natural Resources which prescribed the installation of a clay cap to contain the arsenic within the bridge embankment.

Also in Michigan, construction of a portion of the I-696 freeway in Royal Oak, Oakland County, required the taking and removal of the Howard Plating Company. The facility had been involved in stripping, anodizing, and plating metals in processes using zinc, chrome, cadmium, copper, cyanides, and various alkalis and acids. The 30,000-square-foot facility was located on a 1.5-acre parcel purchased by the Michigan Department of Transportation (MDOT) for $600,000. Hazardous waste contamination found on the site, however, ultimately cost the MDOT almost $2 million to clean up.

Table 2. Continued

Nebraska

Interstate Transfer, a large trucking firm, was investigated during the right-of-way acquisition process for the North Expressway in Omaha. The site contained almost 1/2 million gallons of fuel storage. Six aboveground and one underground tanks were observed. Since the business on the site was active, the Department of Roads opted for side borings (borings off of the property) in conducting a soil investigation. Test results showed minor contamination which was not considered significant and construction proceeded. However, an additional underground tank was unearthed during site work and the #2 diesel fuel found in the soil required extensive cleanup.

Delaware

The right-of-way needed for widening Terminal Avenue, a major access road to the Port of Wilmington, was found by a site assessment to be adjacent to a known hazardous waste site owned by the Halby Chemical Company. Testing--at a cost of approximately $100,000--revealed high levels of zinc, lead, and arsenic on property immediately adjacent to the existing road. Up to $500,000 will be needed to remediate the site, even though project costs are estimated at only $750,000. Because of its cleanup cost, the Delaware Department of Transportation has decided to delay the project until local funds are provided for the cleanup.

New Hampshire

Large quantities of coal tar were discovered by the New Hampshire Department of Transportation at the site of a planned bridge replacement over the Connecticut River between Hinsdale, New Hampshire, and Brattleboro, Vermont. A site safety plan was developed at a cost of $200,000, but remediation has yet to begin.

Florida

In the project development and engineering phase of the construction of I-595 in Broward County, Florida, "table top" assessments lead to the flagging of 260 parcels as potential hazardous waste sites. The $1.3-billion project involved the assessment of 13 miles of right-of-way. On-site assessments subsequently confirmed 21 waste sites and 40 underground storage tank sites. One additional underground tank site was discovered during construction.

Also in Florida, contamination from a leaking underground petroleum tank was discovered on a Right-of-Way safety project in DeSoto County. Although the tank had been repaired, the leaked product had migrated and polluted nearby drinking water wells. It was estimated that cleanup would cost more than $500,000 and take more that two years to complete. On the recommendation of the District Right-of-Way specialist, acquisition of the property was postponed and the project put on hold.

Oregon

Property owned by the Oregon Department of Transportation, Highway Division, off North Union Avenue in Portland was found to be contaminated by wastes that migrated from an adjoining property that contained the chrome plating operations of Allied Plating Company. The Division has spent approximately $300,000 in conducting an environmental assessment. Site closure is expected to cost 2-4 million dollars.

projects in urban areas typically involve existing roadway reconstruction or widening; facility design improvements (e.g., interchange redesign); connector roadway or bypass construction; or bridge replacement or renovation. These kinds of projects appear to be more susceptible to disruption from the discovery of hazardous wastes than projects in less densely populated settings. This is not unexpected in that: (a) there is usually not a great deal of flexibility in the amount or location of land available to build highways in urban areas; (b) hazardous waste sites are more prevalent in areas that are highly developed; and (c) urban areas are more likely to contain abandoned structures and buildings—common sources of contamination.

3. *It is not uncommon to find hazardous wastes on highway right-of-way purchased years ago in anticipation of project construction, and before hazardous wastes became a major public health concern.* This is also, as expected, because many highway agencies acquired substantial rights-of-way years ago in anticipation of particular roadway projects. Since the time of acquisition, the land may have laid vacant or been leased to others by the agency for other activities—activities considered legal at the time of purchase, but which now subject the agency to substantial liability.

4. *Highway agencies have encountered a wide variety of hazardous waste sites, types of hazardous substances, and types of contamination.* Depending on the project and location, highway agencies have encountered surface-contaminated soils; landfills and dump sites; underground storage tanks; contaminated buildings and structures; and contaminated waters under bridges. Moreover, the hazardous wastes uncovered have spanned the spectrum of common hazardous wastes. Improperly disposed of industrial solvents, polychlorinated biphenyls (PCBs), heavy metals, asbestos, and various fuels leaking from underground storage tanks have been among the most prevalent wastes found. The mismanagement of these wastes has resulted in the contamination of surface and subsurface soils; ground-water resources; surface waterways and bottom sediments.

5. *The costs of site investigations and cleanup have had a significant effect on the budgets and schedules of numerous highway projects.* As illustrated in Table 1 and by the examples cited in Table 2, the costs of site assessment, demolition, and hazardous waste removal can often exceed the cost of acquiring a parcel, of relocating, and even of constructing the transportation facility through the tract. In many states, the costs of disposal are particularly high because of the absence of approved hazardous waste disposal facilities. For example, in Virginia wastes must be transported to facilities as far away as Alabama, Pennsylvania, South Carolina, and Texas. The cost of project delay incurred by an agency adds to this cost, which may run into millions of dollars. A project in Kansas, for example, was delayed 6 months when approximately 30,000 cubic yards of material from the Spring River bed required special handling because of its above-normal lead content. Although the cost of handling the material was minimal, the delay inflated the project's cost by an estimated 2 percent, or approximately $87,500 on the $3.5 million project.

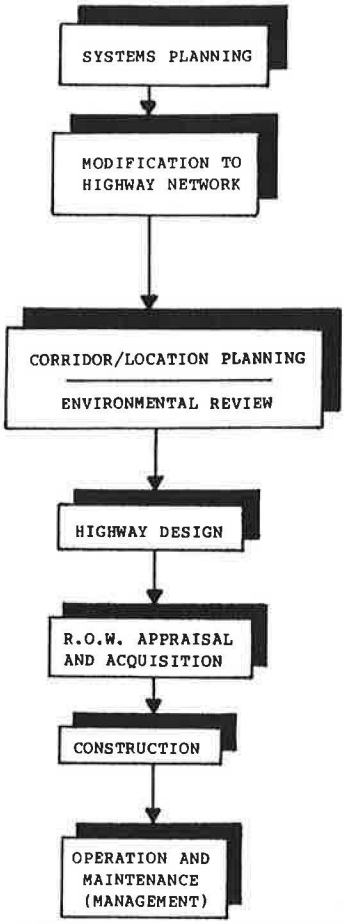
6. *Hazardous waste sites can be discovered at virtually every stage of the highway development process.* The term "highway development process" encompasses all the activities associated with the planning, design, construction, operation, and maintenance of highway systems. While the exact nature of these activities will vary from state to state, the highway development process generally consists of the following activities: systems planning (including subarea planning), corridor/location planning, environmental studies, highway design; right-of-way appraisal and acquisition, construction, and highway operation and maintenance. The extent of systems and corridor planning varies significantly among the states; however, environmental studies, design, right-of-way appraisal and acquisition, construction, operation, and maintenance activities are common to virtually all highway agencies. Figure 1 graphically illustrates the highway development process and summarizes the activities undertaken at each stage.

Highway agencies have discovered hazardous wastes on their rights-of-way during virtually every stage of highway development from preliminary planning through actual construction, as well as during ongoing property management (maintenance). Hazardous wastes have been found prior to property acquisition, or on property and right-of-way already under agency ownership and management. A number of scenarios were found to exist:

- Land in a corridor being considered for a particular highway link was found to be on the EPA's National Priority List (NPL), identifying it as one of the most seriously contaminated tracts of land in the country.
- A parcel of land under consideration for acquisition was found to be on the state environmental agency's list of known, uncontrolled hazardous waste sites.
- Land being considered for purchase was found, after a preliminary site investigation, to contain an abandoned underground storage tank.
- A parcel of land within a proposed right-of-way was found to be contaminated by hazardous waste migrating from adjacent property.
- A waste site or underground storage tank was discovered during bridge excavation and construction.
- Hazardous wastes were found in the vicinity of a roadside rest area, illegally dumped by an unknown third party.
- Property being leased by the highway agency to a retail gasoline outlet was found to contain a leaking underground storage tank.

In conclusion, the experiences of state highway agencies with hazardous waste sites are not that different from those of others involved in real estate transactions. The same kinds of hazardous waste sites, contaminants, and types of contamination are being encountered. There are two distinguishing characteristics about the highway agency experience, however. First, the size of the right-of-way needed for most highway improvements increases substantially the likelihood that any individual highway project will be adversely impacted by an unexpected discovery of hazardous wastes. Highway location and design constraints often make it difficult for highway officials to avoid hazardous waste sites. Second, as a public agency, a highway agency is often held to higher standards of investigation and cleanup when hazardous wastes are found. Public expectations of highway agency resources are often quite high, even though their liability under the law is basically the same as that for anyone else involved in real estate transactions. Highway officials are challenged to respond to these conditions by increasing their awareness of hazardous waste laws and regulations, and taking steps to minimize their liability.

Figure 1. Highway development process.



During systems planning, extensive surveys of land use, travel, traffic, transportation facilities, and regional development plans are undertaken and evaluated. Based upon this information, forecasts of population, economic growth, and travel demand are then made. Present and future deficiencies in the transportation network are also identified. Finally, a long-range, multi-modal transportation plan for the region (or state) is developed. This plan identifies facility operating and policy changes proposed over time for all modes of a transportation system for a given geographic area. Systems planning does not typically specify the locations of proposed highway routes, or prescribe specific highway project improvements, programs, or priorities. Rather, it designates a system of corridors within which it is hoped that feasible locations can be found and construction accommodated.

During corridor/location planning, alternative locations for a proposed highway facility (or transit link) within a corridor are identified, and preliminary technical work is initiated. This level of planning, prior to committing a large amount of resources to one or more options, provides for a more thorough assessment of issues, alternatives, and impacts than is possible during systems planning. Based on this preliminary work, the most feasible alternatives are selected for further development. Each alternative is then evaluated in terms of its social, economic, and environmental impacts, and appropriate documents are prepared and circulated for public comment. The final or preferred location decision--made at the end of this stage--usually establishes many of the more important design features of the project. The project may be cancelled or recycled at this point.

During highway design, one or more preliminary design alternatives are developed. The number of alternatives developed depends on how thoroughly they were evaluated in the corridor/location stage. Care is given throughout the design stage to accommodate all of the mitigation measures identified as necessary by the environmental assessment process. At this point, the project may again be cancelled or recycled.

During right-of-way appraisal and acquisition, the proposed right-of-way is surveyed, properties are appraised and acquired, families and businesses are relocated, and all necessary permits are obtained.

During the construction stage, construction contracts are prepared and let, and the highway project is constructed.

Highway operation and right-of-way maintenance refers to the activities of routine and preventive roadway and right-of-way maintenance, including winter maintenance (e.g., ice control) and roadside development (e.g., mowing, spraying, etc.); and to the activities associated with the leasing and selling of excess agency property.

2. HIGHWAY AGENCY LIABILITY UNDER HAZARDOUS WASTE LAW

Federal, state, and local statutes on hazardous waste can affect dramatically how a highway agency conducts its activities. The legal liability for releases of hazardous materials to the environment makes compliance with these laws very important. Failure to do so can be fatal to a highway program, to the individual project, to agency credibility, and to individual careers. This section summarizes the requirements of selected federal and state laws that establish the liabilities associated with real estate transactions and the cleanup of hazardous waste sites.

Federal Hazardous Waste Laws

The liability faced by highway officials involved in real estate transactions is determined, in large part, by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Several sections of CERCLA become relevant if the highway agency was, is, or should become the owner of a hazardous waste site, regardless of whether or not the agency was responsible for the wastes. Should the highway agency choose to clean up contaminated property, it may become subject to a number of requirements and attendant liabilities under RCRA. The following discussion briefly describes the relevant requirements of these and other federal statutes, and the liabilities they impose upon highway agencies as owners or managers of contaminated real estate.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation and Liability Act (42 U.S.C. § 9601, *et seq.*) is a remedial statute designed to deal with the problems of past mismanagement of hazardous waste. Under CERCLA, the government created a process for identifying liable parties and ordering them to take responsibility for cleanup operations. The government is also given the authority to sue responsible parties for reimbursement of cleanup costs and for damages to natural resources caused by the release of hazardous substances into the environment. The government may also seek an injunction requiring responsible parties to clean up the site themselves. CERCLA also imposes strict notification requirements that mandate respon-

sible parties to notify EPA whenever a hazardous waste has been released into the environment.

Cleanup funds are provided under CERCLA from a trust fund, called Superfund, which receives its revenue from a tax on petroleum and chemicals. The revenue available in the Superfund allows the government to initiate cleanups now, while it seeks reimbursement later. It also provides funds for cleaning up sites where no responsible party with sufficient funds can be found. Unfortunately, there are no sufficient funds in the federal Superfund to clean up all hazardous waste sites. Consequently, sites are prioritized by EPA using a hazards ranking system (HRS) and placed on a National Priorities List (NPL). NPL sites are then targeted for enforcement and remedial action using Superfund monies. The liability for cleanup costs and damages incurred by a responsible party exists regardless of whether the hazardous waste site is listed on the NPL.

Superfund Amendments and Reauthorization Act (SARA)

In response to public concern over the number and speed of site cleanups taking place, CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) in October 1986. These amendments increase significantly the resources available in the Superfund for hazardous waste site cleanup; create a separate cleanup fund for leaking underground storage tanks containing petroleum; institute new procedures for participation in cleanup activities by interested parties; and add new provisions relating to settlement procedures and judicial review. Of special significance to highway agencies and others involved in real estate transactions, SARA provides protection for "innocent landowners" who acquire property without knowing of any contamination at the site, and without reason to know of any contamination. The amendments also authorize the government to indemnify a response action contractor if insurance is not available at a fair and reasonable price, and requires the Occupational Safety and Health Administration (OSHA) to promulgate regulations to protect workers involved in hazardous waste activities.

For further information on the requirements of CERCLA/SARA, refer to the *Superfund Handbook, A Guide to Managing Response to Toxic Releases Under the Superfund Amendments and Reauthorization Act,* 2nd edition, by ERT, Inc. and Sidley & Austin, April 1987.

CERCLA/SARA Liability

CERCLA § 9607 provides that the owner or operator of a facility from which there is a release or a threatened release of a hazardous substance, which causes the incurrence of response costs, shall be liable for:

- All costs of removal or remedial action incurred by the United States government, a state, or an Indian tribe not inconsistent with the National Contingency Plan (NCP).
- Any other necessary costs of response incurred by any other person consistent with the NCP.
- Damages for injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction, or loss resulting from such a release.
- The costs of any health assessment or health effects study carried out under § 104(1).

Under CERCLA definition, the term *owner or operator* includes the United State government, a state, a municipality, a commission, a political subdivision of a state, or an interstate body; a *facility* means any building, structure, installation, equipment, storage container, motor vehicle, rolling stock, aircraft, site or area where a hazardous substance has been deposited, stored, disposed of, or placed; a *release* covers any spilling, leaking, pumping, poring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment; *environment* includes any surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air; and *hazardous substance* includes any substance having certain characteristics or designated by EPA on certain lists. In the event of a release, EPA is given authority to begin containing the release by removing the contaminated material in a temporary cleanup effort and to take remedial action to eliminate further contamination.

Who is liable? Those identified by EPA as liable under CERCLA for cleanup costs are referred to as "potentially responsible parties (PRPs)." A PRP may be: the present owner or operator of a site where hazardous substances have been released; the owner or operator of a site at the time hazardous substances were released; the person who arranges for the disposal or treatment of hazardous substances at a facility; and the person who accepts hazardous substances for transport to a treatment, storage, or disposal facility that it selects.

The lessor of property found to be contaminated may also be found a potentially responsible party. In *United States v. Argent Corp.,* 21 Env. Rep. Cas. 1354 (D.N.M. May 4, 1984), the defendant leased a warehouse on his property to the Argent Corporaton which used hazardous chemicals. Even though the defendant had no connection with the Argent Corporation's business, the federal district court held that as a result of the lease of the property a contractual link was established which precluded the defendant from showing, as required under CERCLA § 107 (b), that the release was caused solely by a third party. A federal district court in *United States v. South Carolina Recycling & Disposal, Inc.,* 20 Env. Rep. Cas. 1753 (D.S.C. February 23, 1984), also held that the lessor was liable for the costs of removing hazardous wastes even though it did not cause the condition. Because a lessor is in a contractual relationship with his lessee as a third party, the courts have generally held that liability cannot be avoided under CERCLA.

Liability for PRPs under CERCLA is strict, joint, several, and retroactive. Liability is *strict* in the sense that it does not matter whether the agency acted knowingly or reasonably. Liability is created simply by the connection of an owner, operator, generator, or transporter with a hazardous waste site (*United States v. Argent Corp.,* 21 Env. Rep. Cas. 1354 (D.N.M. May 4, 1984); *United States v. Conservation Chemical Co.,* 589 F. Supp. 59, 63 (W.D. Mo. 1985)).

In cases where two or more persons contributed to conditions at a site, liability is *joint and several* as well as strict. This means that any site owner or operator, generator, or transporter, can be sought for reimbursement, including the highway agency. Most importantly, each responsible party can be held liable for

the entire amount of response costs, regardless of who was responsible for how much waste (*United States v. Wade,* 577 F. Supp. 1326 (E.D. Pa. 1983); *United States v. A & F Materials, Inc.,* 578 F. Supp. 1249 (S.D. Ill. 1984); *United States v. Northeastern Pharmaceutical and Chemical Co.,* 579 F. Supp. 823 (W.D. Mo. 1984)).

Liability is also *retroactive* in that it attaches to a highway agency not only as a present owner or operator of a site, but also as a prior owner or operator (*United States v. Ottati & Goss, Inc.,* 630 F. Supp. 1361 (D.N.H. 1985)). This factor, coupled with strict liability, changes drastically the old practice of selling property "as is." Contracts and deeds do not protect anyone in the chain of title from Superfund liability. Although an owner or operator contractually arranges for indemnification from another party (such as a seller, buyer, or lessee), the owner or operator will still be primarily liable for cleanup costs even while trying to get reimbursed. Although Superfund allows responsible parties held liable for cleanup costs to seek reimbursement from other responsible parties, this right does not negate the basic liability if things go wrong.

Limits to Liability. As an owner or operator of a hazardous waste site, or as a generator or transporter of waste taken to a site, a government agency may be liable for punitive damages up to treble the costs incurred by EPA if it fails to properly provide reasonable response action in accordance with a formal EPA administrative order. Such treble damages will be imposed on top of the actual cleanup costs.

Because of the complex nature of remedial actions, which often require long-term monitoring programs, hazardous waste cleanups are usually very expensive. Cleanup costs can easily exceed the value of the property. As a responsible party, a highway agency's liability under CERCLA/SARA for a single incident is limited to all costs of response, plus an additional $50 million (depending on the type of site) for any damages imposed under the Act. These include the costs of a health assessment study at the site; removal or remedial action (as long as it is consistent with the NCP); damages for injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such damages; government costs, including attorney fees, oversight expenses, and cleanup costs; indemnifying response action contractors (if used); closure and post-closure maintenance and monitoring at the site; and interest on recoverable expenses.

There are no limits to liability, however, when there is willful misconduct or negligence; where the applicable primary cause of the incident was a violation of safety, construction, operating standards or regulations; or where the agency failed to provide assistance requested by a public official under the NCP (42 U.S.C. § 9607 (c)(1)(D)(2)).

It should be noted, however, that CERCLA only provides for the recovery of response costs. It does not allow a party to seek recovery for personal injuries and property damages. However, such damages can be sought under several common law theories of liability, as well as under several state statutes and regulations.

Defenses Against Liability. Under federal law, sovereign immunity offers state governmental bodies little protection against liability. Pursuant to SARA § 101(b), if a governmental body acquires ownership or control of property involuntarily through bankruptcy, tax delinquency, abandonment, or other circumstances by which it involuntarily acquires title as a sovereign, it is excluded from liability (42 U.S.C. § 9601(b)). This liability exclusion does not apply, however, to any state government which has caused or contributed to the release or threatened release of hazardous substances from a facility. In such cases, the party is subject to the liability provisions of CERCLA § 107, both procedurally and substantively, as if it were a nongovernmental entity.

There are some limited defenses against Superfund liability, however. They are:

1. *Third party defense.* Even though an agency may be a PRP under Superfund, liability will not exist if it can be established that a release or threat of release, and the resulting damages, are solely the result of an act of God, an act of war, or the actions of a third party. To invoke this "third party" defense, a highway agency would have to show that (a) the release was caused exclusively by an act or omission of another party; (b) the agency exercised due care with respect to the hazardous substance concerned; and (c) the agency took precautions against foreseeable acts or omissions of any such third party and the foreseeable consequences. The burden thus would be on the agency to show that this other party is responsible for the release and that the agency was diligent in trying to prevent the release and the resultant contamination. An employee, agent, or contractor (except common carrier by rail) does not qualify as a "third party."

2. *Innocent landowner defense.* Under Superfund, a party can also be released from liability where an "innocent landowner" defense is established. By virtue of § 101(35)(A), an owner of contaminated property may be shielded if the owner acquired the site after the waste was disposed there, and can establish one of the following: (a) at the time of acquisition, it did not know and had no reason to know that any hazardous substances were disposed of on the property; (b) it acquired the property by escheat or other involuntary means, or through eminent domain authority; and (c) it acquired the property by inheritance or bequest.

To use this defense, the owner also must show the exercise of due care with respect to the hazardous substance concerned and precautions against foreseeable acts or omissions of any third party and the consequence.

If a highway agency wishes to invoke this defense because it did not know and had no reason to know of the presence of hazardous substances on the property, CERCLA/SARA requires that the agency "must have taken, at the time of acquisition, all appropriate inquiry into the previous ownership and uses of the property consistent with good commercial or customary practice in an effort to minimize liability (42 U.S.C. S101(35)(B))." CERCLA further specifies that in applying this definition, the courts must consider: (a) any specialized knowledge or experience on the part of the highway agency; (b) the price of the property as compared to its market value if uncontaminated (the assumption is that a disparate price should put the agency on notice of a potential contamination problem); (c) commonly known or reasonably ascertainable information about the property; (d) the obviousness of the presence or likely presence of contamination at the property; and (e) the ability to detect the contamination by inspection.

This defense will be important to highway agencies that use eminent domain. Note that the exercise of eminent domain authority, whether by purchase or actual condemnation, can

cut off liability. This defense will help in cases involving property acquired by inheritance or bequest. An agency must be able to document that the contamination on the property took place before acquisition, and that "due care" was taken by the agency on discovery of the hazardous waste, as this defense requires. When a state highway agency can satisfy the conditions of the innocent landowner defense, the liability for cleanup and damages would revert to other potentially responsible parties.

While the demanding conditions required by the innocent landowner defense are most easily satisfied in association with pending real estate transactions, it may also be possible to invoke the defense on highway agency land that was purchased some time ago and has since laid vacant and unused. Language in the House-Senate Conference Report surrounding SARA hints at the intent of the conferees to protect unwitting purchasers who bought property prior to 1980:

> The duty to inquire under this provision shall be judged as of the time of acquisition. Defendants shall be held to a higher standard as public awareness of the hazards associated with hazardous substance releases has grown, as reflected by this Act, the 1980 Act, and other Federal and State statutes (H.R. Rep. No. 99-962, 99th Congress 2d Sess. (Oct. 3, 1986), p. 187).

The innocent landowner defense as it relates to property acquired many years ago has yet to be tested in the courts.

3. *Other defenses.* By virtue of § 107, no state or local government is liable under Superfund for costs or damages "as a result of actions taken in response to any emergency created by the release or threatened release of a hazardous substance generated by or from a facility owned by another person," except if there is negligence or intentional misconduct. Section 107 also states that no person is liable "as a result of actions taken or omitted in the course of rendering care, assistance, or advice in accordance with the National Contingency Plan (NCP) or at the direction of an on-scene coordinator appointed under such plan" when a release or threat of a release endangers public health or welfare. This does not preclude liability, however, for negligence.

Occupational Safety and Health Administration Worker Protection Regulations

Accompanying Superfund reauthorization in 1986 were amendments that addressed the need to protect anyone who may be exposed to hazardous substances. Under the authority established in SARA § 126(3) tit. III, the Occupational Safety and Health Administration (OSHA) has issued regulations specifically designed to protect workers engaged in hazardous waste operations. The OSHA regulations are contained in 29 CFR 1910.120, *Hazardous Waste Operations and Response,* and are in addition to the coverage under OSHA's Standards for Industry and Construction. They require employers who perform activities at hazardous waste sites or facilities to:

- Identify the hazards present at each site and develop site-specific plans for worker protection. This will typically require that the employer, prior to entry, gather off-site information, conduct perimeter reconnaissance and site characterization; conduct on-site surveys while restricting access; and once the site has been determined safe for other activities, continue monitoring to provide updated information.
- Train employees who might be exposed to hazardous substances (OSHA 29 CFR 1910). Depending on the type of site, the necessary training may involve up to 40 hours of training plus medical monitoring and 8 hours of retraining each year.
- Establish guidelines for the control of the site and the use of equipment engaged in hazardous waste operations. Employers must establish procedures and practices that secure the area and prevent the contamination of personnel as well as the public. Employees must also be trained to understand and practice safe and acceptable drum and container handling procedures.
- Establish requirements for personal protective equipment. Employers must establish means for isolating employees from hazards and specify the use and effectiveness of the personnel protective equipment and other controls.
- Develop informational programs to inform employees of the risks involved in conducting a cleanup action.

OSHA regulations also require the establishment of thresholds for periodic medical surveillance of employees, requirements for air monitoring, procedures for handling hazardous substances, and procedures for decontamination.

Under the Occupational Safety and Health Act Section 18, a number of states have adopted their own state occupational safety and health programs. In these states, state employees engaged in hazardous waste activities must be provided protection as specified in the regulations. Highway agency staff who undertake explicit hazardous waste site assessment activities need to comply with the OSHA regulations. When on-site appraisal, survey, and evaluation activities exclude any assessment of potential hazardous waste contamination, and there is not normally any exposure to hazardous substances, the OSHA requirements do not apply.

Highway employees in states that are not covered by OSHA or a state occupational safety and health program do not technically have to comply with OSHA safety regulations. If adequate and effective hazardous waste training is not provided, however, the agency may expose itself to unnecessary liability and employee lawsuits. Professional liability, accident liability, worker's compensation, and other issues associated with losses or injuries incurred by public employees in hazardous waste activities have not yet been clearly defined. Many labor agreements prohibit employee exposure to certain hazardous activities and may contain other restrictions with respect to hazardous substances. It is strongly recommended that a hazardous waste training program be completed by any highway agency employee involved in any way in the on-site assessment of hazardous waste conditions.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (42 U.S.C. § 6901 *et seq.*) is a federal statute enacted in 1976 to ensure that wastes are managed in an environmentally sound manner, and to protect human health and the environment from the potential hazards of waste disposal. Whereas CERCLA focuses on the cleanup of uncontrolled or abandoned sites, RCRA seeks to better manage active hazardous waste treatment, storage, and disposal facilities so that no new Superfund sites will be created in the future. RCRA regulations promulgated by EPA set up licensing or notification requirements for TSD facilities (those facilities that treat, store, or dispose of waste), or those who generate or transport waste. A hazardous waste generator re-

mains liable under Superfund for its waste if any release occurs during its transportation, storage off-site, treatment, or disposal.

RCRA provides the primary federal definition of "hazardous waste." In defining hazardous waste, RCRA prescribes a step-by-step identification procedure. Initially, one has to determine whether the material is a "solid waste" pursuant to 40 CFR 261.2. The next step is to determine if the solid waste is hazardous pursuant to 40 CFR 261.3. Certain materials listed by EPA in 40 CFR 261.31–33 are automatically deemed hazardous. Other materials must be tested in accordance with Subpart C of Part 261 to determine if they exhibit any one of four characteristics of hazardous wastes (ignitable, corrosive, reactive, or toxic), and are thus deemed hazardous. Exclusions are provided for wastewaters discharged pursuant to an NPDES permit, and for certain types of reuse, recycling, and reclamation. Refer to Appendix A for a more complete description of the RCRA definition of hazardous wastes.

RCRA also authorizes EPA to conduct removal actions, seek injunctive relief, and maintain cost-recovery actions where imminent and substantial danger to the public health or welfare, or environment, is determined to exist.

Hazardous and Solid Waste Amendments (HSWA)

Congress most recently revised RCRA in 1984. The 1984 amendments—referred to as the Hazardous and Solid Waste Amendments (HSWA)—expand the initial scope of RCRA. Of special significance, the HSWA amendments prohibit the land disposal of several types of hazardous waste, particularly untreated hazardous wastes, unless EPA determines that such disposal is protective of human health and the environment. For wastes that are restricted from land disposal, the amendments require EPA to set treatment standards that substantially diminish a waste's toxicity or reduce the likelihood that a waste's constituents will migrate. Beyond specified dates, restricted wastes that do not meet the treatment standards (or wastes that EPA fails to set treatment standards for) are prohibited from land disposal. These "land ban" provisions of HSWA are encouraging the development of more economical and effective means of treating hazardous wastes.

HSWA also makes the permitting of a hazardous waste facility far more difficult than it was under RCRA. Applicants must now submit exposure information on the potential for public exposure to hazardous substances from landfill and surface impoundments, which is then used in developing permit conditions. The permit requirements under RCRA/HWSA are complex, time-consuming, and costly.

Leaking Underground Storage Tank Program (LUST)

RCRA and HSWA also established a program for regulating leaking underground storage tanks (LUST). Under LUST, the design, installation, maintenance, monitoring, and failures of underground storage tanks are regulated for the first time. Owners of underground storage tanks and pipes must do the following: (1) register present tanks (and past removals) with designated state agencies, indicating the age, size, type, and location of the tanks as well as their uses; (2) meet new tank performance standards for new installations; (3) make tanks leak-proof for their entire lives; (4) install leak-detection systems; (5) keep required records; and (6) install no bare steel tanks except in soils that will not cause rust. Regulated substances under the LUST program include both hazardous substances and petroleum products in tanks, but not hazardous waste.

Further information about RCRA and HSWA is contained in *Solving the Hazardous Waste Program: EPA's RCRA Program,* EPA/530-SW-86-037, by the U.S. Environmental Protection Agency, Office of Solid Waste, November 1986; also in the *RCRA Handbook,* by ERT, Inc. and Sidley & Austin.

RCRA/HSWA Liability

Under RCRA § 260.10, a generator is any person, by site, whose act or process creates hazardous waste, or any person who first makes the waste subject to RCRA regulation. Under this definition and current EPA policy, a highway agency can become a generator as soon as it handles hazardous waste over specified limits (100 kilograms (kg) per month for hazardous wastes, 1 kg per month for acutely hazardous wastes), and be subject to full RCRA regulation from that point forward. The agency must then do the following: (1) Give official notice to EPA of its hazardous waste activity. (2) Obtain a generator identification number from EPA. (3) Initiate manifest documents when waste is transported and see that the waste is properly packaged and labeled in accordance with DOT specifications. (4) Use only transporters with EPA identification numbers. (5) Ship only to TSD hazardous waste facilities authorized under the federal program to receive waste (i.e., having EPA identification numbers and with "interim status" or TSD permits). (6) Keep records of all waste shipments and test reports, and file annual reports with EPA. (7) Report any problems with shipments to EPA.

As an underground tank owner or operator under RCRA, a government agency has the financial responsibility to take corrective action when there is a release and to compensate third parties for bodily injuries and property damages by sudden or nonsudden accidental releases. The liability for leaks from underground storage tanks is the same as that for discharges into waters pursuant to the Clean Water Act.

***Note:* A RCRA/Superfund Hotline has been established by the U.S. EPA to answer any questions concerning liability and rights under RCRA and CERCLA. The toll free number is: 1-800-424-9346**

Other Federal Statutes

In addition to CERCLA and RCRA, a number of other federal statutes can be used to bring suit against a highway agency should certain conditions exist. If hazardous wastes on highway property are discharged into a waterway, suit can be brought under the Clean Water Act. If wastes enter the ground and the public drinking water system, violations of the Safe Drinking Water Act may result. Should the wastes for which a highway agency is responsible be burned, the Clean Air Act may be violated. If the waste involved contains PCBs, compliance with TSCA must be ensured. Finally, if the impact of a federally funded highway project on a hazardous waste site is not adequately discussed in an environmental impact statement (EIS), the adequacy of the statement may be challenged under the National Environmental Policy Act (NEPA). All of these statutes, either alone or in conjunction with other laws, may be used to bring suit against a highway agency in violation of its requirements. Table 3 summarizes the provisions of other potentially relevant federal statutes.

Table 3. Other relevant federal statutes.

Clean Water Act (CWA)
33 U.S.C. Section 1251 et seq.

The Clean Water Act provides for comprehensive federal regulation of all sources of water pollution. It prohibits the discharge of pollutants from other than permitted sources, and authorizes cleanup, injunctive, and cost-recovery powers where an imminent hazard is caused by pollution. Other provisions prohibit the discharge of oil and other hazardous substances; impose criminal penalty for failure to notify the appropriate authorities of such discharges; and provide for citizen suits.

The Safe Drinking Water Act (SDWA)
42 U.S.C. Section 300(f) et seq.

The Safe Drinking Water Act provides broad administrative and legal authority to protect public drinking water systems. Primary enforcement authority is given to the states. It applies when any contaminant, defined broadly as "any physical, chemical, biological, or radiological substance or matter" is present in, or about to enter, a public drinking water system.

Clean Air Act (CAA)
42 U.S.C. Section 7901 et seq.

The Clean Air Act provides federal authority to regulate all stationary and nonstationary (e.g., motor vehicle) sources of air pollution. Under Section 112 of the Act, EPA is empowered to promulgate uniform national standards for hazardous air pollutants. Hazardous air pollutants are defined as those likely to cause an increase in mortality, in serious irreversible illness, or in incapacitating reversible illness. While nonhazardous air pollutants are regulated with some discretion, hazardous air pollutant standards are strictly enforced.

Toxic Substances Control Act (TSCA)
15 U.S.C. Sections 2601-2629.

TSCA regulates the manufacture, processing, and distribution in commerce of chemical substances and mixtures capable of causing an adverse reaction to health or the environment. Certain hazardous substances, such as polychlorinated biphenols (PCBs), are regulated under TSCA.

National Environmental Policy Act (NEPA)
42 U.S.C. Section 4231

NEPA requires all federal agencies, and those operating under contract to federal agencies, to take steps to ensure that environmental considerations are given due weight in project decision-making. For every federal action with the potential to significantly affect the environment, a responsible official must prepare an environmental impact statement (EIS) that describes: 1) the environmental impact of the proposed action; 2) the adverse environmental effects that cannot be avoided should the project be implemented; 3) alternatives to the proposed action; 4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity; and 5) any irreversible and irretrievable commitment of resources which would be involved should the project be approved.

State Hazardous Waste Laws

State "Superfund" Statutes

The funding available under CERCLA is not nearly enough to clean up all uncontrolled or abandoned hazardous waste sites. As a result, many states have passed laws similar to the federal Superfund legislation and developed lists of sites targeted for cleanup that are not on the federal National Priorities List. Like their federal counterparts, these laws—referred to as "state Superfunds"—were enacted to address the liabilities and costs that may be incurred by the state in cleaning up hazardous waste sites. They often go beyond federal Superfund in that they may regulate more types of waste, impose stricter liability, afford fewer defenses, create private rights of action to sue for damage to real estate or personal property, allow for "superliens," and mandate "how clean is clean."

Many of the state Superfund statutes resemble the language of CERCLA § 107. Other states, while not adopting the language of CERCLA, have established similar liabilities on purchasers of contaminated property. Courts in these states will probably interpret those statutes in the same way as CERCLA with respect to subsequent landowner liability. Statutes in other states, however, differ from the federal Superfund. In California, for example, the Hazardous Waste Control Act imposes liability not only on the creators of a hazardous waste site, but also provides that owners of polluted land are liable for cost to the state of abatement of the hazardous waste on their land. Liability

is therefore based on land ownership rather than conduct. It can be imposed on operators, producers, transporters, and generators of hazardous waste, and applies to "present and prior owners of the property where the hazardous waste is located." In contrast to federal statute, the costs to the state of cleaning up the site can be charged to the person who violated the statute, including "innocent" owners.

Still other states, however, have provisions that would probably exempt from liability those who purchased the property after it was contaminated. For example, Connecticut law states that costs may be recovered from parties who "directly or indirectly cause releases of hazardous substances." Kentucky exempts owners who are not generators or who are not "dumping or knowingly allowing the dumping" of wastes and have made a reasonable effort to prevent disposal on the property. Similarly, in Maryland, the "person responsible" for the release or threatened release is liable. In Minnesota, the burden-of-proof requirements for establishing liability are less than those in federal law, thereby making it easier to sue potentially responsible parties.

Several state statutes go beyond the framework established by the federal Superfund statute by restricting the transfer of property until the seller verifies that it is free of contamination. These statutes are referred to as ECRAs, named after the New Jersey Environmental Cleanup Responsibility Act (N.J. STAT. ANN. 13:1K–13:1K-13 (West Supp. 1985)). The New Jersey ECRA requires that every commercial and industrial facility that falls within certain Standard Industrial Classification (SIC) categories undergo a detailed site assessment before title can be transferred. The seller must notify the New Jersey Department of Environmental Protection (NJDEP) that it wishes to sell the property. It then must provide NJDEP with a description of its facilities and operations, an inventory of hazardous wastes and substances, maps of locations where there have been spills or releases, and a description of any enforcement actions or permits issued. If the site is determined to be free of any contamination, the seller files a "negative declaration" to that effect. Should contamination be suspected, however, the seller must provide a sampling and analysis plan and procedures for decontamination. If this sampling and analysis indicate the presence of hazardous substances on the property, a cleanup plan must be prepared and the problem remediated before the transaction can take place.

Other states have similar, although usually less stringent, ECRAs. Under Massachusetts General Laws, Ch. 21E, banking institutions and title companies require that detailed site assessments be completed as a condition of sale. New Hampshire (New Hampshire Hazardous Waste Law, Ch. 147-B) and Connecticut (Public Act 85-568 and Public Act 85-443) have enacted legislation similar to Massachusetts. Connecticut's legislation requires that a declaration attesting to the condition of a property be completed by the seller, signed by the buyer, and filed with the state environmental agency. By filing such forms, the seller of the property declares that his or her property is clean and assigns any subsequently discovered hazardous waste problems to the buyer. Maryland, Pennsylvania, and New York are all considering legislation modeled after the New Jersey ECRA, while other states are sure to follow.

In view of the lack of uniformity among state laws, each state's statutes should be reviewed carefully by highway legal counsel to determine the effect of the state's Superfund law upon the highway agency's rights and liabilities.

RCRA Counterparts

As Congress intended, most states have received authorization to implement the federal RCRA program. All authorized state RCRA programs must have regulations that are at least "substantially equivalent" as their federal RCRA counterparts. Some states have more stringent regulations and requirements than EPA. Knowledge of how RCRA is interpreted and administered in the state environmental agency is important in making a decision whether, when, and how to clean up a hazardous waste site.

EPA is also delegating the LUST program to individual states if they do the following: (1) offer state laws at least as stringent as the federal; (2) show authority to compel corrective action; (3) establish financial responsibility; and (4) set new tank performance standards. Since the federal program authorizes and encourages states to run their own LUST programs, and seek this delegation from EPA, it is fair to assume that this will happen in almost every state.

Superlien and Lien Provisions

In conjunction with state Superfund laws, a number of states have also enacted so-called "superlien" statutes that give the state a right to the property of a responsible party as payment for the costs it incurs when cleaning up a hazardous waste site. Most superliens give states priority status over most pre-existing liens, including mortgages on the property being cleaned up. Fearful of having a "superlien" imposed on a property, banks, lending institutions and title companies in many states are requiring that pre-purchase site investigations be performed as a condition of sale. State superlien statutes have been enacted in Arkansas, Connecticut, Massachusetts, Minnesota, New Hampshire, New Jersey, and Tennessee.

Under CERCLA/SARA, § 107(a), the Federal Government can also obtain a lien on property for cleanup costs. This lien is upon all property owned by the responsible party and is effective at the time the costs are incurred at the site, or upon notice to the owner, whichever is later. In contrast to state superliens, however, the federal lien is not considered a priority lien. It is first in priority over subsequent liens *only,* provided that prior liens are established under state law and are filed in the appropriate state records office. If there is no state records office, notice must be filed with the clerk for the federal district court for the district in which the property is located.

Liability Under Common Law

A highway agency that finds itself a responsible party for hazardous wastes may also be sued under a variety of common law doctrines, including negligence, trespass, and nuisance.

Negligence is defined by law as "conduct which falls below the standard established by law for the protection of others against unreasonable risk or harm." To establish negligence, it must be demonstrated that (1) the defendant was under a duty to conform to a standard of conduct; (2) the defendant breached that duty; (3) there was reasonably close connection between the defendant's conduct and the plaintiff's injury; and (4) the plaintiff suffered actual loss or injury.

If hazardous wastes interfere with another's interest in land, a cause of action in trespass may be possible. Grounds for trespass may exist if hazardous wastes migrate onto an adjoining property and injury results. Trespass may be intentional, negligent, or the result of ultra-hazardous activity.

A nuisance is a substantial, unreasonable interference with another's use and enjoyment of land. A nuisance suit can result from an intentional or unintentional discharge of hazardous waste, and may be brought under state law or, where the resulting contamination has an interstate effect, under federal common law.

Common law offers important remedy for money damages for personal injuries and property damages not covered by Superfund. Using these doctrines, victims of hazardous substance releases into the environment may file suit if they suffer damages.

In conclusion, the laws, rules, and ordinances that govern hazardous waste are new, complex, and in flux. The linchpin federal laws, the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund), were enacted as recently as 1974 and 1980, respectively. RCRA regulations were substantially modified in 1984, while CERCLA was modified and reauthorized in 1986. States and localities are still developing hazardous waste laws and regulations, and the nature and stringency of these vary from state to state. The current situation is fraught with uncertainties about legal interpretation. Until case law precedents for a number of issues are more clearly established, it is especially important for highway legal counsel to stay abreast of regulatory developments and legal decisions in this field.

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Chapter 3

MANAGEMENT OF HIGHWAY AGENCY LIABILITIES AND RISKS

Highway agencies can take a number of steps to avoid or minimize liabilities and risks associated with hazardous waste site assessments and cleanups. Policies governing how an agency will handle various hazardous waste situations should be developed, and organizational structures modified to accommodate them. When actually responding to a waste problem, a highway agency may want to consider using contractors familiar with technical and legal details. Finally, a community relations program can be implemented to facilitate response to public concerns and queries. ■ *Section 1 identifies the ways that a highway agency can protect itself against undesirable lawsuits and risk. Beneficial changes that can be made to agency procedures are identified and explained.* ■ *Highway agencies often do not have sufficient resources to invest in full-time staff and other support services needed for hazardous waste site management and regulatory compliance. Section 2 examines how different highway agencies are accommodating their concerns about hazardous waste through staffing and changes to their organizational structures.* ■ *Fiscal constraints in the agency and the need for highly specialized services may place hazardous waste contractors in important roles. Section 3 examines the administrative options for retaining hazardous waste contractors, the criteria that should be employed when evaluating and selecting contractors, and special contract provisions that highway agencies should include in hazardous waste contracts.* ■ *Adverse public reaction is potentially one of the most damaging liabilities incurred by highway agencies involved with hazardous waste sites. Section 4 describes how an agency can develop a comprehensive community relations plan.* ■ *Section 5 contains bibliographic references used in developing the material presented in this chapter.*

1. MINIMIZING HIGHWAY AGENCY LIABILITY AND RISK

The discovery of a hazardous waste site can disrupt substantially the operations of a highway agency. Depending on the circumstances of the discovery, legal counsel may be needed to determine the nature and extent of the agency's liability. Other staff may need to be diverted from their normal activities to assist in formulating and managing the agency's response. Considerable uncertainty will be introduced into the affected project's planning, programming, and budgeting processes as the impact of the discovery becomes known. No functional unit of the agency is insulated from the potential effects an unexpected discovery can have. For financial and administrative reasons, ways to minimize or avoid hazardous waste liability must be seriously explored by a highway agency.

Fortunately, a highway agency is not powerless in its ability to minimize its hazardous waste liability. By making modifications to existing agency policies and procedures, it can address many of the problems highlighted in Chapter 2. Procedural changes can be made at every stage of the highway development process—during the planning and environmental assessment stage of a project's development; during highway design; in conjunction with property appraisal and acquisition; during construction of the highway project; and in conjunction with the agency's management of existing property and right-of-way. Procedural guidance can also be developed by an agency on how to manage hazardous waste site remediation activities so as to limit its liability.

This section explores ways to minimize liability at each stage of the highway development process. It examines in detail the recommended procedures and available options to agency decision-makers if hazardous wastes are found at each stage. Figure 2 summarizes these actions. While no prescriptions can be offered, the following advice will be useful in formulating an agency response to the threat of hazardous waste sites.

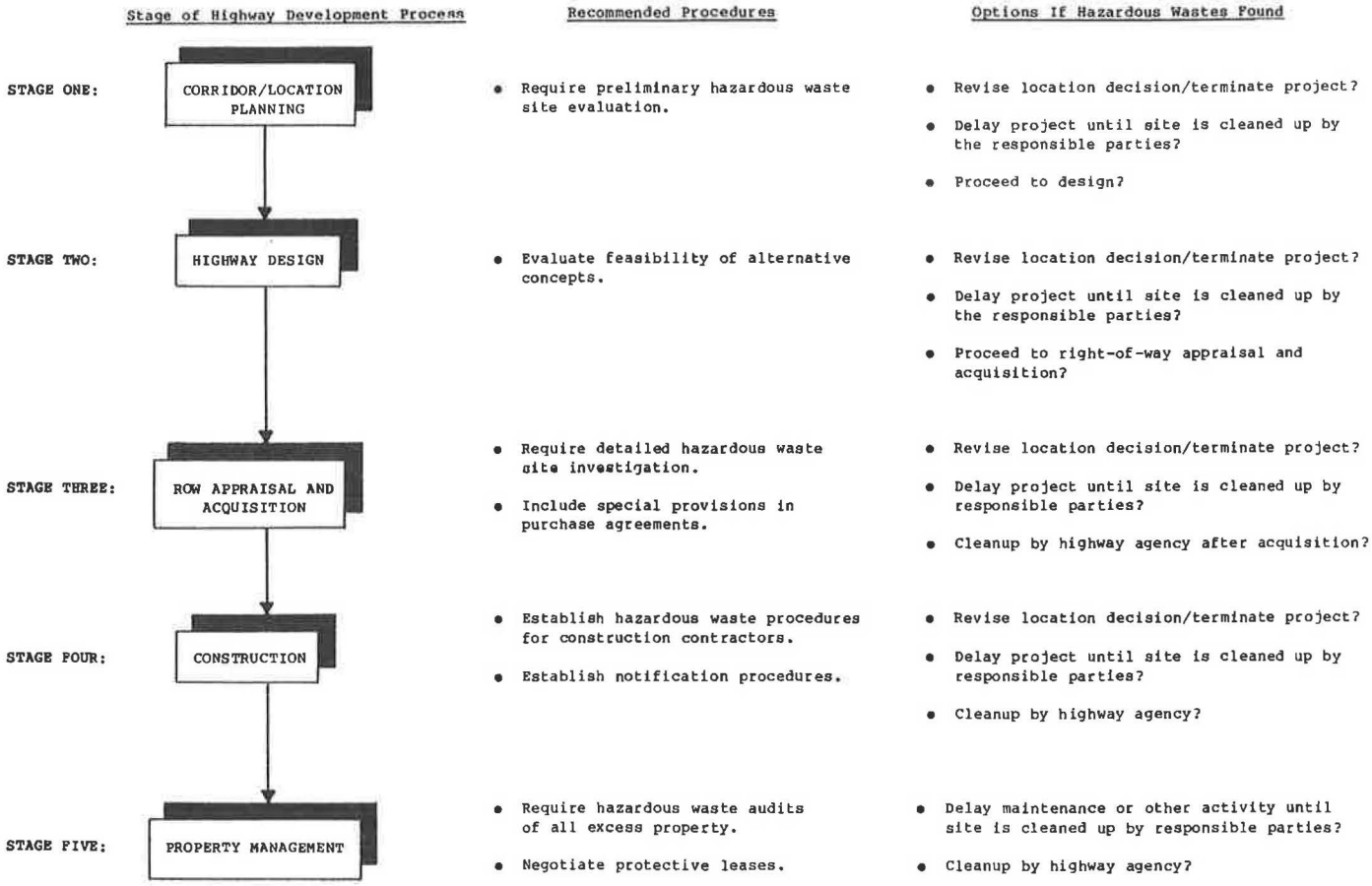
Minimizing Liability During Highway Planning and Environmental Review (Stage One)

The liability and responsibility for cleanup is automatically assumed by a highway agency when a contaminated property is acquired, unless the conditions of certain defenses are met. It is imperative, therefore, that the presence of hazardous wastes: (1) be identified as early in project planning as possible; (2) be used in the selection of the preferred alternative; and (3) certainly be known before property acquisition. Knowledge of the existence of, or potential for, hazardous wastes in a corridor is essential in assessing the overall environmental impact and costs of a proposed action. Depending on the size and nature of a site, such knowledge can have as great an impact on the selection of a preferred alternative as any other environmental or design feature.

The importance of early identification and action is reflected in FHWA's Technical Advisory T6640.8A, "Guidance for Preparing and Processing Environmental and Section 4(f) Documents," October 30, 1987, which states:

> Hazardous waste sites are regulated by the Resource Conservation and Recovery Act (RCRA) and the Comprehensive En-

Figure 2. Ways to minimize highway agency liability during highway development.



vironmental Response, Compensation and Liability Act of 1980 (CERCLA). During early planning, the location of permitted and nonregulated hazardous waste sites should be identified. Early coordination with the appropriate Regional Office of the EPA and appropriate State agency will aid in identifying known or potential hazardous waste sites. If known or potential waste sites are identified, the locations should be clearly marked on a map showing their relationship to the alternatives under consideration. If a known or potential hazardous waste site is affected by an alternative, information about the site, the potential involvement, impacts and public health concerns of the affected alternative(s), and the proposed mitigation measures to eliminate or minimize impacts or public health concerns should be discussed in the draft EIS. If the preferred alternative impacts a known or potential hazardous waste site, the final EIS should address and resolve the issues raised by the public and government agencies.

Identifying hazardous wastes early in the process has a number of benefits. It will ensure public safety by minimizing potential dangers to highway agency and other personnel from hazardous chemicals. These dangers include fire, explosion, asphyxiation, and exposure to wastes through inhalation or skin contact that may result in immediate or long-term health effects. It will reduce the likelihood of roadway redesign or project termination, and their attendant costs. It will also reduce the possibility and cost of litigation against the highway agency. It will minimize the need for project redesign and other construction delays. And it will enable the highway agency to avoid the adverse publicity that is associated with owners of contaminated property.

Require Preliminary Hazardous Waste Site Evaluations (Recommended Procedure)

To identify the presence or potential for hazardous wastes, a preliminary hazardous waste evaluation should be conducted for every parcel of land within the likely right-of-way for a project. At a minimum, this should involve a review of known land ownership and land use operations (past and present) within the project's area of influence. It should also include the examination of hazardous waste site lists available from EPA or the state environmental agency. As resources allow, however, a more thorough preliminary hazardous waste site evaluation may be in order.

What Is a Preliminary Hazardous Waste Site Evaluation? A preliminary hazardous waste site evaluation refers to the effort of assessing the potential for discovering hazardous wastes on a particular property. A preliminary site evaluation should determine if: (1) the property is a known hazardous waste site; (2) there are known hazardous waste sites in the property's vicinity; (3) the property was ever occupied by a company that either used, generated, or stored hazardous wastes; or (4) any neighboring properties are or were occupied by companies in-

volved with hazardous materials or wastes. It is also intended to identify the potential for hazardous waste contamination from neighboring properties. Migration from adjacent or nearby properties is often overlooked as a potential source of contamination.

A preliminary site evaluation can involve any or all of the following activities: research of existing records and files, collection and review of available land use maps, evaluation of available photographic information, conduct of personal interviews.

A preliminary site evaluation will document the history of the site, focusing particularly on any industrial, commercial, or waste disposal activities that have taken place there. This history should include identification of past and present owners using appropriate property maps, subdivision maps, and deeds. Wastes that may be on the site can be anticipated by researching the products manufactured or materials dumped in the past, and the nature of production or treatment processes.

The preliminary evaluation will also cover the permit and enforcement history of the property in order to check what past and present activities were properly licensed by federal, state, and local agencies and boards. It will include visits to environmental agencies to check for violation notices and enforcement orders so as to assess the likely costs of bringing property into compliance. If this enforcement history includes litigation, pertinent court documents will need to be collected to identify its potential effects on future uses of the property and the likelihood of awards for money damages against the agency as new owner. It may also include a review of activities on adjacent property. (See Chapter 4, section 1, "Preliminary Hazardous Waste Site Evaluation," for a detailed description of the activities associated with this kind of evaluation.)

Because a preliminary site evaluation involves off-site records research, it can usually be performed by highway agency staff (or others) without their having to enter a site and be exposed to potentially hazardous situations. A thorough preliminary site evaluation will yield a number of benefits. It may provide all the information needed to make a decision about the agency's future involvement with the property, and thus eliminate the need for expensive on-site data collection (i.e., a detailed site investigation). It usually also identifies the most likely location(s) where contamination would exist, if present, thereby ensuring more effective use of agency resources should it become necessary to do on-site soil or ground-water sampling. And it can substantially reduce the cost of chemically analyzing soil and ground-water samples by focusing the analyses on target chemicals identified during the preliminary research, instead of scanning for all EPA priority pollutants.

Who Should Perform the Preliminary Evaluation? Who conducts the preliminary site evaluations is a decision that must be made by the highway agency on a project-by-project basis. It may be desirable to retain a contractor with experience in performing contamination surveys. An experienced contractor will be familiar with site evaluation procedures and available sources of information. Local hazardous waste firms may also bring an important familiarity with the local area. This familiarity may be particularly helpful when deciding the appropriateness and cost of employing special detection or remote sensing techniques at the site. (See section 3, "Securing Contractor Assistance," for guidance on how to select a qualified contractor.)

Alternatively, highway agency staff may be trained to perform certain investigative functions. Most of the activities associated with a preliminary site evaluation involve the research of agency records and files. These activities can be performed by agency staff with minimal training. Other activities involving remote sensing devices, for example, will require more specialized skills. Agency staff involved in more sophisticated data collection and interpretative tasks should have the proper training.

How Should the Evaluation Be Documented? The results of the off-site evaluation should be accurately and completely documented, and presented with other environmental impact information as part of federal and/or state mandated environmental assessment documents. Scrupulous records should be maintained of the basis and rationale for any decisions regarding hazardous wastes. All information gathered during this investigative phase should be carefully organized, catalogued, and documented. The names, addresses, and phone numbers of any individuals interviewed should be documented with the date and time of the interview. Documentation is extremely important because part or all of it may serve as the basis not only for agency decision-making, but also for future legal action.

It will also be important to store all hazardous waste-related investigative data in a safe and secure area. Most agency records are stored for safekeeping and then discarded after a limited number of years. Hazardous waste site information, however, may be important in future litigation. Therefore, it should be stored indefinitely.

What If Hazardous Wastes Are Found? Several considerations must be weighed when selecting a preferred corridor and alternative. The existence, or suspicion, of hazardous wastes within or adjacent to the right-of-way is one important consideration (see Figure 3). Although no definitive guidance can be given on how an agency should weigh various factors in the selection process, the following advice may be useful when deciding how to respond to the discovery of hazardous wastes at this time.

Based upon the results of the preliminary investigation, agency decision-makers will have the options of: (1) selecting an alternative corridor or alignment that avoids the waste site; (2) delaying the project until the discovered wastes have been cleaned up by the responsible parties; or (3) proceeding to design and exploring engineering and design ways to avoid the site.

If a hazardous waste site can be avoided, it is obviously best to do so. It is especially advisable to avoid hazardous waste sites that are on EPA's National Priorities List (NPL), the state environmental agency's priority list, or for which the owners or responsible parties are not known.

Cleaning up an NPL or other large and problematic site is very expensive and time-consuming. The highway agency should obtain EPA and state lists of priority and potential cleanup sites. If the affected highway project is not an extremely important one, and the prospect of high project costs and a long delay are unacceptable, sites on these lists are best avoided.

The highway agency should also be familiar with EPA's Hazardous Ranking System for designating NPL sites and with comparable state criteria for listing sites. By matching the situation found at a site with the NPL and state criteria, the agency can also avoid sites that are not yet designated but may be in the future.

What If Responsible Parties of Sites Are Unknown? Because the complex nature of remedial actions is often coupled with long-term monitoring programs, the cost of cleanup can easily exceed the value of the property. Faced with enormous cleanup

costs, property owners often abandon their "dirty" property rather than pay for cleanup. Consequently, a highway agency may encounter a situation where a property targeted for acquisition has been abandoned and it is impossible to identify the party responsible for the contamination.

In such a situation, it is advisable to avoid taking title to the property unless the extent of the contamination is known and the cost of cleanup is reasonable. Once the property is purchased, the agency assumes the liability and risks that accompany any contaminated property. In other words, the highway agency may be required to pay substantial costs for the entire cleanup even though the chemicals are not agency property, the property was not the agency's at the time the chemicals were dumped, and the agency did not contribute in any way to conditions at the site.

In sum, if (1) hazardous wastes are confirmed to exist on a site, (2) the property is suspected from its former uses to contain hazardous wastes, or (3) it is adjacent to a property with known or suspected contamination, it is probably wise to avoid it.

Minimizing Liability Through Highway Design (Stage Two)

Depending on the type of contamination present, and the relationship of the highway project to the contaminated parcel, it may be possible to avoid property acquisition by modifying the roadway alignment or configuration in the vicinity of the contamination.

Evaluate Feasibility of Alternative Concepts (Recommended Procedure)

Notwithstanding the physical, technical, and safety constraints that may preclude certain options, project design modifications have been used by many state highway agencies to avoid contaminated land. As illustrated by the examples below, design modifications can take many forms:

1. *Minor alignment modification.* In Boise, Idaho, the Idaho Department of Transportation modified its design of the Orchard Extension Project to avoid right-of-way involvement with the Wallace Plating Company.
2. *Major configuration modification.* In Michigan, the Michigan Department of Transportation changed its design of a proposed interchange from four to three quadrants in order to avoid suspected contamination.
3. *Modification of project concept.* In Illinois, the Illinois Department of Transportation proposed to construct a new fixed bridge at Division Street over the North Branch of the Chicago River. Sampling of sediments in the vicinity of the project by the Army Corps of Engineers revealed levels of polychlorinated biphenyls (PCBs) in concentrations above 50 parts per million. The presence of PCBs in these concentrations requires that the dredging material be handled and disposed of in accordance with guidelines established under the Toxic Substance Control Act. The cost of satisfactorily handling the PCB-contaminated material associated with the new construction was estimated by EPA at $100 million. To avoid the need for dredging and removal of PCB-contaminated sediments from the River, Illinois DOT and the Chicago Department of Public Works shelved the bridge replacement plan in favor of major rehabilitation. The cost of project redesign is expected to approximate $450,000 and delay the project for at least 2 years.

Depending on the size of the hazardous waste site and its location, it may also be feasible to avoid the site by "bridging" the contamination. Although the costs of constructing a con-

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In early 1980, the Delaware Department of Transportation, Division of Highways, initiated planning for the relocation of Delaware Route 7 in the vicinity of U.S. Route 13. During preparation of the environmental assessment for the project, it was discovered that one of the proposed alignments crossed the Tybouts Corner Landfill. The landfill had been used as a municipal dump site from December 1969 to July 1971. It was operated as a sanitary landfill, with the refuse spread and compacted when received, and then covered with six inches of soil at the end of the day. The refuse collected was thought to consist principally of garbage, paper, lawn trimmings, and miscellaneous materials.

In 1976, one private well in the area was found to be contaminated. Testing revealed the presence of very high levels of heavy metals and other chemicals associated with cancer, birth defects, and diseases of the liver and nervous systems. Based on information available at that time, the known contamination was not considered a major obstacle to construction through the landfill.

Engineering considerations,, however, would have made it necessary to remove an average of 15 feet of fill in order to construct the proposed roadway through the landfill. Due to the excessive cost of such excavation, an alignment that avoided the Tybouts Landfill was selected as the preferred alternative.

Further field investigations and sampling in the vicinity of the site by Delaware Department of Natural Resource and EPA led to the discovery of more widespread water contamination than previously thought. The Stauffer Chemical Company was eventually alleged to have illegally dumped industrial chemicals at the site during its use as a municipal landfill, causing the leachate contamination. In October 1981, the Tybouts Corner Landfill was listed by EPA as one of the ten worst hazardous waste sites in the country.

Figure 3. Route 7 and the Tybouts Corner Landfill (Delaware).

tinuous structure over a hazardous waste site may be prohibitively expensive, the use of such air rights may deserve consideration under certain circumstances. The bridging of sites has been used in the past by highway agencies when confronted with unacceptable soil stability problems presented by, for example, sanitary landfills.

Of course, modifying a roadway's design to accommodate a hazardous waste site can be complex and expensive. The rehabilitation of the Division Street bridge in Chicago, for example, precluded upgrading the facility to current geometric standards for lane width. As illustrated by the experiences below, the trade-offs and difficulties involved may not always be obvious at the outset:

1. In North Carolina, construction on I-277 in Charlotte required the taking of the Rowe Corporation, a firm involved in the manufacture and sale of equipment used by the textile industry. A chrome plating firm had operated on the site in the 1950's and contaminated the ground water as well as area soils. The Rowe Corporation was operating a wastewater treatment facility to rectify the ground-water problem.

The proposed project principally involved filling on the property. However, there was a small stream that ran through the property which had to be saved. And to accommodate the stream, considerable excavation was needed to install a 54-in. pipe.

To avoid disturbing the identified waste, and the expense of excavation, it was decided to reroute the drainage along existing streets bypassing the contaminated area. By rerouting the drainage, however, a new drainage problem was created on approximately 1.8 acres of land outside the right-of-way. Although this area may have been an uneconomic remnant, the revised design necessitated its inclusion in the project's right-of-way, at an additional cost.

2. In Florida, construction of the I-595/Port Everglades Expressway required the relocation of a railroad mainline. The revised rail alignment, in turn, required the taking of the southeast corner of property used by Uniweld Products, Inc. Results of chemical analysis of soil samples collected on the Uniweld property showed very high concentrations of various volatile organics, especially trans-1,2-dichloroethylene. Given the cost of cleaning up the contamination, the Florida DOT opted to revise the initially proposed rail alignment and eliminate taking of the Uniweld Building. This required geometric changes to the I-595 structure spanning the rail corridor, and minor adjustments to the design of several piers and spans on the mainline I-595 bridges over the rail corridor.

It may also be possible to avoid the wastes by purchasing only an easement of the affected property; however, wastes from the clearly contaminated portion of a parcel may have already migrated onto the easement. Therefore, unless there is substantial assurance that wastes have not and will not migrate in the future, the highway agency cannot be sure it is not buying a liability.

If, after exploring alternative design concepts, the waste site can still not be avoided through design, agency decision-makers will again have the options of: (1) selecting an alternative corridor or alignment that avoids the waste site; (2) delaying the project until the discovered wastes have been cleaned up by the responsible parties; or (3) proceeding to property appraisal and acquisition.

Minimizing Liability During Property Appraisal and Acquisition (Stage Three)

While it is the best policy to avoid encroachment and the acquisition of contaminated property, there may be circumstances where a known or suspected hazardous waste site must be acquired. When other considerations make it necessary to acquire a known or suspected waste site, it is usually advisable to conduct a detailed hazardous waste site investigation, particularly when the former land use is one typically associated with hazardous waste activities.

Require Detailed Hazardous Waste Site Investigations (Recommended Procedure)

Although no definitive guidance can be given concerning the need for an on-site investigation, factors to be considered in making this decision include the following: (1) If there is actual knowledge from the off-site investigation that chemicals were used or produced at the site, a more thorough on-site evaluation will usually be in order. (2) If the prior use of the site was industrial, or the site is located in a historically industrialized area, it may be prudent to investigate further. (3) If the proposed taking involves the demolition of existing structures, concern about asbestos insulation and underground storage tanks may warrant a more thorough investigation. (4) Even if prior use of the site was not industrial, a detailed site investigation may be in order if there is reason to believe that: (a) capacitors or transformers containing PCBs are present at the site; (b) buried tanks (perhaps containing fuel oil or other chemicals) are at the site; (c) construction debris is buried at the site (which might include asbestos); or (d) the site was a former fill or municipal dump. (5) If the cost of the project is significant, the risk of losses if the evaluation is inadequate is greater. Costly projects probably also warrant a more thorough field study.

Conducting a detailed site investigation also benefits the agency should it have to exercise the innocent landowner defense in the future. While no legal criteria or standards exist for defining what constitutes a thorough site assessment under the innocent landowner defense, a significant burden of proof will be placed on an agency to show that it undertook a "state-of-the-art" inquiry based on sound technical and scientific information *as it existed at the time of purchase.* Moreover, as a party involved in large-scale real estate transactions, a highway agency will be held to a higher standard of detection than those involved in smaller, residential property transactions.

What Is a Detailed Hazardous Waste Site Investigation? A detailed site investigation determines the nature and scope of the hazardous waste problem identified or suspected from a preliminary site evaluation. During a detailed site investigation, information is gathered on: (1) The sources of contamination that are present (What are the contaminants of concern at the site which may adversely affect the environment or human health? What quantities are present and what are their hazard characteristics (toxic, corrosive, ignitable, reactive) singularly or in combination?). (2) The potential for release of the materials (What is the likelihood that a release to the environment will occur at the site? What are the conditions that separate the wastes from the environment?). (3) The pathways to receptors (A pathway is the route by which the contaminant can migrate and come to affect human health and the environment. The primary pathways of concern are ground water, surface water,

and air. However, other pathways such as soil and direct contact are sometimes a concern. Pathways can be modified or eliminated by natural site features or engineered structures. If an underground tank is contained, for example, concern about the ground-water pathway would be diminished). (4) The nature of the receptors (A receptor is the person, population, environmental resource (plant, animal, etc.) that would be affected by the wastes).

A detailed site investigation will include an exhaustive physical survey of the site covering topography; geologic setting; surface and ground-water flow; building and utility layouts; and the condition of all structures above and below ground, including underground tanks. The survey must be thorough enough to identify suspicious site characteristics such as liquid breakouts, soil discoloration, odors, abnormalities in vegetation, and extensive filling and regrading. It must locate buried objects in the ground such as pipes, drums, and tanks. It may require drilling in order to sample ground water and subsurface soils, and to test for contamination. In addition, it requires the development of a Site Safety Plan. At a minimum, a Site Safety Plan will address the following issues: personnel and responsibilities, site characterization, personnel training, personal protective clothing and equipment, medical program, site sampling and monitoring plans, site control, decontamination procedures, and standard operation procedures.

The profile of a site that emerges from a detailed site investigation is used to assess the relative risks of doing work at the site and deciding what options are appropriate for remedial action. Risks exist at a site whenever a source of contamination, a pathway, and a receptor are all present at a significant level of concern. (See Chapter 4, section 2, "Detailed Hazardous Waste Site Investigations," for a detailed description of the different field techniques for identifying hazardous wastes, and the requirements of site safety and sampling plans.)

Who Should Conduct a Detailed Site Investigation? There are a number of hazards and risks associated with the conduct of a hazardous waste site investigation. Table 4 summarizes these risks and identifies ways they can be minimized. In recognition of the actions necessary to minimize site investigative risks, it may be advantageous to employ private contractors for most, if not all, aspects of field investigations. Because they are specialists in the field, contractors will have current knowledge of the latest technology and regulations, and their personnel will have received and maintained the necessary training for safely handling hazardous wastes. Under this scenario, highway agency staff would participate by identifying and contracting with a suitable hazardous waste firm or laboratory, monitoring their work, and evaluating the results. (See section 3, "Securing Hazardous Waste Contractor Assistance," for assistance on how to select and evaluate contractors for this work.)

At a minimum, highway agency staff who become involved in any way in the on-site assessment of hazardous waste conditions must successfully complete a hazardous waste training program. Agency staff who become involved in specific site investigative activities, involving underground storage tanks, for example, will require additional, specialized training. And, should highway agency supervisors suspect hazardous wastes, they must disclose it to affected staff. Failure of program managers to inform staff of the potential for exposure, or of affected staff to complete the proper training, may prompt judicial action.

When should the Investigation Be Performed? It is important that adequate time and funding for a thorough site assessment be allowed and that it be performed before acquisition. Results of the site assessment will provide essential input to the appraisal, and they may also provide information necessary for developing alternative design concepts. If more detailed site information is needed to evaluate design options, the investigation should be performed as soon as possible after the location studies have been completed and approved.

Ideally, a detailed field investigation should be done before executing a purchase agreement. If not, the purchase agreement itself should provide for a site assessment, much like it may provide for structural and property line surveys (including asbestos inspections). The purchase agreement should expressly state that acquisition is contingent upon favorable results of a site assessment. Below is a simple, sample clause that might be included in a purchase agreement by the highway agency to address the need for a site assessment:

> Within __ days after the date hereof, the Agency shall have the right, at Agency's cost, to select a reputable consulting engineer to inspect the Property and review Seller's environmental permits, reports and related documents and plans, and furnish Seller and Agency with a report on (1) any contamination or conditions which would create liability for removal or correction or interfere with the Agency's intended use of the Property and (2) the steps, if any, which may be necessary to bring the Property into compliance with applicable environmental legal requirements.
>
> The Seller shall, at Seller's cost, undertake such necessary steps to the reasonable satisfaction of the Agency, its consultant, and any regulatory agencies whose approval is necessary to confirm such compliance. [J.M. Manko, Esquire, "Hazardous Substances and Other Pitfalls: A Legal Review of Brokers' Responsibilities in Handling Industrial Real Estate Transactions," S.I.R. Educational Fund/Perspective 13, Nov./Dec. 1986, p. 8.]

This kind of clause will allow the highway agency to rescind the purchase contract before the closing if hazardous wastes are found. Alternatively, the clause may provide for price reduction, renegotiation, or return of the property.

How Can Right-of-Entry Be Obtained? If the inspection is being done by EPA staff, permission to enter the property is granted EPA by the Superfund Amendments. SARA authorizes EPA personnel to enter facilities, review records, and take samples as necessary to perform or determine the need for remediation. This authority also extends to property that is adjacent to a suspected source of contamination. EPA is also expressly authorized by CERCLA/SARA (§ 104) to demand information relating to the owner's ability to pay for or perform the cleanup. In the event access is denied by the owner, EPA is empowered to obtain an administrative search warrant or court order to proceed with the investigation.

If the state environmental agency is assisting in the site investigation, its staff may also have access to property under SARA. Under the provisions of CERCLA/SARA § 104(e)(1), "Any duly designated officer, employee, or representative of a State or political subdivision under a contract or cooperative agreement" with EPA is also granted authority to enter property for the purpose of conducting hazardous waste investigations. Most state environmental agencies are operating under EPA agreements.

Unless highway agency staff team up with state or federal EPA personnel, however, they cannot avail themselves of this right-of-entry authority for the purpose of conducting a hazardous waste survey. To gain access to a property, highway agency personnel will need the written consent of the owner. The highway agency will also have the responsibility of nego-

Table 4. Ways to minimize risk during detailed on-site investigations.

TYPE OF RISK	CIRCUMSTANCES	WAYS TO MINIMIZE RISK
Exposure of workers or visitors to hazardous chemicals.	This risk may exist when workers are investigating the site and/or visitors are traversing or viewing the site.	• Train workers in OSHA worker protection requirements or employ already trained personnel. • Develop a Site Safety Plan that delineates worker responsibilities, protective clothing requirements, site control and monitoring requirements. • Develop a Site Safety Plan that prohibits visitors from locations on or near areas where releases of hazardous materials might occur.
Exposure of nearby residents and the general public to hazardous chemicals due to the inadvertant release of contaminants to the air or ground water.	This might occur during the course of drilling when a tank is punctured and contaminants are released to the air, or when a boring device moves through a contaminated area into an aquifer, underground stream or other body not previously contaminated but capable of spreading the contamination.	• Employ personnel trained in OSHA worker protection requirements. • Develop a Site Safety Plan that describes the risk associated with each operation to be performed, standard operating procedures, container handling procedures, and contingency plans in the event of an unexpected release. • Develop a conservative sampling plan.
Failure to detect hazardous substances after employing appropriate sampling techniques and detection methods does not guarantee that wastes do not exist on the site.	This risk may exist when a highway project is on a tight schedule and there is not enough time or funding to perform an adequate site investigation. Even when a site assessment has been completed, the number and dimensions of the unknowns (e.g., movement and condition of contaminants at any given time; the hydrogeologic surroundings) often make it difficult to accurately profile a site.	• Develop quality assurance/quality control program for sampling, lab work, and analysis. • Stay abreast of and employ state-of-the-art hazardous waste detection techniques.

TO: State of California
Department of Transportation
District

_____

_____

It is my (our) understanding that the following facts pertain to the property I (we) own located at _____ and shown outlined in _____ on the attached map(s):

1. The property or a portion thereof is needed for construction of a transportation project identified as

_____

_____

2. The Department of Transportation finds it necessary to enter upon the property previously described for gathering data needed to complete final project design and appraisals for right-of-way acquisition for the transportation project noted previously.

3. The purpose for such entry onto the property is to take samples of soil and ground water to determine whether the site has been contaminated by hazardous substances.

I also understand that in return for granting permission to enter my property, the Department of Transportation will:

1. Retain a qualified contractor to perform the above-described test and to determine whether or not further site testing must be done. The substances to be tested consist of:

_____

_____

located at _____

_____

2. Require the contractor to coordinate the testing with the owner/operator's schedule. Unless objected to by the owner/operator, the testing will be performed during normal business hours. Forty-eight (48) hours' notice will be given to the owner/operator of the property prior to entry upon the property.

3. In accepting this Permit to Enter, agree, insofar as it may legally do so, that it will repair and restore or pay the cost of repairing and restoring any property damaged as a result of work done by the Department of Transportation or the Department of Transportation's contractor(s); further that it will insofar as it may legally do so, indemnify and save harmless the undersigned against all claims, demands, suits, judgements, expenses, and costs on account of injury to or death of persons or loss of or damage to property arising out of the performance of such work by the Department of Transportation or the Department of Transportation's contractor(s). This agreement of indemnification does not extend to property damage the undersigned may have suffered by reason of hazardous waste on the property. Nor does it indemnify the owner(s) from any liability as a consequence of the presence of hazardous waste on the property.

4. Pay the operator of the property to be tested the amount of _____ to compensate for the interference with the possession and use of the property.

It is understood that if the Department of Transportation discovers the presence of contamination on the property through the tests described herein or from other sources, further testing may be required to determine the extent of the contamination. That testing may be required by the Water Quality Board or the Department of Health Services and if performed by the Department of Transportation's contractor, will require a further Permit to Enter either by owner permission or by court order.

If no contamination is found, the Department of Transportation will proceed to negotiate without unnecessary delay with the owner(s) to agree upon the terms of compensation, and if agreement cannot be reached, to promptly commence eminent domain proceedings.

On the basis of the above, a Permit to Enter is hereby granted with the understanding that this Permit to Enter is not a waiver of the right to compensation for such property or any remedy authorized by law to secure payment therefor.

Date _____ By _____

Accepted:

_____

_____

Deputy District Director
Right-of-Way

Figure 4. Right-of-entry form.

tiating access to a property for any contractors it hires to perform the hazardous waste field surveys.

It may be possible to voluntarily obtain a written agreement, signed by all interested parties, granting access for the expressed purpose of performing a site assessment. Figure 4 provides a copy of the permission form used by the California Department of Transportation to access property for hazardous waste investigations. Note that the agreement must: (1) identify the locations on the property to be investigated, (2) specify the substances to be tested for, (3) indicate the time of day that testing will be performed, (4) specify the terms (if any) for compensation, and (5) provide for limited indemnification. The agreement should also state that no other contracts shall be entered into until the site assessment is conducted, and that the site assessment does not obligate the agency further to the present landowner.

Should a property owner refuse to allow the highway agency to conduct a hazardous waste site assessment, it may be necessary to seek a court injunction specifying the exact kind of testing to be performed. Of course, a property owner who refuses to cooperate should be viewed with suspicion. Consult legal counsel whenever you are preparing a right-of-way agreement to ensure that the highway agency is properly indemnified.

Timing is important. Sufficient time must be allowed to obtain right-of-entry, to properly characterize the site, and to appraise its value, as the following experience of the Michigan Department of Transportation (MDOT) demonstrates.

> In Michigan the construction of a portion of I-696 freeway in Oakland County required removal of the Howard Plating Company. The Howard Plating Company used zinc, chrome, cadmium, copper and cyanides during its plating operations. Portions of the building and soils around the structure were contaminated, requiring special handling and treatment. The site had been identified by the Michigan Department of Natural Resources (DNR) as a hazardous waste site in need of cleanup, but no official action had been initiated against the company by the DNR.
>
> Because of scheduling requirements, the MDOT initiated condemnation proceedings before taking steps to determine the actual magnitude of the contamination. And to obtain right-of-entry to the Howard Plating site, the Department had to agree not to reduce its offer to the company on the basis of its findings. As a result, the evidence found could not be used to establish the site's fair market value.

What If Hazardous Wastes Are Found? If the results of the on-site investigation confirm the presence of hazardous wastes, agency decision-makers will have the options of: (1) once again revising its location decision; (2) delaying the project until the discovered wastes have been cleaned up by the responsible parties; or (3) proceeding with property appraisal and acquisition. While this decision must be made on a site-by-site basis, the following advice may be useful when deciding how to proceed.

If hazardous wastes are found, and the potentially responsible party is known, the highway agency is strongly advised to require the responsible party(s) to clean up the site before taking title. While the delay suffered may be unacceptable, it may represent a small price to pay in contrast to the considerable liability that might otherwise be assumed with ownership.

Alternatively, if the affected highway project is an extremely important one, and the prospect of a long delay is unacceptable, it may be advantageous for the highway agency to factor the cost of the cleanup into the property's appraised value, purchase the property, and take the responsibility itself for cleanup. Officials will have to weigh a number of pros and cons in making this important decision. Table 5 summarizes the pros and cons of agency cleanup. The California Department of Transportation initiates hazardous waste cleanups only where minor cleanups are involved, or where unacceptable delays may result from major cleanup projects. Situations in other states may warrant different decisions on different projects.

When this option is exercised, the agency should be able to recover most of its cleanup costs under the provisions of its state Superfund statutes. If the site is a Superfund site, recovery would be under CERCLA from the federal Superfund.

To ensure that it does not come to bear more than its fair share of the cleanup costs, however, a thorough investigation of the financial condition of the responsible parties should be conducted before proceeding very far. Present and previous owners and responsible parties often claim bankruptcy as a way of escaping their cleanup responsibilities. While the adoption of CERCLA and its state law counterparts has impeded the ability of responsible parties to discharge their site cleanup obligations through bankruptcy or abandonment, case law is still developing in this area. Normally, a debtor is protected against all litigation which has or may be brought against it upon filing a Chapter 7 or Chapter 11 petition in bankruptcy court. This "stay" prevents the unorganized liquidation of the debtor's estate by providing complete, but temporary relief from creditors. However, it is not clear from case law whether or not a governmental request for monetary damages is exempted from this stay. Some courts view a request for monetary damages as within the stay. Others view environmental liability claims as not dischargeable under bankruptcy proceedings.

There is similar uncertainty in the courts regarding the priority of claims for hazardous waste cleanup costs. Bankruptcy law provides that the security interest of an estate (i.e., recorded debts) be satisfied first, administrative costs second, and payments to unsecured debtors last. Once again the courts are split on which category the costs of environmental cleanup fall into. Severe court decisions suggest treating environmental cleanup costs as administrative expenses. Others have failed to grant priority to environmental damage claims (*United States v. Johns Mannville,* 18 Envn't Rep. Cas. 177 (D.N.H.H. 1982); *Ohio v. Kovacs,* 105 S. Ct. 705 (1985); *Midlantic National Bank v. New Jersey Department of Environmental Protection,* 106 S. Ct. 755 (1986); *Southern Railroad Company v. Johnson Bronze Company,* 758 Fed. 2d. 137 (3rd Circuit 1985)).

In light of these uncertainties, legal counsel should check the solvency of the responsible party(s) before purchasing a property where contamination is suspect. If there is reason to believe that the responsible party(s) is going to (or already has) filed a bankruptcy petition for the property of interest, agency legal counsel should look to local precedent to determine whether the environmental cleanup debts the highway agency would incur will be given priority in bankruptcy proceedings.

How Should Contaminated Property Be Appraised? Most real estate appraisers have limited experience in evaluating contaminated properties. California has established a voluntary program for the registration of environmental assessors; however, the appraisal profession is not regulated in most states. Ideally, the appraisal should account for the short- and long-term costs to clean up a site, as well as any subsequent liability that may be inherited with the taking of title to a contaminated parcel. There is only limited experience in estimating the monetary value of such liability.

Table 5. Pros and cons of highway agency cleanup.

Benefits

- **Time Savings.** Cleanup by the highway agency may be accomplished on a faster track (less red tape, etc.) than that of the responsible parties.
- **Control.** By assuming cleanup responsibility, the highway agency will have control over the front-end studies that determine cleanup costs, the actions to be taken, and follow-through.
- **Negotiating Leverage.** Active participation in the cleanup will broaden the highway agency's negotiating powers and foster improved communication with government authorities. As a "sister agency" to the state environmental agency, it may be able to influence the process in its favor.
- **Favorable Publicity.** By voluntarily taking the responsibility for cleanup, the highway may be able to generate favorable reviews as a good environmental citizen.
- **Avoidance of "Toxic Tort" Liability.** Generally, any "toxic tort" liability (e.g., personal injury) increases as cleanup is delayed. By expediting the cleanup process, the highway agency may be minimizing the potential for future toxic tort suits.

Disadvantages

- **Unfair Burden.** The highway agency may, depending upon the circumstances, come to bear more than its fair share of cleanup responsibilities and costs.
- **Ongoing Liability.** While the government may accept the agency's cleanup offer, it may not release it from all liability (for example, from potential ground-water contamination).

Procedurally, the property should be appraised first as if it were "clean" and free of hazardous wastes. The market value of the contaminated property can then be estimated by deducting the cost of cleanup, determined from the results of the field survey. A qualified hazardous waste contractor experienced in dealing with the kinds of contamination discovered can provide the estimate of cleanup costs.

Other considerations that should be factored into determination of the fair market value include local regulatory cleanup requirements; market data, if available, involving sales offers or listings of properties with similar contamination problems; opinions of developers, brokers, or other informed persons knowledgable in the marketability of contaminated parcels; and any other pertinent data and information.

There may be projects where the cleanup of the hazardous materials does not affect the value of the property. In general, however, the fair market value of the property will be affected whenever hazardous wastes must be removed in order to put a property to its highest and best use.

It is often very difficult to characterize accurately the extent of the identified contamination and the attendant cleanup costs. While cost estimates will reflect the best available information, significant gaps between estimated and actual cleanup costs may be anticipated.

The experiences of the Washington Department of Transportation demonstrate the importance of conducting a thorough site investigation and the difficulty in obtaining reasonable cost estimates. Initial estimates for treatment and disposal of hazardous wastes on the I-705, Tacoma Spur Project, were significantly underestimated because larger quantities of wastes were discovered during the actual disposal operations. The approximate bid price and final disposal costs are listed below.

Material	Original Contract Amount	Final Cost
Tar	$ 45,000	$ 4,800,000
Oily Soils	106,000	350,000
Copper	Not Bid	560,000
Water Treatment	50,000	320,000
Total	$ 201,000	$ 6,030,000

Because of the uncertainties surrounding cleanup cost estimation, it is strongly suggested that settlements be based on cleanup prior to acquisition. Where cleanup occurs after acquisition, the amount of the cleanup should be withheld whenever possible. There should also be an agreement that if the actual cleanup costs exceed the agreed-upon amount, the responsible parties will reimburse the highway agency (or contractor) for the additional costs. Refunds should be provided if the cost of cleanup is less.

What Should Right-of-Way Certification Include? Although not required by FHWA, it may be advantageous as a matter of agency policy to require that the status of the highway agency's actions concerning hazardous waste be disclosed in the Right-of-Way Certificate. Agency officials could be required to certify, for example, that either of the following is true: (1) they have no current knowledge of hazardous materials usage or contamination of soils or ground water by hazardous materials on the right-of-way; and (2) any hazardous materials have been removed or any contamination of soils or ground water has been

remedied or is under regulatory or enforcement supervision by the state environmental agency.

To "codify" its policy regarding the acquisition of contaminated property, a highway agency is encouraged to include hazardous waste certification requirements as part of its right-of-way certification procedures. As a requirement of right-of-way certification and acquisition in California, for example, the following policy is in effect:

> The Department will not pay for the cleanup of hazardous waste generated by other responsible parties. Any property known or suspected to be contaminated with hazardous waste will not be acquired until one of the following actions has taken place:
>
> 1. The suspected site has been sufficiently investigated to the point of providing a reasonable assurance that no significant hazardous waste problem exists.
> 2. The confirmed hazardous waste site has been cleaned up by the responsible party prior to possession by the Department.
> 3. A determination has been made that the hazardous waste will cause no impediment to the construction of the proposed project or to the anticipated subsequent use by the Department and the public.
> 4. The estimated cost of the hazardous waste cleanup has been reflected in the acquisition offer in those cases where the Department will do the cleanup work.

Exceptions to this policy can only be made with the prior written approval of the Division of Right-of-Way and with the concurrence of the Division of Project Development.

Include Special Provisions in Purchase Agreements (Recommended Procedure)

What if hazardous wastes are not found? The absence of physical evidence of hazardous wastes does not always mean the property is "clean." Are there ways to minimize agency liability against the discovery of wastes after property acquisition? The answer is yes.

Should the highway agency acquire property later found to be contaminated, it may seek several remedies under its real estate contract and under consumer law. In some states, for example, the theory of Warranty of Merchantability provides a right to monetary damages from the seller because the property is no longer suitable or of the same nature contracted for. In other states, theory known as "waste" may allow the agency to bring suit against the seller for activities that destroyed the value of the property. Most states have consumer protection statutes which provide remedies to purchasers of property where the seller has misrepresented facts or failed to disclose material facts that would have changed the agency's mind about the purchase.

Still other remedies lie in actions for fraud and misrepresentation. The role of caveat emptor ("buyer beware") applies to contracts for the sale of land. However, this doctrine does not bar a purchaser from relying on the statement and representations of a seller as to the material facts that are available to the seller and not to a buyer exercising reasonable diligence. A buyer is able to rescind a contract for sale of property whenever such misrepresentation of the seller relate to the land, its physical condition, or its quality.

To further protect itself, however, it is recommended that the highway agency seek to negotiate indemnification and other cost-sharing agreements in the original contract for sale.

Indemnification Agreement. An indemnification agreement creates an obligation on the part of the seller to pay some or all of the hazardous waste cleanup costs once they have been incurred. Indemnification agreements between former landowners and new landowners have been held to require payment of hazardous waste cleanup costs (*Mardan Corp. v. C.G.C. Music Ltd.*, 804 F. 2d. 1454 (9th Circuit 1986)).

An indemnification agreement should be carefully drafted. A properly worded indemnification agreement can allow the agency to avoid lengthy settlement negotiations through CERCLA and state cost recovery procedures. An agency should identify, when the right to indemnification occurs, who first must pay for the cleanup, what are the upset limits for cleanup (if any), and how to settle upon what should be done to clean up a site. Also, because litigation expenses are often substantial, the indemnification agreement should include a duty to defend. In such a case, if the highway agency is sued, the seller pays for or provides the agency's defense. Inasmuch as the seller also will be named as a potentially responsible party, the same lawyer probably can defend all parties. Of course, separate representation would be necessary if disputes arose concerning the applicability of the indemnification agreement or its interpretation. This provision, therefore, should not add any significant expense to the transaction and may save the agency considerable expense.

While indemnification provisions are binding between the parties involved, they will not excuse the agency from third-party claims under CERCLA, and do not bind federal or other agencies that are not parties to it.

Other Cost-Sharing Arrangements. As an alternative to a complete indemnification agreement, a highway agency may consider a cost-sharing arrangement where the agency agrees to share cleanup cost, perhaps resulting in a lower purchase price. Alternatively, the agency may want to include buy-back provisions, where the seller agrees to take back the property and reimburse the agency if hazardous wastes are discovered.

The inclusion of indemnification or cost-sharing provisions may not be appropriate in every real estate transaction. Some of the factors that should be considered by the highway agency in making this determination are: (1) the likelihood that the unexpected will in fact occur; (2) the size and cost of the highway project and the cost of delay during the project should a dispute over the apportionment of costs arise; (3) the likely cost of such a cleanup; and (4) the degree and nature of past (and expected future) dealings with the property owners. Also, the negotiation of indemnification and cost-sharing agreements requires expert legal and technical input and advice. Seek professional assistance from environmental engineers and lawyers when considering the use of these kinds of provisions.

Minimizing Liability During Highway Construction (Stage Four)

No matter how extensive a field investigation, the possibility exists that hazardous wastes on a site will go undetected until excavation is initiated. If buried containers or raw waste is uncovered—or even suspected—during construction, construction should be stopped at once and measures taken to protect susceptible, nearby wetlands or ground-water sources. Thorough records will also need to be kept for use in subsequent litigation. It may be desirable to establish specific procedures for dealing with hazardous waste sites unexpectedly unearthed during construction.

Establish Hazardous Waste Procedures for Construction Contractors (Recommended Procedure)

To guard against undesirable liability, the highway agency can establish special procedures to be followed by its construction contractors should they encounter unknown hazardous wastes. These procedures should require that all work be stopped immediately; the area secured; and workers and the general public not be allowed to enter the area. Special provisions specifying these procedures should be included in the construction contracts for all projects where excavation may uncover undetected hazardous wastes.

It is essential that the suspected hazardous substances be left in place until the chemicals have been identified. Once contaminated soil or debris has been removed from the ground and leaves the site, it is considered a hazardous waste (if the concentration exceeds regulatory levels). In such cases, the construction company becomes a hazardous waste generator, and the highway agency becomes subject to the provisions of RCRA. If the waste is left in place, however, disposal may not be necessary until responsibility for the waste has been resolved.

At a minimum, the construction contract should be as clear as possible in describing: (1) the conditions under which the contractor is likely to suspect hazardous wastes and be allowed to discontinue work; (2) who is to be responsible for identifying the type and quantity of the material uncovered, and for removing it; (3) the need for work change orders; and (4) how the contractor is to be compensated for subsequent delays.

Construction contract provisions dealing with hazardous wastes are being employed by a number of highway agencies, including the Alabama Highway Department, California Department of Transportation, North Carolina Department of Transportation, Ohio Department of Transportation, and South Carolina Department of Highways and Public Transportation. Table 6 contains sample contract provisions used in South Carolina and California. The same precautions required of contractors should be required of agency staff involved in soil boring and other potentially hazardous site activities.

It should be noted that other provisions may be requested of the highway agency by the construction contractor. Many construction firms are becoming increasingly aware of the possibility of uncovering hazardous wastes during construction and are requesting that the following provisions be made in their contracts:

Table 6. Sample construction contract provisions concerning hazardous wastes.

South Carolina Department of Highways and Public Transportation

If the contractor encounters or exposes during construction any abnormal condition which may indicate the presence of a hazardous and/or toxic waste, work in this area shall be immediately discontinued and the Engineer shall be notified.

Abnormal conditions shall include, but shall not be limited to, the following: presence of barrels; discolored earth, metal, wood, etc.; visible fumes; obnoxious or unusual odors; excessively hot earth; smoke; or any other condition which appears abnormal that could be a possible indicator of hazardous and/or toxic waste. The conditions shall be treated with extraordinary caution.

The Contractor's operation shall not resume until so directed by the Engineer.

Disposition of the hazardous and/or toxic waste shall be made in accordance with the requirements and regulations of the Department of Health and Environmental Control. Where the Contractor performs necessary work required to dispose of these materials, payment will be made at the contract unit price for items applicable to such work, or payment shall be made in accordance with Subsection 104.04 or 109.04 of the Standard Specifications. Should the disposition of waste material require special procedures by certified personnel, the Department will make arrangements with qualified persons to dispose of the material.

California Department of Transportation

If the Contractor encounters material in excavation which he has reason to believe may be hazardous waste, as defined by Section 25117 of the Health and Safety Code, he shall immediately notify the Engineer in writing. Excavation in the immediate area of the suspected hazardous material shall be suspended until the Engineer authorizes it to resume.

If such suspension delays the current controlling operation, the Contractor will be granted an extension of time as provided in Section 8-1.07, "Liquidated Damages," of the Standard Specifications. If such suspension delays the current controlling operation more than two working days, the delay will be considered a right-of-way delay and the Contractor will be compensated for such delay as provided in Section 8-1.09, "Right-of-Way Delay," of the Standard Specifications.

The Department reserves the right to use other forces for exploratory work to identify and determine the extent of such material and for removing hazardous materials from such areas.

- Increases in the price of the construction contract to cover costs of increased health and safety requirements, and future worker lawsuits.
- Increases in the price of the construction contract to include the cost of insurance to cover the above costs. Most insurance companies are not issuing policies that cover payment of cleanup costs if hazardous wastes are encountered during "typical" construction. However, it may be possible to negotiate some type of insurance for this contingency. Whether the cost of such insurance would be worth its benefits will depend on the coverage provided and the situation.
- Additional compensation if hazardous wastes are found and the construction firm's personnel are called as witnesses in future litigation or for negotiations. Because recovery of the response costs will be sought in such cases, the contractor may want the contract to indicate that the cost of being an expert or negotiator is not covered under the initial contract. If contractor personnel are to be available as participants in cost recovery negotiations, their compensation rates should probably be based on the prevailing hourly rate at the time of the testimony or other work. If inclusion of a cost figure in the original contract is insisted upon, it should include a "not to exceed number of hours." Also, it should establish a fixed time period for providing these services. If the period expires, the price would be renegotiated.
- Full or partial indemnification from the highway agency, holding the contractor harmless from any or some portion of the increased costs resulting from the presence of chemicals, including the costs of lawsuits by workers, the government, or local residents.
- Provisions specifying who is, in fact, the generator, transporter, and disposer of any hazardous wastes that are found.
- Provisions, where justified and otherwise appropriate, for the costs of worker safety monitoring, e.g., biomonitoring, to provide information that could be used to defend a worker toxic tort lawsuit.

Seek the advice of legal counsel when confronted with requests from highway construction contractors for provision of these kinds. In most cases, a highway construction contractor—unfamiliar with the legal and technical problems posed by hazardous waste—should not be given the responsibility of handling a suspected or confirmed hazardous waste problem. Samples of the unidentified substances will need to be collected and analyzed at certified laboratories. Highway construction crews are not typically trained in the appropriate procedures. They will also be unfamiliar with their legal responsibilities, safety procedures, and cleanup techniques. The agency should seek the services of a contractor specializing in hazardous waste site assessments and remediation whenever wastes are discovered during construction. (Section 3 of Chapter 3, "Securing Hazardous Waste Contractor Assistance," provides guidance on how to identify, evaluate and select contractors for this work.)

To avoid excessive construction delays, it may be possible for construction to proceed on other segments of the project. However, if construction must continue at the site—e.g., to prevent the collapse of a ditch or some other problem—the use of appropriate protective equipment by construction workers at the site should be required. All workers involved with hazardous waste, including construction workers, must comply with the OSHA Interim Final Standards to Protect Workers in Hazardous Waste Operations, 51 Fed. Reg. 45, 654 (December 19, 1986). Failure to use protective equipment increases the risk that at some later time workers will sue the construction company and the highway agency for exposure to the chemicals.

Establish Notification Procedures (Recommended Procedure)

The liability faced by a highway agency and its construction contractor can also be reduced by establishing procedures specifying who is to notify whom in the event of a waste discovery during construction. The National Contingency Plan, 40 C.F.R. 300, provides that any person in charge of a vessel or facility generating, storing, disposing, or transporting hazardous substances must immediately notify the National Response Center (NRC) upon receiving knowledge of a hazardous release if the release is above the threshold for reportable quantities as defined by EPA regulations set forth in 40 C.F.R. 302. This means that any discovery of hazardous substances on a property by agency employees (or contractors) must be reported to the NRC if the release constitutes a "reportable quantity." The NRC can be reached at 1-800-424-8802 to satisfy these federal reporting requirements. This reporting requirement is triggered whenever the highway agency itself is the source of a reportable release, or it detects contamination from a user of its property or abutting property.

Pursuant to CERCLA § 102(a), EPA is in the process of promulgating regulations establishing thresholds for reportable quantities for the release of hazardous substances. Reportable quantities for "extremely hazardous substances" have been established, and are listed at 40 C.F.R. 355. Reportable quantities for hazardous substances designated under CERCLA § 101(14) and the Clean Water Act § 311(b)(2)(A) are listed at 40 C.F.R. 302. Under CERCLA's reporting requirements, releases of hazardous substances for which reportable quantities have not yet been established must be reported to the NRC if they are one pound or more.

Most states have similar reporting requirements and toll-free telephone numbers. Notification triggers activation of state and local contingency plans, which contain procedures that vary from state to state. In general, state requirements usually involve notification of the state environmental agency's emergency response division, and coordination of such local authorities as the police and fire departments and local board of health. Agency personnel should be familiar with the federal and state lists of hazardous substances, federal and state thresholds for reportable quantities, and which federal, state and local authorities must be notified.

To "codify" the above notification procedures, it may be useful to develop a Construction Hazardous Waste Contingency Plan. Figure 5 contains the Construction Hazardous Waste Contingency Plan in use by the District Offices of the California Department of Transportation. It identifies not only appropriate state and other government agencies to contact, but also which staff within the Department should be notified in the event of an unexpected discovery.

Minimizing Liability During Property Management (Stage Five)

Require Hazardous Waste Audits of All Excess Property (Recommended Procedure)

For the Interstate Highway System, Congress made available

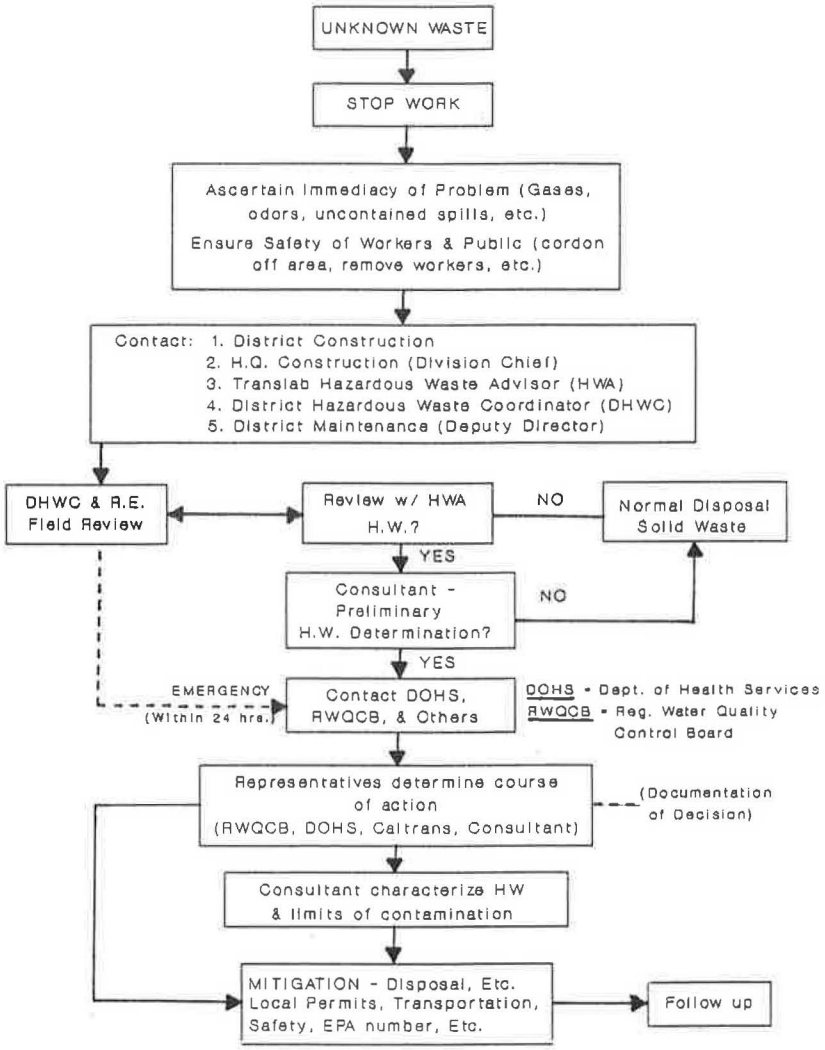

Figure 5. Construction hazardous waste contingency plan—California Department of Transportation.

to states the legal resources of the Federal Government to acquire early possession of right-of-way. A federal revolving fund permitted the acquisition of rights-of-way for up to 10 years in advance of construction. Similar state funding programs were established for advanced acquisition. Since acquisition, this "excess property" may have laid vacant, or may have been leased by the agency to others for various activities.

In the face of increasing public controversy, and more stringent environmental requirements, many of the highway projects for which advanced right-of-way purchase was made are being eliminated from state highway plans and the excess property made available for sale.

To prevent the sale of contaminated land, a preliminary or a detailed site investigation, or both, should be required of all excess property managed by the agency where there is uncertainty surrounding the land's prior use or the activities being conducted on neighboring property. Undertaking a hazardous waste "audit" prior to sale of excess property provides DOT management with the assurance that the land will not be a source of liability in the future. It also provides a defense against future accusations by an owner that the agency was the source of contamination subsequently found on the property. If located in a state with an "ECRA-type" statute, the audit may provide the agency with the means to certify that it is in compliance with these real estate transaction requirements. By identifying the need for any remedial action, the results of such an audit can be used by the agency to estimate future costs and spending plans. By knowing about contamination before the sale of its property, the agency also has the opportunity to more positively influence public reaction than it would otherwise.

Negotiate Protective Leases (Recommended Procedure)

When a highway agency leases land for various purposes, including user services like gasoline stations, it will be liable for the contamination caused by its lessee. There are several steps a highway agency should take to minimize its liability under lease arrangements. Specifically:

1. *Screen prospective tenants and their activities.* An agency should prevent environmentally irresponsible tenants from occupying agency-owned property. Just as landlords screen tenants' credit references to make sure they can pay the rent, so

too should a highway agency screen tenants to ensure that they will be environmentally responsible during occupancy of the property. To screen prospective tenants, an agency should take the following two steps: (a) require prospective tenants to complete a questionnaire describing their type of business and proposed hazardous waste and hazardous materials handling practices; and (b) check each prospective tenant's environmental reputation and compliance record.

2. *Include indemnification provisions in the lease agreement.* Include language in the lease agreement that will provide maximum protection to the agency, as the property owner, from inheriting responsibility for environmental damages. Although the highway agency will not be released from CERCLA liability, it can incorporate an indemnification clause in a lease which reflects the quality of the site at the time the lease begins and holds the tenants responsible for all contamination cleanup costs that might be incurred subsequently.

3. *Require the tenant to obtain private insurance.* As part of the lease agreement, a highway agency may also require its tenants to obtain private insurance or self-insurance sufficient to cover any potential costs of cleanup. Such a provision will ensure that the highway agency does not bear the burden of cleanup because the costs exceed the resources of the lessee as a responsible party.

4. *Monitor the tenant's activities during occupancy.* Proper hazardous materials and waste handling, storage, and disposal is expensive. A tenant may be encouraged to cut corners to reduce these costs. An agency should monitor the tenant's activities regularly to assure its commitment to maintaining a "clean" site. To do this, an agency should conduct an on-site environmental risk assessment as soon as the tenant occupies the site. This baseline environmental conditions report can then serve as the basis for updating the lease agreement at a later date. In addition, the agency should take the following steps.

Periodically reassess the tenant's environmental commitment by performing spot inspections—provide for such spot inspections in the lease agreement. Request that a copy of any environmental agency inspection reports be sent to the highway agency either by the tenant or the regulatory agency. Require notification before underground tanks and sumps are installed or removed. Require prior approval for substantial changes in the amounts or types of hazardous chemicals manufactured, used, or stored by the tenant. Require notification before tenants embark on any subsurface investigation for contamination.

5. *Evaluate the site thoroughly before terminating the lease.* Tenants do not always properly abandon their underground sumps and tanks when they vacate a property. Tenants have also been known to dump remaining chemicals down the sewer or leave them on the property when they prepare to leave. Prevent a vacating tenant from leaving unwanted contamination by reviewing with the tenant the agency's expectations for hazardous waste removal from the site upon termination of the lease; by requesting proof that drums, tanks, sumps, and other stored hazardous materials have been properly removed and disposed of; and by inspecting the property after the tenant has vacated for signs of contamination.

Minimizing Risks Associated with Site Remediation Activities

As a responsible party, a highway agency may have to assume responsibility for cleaning up a site. While every effort should be made to identify and involve other potentially responsible parties in the remediation process, the highway agency—as a "deep pocket"—may find itself in a leadership role. When placed in this position, the agency should respond as an "active" participant, willing to pay for its fair share of the cleanup costs.

As a participant in a site remediation process, the agency will be responsible for evaluating alternative remedial actions or techniques, developing a remedial design package (detailed plans and specifications for conducting the cleanup), and performing actual remediation (including post-closure monitoring, if needed). Several risks associated with these activities must be addressed by the highway agency when exercising this responsibility. Table 7 summarizes these risks and identifies ways that they can be minimized.

Through pre-acquisition site assessment, most hazardous waste sites can hopefully be avoided. The infrequency of discovery, coupled with the need for highly specialized services, will usually make it more cost effective to retain private contractors and consultants trained in this field to perform the needed site remediation activities. Moreover, the safe conduct of many of these activities requires extensive experience and skill, usually reserved for hazardous waste contractors and consultants. Nevertheless, there may be circumstances under which the highway agency finds it beneficial to commit the resources to develop in-house hazardous waste site remediation expertise.

Regardless of who cleans up the site, steps must be taken to minimize the liabilities and risks to those involved. Only those who can demonstrate an ability to satisfy the following criteria should be allowed to participate in this potentially dangerous activity:

1. *They should have an up-to-date awareness of all applicable federal and state regulations, and be familiar with the hazardous waste site remediation process (federal and state).* The site remediation process is a complex one that wrestles with the very difficult issue of: "How clean is clean?". Federal laws do not contain specific cleanup criteria. Such criteria are commonly a combination of indirect standards, surrogate standards, regulatory perceptions, and hard negotiation. Each site is a mutually exclusive event with its own negotiated cleanup standard that will depend on a number of factors, such as the nature of the contaminants and of the site. There is no set of standards that is universally applicable. Further, there is no single recognized process for applying available standards. For many contaminants, information about health and environmental risks is extremely limited. In most cases, quantitative risk assessments cannot be performed or are prohibitively expensive and time-consuming. At a site, some contaminants may be regulated by one law, while others will be regulated by another. (For example, PCBs are regulated by TSCA but not by RCRA.) Standards may vary considerably, depending on a number of factors.

Two sources of standards are *best professional judgment* and *pre-existing standards.* Best professional judgment may consist of the opinion of one or more experienced professionals as to the appropriate level of cleanup for a site. Pre-existing standards may be either design or performance standards (for example, meeting discharge limits for a contaminant under the National Pollution Discharge Elimination System (NPDES) of the Federal Water Pollution Control Act (WPCA)). Standards may be chosen through judicial or administrative process, through voluntary agreement, or through governmental (state, local, or federal) action.

Table 7. Ways to minimize risks associated with site remediation.

SITE ACTIVITY	TYPE OF RISK	WAYS TO MINIMIZE RISK
ALTERNATIVES ANALYSIS & SELECTION	• Selected remediation techniques become inappropriate due to: (a) Changes in applicable regulation (regulations are developing and, often, becoming more stringent; basic liability issues are still being argued in court). (b) Advances in cleanup technologies (promising techniques are still being developed and tested; basic science in certain areas presents unanswered questions).	• Stay abreast of applicable hazardous waste regulations and state-of-the-art remediation technologies. Opt for waste destruction and detoxification over off-site disposal; on or off-site treatment over off-site disposal.
REMEDY DESIGN	• Complexity of the problem requires the development of an unproven design concept.	• Stay abreast of state-of-the-art remediation technologies and design concepts.
	• Proposed design does not work properly, or is not implemented properly (due to synergistic or paradoxical effects with chemical combinations temperature changes, etc.).	• Require use of proven design concepts and technologies whenever possible.
TREATMENT	• Workers at the site become exposed to hazardous chemicals during the cleanup operation.	• Employ personnel trained in OSHA worker protection requirements. • Develop Site Safety Plan that delineates worker responsibilities, protective clothing requirements, site control and monitoring requirements.
	• Visitors to the site (e.g., members of the press, DOT staff involved in contract monitoring activities) become exposed to the hazardous substances present.	• Employ personnel trained in OSHA worker protection requirements. • Develop Site Safety Plan that prohibits visitors from locations on or near areas where releases of materials may occur.
	• Area residents or public-at-large become exposed to hazardous chemicals as the result of releases during cleanup operations.	• Employ personnel trained in OSHA worker protection requirements. • Develop a Site Safety Plan that describes the risk associated with each operation to be performed, standard operating procedures, container handling procedures, and contingency plans in the event of an unexpected release.
	• Cleanup is delayed due to: (a) Bureaucratic requirements (new technologies go through lengthy review and permitting processes). (b) Emergencies (spills, explosions, fires). (c) Adverse weather conditions (hot weather exacerbates heat stress; wind conditions dispense contaminants and halt work).	• Develop a Site Safety Plan that describes the risk associated with each operation to be performed, standard operating procedures under different weather conditions, contingency plan, etc.
	• Selected remedies may be ineffective, resulting in further exposure of the public to hazards present at the site (equipment vendors may pressure agencies to use new and unproven technologies).	• Perform post-closure monitoring to detect technology failure as soon as possible. Take further action to remedy the problem.

The practical aspects of hazardous waste cleanup must also address what is realistically feasible. For example, restoring a contaminated aquifer to a pristine state may be technically possible, but not economically practical or necessary for resource protection. Cleanup of a portion of the site may be one solution. In some cases, a decision not to clean up the site may be appropriate.

In summary, several factors must be considered when determining an appropriate level of cleanup. These include:

- *Legal and regulatory requirements.* The recently passed Superfund amendments (SARA) establish permanent remediation as the goal of hazardous waste cleanups. Cleanup standards under CERCLA require that preference be given to the choice of a remedial action that will permanently reduce the toxicity, mobility, or volume of hazardous substances, and to remedies utilizing alternative treatment technologies. EPA is directed to select remedial actions that will satisfy "applicable, relevant and appropriate" ARARs set forth under other federal or more stringent state standards. EPA is presently establishing treatment standards for several wastes that are banned from land disposal. These include dioxin, certain solvents, and liquid wastes containing certain metals, cyanides, PCBs, and halogenated organic compounds. These standards are currently being phased in, and will be completed by 1990. While waivers from these standards can be obtained, states can object to the selection of remedial actions that do not attain federal or state standards.

State law varies with respect to cleanup standards. One state is presently promulgating regulations for contaminated soil and debris due to become effective in November 1988. Other states, such as California, are developing applied action levels based upon research on health effects and risk to determine what levels of contaminants are acceptable in site mitigation.

- *Site usage.* Both usage by DOT and usage by others should be considered. For example, treatment of sediment under a bridge may require one level of cleanup to prevent corrosion of supports and another level to enhance environmental conditions for aquatic life.
- *Site location.* A site in a congested urban or suburban area may require a more intensive level of cleanup than one in an isolated rural area.

There are no prescribed ways to handle these difficult issues. An experienced contractor or consultant, however, may be of assistance in providing expert advice on how to negotiate on these important matters.

2. *They should be familiar with the development, applicability, and effectiveness of state-of-the-art remediation techniques.* The remediation techniques selected for a particular waste problem should not only satisfy current regulatory requirements, but should also be appropriate and effective. The individuals or firms involved in site remediation should have a track record in dealing with the specific kinds of hazardous waste problems of concern (e.g., leaking underground storage tanks). See section 3, "Securing Contractor Assistance." for guidance on how to identify, evaluate, and select remediation contractors. Also see Chapter 4, section 3, "Hazardous Waste Remediation Technologies," for information on the applicability of different technologies to different hazardous waste situations.

3. *They should be experienced in the development and employment of Site Safety Plans as required under the NCP and recent OSHA Regulation* (29 C.F.R. 1910.120). As described earlier, all employers involved in any aspect of hazardous waste site management, including remediation, must develop a Site Safety Plan. This plan establishes the policies and procedures to protect workers and the public from the potential hazards present at a site. A summary of the items that must be covered in a Site Safety Plan is provided in Chapter 4, section 2, "Detailed Hazardous Waste Site Investigation." Highway officials should ensure that selected remediation contractors or assigned agency staff are familiar with these requirements and procedures. In addition, the agency should provide for frequent inspections of site conditions, facilities, equipment, and activities to ensure that the Site Safety Plan is adequate and being followed.

> ***Note:*** **On August 5, 1988, the Federal Highway Administration (FHWA) issued its guidance on how state agencies should respond to the threat of hazardous waste sites. As stated in its introduction, the intent of this document, "Interim Guidance—Hazardous Waste Sites," is to "provide a framework around which effective processes for dealing with hazardous substances/wastes can be built." Development of the guidance that appears in the FHWA guidance document occurred during, and in close coordination with, this research project. State highway officials are urged to consult FHWA guidance before acting on the advice in this section and developing operational plans tailored to their problems and needs.**

2. STAFFING AND ORGANIZING TO MEET THE CHALLENGES OF HAZARDOUS WASTE SITES

To take action on the recommendations presented in section 1, highway agency management must decide who will be given the authority to do what. This section examines several means of organizing and staffing to maximize agency hazardous waste liability. Each is discussed briefly in terms of its advantages and disadvantages, its resource needs, and the type of project and site conditions for which it is best suited. In general, there is no "best" way for a highway agency to deal with the problem of hazardous waste sites. Different uses of personnel and organizational structures will be appropriate for different situations. A highway agency must assess its own resources, the likelihood of encountering hazardous waste situations, and the availability of assistance from outside sources (consultants, other agencies) when determining the specific mix of personnel sources and organizational approach to take. Examples are provided to illustrate the different approaches being taken by highway agencies across the country.

Management Objectives

While the approaches may differ, several important objectives should be kept in mind when evaluating alternative ways of assigning hazardous waste responsibilities within the agency. These are interagency coordination, the relationship of the highway district offices with central administration, and interdisciplinary coordination.

Interagency Coordination

Cooperation and communication with federal and state reg-

ulatory agencies is essential in arriving at timely and cost-effective solutions to hazardous waste site problems. Every hazardous waste management plan requires a mechanism for interagency coordination. Most states have received authority from EPA to manage their own hazardous waste programs; therefore, a highway agency should establish a line of communication with the designated agency and the EPA regional office.

Relationship of Highway District Offices with Central Administration

Most state highway and transportation departments have highway districts or field offices. Most of an agency's design, construction, and maintenance is typically accomplished through these offices. District personnel also have the greatest exposure to the public. Therefore, an agency must be sensitive to the role of its district offices and the flow of information and data between districts and central administration.

Interdisciplinary Coordination

Departments within a highway agency that are responsible for corridor or location planning, facility design, right-of-way appraisal and acquisition, legal review, and construction all play important roles in minimizing agency hazardous waste liability. Agency management is encouraged to see that each department modifies its policies and procedures in some or all of the ways suggested in the preceding section. However, sufficient coordination must also exist between the departments. Planners and engineers have an obligation to alert designers of potential right-of-way problems at the earliest possible stage of project development, thereby providing sufficient time to explore design alternatives. If design alternatives will not avoid or solve the problem, the right-of-way department needs to be informed at once. More time and money can then be provided for the right-of-way phase. Any recommended staffing and organizational changes must also facilitate the coordination and communication between departments and functional areas in the agency.

Staffing Options

In general, hazardous waste assistance can come from: (1) in-house hazardous waste specialists; (2) other agencies and organizations (e.g., state environmental agency, Attorney General, local universities); or (3) hazardous waste contractors and consultants. These options are discussed in more detail below.

In-House Hazardous Waste Specialists

It may be desirable to establish an in-house core staff to provide basic hazardous waste capabilities. This core staff would work with the appropriate agency departments to ensure that hazardous waste site concerns are being systematically considered during day-to-day activities. The staff personnel do not need to be trained to perform specialized site investigations or remediation. They could, however, assist in the research performed as part of a preliminary site evaluation and in agency training. Agency training is a particularly important responsibility. Environmental staff, surveyors, drillers, right-of-way personnel, and construction management personnel must all be able to recognize potential hazardous waste sites.

Because of the broad responsibilities given in-house specialists, they should be in key positions to facilitate information flow, coordination, and staff integration. Depending on an agency's organizational structure and resources, hazardous waste specialists can be situated in either: (1) the agency's central office, where they can provide assistance to all field offices and departments; or (2) in individual district offices where they can assist in all of the departments under district supervision.

For example, in Minnesota, a Hazardous Waste Coordinator position was established in the Minnesota Department of Transportation to coordinate Department policy on hazardous waste. The Coordinator develops training programs, represents the Department on interagency teams, and assists in developing solutions to project-specific problems with hazardous wastes. In Florida, an Environmental Specialist in the District Bureau of Environment monitors projects from the preliminary design and engineering (PD&E) phase through acquisition. Among other duties, this person conducts off-site hazardous waste-related research and provides for right-of-way contamination certification. Similarly, in Michigan, an environmental scientist has been hired for each of the district offices to conduct right-of-way evaluations for hazardous wastes.

Use of Personnel from Other Agencies

A highway agency may also look to other state, regional, county, or local agencies for assistance. Of particular importance will be the EPA regional office and the state environmental agency. These agencies will be able to provide lists of known hazardous waste sites that should be avoided. They may also provide personnel to perform selected site assessment activities.

Opportunities for resource-sharing may also exist. In several states, arrangements are being considered whereby DOT boring and heavy construction equipment is made available to the state environmental agency for site assessment and underground storage tank removal operations. In return, the DOT has access to the hazardous waste detection equipment and laboratory analysis services of the environmental agency. In considering resource-sharing, the agency must assess the extent to which the desired expertise will be available when needed, and how reliable other agencies will be in lending staff or devoting time to the agency's waste problems. Formal agreements are desirable in almost all cases, while reimbursement for services may be desirable in others.

In Wisconsin, a cooperative agreement exists between the Wisconsin Department of Transportation (DOT) and the Department of Natural Resources (DNR), whereby DOT agrees to provide DNR with copies of notices of intention to make changes in the state highway system. DNR, in turn, agrees to review the plans and make recommendations concerning the proposed location, design, construction, or maintenance procedures.

Use of Hazardous Waste Contractors and Consultants

Hazardous waste contractors will be an especially important

resource to many highway agencies. Highway officials may find it cost effective to hire experts whenever the agency becomes involved in complex site assessment activities. These contractors and consultants are trained in health and site safety procedures, knowledgeable of the signs and warnings of hazardous wastes, and familiar with the latest techniques and technologies used in the field. Of course, care must be taken to hire qualified contractors who not only have requisite skills, but also will be available when needed.

Section 3, "Securing Hazardous Waste Contractor Assistance," provides guidance on how an agency might administratively solicit contractor assistance, evaluate proposals for services, and develop well-drawn contract documents.

When relying on outside experts, procedures must be in place to ensure coordination and regular communication between the agency and the contractors. This is essential to the timely and successful completion of the contracted duties. To facilitate coordination and information flow, it is usually necessary to hire or assign in-house staff to oversee and evaluate the contracted work.

Organizational Structure Options

The foregoing personnel can, in turn, be organized as part of: (1) an existing unit or department of the highway agency, (2) a new specialty unit or department; (3) an interdisciplinary in-house task force; or (4) an interdisciplinary consultant team.

Integration into Existing Highway Agency Unit

The least disruptive way to integrate in-house hazardous waste specialists into the agency decision-making process is to add them to the staff of existing units. Seek to place them in positions that are close to the source of the hazardous waste problems being encountered and will cause the least internal conflict. Planning and environmental units of the agency, whether in the district offices or central office, are logical locations for such staff additions.

Establishment of New Specialty Unit

It may be desirable to establish a new agency unit for the specific purpose of providing hazardous waste services. The Iowa Department of Transportation is considering establishing a distinct Office of Hazardous Waste Remediation. While this may be a practical option in some states, take special care to ensure that the new unit does not polarize the other offices it is designed to be helping.

In-House Interdisciplinary Task Force

Highway agencies commonly use an in-house interdisciplinary task force to deal with hazardous waste problems. In-house task forces have several advantages. First, because they involve in-house staff, task forces can quickly and accurately characterize the kinds of hazardous waste problems that are most frequent, and should therefore be of highest priority to the agency. Second, they can become operational quickly because they do not involve immediate capital outlays for staff. Third, such task forces offer flexibility in their membership. As the priorities of the agency change, so too can membership and involvement of agency staff on the task force. In-house task forces are also convenient mechanisms for involving representatives of other state or federal agencies (e.g., Attorney General, state environmental agency).

Several states rely on task forces to initiate work on agency hazardous waste issues. In Minnesota, for example, the Minnesota Department of Transportation established an internal Hazardous Waste Task Force in 1985 to provide its District Offices with guidance on hazardous waste issues they were confronting. At its inception, task force membership consisted of representatives from the following departments: employee safety, district safety, maintenance, construction, motor carrier safety and compliance, and environmental services. Representatives from preliminary design, right-of-way and the state Attorney General's Office were recently added to the task force. Since its creation 2½ years ago, this task force has been responsible for: (1) developing a Spill Response Plan; (2) developing a hazardous awareness training presentation for agency staff; (3) designating hazardous waste specialists in each District office; (4) training drill teams and soil boring crews on hazardous waste recognition and safety precautions; (5) developing procedures for handling the cleanup of illegally dumped wastes on agency right-of-way; (6) developing policy and procedures to be used in route and facility location planning; and (7) developing a policy towards the leasing agency property to potential hazardous waste generators.

In California, a specialty task force was created in the Department of Transportation to identify the procedures that agency staff should follow during environmental, design, right-of-way, and construction activities.

Interdisciplinary Consultant Teams

Whereas the interdisciplinary in-house task force deals best with the development of agency policy and procedures, interdisciplinary consultant teams are most effective in addressing the hazardous waste problems associated with a specific site or project. In this type of arrangement, one or more consultants are hired by the agency, under the supervision and control of in-house staff.

Because of the complexity of hazardous waste management and the number of unknowns that may exist at a given site, a team of hazardous waste consultants may be most suitable for monitoring and responding to situations that may develop. The use of specialized services, when carefully managed by agency staff, will reduce the possibility of costly errors and unnecessary duplication of effort, while increasing the probability of making the best decision about handling, treatment, or disposal of the waste.

The use of interdisciplinary consultant teams may be appropriate in many circumstances, but is, perhaps, most clearly illustrated in the case where hazardous waste management and right-of-way construction must occur simultaneously. This situation was faced by the Pennsylvania Department of Transportation.

The Pennsylvania DOT is currently constructing a portion of I-476 (the Blue Route) across the Mayer Landfill. This landfill, perhaps not atypical of many landfills, accepted virtually any item—including cars, refrigerators, unusable building materials, waste drums, and so forth. While hazardous wastes were

known to be present, the wastes were of unknown kinds, they were in unknown quantities, and they were located at unknown depths. EPA had studied and rejected the landfill as a potential Superfund site, concluding that the threat to public health from migration of pollutants into ground water was minimal because the landfill was in a rock quarry.

However, when PennDOT bought the landfill as a right-of-way, route construction presented a series of complex problems. To assess what kind of design was possible, a working team was formed consisting of the PennDOT environmental official and other PennDOT personnel, the environmental engineering contractor, and the engineering firm developing the bridge design.

The final design incorporated sinking a minimal number of caissons into the landfill. Developing this alternative was only possible in tandem with an intensive environmental investigation into the characteristics of the waste in the landfill. Further, because even a state-of-the-art study could not predict whether sinking the caissons would encounter unknown and potentially dangerous (e.g., toxic, explosive) wastes, careful strategic planning had to be done beforehand, using the expertise of all participants. This cooperative problem-solving effort will continue throughout the portion of the project that involves construction into the landfill.

3. SECURING HAZARDOUS WASTE CONTRACTOR ASSISTANCE

The practice of contracting for services is not foreign to state highway agencies. Because of work force reductions and the trend towards privatization, agencies use private contractors and consultants for many activities, particularly design and maintenance. Contracting is also used to obtain highly specialized services. Decisions to employ contractors reflect agency budget realities, constraints associated with the state's civil service system, or hiring freezes.

Many state highway agencies will not find it cost effective to employ a full-time staff expert who specializes exclusively in hazardous waste site evaluation, investigation, and remediation. States with minimal highway construction programs will be particularly hard-pressed to justify the cost of training and equipping agency staff to deal with infrequent hazardous waste discoveries. Consequently, contractors and consultants may provide important hazardous waste services in these states.

Which hazardous waste site activities are best left to private contractors? Opinions vary from state to state, and among districts within a single state highway agency. This section examines the contributions that contractors can make and how department of transportation staff can approach the selection of different contract services.

Administrative Options

As described below, there are several administrative options for securing contractor assistance: statewide contracts, informal invitation to bid, and formal request for proposals (competitive bidding). The feasibility of the options will depend on how quickly the agency needs the specialized services and the constraints imposed by state procurement policies and procedures.

Statewide Contracts

Most state environmental agencies are extremely active in investigating and remediating uncontrolled hazardous waste sites. Many of these agencies have already screened and evaluated local hazardous waste contractors on their abilities to provide certain services, including: conducting preliminary hazardous waste evaluations, performing detailed site investigations, preparing remedial design plans, preparing site safety plans, and conducting actual cleanup operations.

Before proceeding on its own, the highway agency should check with its "sister" environmental agency to determine if: (1) lists of approved hazardous waste contractors exist; (2) particular types of contractors have already been brought under contract; and (3) the highway agency can access needed services through this existing arrangement. Many response or cleanup tasks involving small sites and contained wastes (e.g., drums) can usually be handled through a statewide contract already established and operational with the state environmental agency.

If such an arrangement is not available, the highway agency itself might consider letting a statewide contract for hazardous waste services. Contractor assistance could be solicited on an as-needed basis for preliminary site evaluations; field sampling and analysis; on-site monitoring; site safety plans; and actual cleanup.

Having a preselected contractor "on-board" to provide "immediate" services may minimize the impact on a project's schedule that the unexpected discovery of hazardous wastes might otherwise have. While this administrative option will be appropriate for certain "standard" services, such as record reviews and underground storage tank removals, it will generally not suffice for complex situations. It may also not be allowable under certain states' contract procurement regulations.

Informal Invitation to Bid

Some states allow agencies to procure contractor services up to a specified ceiling amount without having to complete formal bidding procedures. Where this is allowed, prospective contractors are invited to submit proposals and bids in response to an informal request from the agency. Evaluation and selection are made in accordance with the agency's own criteria and timetable. Contractor services can usually be obtained within 1 to 2 months under this arrangement. The high cost of hazardous waste services, however, when coupled with low bid ceilings, precludes the use of this arrangement for many site activities.

Formal Request for Proposals and Competitive Bidding

For complex hazardous waste problems, Requests for Proposals (RFP) will be necessary, if not required by state procurement procedures. Under this procedure, a description of the specific hazardous waste problem is prepared by the highway agency, and qualified contractors are invited to prepare a proposal on how they would provide the needed services. Cost estimates are also prepared and submitted. Specific requirements concerning such items as notification of the availability of the RFP; attendance at pre-proposal meetings; the selection process and timetable; and pre-award audit requirements make the RFP

process an expensive and time-consuming one for the contractor and the highway agency alike. It usually takes 4 to 6 months to secure contractor services under RFP procedures.

Criteria for Contractor Selection and Evaluation

To identify and evaluate prospective contractors, the agency should, to the extent possible, develop a Request for Qualifications (RFQ) tailored to its needs. The criteria for contractor selection and evaluation described below can be used in developing the RFQ. Because of the technical nature of the work involved, it is advisable to involve a member of the state environmental agency and other technical experts in the evaluation process.

The names of reputable hazardous waste contractors can usually be obtained from the EPA regional office or from the state environmental agency. There are also directories available, listing the products and services available from different companies. One of these directories, the *Hazardous Materials Control Directory,* is produced annually by the Hazardous Materials Control Research Institute in Silver Spring, Maryland. It contains the names, addresses, and specialty areas of about 5,000 companies involved in various aspects of hazardous waste management. Companies are listed alphabetically, geographically, and by areas of specialty. By consulting local environmental agencies and available directories, a fairly comprehensive list of contractors offering specific services can be developed.

To evaluate and select from among the available companies, a highway agency should ask every interested contractor/consultant to provide it with information sufficient to answer the following questions:

1. *Corporate background.* How long has the firm been in business? What types of hazardous waste and other services can the firm provide? Does the firm have sufficiently trained staff in-house, or will it rely on subcontracts or other arrangements to provide qualified personnel? Does the firm have a reputation in the community and the profession for quality work and integrity? (Check the firm's credentials with client references provided by the firm, the EPA, and the state environmental agency. Also, visit the firm's office to get a feel for its level of professionalism.) Has the contractor successfully completed other, similar projects to the satisfaction of the client? (Review previous site assessments or similar studies performed by the firm.) How financially secure is the firm? Does the contractor have insurance or other financial capabilities to cover claims that might arise from the improper conduct of its duties? Is the contractor financially capable of meeting the contract requirements?

2. *Staff qualifications.* Who will perform the work and what are their qualifications? Is there the proper mix of geologists, hydrogeologists, environmental engineers, and chemists? Interview key personnel of the firm and the personnel most likely to be responsible for performing the work. (These people should be evaluated for their understanding of the issues involved, their apparent technical competence, and their ability to clearly articulate their thoughts.) Has the assigned staff completed the OSHA training requirements? (The selected contractor should not only be familiar with these regulations, but should have an aggressive program in place for compliance. The highway agency should receive assurance to this effect.) Do the contractor's key personnel—particularly the assigned staff—display a good understanding of the legal and regulatory issues involved in hazardous waste management, including its own as well as the agency's responsibilities regarding notification and liability? What assurances can be given that the assigned staff will be available, and can be quickly mobilized? Can the assigned staff demonstrate an ability to prepare a report that presents technical data in a manner understandable by nontechnical people?

Because different hazardous waste site activities require different skills and expertise, the following additional information should be requested when seeking site investigation, remedial design, or remediation services:

1. *Preliminary site evaluation.* What would the firm's work plan for a "typical" site evaluation consist of? Will special detection techniques be used? If so, when and at what cost? (See Chapter 4, section 1, "Preliminary Hazardous Waste Site Evaluation," for a description of the tasks typically involved in this kind of investigative activity. Use the information presented there to evaluate the reasonableness and comprehensiveness of the contractor's proposal.)

2. *Detailed site investigation.* What would the firm's work plan for a "typical" site investigation consist of? What type of field surveys would be used? What kind of sampling plan would be recommended? What will the site safety plan consist of? What standard QA/QC procedures will be employed? What laboratories will be used for sample analyses? (Once again, refer to Chapter 4, section 2, "Detailed Hazardous Waste Site Investigations," for a description of the types of surveys, how to develop a sampling plan, what should be covered in a site safety plan, and what QA/QC procedures should be in place. Use this information to evaluate the contractor's knowledge and experience.)

3. *Remedial design.* What experience can the contractor demonstrate in developing a remedial design package? To evaluate contractor proposals in this area, compare the familiarity shown by the contractor in his proposal with the following checklist of items in a typical remedial design package:

- *Design.* This will typically have at least two phases: preliminary design and final design. More complex projects may have an intermediate design phase. One suggested phasing is: preliminary—at least 30 percent of the design; intermediate—at least 60 percent of the design; prefinal—90 percent; final—100 percent. Phasing and concomitant review are important in remediation projects (especially when road or bridge construction is involved) because new information may necessitate an alteration of design.
- *Plans and specifications.* Drawings and technical specifications must correlate with each other and must accompany each design phase.
- *Legal and regulatory requirements.* The contractor must assure the agency that all applicable federal, state, and local laws and requirements are being met in the design, construction, and operation of cleanup measures. The contractor must also identify the nature, process for filing, and fee schedule for items such as construction and operating permits; monitoring and testing requirements; and variances.
- *Equipment startup and operator training.* All setup and operating procedures for treatment systems must be spec-

ified. This includes any special training for personnel involved in any phase of cleanup.

- *Site health and safety plan.* This plan should meet all applicable regulations, including Occupational Safety and Health Administration (OSHA) requirements, and should be sufficient to protect those on-site and in surrounding communities from safety and health hazards (e.g., exposure to toxic substances).
- *Quality assurance plan.* All aspects of the project must meet described standards of quality. Procedures must be in place to monitor operations and ensure acceptable results. Staff responsibilities for this should also be specified.
- *Additional studies.* Additional studies, such as bench, pilot-scale, and field studies, may need to be made during the course of operations. Provision should be made for this possibility.
- *Operation and maintenance plan.* Many remedial projects require operation and maintenance (O&M) plans. A typical O&M plan includes a description of normal procedures; potential operating problems and solutions; monitoring needs and frequency; safety precautions; equipment and paperwork needs; and annual costs.
- *Cost estimate and schedule.* The total project cost should be estimated, reflecting current prices for labor, material, and equipment, plus a schedule for accomplishing all tasks.

4. *Site remediation.* Is the contractor familiar with the types of control, treatment, and disposal technologies that have been selected for implementation? What will the site safety plan consist of?

As described above, contractors will have to prepare an approved health and safety plan for its workers. If the plans submitted by a firm were used for previous Superfund cleanups and are more stringent than the OSHA Regulations, they should be acceptable. If the plans are less stringent, however, the highway agency should require the contractor to use the OSHA regulations, even where they may not be legally applicable. The agency must weigh the costs of conforming the plans to the most stringent requirements versus the risk of future litigation. A health and safety plan that is less stringent than those previously approved by EPA and others may be cited by workers, former workers, or nearby residents in future lawsuits as evidence of negligence. Thus, the agency's risk of being held liable in such toxic tort litigation is increased.

To provide continuity, a highway agency may want to consider retaining the same engineering firm for all steps of the remediation process. Assuming that the firm is capable and experienced in hazardous waste management, the advantages of using such a "turnkey" service include tighter control over a complex process, less need for administrative coordination, and less "shopping" for a mix of companies by the highway agency. Where using one firm is not possible, the highway agency (and the official in charge) must make sure that the information (reports, drawings, etc.) supplied by each contractor be given to, reviewed, and, where possible, used by the succeeding contractor. If at all possible, one individual (either in the highway agency or in a lead engineering firm) should provide management continuity for the project.

Special Contract Provisions

A written contract will need to be executed with the selected contractor and consultant team. It must delineate as clearly as possible: (1) a description of the services to be performed; (2) a listing of the key personnel responsible for accomplishing the work; (3) the arrangements with subcontractors and consultants; (4) a timetable for completing the work; (5) a provision describing under which jurisdiction the contract terms will be interpreted; (6) a provision governing whether and to what extent the contract obligations can be assigned; (7) a budget, including a statement of the rates and procedures for handling cost overruns; and (8) a description of how payment will be made. Other provisions, in addition to these "standard" ones, should also be negotiated in a hazardous waste contract to protect the interests of the highway agency and shield it from liability.

When contracting for hazardous waste site investigation services (sampling, etc.), the agency should seek to include provisions covering the following items in the contract document:

1. *Right-of-entry.* Specify who is to obtain permission to enter the property. If the highway agency does not own the site, it will have to warrant that all necessary permissions for the contractor to enter the site and conduct subsurface investigations will be obtained.
2. *Subcontractor selection.* Circumstances may arise where it is necessary to hire subcontractors, in addition to those already identified by the prime contractor. The contract should give the highway agency control over the hiring of any additional subcontractors if there is a demonstration of need and due notification from the prime contractor.
3. *Worker protection.* Whenever hazardous substances are known, assumed, or suspected to exist, the contractor should be required to take appropriate precautions to protect the safety and health of the assigned staff, and to comply with all applicable federal and state laws (including staff training in conformance with OSHA worker protection requirements).
4. *Notification.* Upon discovering of suspected hazardous wastes, the contractor should be required to notify appropriate highway agency staff and all required federal and state environmental officials.
5. *Treatment of contaminated samples.* Soil, water, and other samples obtained from the site may be contaminated by hazardous substances. The contractor should be required to employ special precautions in the containment, labeling, transportation, testing, and storage of such samples. These precautions are necessary to ensure the integrity of the samples, to protect those who might come in contact with them, and to prevent their unauthorized removal, use, or disposal. To the extent practicable, the contract should also specify the sample disposal procedures to be used.
6. *Treatment of contaminated equipment.* The contractor should be required to properly decontaminate any equipment that may become contaminated during the site investigation. Similarly, the contractor should be required to properly dispose of any contaminated consumables.
7. *Indemnification.* The contract document should provide indemnification and "hold harmless" clauses between the agency and the contractor covering negligence, gross negligence, and willful misconduct in the contractor's performance. In addition, however, many hazardous waste contractors are now

seeking indemnification from claims that might arise from their activities. Requests for indemnification may be made on several fronts:

- *Indemnification from claims by current property owner.* The discovery of hazardous wastes on the property may reduce the property's value and spur the owner to initiate recovery action against the contractor. The agency may be asked to defend, indemnify, and hold the contractor harmless from any claim or liability for injury or loss of any type arising from the contractor's discovery of unanticipated hazardous wastes on property not owned by the agency. The agency might also be asked to compensate the contractor for any time spent or expenses incurred.
- *Indemnification from claims arising from sampling-related contamination.* There is some risk that sampling may contaminate certain subsurface areas. This might occur, for example, when a boring device moves through a contaminated area into an aquifer, underground stream, or other body not previously contaminated, yet capable of spreading the contamination. Because nothing can be done to prevent such an occurrence, and because sampling is a necessary part of the on-site assessment work, the agency may be asked to defend, indemnify, and hold the contractor harmless for any claim or liability that arises as the result of contamination from sampling. The contractor may also request that the agency pay for any defense-related expenses.
- *Indemnification from claims arising from failure to discover hazardous wastes.* Failure to discover hazardous substances after employing appropriate and agreed-upon sampling techniques does not guarantee that they do not exist on the site. The agency may be asked to defend, indemnify, and hold harmless the contractor from any claims or liability arising from his failure to detect the presence of hazardous wastes through techniques commonly employed for the purpose. Again, the contractor may also seek reimbursement for the costs incurred.

Many states are prohibited from providing indemnification to contractors. Where indemnification is allowed, it should be limited in the following ways: (1) consistent with applicable statute, so as not to include damage from the sole negligence or willful misconduct of the contractor; (2) to the extent funds are appropriated and allocated; (3) to a stated amount, with a "deductible" in the amount of existing insurance; and (4) to a specific risk, i.e., arising from the handling of hazardous materials. When confronted with indemnification requests from a contractor, seek the advice of legal counsel familiar with state contract law.

Contracts for waste disposal, transportation, and treatment services are usually written by the companies providing the specialized service. Because they contain "boiler plate" provisions slanted in their favor, these contracts should be scrutinized by agency legal counsel to ensure that they meet the agency's needs as well as those of the contracted firm. To protect the agency's interests, provisions covering the following items should be included in the contracts:

1. *Insurance.* The contract should clearly state that the transportation, disposal, or treatment firm has insurance and what its conditions and limits are. Once again, most cleanup firms will seek a broad, "hold harmless" or indemnification provision in their contracts, particularly if they are having difficulty obtaining insurance. These "hold harmless" clauses will: (a) provide that all damages, costs, and losses relating to the transportation, disposal, or treatment of the hazardous waste are to be paid by the highway agency, unless they are negligent; and (b) require that the agency pay for or defend any lawsuit relating to the waste brought against the transporter, disposer, or treatment facility. Most states do not allow government bodies to enter into such agreements. If, however, the agency is allowed to accept such a "hold harmless" clause, negotiate its language carefully. Be particularly wary of agreeing to defend another company in any lawsuit, because even frivolous lawsuits result in costs.

2. *Partial indemnification.* As with site assessment contractors, the contract should provide a "hold harmless" clause between the agency and the contractor covering contractor negligence, gross negligence, and willful misconduct. In addition, the highway agency should seek indemnification from the transportation, disposal, or treatment firm if it sends wastes to a site not specified in the contract or if the compliance status of the site is not as represented by the disposal or treatment firm. Also, if the contract is with a common carrier (e.g., a railroad), the agency should attempt to include a provision that the common carrier is subject to the same standard of liability as the agency, regardless of its status as a common carrier. The law in many states is that common carriers cannot be held strictly liable. Without such a provision, if there is an accident during transportation, the agency will probably be held strictly liable. The transporter may be held liable only if it is negligent. The agency can protect itself with a carefully worded partial indemnification agreement.

3. *Corporate liability.* The contract should provide that all contract provisions are effective on future corporate entities of the other party. This is an increasingly important provision as more small hazardous waste firms merge to form larger "conglomerates" capable of providing, in the absence of adequate insurance, the necessary financial resources to compete in the hazardous waste business.

4. *Compliance with federal, state, and local laws.* Include an explicit provision that the party transporting, disposing, or treating the hazardous waste is in compliance with all applicable federal, state, and local laws. The agency should obtain documentation from them demonstrating this compliance. Check independently with the state environmental agency and EPA's regional office to determine whether the facility to which the wastes are to be sent is in compliance with state and federal environmental regulations. Obtain a copy of the selected facility's recent compliance history. The agency may be subject to a greater risk of liability for a Superfund response action at the facility or a toxic tort lawsuit if the facility has a poor compliance record.

5. *Waste characterization.* The agency should clearly and completely identify all the chemicals in the waste sent to a treatment or disposal facility to avoid any claim at a later date that there was fraud or misrepresentation that could make the agency liable for all costs.

6. *Contingencies.* The contract should provide a mechanism for addressing changes in regulations or standards governing technologies (and, therefore, the technologies and the use of them) while the contract is in process. The contract should also anticipate contingencies, such as the unexpected discovery of

additional hazardous wastes, and specify how the cost and time implications of such contingencies will be handled.

7. *Miscellaneous provisions.* There should be an explicit statement that the agency waives no rights or defenses. Include a *force majeure* clause, and examine it to ensure it is not one-sided. If desirable, include a confidentiality provision.

In closing, it is important to recognize that the hazardous waste industry has expanded rapidly in response to environmental regulations over the past 7 years. Many companies without proven track records in the field have been started during this period to respond to the market demands fostered by these requirements. The unavailability of accurate, consistent, and thorough information about many of these companies makes the task of evaluating and selecting hazardous waste contractors a particularly difficult one for highway officials. While problem contractors will undoubtedly disappear as the hazardous waste industry matures, caution must be exercised by agency legal counsel. The importance of hiring qualified hazardous waste contractors, and of preparing "tight" contract documents, cannot be overemphasized.

4. DEVELOPING A COMMUNITY RELATIONS PLAN

Any situation involving hazardous wastes may arouse the concerns of the local community. If the public fears releases of hazardous substances from the site and presses for costly cleanup techniques or initiates lawsuits, the problem will become more difficult to manage. Therefore, when a highway agency has responsibility for land containing hazardous wastes that may be of public concern, it should develop a community relations plan to turn public response to its benefit. A community relations effort serves two functions. First, it addresses public concerns about how a highway agency is handling hazardous wastes found in a ROW. Second, it integrates community needs into the resolution of the situation.

How a community will respond to a waste problem—and thus the types of community relations efforts highway agency will need to undertake—depends on several factors. Often the size and technical complexity of site cleanup determine how comprehensive and detailed a community relations program must be. Other factors that may influence the level of citizen concern include: the size and location of the community; media interest; the number of families potentially affected by the wastes; and the presence of active citizen or environmental groups in the community.

Once public concern is aroused, citizens will want information about the effects of exposure on their health and environment, both before and during road construction. The highway agency may either be perceived as a helpful agent (a remover of a problem) or as a harmful one (literally "stirring up" trouble). The fears that grave harm may have already resulted could cause citizen response, if poorly handled, to become yet more strident. On the other hand, a carefully conducted community relations effort can foster trust in the highway agency and its remediation program.

Here are the steps a highway agency should follow in developing a community relations plan:

1. Determine if the highway agency itself will handle the program, or if responsibility will be turned over to a state environmental agency or a consulting firm. Be clear about the role of district personnel and central office staff. Whatever the decision, all agency officials involved in the project must see themselves as in the business of public relations.
2. Identify the federal and state regulations under which the land or the hazardous waste site falls and follow any required community relations procedures. For instance, the EPA provides detailed guidelines for community relations programs concerning sites that fall under Superfund regulations.
3. Decide if the hazardous wastes will be contained on-site or be removed. Leaving wastes on-site can arouse greater community concern and may involve the highway agency incite community relations for a longer period of time.
4. Identify the stages of hazardous waste management that will require public relations—e.g., assessment and remediation—and determine the appropriate approach to public relations in each stage. Different stages may require different approaches.
5. Determine how accurate information concerning the need for and approach to hazardous waste management can be distributed and explained to the community. The appropriate techniques will vary by community, but the best way to reach concerned citizens is usually through small, informal efforts that are conducted periodically and do not skirt the emotional or difficult issues involved.
6. Give citizens an opportunity to comment on and provide input to ongoing and proposed site work.
7. Focus and resolve conflict among various public groups and the highway agency. Progress on a project can be slowed or halted if conflicting groups carry enough political clout.

The public relations techniques used must be tailored to the community and site involved. The following are possible options:

1. Telephone contacts.
2. On-site discussions. If the threat to human health or the environment is particularly acute at the site, the highway agency should consider establishing an on-scene information office. A person could be stationed full-time in a trailer to respond to inquiries and to prepare fact sheets.
3. Media appearances, news conferences, or news releases.
4. Citizen group meetings.
5. Briefings with local government officials, often before a news conference and meetings with citizens.
6. Exhibits, for example, charts, diagrams or photographs. Target audiences can be the public, environmental groups, or the media. Exhibit site is determined by target audience.
7. Fact sheets and progress reports. In Pennsylvania, for example, a consultant group publishes a monthly review of design and construction activities on Interstate 476.
8. Formal public hearings or public meetings.
9. Presentations.
10. Public inquiry responses. An agency contact should be assigned to provide consistent and accurate information to inquiries.
11. Small group meetings or workshops.
12. Site tours.
13. Information repositories.

A public relations program is an important part of an agency's overall strategy for dealing with hazardous waste sites. See section 5, "Bibliography and References," for additional guidance on how to develop an effective public relations program.

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Chapter 4

IDENTIFICATION AND REMEDIATION OF HAZARDOUS WASTE SITES

This part of the compendium provides a detailed description of the activities associated with the identification and remediation of hazardous waste sites. Highway agencies with plans to create an in-house hazardous waste capability will find this part helpful in understanding the training and experience needed by staff to perform certain duties. Highway officials will also find the information in this part useful in selecting, evaluating, and monitoring the activities of hazardous waste contractors. ■ *Section 1 describes how to perform a preliminary hazardous waste site evaluation—an essential activity that should be undertaken by, or on behalf of, a highway agency before every real estate transaction.* ■ *Section 2 describes the elements of a detailed hazardous waste site investigation.* ■ *Section 3 describes the techniques and technologies available for cleaning up different kinds of hazardous waste. It also describes the factors to be considered when selecting and implementing a remedial action.* ■ *Section 4 contains bibliographic references used in developing the material presented in this chapter.*

1. PRELIMINARY HAZARDOUS WASTE SITE EVALUATION

The risks of Superfund liability can be significantly reduced by conducting a preliminary hazardous waste site evaluation prior to acquiring a property. A preliminary hazardous waste evaluation may involve any or all of the following activities: research of existing records and files, collection and review of available land use maps, evaluation of available photographic information, and conduct of personal interviews. Each of these activities can yield useful information on the past and present uses of a particular parcel of land. This section describes these activities and available sources of information.

Review of Existing Records and Databases

Depending on the size and number of tracts under evaluation, a large amount of information can be compiled from existing records and files. National hazardous waste databases that have been set up under federal legislation can be searched. In addition, a range of state and local sources of information can be accessed for hazardous waste information. To the extent that time and budget permit, all potential sources of information should be examined.

Federal Information Sources

Table 8 identifies federal agencies that may have information or evidence of regional hazardous waste sites or activities. These agencies should be consulted periodically for information that may be of value in assessing the historical or current uses of property under consideration for purchase by the highway agency.

The U.S. Environmental Protection Agency maintains a number of useful databases concerning potential waste sites, existing known waste sites, spill sites, disposal sites, and hazardous waste

Table 8. Federal sources of information.

U.S. Environmental Protection Agency (EPA)
U.S. Coast Guard
U.S. Department of Agriculture
Soil Conservation Service
Agricultural Stabilization and Conservation Service
Forest Service
U.S. Department of the Interior
Fish and Wildlife Service
Bureau of Land Reclamation
U.S. Geological Survey
U.S. Army Corps of Engineers
U.S. Census Bureau
Federal Emergency Management Agency (FEMA)
National Oceanic and Atmospheric Administration
Department of Justice
Securities and Exchange Commission
National Aeronautics and Space Administration

transporters, producers, and managers. These databases—described below—can be accessed from EPA regional offices.

Comprehensive Environmental Response, Compensation and Liability System CERCLIS. The Comprehensive Environmental Response, Compensation and Liability System (CERCLIS) is the most complete and up-to-date list of potential hazardous waste sites in the country. The list presently contains approximately 26,000 sites and is updated twice weekly. This computer listing can generate sublists by zip code, county, city, or site names. The database provides: the location of the site with street address, city, county, zip code, latitude, longitude, and a reading on the accuracy of the location; whether the site is on the National Priorities List (NPL); whether it is a federal facility; the date of site discovery; the date of preliminary assessment; the date of site inspection; and the date that the site was given a hazardous ranking score. The list has no technical information on the sites; more specific information must be requested separately.

To access CERCLIS an agency must request the desired information, in writing, from the appropriate EPA regional office's Freedom of Information Office. When sites have been located, through CERCLIS or elsewhere, another written request to the same address can be made for the technical information gathered in the preliminary assessment and site inspection. Each state submits a list of potential waste sites that is compiled into the CERCLIS list. Some of these sites have been partially or fully characterized by preliminary and site inspection and some have been ranked for the NPL. The hazardous ranking scores of specific sites are also available at EPA regional offices.

For more detailed information from CERCLIS, contact EPA in Washington, D.C. The CERCLIS list of hazardous waste sites is also available through the National Technical Information Service (NTIS).

National Priorities List. The National Priorities List (NPL) ranks hazardous waste sites according to highest priority for cleanup under Superfund. The NPL has the locations and names of approximately 800 sites along with their NPL ranking (i.e., an estimation of the urgency of cleanup). Much off-site data collection and on-site sampling were performed to rank the site. This information is available through the EPA regional office and is accessed as part of CERCLIS. The NPL is updated every 6 months. Highway officials would be wise to avoid any property with an NPL site, unless cleanup is slated or completed.

Emergency Response Notification System. The Emergency Response Notification System (ERNS) contains information on any significant spill of potentially hazardous material. The U.S. Coast Guard or the EPA regional office can access ERNS and may be able to locate past or recent spills on or adjacent to existing or potential highway rights-of-way.

Hazardous Waste Data Management Information System. The Hazardous Waste Data Management Information System (HWDMIS) is EPA's most comprehensive hazardous waste data system. It contains a wide variety of information on, for example, all generators, transporters, treatment, storage, and disposal facilities that notified EPA of their activities (approximately 50,000 entries). Names, addresses, facility type, and waste types handled are identified. It gives the results of inspections of RCRA facilities (this is a regional database that includes inspection date, type, status, and responsible agencies). It also includes the enforcement actions taken against RCRA facilities, including enforcement type, status, violation type, and penalties imposed.

Sublists from this computer database can be generated by county or zip code, and can be obtained by writing to: Freedom of Information Office, Mail Code A101, Environmental Protection Agency, 4701 M Street, S.W., Washington, D.C. 20460.

Underground Storage Tank Database. EPA has established requirements for underground storage tank reporting in 40 C.F.R. 280.22. Notification is required for all underground storage tanks that have been used to store hazardous substances since 1974, that are in the ground as of May 1986 or are brought into service after May 1986. Tanks with less than 1,100-gal capacity used for farm or residential motor fuel storage are exempt, as are tanks for residential heating oil storage (state and local regulations may not exclude these tanks). Owners must report the use status, age, capacity, location, and substance stored for all tanks. Reports are made to designated state agencies. (For the designated agency in your state, see Fed. Reg. Vol. 52, No. 74, Appendix II, April 17, 1987.)

Superfund Comprehensive Accomplishments Plan. The Superfund Comprehensive Accomplishments Plan (SCAP) is a computer database containing information on the remedial, removal, and enforcement actions at NPL sites. This list will eventually be a sublist under CERCLIS. It contains specific information on approximately 800 sites and can provide the highway planner with excellent previous survey data on certain NPL sites. Information from this database can be accessed through the appropriate EPA regional office.

. *Surface Impoundment Assessment.* This database contains extensive information about known hazardous pits, ponds, and lagoons (approximately 200,000 entries). Information on this database can be obtained from the EPA at Research Triangle Park in Durham, North Carolina, or at the ten regional EPA offices.

State and Local Information Sources

State and local agencies are excellent sources of information regarding past and present hazardous waste-related activities at a particular site. Tables 9 and 10 identify agencies and organizations that can provide historical or current records and files.

Table 9. State sources of information.

Environmental Protection or Public Health Agencies
State Geological Survey
State Fish and Wildlife Agencies
Attorney General Office
State Fire Marshal
Occupational Health and Safety Agencies

Table 10. Local sources of information.

County or Local Registry of Deeds
County or City Health Departments
Local Fire Department
Local Police Department
Local Water and Sewage District
Local Media
Local Chamber of Commerce
Local Planning Boards
Local Library
Local Contractors (e.g., well drillers)
Local Historical Society
Community at Large

When the present or former occupants of a site are known, company records and log books will also be extremely informative. Several of the most promising sources of information are discussed further below.

State Environmental Agency. This is one of the most valuable sources of information on sites that do not appear on the NPL, but where wastes have been confirmed or are strongly suspected. The state environmental agency also has information on permits that were issued to current and past site owners. Investigate the owners' compliance history with the permit requirements.

State Attorney General's Office. The environmental protection office of the state Attorney General's office records cases of enforcement on hazardous waste issues. After a title search has been completed, provide the names of all property owners of the site to the Attorney General's office to find out whether there has been any litigation concerning the property. If the site is a hot spot of legal issues, the land should probably be abandoned as a potential highway right-of-way.

County/Local Registry of Deeds. The history of ownership and land uses of a parcel can be found at the county or local registry of deeds. It may be most expedient to have a lawyer who is familiar with title searches do this work. If the historical profile of the property references any of the land uses listed in Table 11, further investigation of the site is usually warranted.

Local Fire Department. Normally, the state requires that all potentially flammable or explosive substances and storage facilities for hazardous waste, including laboratories, industries, gas stations, and so forth, file for a permit or license from the local fire department. Fire department records of hazardous substance users are open to the public and can be accessed by property location. Most departments develop prefire plans for commercial and industrial properties that identify hazardous substance use by identity, location, and quantity.

The local fire department is also likely to be the depository of much of the hazardous substance information required under Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Known as the Emergency Planning and Community Right-to-Know Act of 1986, Title III requires that the governor of each state appoint an emergency response commission by April 17, 1987. This commission designates emergency planning districts within the state and appoints members of local emergency planning committees. Each local committee

Table 11. Land uses typically associated with hazardous waste.

Land uses that involve any of the following operations, processes, or activities are likely to generate hazardous wastes and to have chemical or fuel storage facilities on-site.

1. Repair and maintenance of motor vehicles (automobiles, aircraft, trucks, construction equipment, RVs).
2. Electroplating and other metal manufacturing and fabricating operations.
3. Metal finishing, refinishing, and etching (auto body, printed circuit board manufacturing, jewelry fabrication).
4. Operation or repair of printing and reproduction equipment.
5. Dry cleaning and laundry services.
6. Photographic processing and printing.
7. Analytical laboratory operations.
8. Building and excavation of structures and roads.
9. Provision of home, industrial, or commercial pest control.
10. Chemical manufacture, formulation, or processing.
11. Warehouse operations.
12. Manufacture, formulation, or processing of pesticides or agricultural products or chemicals.
13. Home, garden, pool or agricultural supply manufacturing.
14. Textile manufacturing (including fabric dying and finishing).
15. Manufacture, refinishing, or stripping of furniture or wood products.
16. Cosmetic manufacturing or processing.
17. Chemical treatment of lawns, gardens, yards, or provision of other landscape and tree services.
18. Pressure treating or preserving wood products.
19. Building and repair of boats.
20. Production and repair of shoes.
21. Paint formulation and mixing.
22. Metal galvanizing.
23. Drum, barrel, and tank reconditioning.
24. Battery manufacturing, rebuilding, or recycling.
25. Solvent recycling.
26. Scrap metal and junk yard operations.
27. Chemical and petroleum product storage facilities (both above and underground tanks and flammable storage rooms).
28. Landfills.
29. Receive bulk deliveries of raw or processed materials.
30. Lessor or renter of vehicles, maintain fleet operations, rent equipment.
31. Product distribution, consolidation, and shipping operations.
32. Waste or spent product incineration.
33. Nursery and greenhouse operations.
34. Schools, auditoriums, and other facilities with large heating requirements.
35. Recycling facilities.

must prepare an emergency response plan by October 17, 1987.

To support this emergency planning effort, every facility that is required, under the Occupational Safety and Health Act of 1970 (OSHA, Pub. L. No. 91-596) and subsequent regulations, to prepare and have available a material safety data sheet (MSDS) must submit this MSDS or a list of its hazardous chemicals to the local fire department. As this local database develops, it will become a valuable source of hazardous chemical information.

Local Water Department. City water departments are responsible for monitoring municipal water quality to ensure safe drinking water. They are, therefore, generally cognizant of the potential polluters of their waters and might also be of help in locating potential hazardous waste sites or contaminators.

Company Records. Company records, if retrievable, may provide excellent data on the source and extent of contamination. Past and present facility owners' names and addresses can be located in a title search. Facility representatives may be able to provide records, log books, receipts, supply company records, waste hauler and transporter records, waste storage inventories, manifests, and shipping orders. Facility owners can provide the names of plant managers or employees who may be more knowledgeable about a particular plant. When company records are made available, use them to determine, as applicable, the chemicals used by the company, the method(s) and location of waste storage and disposal activities, the location of raw material or product storage tanks, and the location of sumps, drains, and waste piping. Some businesses may be willing to provide a permitting history and files containing information on legal actions or regulatory violations.

Land Use Maps

Land use maps, present and past, may also provide valuable information about the potential for hazardous wastes on a site. Maps can indicate not only the ownership and occupants of a parcel but also where on the property certain hazardous waste-related activities took place, where hazardous materials were stored, or where hazardous waste pits or lagoons were placed.

The U.S. Geological Survey (USGS) National Cartographic Information Center (NCIC) can provide land use maps dating back to 1800. These maps are stored on microfilm and can be viewed at the four USGS regional offices. They can also be purchased for about $12.00 per map by submitting a written request to the closest regional office:

- Western Mapping Center, 345 Middlefield Road—Mail Stop 439, Menlo Park, CA 94025.
- Rocky Mountain Mapping Center, Mail Stop—604, Box 25046, Denver Federal Center, Denver, CO 80225.
- Mid Continental Mapping Center, 1400 Independence Road—Mail Stop 200, Rolla, MO 65401.
- Alaska Office-NCIC, U.S. Geological Survey, Skyline Building, 218 E Street, Anchorage, AK 99501.

Maps can also be accessed through the National NCIC in Reston, Virginia: National Cartographic Information Center (NCIC), U.S. Geological Survey, 507 National Center, Reston, VA 22090.

For historical land use information, the Sanborn Map Company (629 Fifth Avenue, Pelham, New York 10803) may be able to provide detailed information on the location and contents of specific buildings. Sandborn maps, created in the 1860's for fire protection and insurance purposes, can provide a profile of the historical uses of a particular location in many industrialized areas. Unlike USGS maps, which provide block information, Sanborn maps (if available for the geographic area of interest) provide information on the historical uses of a building. Maps from the 1960's through the present day are available for sizable portions of over 11,000 communities with populations over 2,000. Maps of the land uses in major urban areas are updated annually.

Aerial Photographs

Aerial photographs can be used to document the chronology of changes in an area's land use and to identify suspected hazardous waste sites. To use aerial photographs for locating potential hazardous waste sites, compare older aerial photographs with more recent ones. Starting with the earliest available photos, examine each one carefully for small changes in land use. Look for:

- *Obvious physical indicators of contamination.* These include: tanks, pits, lagoons, ditches, plumes of pollution in surface waters, railroad beds, loading ramps and docks, waste and material piles, landfills, and burning areas. The photographic record may indicate the position and burial of materials over time.
- *Changes in soil conditions.* Differences in color or tone indicate variation in the hydrological and textural characteristics of the soils. Coarse-textured soils appear light grey on black-and-white photos as the result of relatively rapid drainage. These lighter tones may indicate paths for the movement of contaminants. Barren areas devoid of vegetation will also appear lighter in tone, indicating mineral soil. Aerial photos can also identify wetlands, floodplains, erosion-prone soils and permafrost areas. This is valuable because drainage or other problems may make a parcel of land unsuitable for highway construction.
- *Changes in vegetation.* Vegetative conditions indicative of problems can be interpreted from aerial photographs. These conditions include: (1) barren soil areas; (2) decreases in the number of plants; (3) changes in the vigor of plants; (4) absence of characteristic plant species; (5) presence of dead trees or shrubs; (6) early "fall" colors or senescence in plants; and (7) presence of plant species adapted to toxic environments.

Aerial photos can also provide a general idea of site environs as well as potential pollution receptors and patterns of dispersion. Preparing an annotated base map with suspect areas and dates can be helpful for organization. Combining more traditional research (e.g., title research) with aerial photographs at concurrent dates is particularly effective in identifying potential hazardous waste sites.

Aerial photographs are also archived at the USGS and can be obtained by a written request. The USGS is a clearinghouse for photographs and can usually provide aerial photographs in a wide variety of scales as far back as the early 1900's. When requesting aerial photographs from the USGS, be as specific as possible in terms of location, scale, years, types of photographs (infrared, color, or black and white). Photographs range in price from $6 to $65 and will be received 3 to 5 weeks after requested. Priority orders can be sent out in five working days at triple

the normal price. The NCIC may also be able to provide aerial photographs of the area of interest.

The U.S. Geological Survey has also compiled large amounts of Side Looking Airborne Radar (SLAR) data since 1980. SLAR provides radar images of the land surface with a high level of detail. These images are useful in interpreting topographic maps of the same scale. The detail in these radar images can also help a highway planner identify suspect areas of structural weakness, landslide, prone areas, glacial features, and other potential geologic hazards. These data are also available through written request to the appropriate regional office of USGS in the form of photographs, radar mosaics, and digital data tapes for Geographic Information Systems (GIS) (see below). The photographs, called image strips, are usually the most useful for evaluation.

If the land under consideration contains or is adjacent to a known hazardous waste site, aerial photographs of the site may also be available through the Freedom of Information Office at the appropriate EPA regional office. Photographs of known hazardous waste sites are kept and interpreted at the EPA's photographic interpretation centers (Environmental Monitoring Systems Laboratory (EMSL-LV), Remote Sensing Branch, P.O. Box 15027, Las Vegas, NV 89114; Environmental Photographic Interpretation Center (EPIC), P.O. Box 1587, Vint Hill Farm Station, Warrenton, VA 22186). Call the interpretation centers to ask about the availability of aerial photographs and to identify the appropriate EPA office through which to submit a formal request. Also ask for available interpretive data on the photographs that are requested. Photographs in stock should be received in a month or less.

In rural areas, the U.S. Department of Agriculture may be able to provide historical aerial photographs. Department of Agriculture photographs are archived by the Agricultural Stabilization and Conservation Service at the following location: Aerial Photograph Field Office, P.O. Box 30010, Salt Lake City, UT 84130.

Aerial photographs taken before 1950 are available through the National Archives at the following address: General Service Administration, National Archives, Cartographic Branch, 8th and Pennsylvania Ave., N.W., Washington, D.C. 20408.

Canadian aerial photographs, if needed, can be obtained from the Canadian National Air Photo Library: Canadian National Air Photo Library, Surveys and Mapping Building, 615 Booth Street, Ottawa, Canada K1A OE9.

Other Canadian remote sensor data can be obtained from the Canada Center of Remote Sensing: Canada Center of Remote Sensing, 717 Belfast Road, Ottawa, Canada, K1A OY7.

On the local level, many municipalities periodically conduct aerial surveys. Consult with local authorities to determine the availability of such photographs in the area of interest. There are also over 200 private aerial photography mapping companies in the United States. Often these companies archive their aerial historical photographs, and will provide them at a nominal fee. Aerial mapping companies can be found in the Yellow Pages of the telephone directory or through professional directories, e.g., Photogrammetric Engineering and Remote Sensing. In addition, any one of these companies can be hired to take aerial photographs of specific areas if no existing or very recent photographs can be located. Alternatively, hiring or chartering a private plan to fly over the land so that agency personnel can take 35-mm or video pictures can be less expensive and provide valuable information.

Personal Interviews

Interviewing community residents is an important means of confirming suspicions about potential hazardous waste contamination. Local residents and officials can often provide information that is not contained in existing records. Zoning, planning, tax, and administrative personnel may be able to provide historic information not otherwise available. Former company employees can also provide invaluable information on the firm's operations and activities that may have involved hazardous materials. Abuttors are generally aware of operations that took place on a parcel of land and may be able to describe situations that warrant further investigation.

Other Site Evaluation Techniques

The foregoing activities may provide sufficient information to assess the potential for contamination on a property under evaluation. However, it may be necessary or desirable to conduct additional studies before proceeding with a detailed site investigation. One or more of the following remote sensing techniques may be employed to gather more information about the site. Remote sensing refers to a range of techniques for detecting, measuring, and mapping areas from a distance, usually from above. Large areas of land can be surveyed quickly in this way.

Aeromagnetometer Surveys

Aeromagnetometer surveys can be used to locate anomalies in underground magnetic fields. This technique is often employed to discover abandoned underground storage tanks and buried drums. Aeromagnetometer data can also show underlying structural geology and lithography.

Radar

Radar can be used at day or night to differentiate grain sizes of surface sediments. This can be very useful in determining dispersion of contaminants from a waste site because liquids disperse more quickly through coarse sediments. Synthetic Aperture Radar (SAR) is a new, but widely used, technique for mapping geologic structure, soil types, and land use. SAR has practical applications in route selection for roads and pipelines.

Geographic Information Systems (GIS)

Collected remote sensing data can be interpreted with the aid of computers by entering entire maps into computer systems as coordinates. The computers can aid the researcher in manipulating these maps in scale, perspective, content, and color to gain the maximum information possible. Geographic Information Systems (GIS) are three-dimensional computer mapping tools that can store and synthesize multiple layers of information on particular regions. The U.S. Geological Survey is the lead federal agency in setting up GIS nationally. The U.S. Environmental Protection Agency (as well as state transportation departments, state and federal environmental agencies, the U.S. Soil Conservation Service, and even some cities, counties, and newspapers) currently use GIS for their own purposes. The two

most common systems are ARC/INFO and Intergraph. Highway administrations and transportation departments generally utilize Intergraph because of its engineering capacity; it has the ability to scale up to large regional maps and down to specific road construction with engineering detail and design.

GIS may be useful in an ROW evaluation in two ways. First, it will be a valuable information source if another group has already entered data on the area under consideration into a GIS. Second, if the highway agency has access to a GIS, it can provide tools for synthesizing and analyzing data. Important capabilities of GIS include:

- *Programming.* These systems are completely programmable so that any pertinent data sets can be entered. Map data can be entered and digitized at any scale and the computer can integrate these data for uniform access. If a region undergoing a ROW evaluation is already mapped on another agency system (e.g., USGS, EPA, the state highway agency system), that information can be accessed as a data tape or on maps. Other pertinent information can be added to the system or whole new systems created for site mapping and characterization. Data sets may include: NPL sites, potential hazardous waste sites, existing highways, proposed highways, ground-water flow, public or private drinking wells, industries, residential areas, topography, geologic data, sedimentological data, climate, winds, stream or road networks.
- *Map creation.* Once the data have been entered into the system, they can be accessed on a terminal or printed on maps with any different combinations of relevant data sets and at any appropriate scale. For instance, a map of proposed highways and potentially hazardous waste sites could be extremely useful. This type of system can also create (large-scale) detailed site maps with inset (small-scale) reference maps for perspective. The map creation capabilities of GIS are virtually limitless.
- *Relational databases.* All GIS have relational databases for any set of specific attributes, parameters, or details surrounding any spot on the map. These databases become extremely useful for site descriptions. For example, for a given road a relational database might include: traffic flow rates, traffic patterns, traffic light timing, construction sites, or any other set of data that the operator wishes to enter and access.
- *Flow modeling.* The systems are also extremely useful for flow modeling. For instance, given certain parameters on pollution volume, wind, water, soil, and dispersion data, the system can model potential impacts of hazardous releases.

Centralized Geographic Information Systems might eventually provide a dynamic, standardized national database for geographic and environmental information. Digitized data layer tapes are presently available at the NCIC in Reston, Virginia (see address under "Land Use Maps"). Contact the NCIC to ask about available GIS data.

2. DETAILED HAZARDOUS WASTE SITE INVESTIGATION

A detailed site investigation relies heavily on the information gathered during a preliminary site evaluation. It generally begins with a field survey, proceeds to the development of sampling and site safety plans, and ends with implementation of the plans and analysis of the results. Table 12 summarizes the information gathered during detailed hazardous waste site investigations.

Types of Field Surveys

Perimeter Reconnaissance

At sites where the hazards are largely unknown and access on the site perimeter is limited, visual observations and limited atmospheric sampling conducted from the property's perimeter is often useful. Although a perimeter inspection will not always produce definitive information about conditions within the site's actual boundaries, it can often be performed by a highway official without the attendant risk of entering a largely unknown environment. Again, only specialists trained in the use of protective equipment and the handling of hazardous wastes should enter potentially contaminated or otherwise hazardous areas.

On-site Survey

In preparation for an on-site survey, the information gathered off-site should be synthesized onto a map that includes the entire potential ROW area as well as the nearby surrounding land. The map should identify all potential areas of contamination or unusual conditions, such as deteriorated or damaged containers, buildings, or vehicles; discolored liquids, spills, oil slicks, or other suspicious substances; and dead animals or plants.

An on-site survey will typically involve the collection of samples. Sampling can be conducted in two parts: (1) preliminary sampling, which can be conducted during the course of the on-site survey, and (2) more detailed sampling, which can be done after the survey is complete and a sampling plan has been prepared. The on-site survey will usually not involve detailed sampling. At this point in the assessment, very little may be known about the site. Thus, elaborate sampling could be wasted or results misinterpreted. If collection of preliminary samples is performed, great care should be taken to ensure the safety of the personnel involved.

Any person involved in an on-site evaluation must be properly trained and equipped. See the subsection on "Development of a Site Safety Plan" for a description of the requirements that must be met. The level of training should be consistent with the worker's job function and responsibilities. Training should include both classroom instruction and "hands-on" practice.

In general, field personnel conducting on-site surveys should bring a notebook and a camera with color film to record any observations. Particular attention should be paid to locations that off-site research has indicated may have hazardous waste problems. Visual inspections should be avoided when the weather would impede vision and note taking.

When walking the property, note any indicators of potentially hazardous conditions, such as container colors, markings or labels, or vehicle placards. In addition, the amounts, types, and locations of hazardous substances should be inventoried. Also note all types of containers, impoundments, or other storage systems that may contain hazardous materials. These include metal or plastic drums or barrels, above-ground tanks, underground tanks and associated piping systems, compressed gas cylinders, and pits, ponds, or lagoons.

The condition of all containers and storage systems should also be noted, including leaking, bulging, damaged, or visibly corroded or rusted containers; types and quantities of material in containers; and labels or markings indicating container contents.

Table 12. Information gathered during detailed site investigation.

Sources of Contamination

- Quantity of hazardous material
- Toxicity
- Persistence

Potential for a Release of a Hazardous Substance

Ground-Water Route
- Depth to aquifer of concern
- Net precipitation
- Permeability of the unsaturated zone
- Physical state of the material
- Containment of the material

Surface Water Route
- Slope and intervening terrain
- 1-year, 24-hour rainfall
- Distance to nearest surface water
- Physical state of the material
- Containment of the material

Air Route
- Wind direction
- Distance to nearest population
- Containment of the material

Pathways to Receptors

Ground-Water Route
- Distance to neareast well/population served

Surface Water Route
- Distance to sensitive environments
- Population served/distance to dowstream intake

Air Route
- Land use
- Population within a 4-mile radius
- Distance to sensitive environments

Other
- Soil
- Direct contact

Nature of Receptors

- Sensitive environments (plants, animals, drinking water supplies)
- Population size

Source: EPA Hazard Ranking System Users Manual, 40 CFR Part 300, Appendix A.

The field surveyor should also look for signs of underground storage tanks such as piping systems that extend into the ground. Any piping systems should be traced as far as possible. For underground tanks, sumps, and piping systems, determine whether gasoline, diesel fuel, pure chemicals, waste chemicals, or other substances remain. If neighbors or former owners can be located, ask them about their knowledge or suspicion of leaks. Underground leaks are very common and may go undetected if leak tests are not sufficiently precise or if the leaks occur in piping that cannot be easily tested.

Record the physical condition of all materials (i.e., gas, liquid or solid), in addition to their color, turbidity, and general behavior (e.g., foaming, vaporizing). Note wind barriers (e.g., hills, buildings) along with the potential pathways of dispersion (e.g., air, surface water, ground water, soil, animals). Map the flow of surface drainage, including ditches, streams, channels and piping systems within, from and to the property. Note any natural and artificial barriers to contaminant dispersion, such as topographic features, berms, dikes, or walls.

Record any evidence of chemical spills or dumping, including discolored pavement near storm drains, shipping docks, or driveways; stained or discolored soil or waste piles; and sudden changes in vegetation or a distinct lack of vegetation in a particular area.

Where there are buildings involved, note their structural integrity, along with potential areas of chemical contamination such as floor drains, analytical laboratories and sinks, waste discharge pipes, sewer systems, roof exhaust areas, and chemical storage areas. Rafters, ventilation ducts, sumps, crawl spaces, window wells, tanks, and the like should be inspected for deterioration as well as chemical residues or contaminated particulate matter. Examine all containers within buildings. Record the location of building foundations, which may indicate past activities involving chemicals. Some buildings may contain asbestos as an insulating medium. Note the integrity of the asbestos material (i.e., is it friable, or is it wrapped or totally enclosed in some kind of covering). Buildings that are suspected of containing asbestos should be inspected according to EPA-rec-

ommended guidelines (U.S. Environmental Protection Agency, *Asbestos-Containing Materials in School Buildings: A Guidance Document,* Part I, March 1979).

Wherever contamination seems possible, a sequenced program of sampling and analysis should be conducted (see "Development of a Sampling Plan" below) to characterize the problem. Note the locations and the types of samples that may be needed.

Development of a Sampling Plan

If hazardous contaminants are suspected at a site either before or as the result of a field survey, qualified individuals or a contractor should characterize pollutants by collecting samples from the suspicious areas (i.e., spills, stained soil, etc.) and analyzing them to determine the identity and concentration of potentially hazardous substances. The amount and type of sampling necessary to adequately characterize contaminants depend on the nature of the site.

For example, if information garnered from off-site research reveals that a gasoline service station was previously located at the site, and preliminary air sampling reveals high levels of aromatic hydrocarbons, it may be prudent to conduct geophysical tests or soil sampling, or both, to determine if a leaking underground storage tank has contaminated surrounding soil or underlying ground water. If aerial photographs indicate that a chemical spill may have occurred on a site, soil samples should be collected and analyzed for contamination. Depending on the site, several types of media may need to be sampled including soil, sediment, surface water, ground water, air, radiation, and biological species.

Before sampling activities begin, the project should be thoroughly detailed in a Sampling Plan. Among the items the Sampling Plan should address are existing work or background, objectives of the sampling, number and types of samples needed, sampling scheme(s), sampling methods and procedures, equipment and personnel, and quality assurance/quality control procedures.

Existing Work or Background Information

Review of existing background information is crucial in determining risks involved in sampling. This information can help sampling personnel to make judgments concerning protective equipment needed, type of sampler and sample containers to use, volume of sample to take, or even whether to sample at all.

In addition, this section of the Sampling Plan should include regional or state maps of the investigation area as well as detailed maps and photographs of the local site. Of particular importance to the investigators is information pertaining to the composition and characteristics of the wastes, adequate storage or destruction of wastes on the site, routes by which the wastes could migrate off site, and effects that would or might occur through the discharge of the waste.

Sampling Objectives

The next step in the development of any Sampling Plan is to establish the objective of the sampling. The objective will dictate many subsequent sampling choices, including methodology, sites, types of samples to be collected, number of samples needed, and so on.

The purpose of sampling at hazardous waste sites is to acquire data about the identity of on-site contaminants present and the extent to which these substances have migrated into the surrounding environment. Samples should be representative of the media under investigation, in other words, they should possess the same qualities or properties as the material under investigation. However, collection of a truly representative sample (especially when dealing with hazardous waste samples) can be quite difficult. Therefore, a sampling strategy should be developed based on certain statistical considerations. The most comprehensive source for more detailed information on sampling and sampling strategies is: U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste* (SW-846), 3rd edition, November 1986. The following sources may be referred to for additional information: Harvey, R. P., "Statistical Aspects of Air Sampling Strategies," in *Detection and Measurement of Hazardous Gases;* edited by C. F. Cullis and J. G. Firth, Heinemann Educational Books, London, 1981. Mason, B. J., "Protocol for Soil Sampling: Techniques and Strategies," U.S. Environmental Protection Agency, Environmental Systems Laboratory, EPA-600/54-83-0020, March 30, 1982. Smith, R. and G. V. James, "The Sampling of Bulk Materials," The Royal Society of Chemistry, London, 1981. U.S. Environmental Protection Agency, "Handbook for Sampling and Sample Preservation of Water and Wastewater," EPA 600/4-82-0229, September 1982.

Types of Samples

A *discrete* sample is one that is representative of a single sample site at a specific point in time. The entire sample is collected at one particular point and all at one time. A *composite* sample is composed of a number of samples, collected at various sampling sites and/or at different points in time, and combined into a single sample.

When collecting hazardous samples, it is advisable to collect only discrete samples. Composite samples cannot be representative of the material being sampled because the compositing procedure cannot be duplicated with any great degree of reproducibility. The changes in chemical nature of the sample that may occur through compositing also supports collection of discrete samples. Additionally, the combining of samples of unknown hazardous content in compositing may pose a safety risk.

Composite samples, however, may give an "average" concentration or composition and may be an alternative to analyzing numerous discrete samples. If a relatively large number of composite samples are collected and analyzed, it is possible to achieve better representation of the material being sampled than with discrete sampling; however, the savings in analytical costs that are often associated with composite sampling is also lost.

Number of Samples

To ensure an adequate quality control program, multiple samples should be collected. When collecting samples during site investigations, duplicate samples must be collected: one sample is used for the initial analysis; the other is used to check re-

producibility of the data. Duplicates are essentially identical samples collected at the same time, in the same way, and contained, preserved, and transported in the same manner.

Along with the sample, a sample blank should be sent to the laboratory. Sample blanks are samples of deionized and distilled water, rinses of collective devices, or sampling media that are handled in the same manner as the sample and subsequently analyzed to identify possible sources of contamination during collection, preservation, or handling.

Sampling Schemes

The selection of a sampling scheme will depend on various factors—two of the most important being the project objectives and the information available on the parameter(s) of interest (e.g., time, spatial distribution, variability). Among the sampling schemes that may be chosen are random sampling, systematic sampling, stratified sampling, judgment sampling, and hybrid sampling.

Random sampling depends on the theory of random chance probabilities to choose representative sample locations. It is generally used when little is known about the material and location. Tables of random numbers should be used to eliminate any bias of the sample collector.

Systematic sampling involves collecting samples at predetermined, regular intervals. It is the most commonly employed sampling scheme; however, care must be taken to avoid bias. For instance, if there are periodic variations in the material to be sampled so that the plan becomes partially phased with these variations, bias can result.

Stratified sampling divides the sample population into groups based on knowledge of sample characteristics gained through prior site surveys or investigations. This scheme reduces the number of samples needed to attain a specified precision and increases the precision of the estimates made by sampling.

Judgment sampling is often employed, especially when the intent of the sampling is to document the presence of contamination. However, because this approach tends to allow the sample collector to influence decisions, care must be exercised. If judgment sampling is employed, enough samples should be collected to lend credence to any conclusion drawn about the area under investigation.

Hybrid sampling consists of a combination of the types previously described. In reality, most sampling schemes are hybrid. These schemes are the methods of choice since they allow for greater diversity without compromising the objectives of the program.

Sampling Methods

Major emphasis should be placed on the selection of sampling methods. There are hundreds of sampling methods which can be selected for use in hazardous waste site investigations, all of which have certain merits that warrant consideration. Therefore, the following criteria should be examined and evaluated for each sampling method:

- *Safety.* Use sampling methods and procedures that minimize the risk to sampling personnel.
- *Practicality.* Select simple procedures that are easily adapted to a variety of situations and equipment that is easy to operate.
- *Reliability.* Use only sampling methods that have proven to be reliable and precise.
- *Representativeness.* Select methods capable of delivering representative samples. For example, if a homogeneous waste pile is discovered on a site, one or two samples may suffice; however, if the waste pile is obviously a mixture of several different substances, more samples should be collected.
- *Economics.* Consider the costs of equipment, labor, and maintenance in relation to the overall benefit of the method.

Field Techniques for Identifying Hazardous Wastes

Soil Sampling

Often a site consists only of contaminated soil. Soil sampling can provide information about the existence and extent of contaminant migration, and can often detect hazardous contaminants before they migrate into the underlying ground water. Different soil types can affect the rate of contaminant migration; therefore, it is important to record in the sampling log book soil characteristics such as grain size, color and odor, and sample location and depth.

The physical properties of the soil (such as grain size, cohesiveness, and associated moisture) and other factors (such as depth to bedrock and water table) will limit the depth from which samples can be collected and the method required to collect them. Sampling near the soil surface can often be accomplished with a minimum of special training, equipment, or cost. Sampling to greater depths, however, may require more detailed sampling methods and professional assistance.

Collection of samples from near the soil surface can be accomplished with tools such as spades, shovels, and scoops. Soil augers and sampling triers can be used to effectively collect soil cores and soil samples at depths to about 6 m. Care must be exercised to avoid using chrome-plated devices that can easily scratch, thereby contaminating the sample. Bucket-type augers can be used directly for soil sample collection or to advance a borehole to the desired depth so that a thin wall tube sampler can be employed. This tube is forced into the soil, and is then extracted. Friction holds the sample material in the tube during extraction. Interchangeable cutting tips also facilitate smoother penetration with reduced sample disturbance.

Kits are also available that include a tube sampler, cutting tips, an auger point, and a series of extension rods. These kits allow for hand augering a borehole. The auger can then be removed and the tube sampler forced into the soil at the completion depths. Although kits are available with sufficient tools to reach depths in excess of 7 m, soil structure, impenetrable rock, and water levels usually prevent reaching such completion depths.

Sediment Sampling

Sediment samples should be collected from both upstream and downstream of a suspected contaminant area, and in areas where sediment deposition is significant. Generally, sediment

collects where surface waters are quiescent. Sediment samples can be collected in much the same manner as soil samples (using equipment such as scoops, trowels, and coring devices). However, a number of additional factors can complicate the sampling process, such as the presence of rocks, debris, and organic material, and the variation in sediment composition with distance from inflows, discharges, and other disturbances. Sediment sampling must reflect these variations.

Devices such as dredgers, grab samplers, and gravity corers (e.g., Phlegers) are specifically designed for sediment sampling. Dredgers and grab samplers are clamshell-type scoops that are activated by levers. These devices are opened by sampling personnel, latched into place, and then slowly lowered to the bottom. When the tension is released on the lowering cables, the latches release, enabling the jaws of the shells to grab bottom samples. The lifting action of the cables on the lever systems closes the clamshells, trapping the samples within them.

Grab samplers are not, however, capable of collecting undisturbed samples. Gravity corers can be used for this purpose. A gravity corer is a metal tube with a check valve on the top that allows water to pass through the corer on descent but prevents the sample from being washed out during recovery. Thus, essentially undisturbed samples which represent the profile of the strata are collected.

Surface Water Sampling

Surface water samples can be collected using sterilized vials, bottles, beakers, bailers, or other containers. Samples from shallow waters can be easily collected by merely submerging the sample container. This method is simple and generally representative of the sampling medium; however, the external surface of the container becomes contaminated with any chemicals in the water. In general, sampling devices that are disposable, or are constructed of a nonreactive material such as glass, stainless steel, or Teflon should be used. The use of disposable samplers ensures that cross contamination is avoided, and may be less expensive in the long run.

Other surface water sampling devices include dippers, beakers with handles and pour spouts, and beakers with extension tubing attached so samples beyond arm's reach can be collected. Peristalic pumps can extend the lateral reach of the sampler and also allow sampling at depth. Kemmerer bottles allow for collection of water samples at a specific depth.

Ground-Water Sampling

Ground-water samples can be collected from either wells or springs and seeps. While sampling from springs or seeps is considerably easier than from wells, it is often less indicative of actual ground-water quality than well sampling. This is because the microorganisms inhabiting springs and seeps alter the oxygen content, pH, and nutrient and metal concentrations in the water. Sampling from springs or seeps can be performed using many of the same methods and equipment as surface water sampling. The sampling devices are lowered into the wells to collect samples.

Ground-water sampling from wells is a complex process. The methods and techniques for placing and constructing the wells are varied and complicated. Factors such as ground-water flow, direction, and volume must be considered in the context of the overall geohydrology of the area. The appropriate well location, depth, diameter, design, and construction material must be determined for each specific ground-water sampling program. Because these factors are so difficult to determine and because ground-water sampling from wells is extremely expensive, an expert should be consulted before any attempts are made to locate and drill ground-water sampling wells.

Air Sampling

Air sampling can be used to indicate potential safety problems and to screen for the presence of airborne contaminants. Atmospheric chemical hazards can be assessed using a variety of sampling equipment and monitoring devices. For air sampling results to be meaningful, the wind speed and direction must be taken into account (contaminant concentrations will vary depending on whether the sample is taken upwind or downwind from the site), as well as the temperature and precipitation levels. Also, ambient concentrations of airborne contaminants are affected by the topography of the surrounding area.

Portable, direct-reading instruments can detect contaminant concentrations as accurately as one part per million. Direct-reading instruments provide information at the time of the sampling, thereby enabling immediate decision-making. Information provided by direct-reading instruments can be used to determine: (1) whether respiratory protective equipment is needed; and (2) what the most appropriate equipment is for further sampling. Oxygen indicators and combustible gas detectors can assess the presence of dangers such as oxygen deficiency, explosivity, and flammability.

Radiation Sampling

Exposure to even small amounts of radiation can cause severe damage; therefore, experts should be contacted if there is any suspicion of ionizing radiation at a site. These experts can then proceed to sample using appropriate personal protective equipment and clothing.

Biological Sampling

Occasionally, biological sampling is conducted at a site. Sampling of vegetation and some wildlife species at a site may indicate the presence of contaminants that otherwise go undetected. Certain chemical compounds, such as PCBs, can accumulate in plants and organisms such as fish and turtles. While water sampling may indicate extremely low or nondetectable quantities of contaminants, vegetation sampling may show that certain hazardous chemicals have been taken up by area plants. Similarly, analyses of fish or other wildlife may reveal the presence of tumors or other potential indicators of chemical contamination. Caution must be exercised in interpreting the results of wildlife sampling because the migratory or roving nature of most wildlife provides opportunities for chemical exposure in areas other than the sampling area.

Container Sampling

Containers (drums, tanks, etc.) should only be sampled when necessary because opening drums or other sealed containers can

be extremely hazardous to sampling personnel unless proper safety procedures are followed. Only qualified personnel who are experienced in handling drums and other containers should be involved in this sampling step.

All drums should be "shock tested" using remote techniques before sampling to ensure that they do not explode or spew hazardous gases onto sampling personnel. Drums and other containers should not be moved or opened for sampling unless they are structurally sound. Several types of equipment can be used to open containers for sampling, including pneumatically operated impact wrenches which remove drum bungs; hydraulically or pneumatically operated drum piercers, cutters, and drills; and backhoe-mounted puncture spikes for penetrating drum tops. Picks, chisels, and firearms should *not* be used to open drums. Once a container has been opened, its contents may be sampled using glass rods or vacuum pumps.

Underground Tank Sampling

Underground storage tanks (USTs) represent one of the more common hazardous waste problems highway officials may encounter. Underground storage tanks may be used to store petroleum products, chemicals, hazardous wastes, and other liquids. Leaks from these tanks or their ancillary equipment (piping, couplings, pumps, and valves) are an increasing problem—the steel tanks prevalent in the late 1950's and 1960's are subject to corrosion, while the more recent fiberglass tanks will leak if they are installed improperly.

Once in the ground, leaked oil or chemicals can take three forms: (1) a free product mass coating the soil, (2) water-soluble components that dissolve and move into the ground and surface water, and (3) a vapor that fans outward from the leak source.

Buried tanks, drums, and wastes can be detected using geophysical sampling methods described below. Leaked oil or chemicals can be identified through various sampling procedures or through special leak detection techniques (see "Special Detection Techniques" below).

Geophysical Sampling

Frequently, subsurface conditions must be properly evaluated to understand how potential hazardous contaminants can migrate in soil, rock, and ground water. If necessary, remote sensing or subsurface geophysical investigative techniques may be used to locate buried wastes, containers, or contaminant plumes. Geophysical surveys provide information on subsurface lithology, hydrologic barriers, porosity, and permeability, all of which are key factors in understanding the ground-water regime at a site. Geophysical information can be evaluated to determine the potential for contaminants to migrate along subsurface pathways (ground water, rock fractures, underground trenches).

Most geophysical techniques are ideally suited for site characterization because they are nonpenetrating, can be rapidly executed, and are often less expensive than other characterization methods. Each geophysical technique employs different wavelengths and is capable of providing diagnostic information at varying resolutions and for varying depths. Common geophysical investigative methods include the following.

Seismic reflection and refraction are used to locate subsurface structural features such as buried valleys (which may control accumulation of contaminants) and to identify the depth to the ground water. Seismic refraction techniques measure the acoustic velocities of waves that penetrate the underlying rock formations, thereby highlighting features such as low permeability bedrock, high porosity sand or unconsolidated material, and ground water.

Electrical surveys include electrical resistivity or conductivity and electromagnetic induction. In electrical surveys, an electrical signal is sent to a receiver through both the air and the subsurface material. If an anomaly in the subsurface conductivity is detected, the induced signal sent to the receiver is changed significantly and the instrument indicates it. Because most ground-water contaminants alter the electrical conductivity of ground water, surface electrical surveys can map leachate plumes from ground-water contamination sources. The areal extent, configuration, and concentration of the contaminant plume can be determined by these surveys. In addition, the extent of waste sites such as landfills can be determined.

Electrical resistivity or conductivity is used to characterize soil types and to identify soil and ground-water contamination. Resistivity or conductivity surveys are performed by inserting electrodes into the ground, inducing a galvanic current. The resulting voltage is measured and vertical changes in electrical properties or changes in electrical properties at different locations indicate changes in soil type or existence of contaminants.

Electromagnetic induction (EMI) is used to explore the extent of ground-water contamination and to map contaminant plumes. Unlike resistivity or conductivity techniques, this method requires no actual contact with the ground surface. EMI is also generally less expensive and provides information more rapidly than electrical resistivity. However, EMI is limited in the depths that it can explore and is less versatile for many applications because it is susceptible to "noise" from power lines, industrial grounding systems, pavement, and near-surface layers of highly conductive or resistive rock.

Magnetometers are portable, lightweight, durable, hand-held instruments that can detect buried iron or steel, such as drums. A magnetometer survey maps the earth's local magnetic field; small anomalies in the magnetic field are caused by near surface features such as buried drums. The survey also allows an estimate of the depth and mass of the buried objects.

Ground-penetrating radar can be used to map bedrock and water table features as well as to locate buried drums and trenches. Because of the high frequency energy used, ground-penetrating radar provides high-resolution data on both surficial geology and buried objects. The depth of penetration depends on the electrical properties of the soil or rock encountered. Ground-penetrating radar offers the highest level of detail available from most subsurface geophysical techniques. It can also detect plastic containers, which generally cannot be detected using many other remote sensing techniques.

Sonar devices use sonic or ultrasonic waves to detect the presence and location of submerged objects. The sonic frequency waves are produced by the device, which frequently is towed behind a boat. The waves pass through the water undeterred. When the waves strike an object, they are reflected back from the object. Sonar devices enable a profile of the bottom of a lake, pond, river, or bay to be developed, including any submerged dump sites, barrels, or other debris.

Borehole geophysics is a technique originally developed by the oil industry to measure physical properties of subsurface materials using probes lowered into boreholes. The techniques can

be applied to hazardous waste site investigations to enable interpretation of soil porosity, permeability, lithology, and pore fluid properties and content.

Sampling of Structures and Buildings

In some instances, it may be necessary to determine the depth of penetration of contaminants into porous material such as wood, wallboard, or concrete. In these cases, small sections of the potentially contaminated structural materials (e.g., corings) should be collected for analysis. This information then may be used to determine if building dismantling or demolition is appropriate and what level of worker protection is necessary to conduct these activities.

Special Detection Techniques

Canine Olfactions. Some highly innovative techniques for detecting hazardous substances are now being explored for use at waste sites. One technique that has received considerable attention is canine olfaction. Because dogs have such an acute sense of smell, they can detect minute amounts of certain chemicals, such as toluene and trichlorophenol, at distances as great as 50 ft from the source. Other potential applications of canine olfaction include determining the adequacy of decontamination of equipment and protective clothing, and detecting leaks from underground storage tanks.

Soil Gas Analysis. Monitoring of soil gases can serve as a quick method to determine the extent of pollutant migration or to establish the boundaries of a site containing buried wastes. Because soil-gas exchange with the ambient atmosphere dilutes gaseous compounds and makes them difficult to detect, soil sampling can provide a more concentrated source for detecting buried wastes. Gas samples can be obtained from test holes using nonsparking probes. The probes are attached to the gas inlet valves of gas monitors designed to measure ambient air concentrations. This method enables rapid determination of the extent of a waste site. The technique can also be used to sample wells for gases and vapors that have escaped from the ground water, thereby indicating the extent of ground-water contamination.

Soil gas analysis is also an effective, nondisruptive method for detecting and determining the extent of subsurface contamination from leaking underground storage tanks. Most materials stored in underground tanks contain volatile organic compounds that migrate as gases to the surface. By measuring the volatile organic compounds in the vicinity of the tanks, contaminant plumes can be identified. A key advantage of soil gas analysis over other investigative methods is that it can be conducted at a lower cost and with less disturbance than drilling or digging of test pits.

UST Leak Detection Methods. Detecting leaks from underground storage tanks is neither simple nor certain. There are, four basic ways to approach leak detection: (1) volumetric leak testing, (2) nonvolumetric leak testing, (3) inventory control, and (4) monitoring systems. No method is perfect.

Volumetric or quantitative leak testing detects a change in tank volume by measuring parameters such as liquid level, temperature, pressure, and density.

Nonvolumetric or qualitative leak testing usually involves using another material besides the product. This material, typically helium, is used to pressurize a tank. A loss of pressure or the detection of the helium gas outside the tank indicates a leak. Most of these tests can identify a leak in a relatively short period of time; however, these tests can also increase an existing leak or create an explosion hazard if done improperly.

Inventory control is a system based on product record-keeping, regular inspections, and recognition of the conditions that indicate a leak has occurred. Of the four categories, inventory control is the most basic and the least expensive, and this technique is widely applicable to any product stored or transported in pipelines.

Leaks in USTs can also be detected by monitoring the environmental effects of a leak inside or outside the tank. This type of monitoring typically entails drilling ground-water monitoring wells and performing chemical analyses. These methods do not provide information on leakage rates or the size of the leak; however, once installed, a monitoring system enables more frequent checking to be made for leaking tanks than do the other approaches.

Secondary containment systems may have monitors that can also detect leaks. In a secondary containment system, there are two impermeable barriers. The first barrier is the wall of the tank itself; the secondary barrier may be a second tank wall, a concrete vault, or a liner. If a leak occurs through the first wall, the secondary barrier prevents the escape of wastes to the environment. The secondary containment system also provides an enclosed space in which leaks from the primary tank system can be easily detected and removed.

Tank excavation monitoring systems are aimed at detecting a spill or a leak before the contamination spreads beyond the tank excavation or its immediate surroundings. The leak or spill sensing mechanisms that may be used in tank excavation monitoring systems include thermal conductivity sensors, electrical resistivity sensors, gas detectors, and sample analysis.

Development of a Site Safety Plan

Anyone who may be exposed to hazardous substances must be protected against the potential hazards. Under the authority established in SARA § 126(3) tit. III, the Occupational Safety and Health Administration (OSHA) has issued regulations specifically designed to protect workers engaged in hazardous waste operations. These regulations are contained in 29 C.F.R. 1910.120, *Hazardous Waste Operations and Response,* and are in addition to the coverage under OSHA's Standards for Industry and Construction.

Under these requirements, employers who perform activities at hazardous waste sites or facilities must establish a Site Safety Plan—a blueprint that outlines the policies and procedures by which work is to be done at the site. The Site Safety Plan identifies all the measures that will be undertaken to minimize the likelihood of an accident during both normal and adverse weather conditions. It should be written and modified, as necessary, as additional information becomes available from a preliminary site assessment.

At a minimum, a Site Safety Plan must address the following items:

1. *Personnel and responsibilities.* Before field work and sampling can commence, a field team must be organized. The Site

Safety Plan will identify the project staff and delegate the following responsibilities:

- Project Team Leader—is primarily an administrator when not participating in the field investigation.
- Field Team Leader—is responsible for the overall operation and safety of the field team.
- Site Safety Officer—is primarily responsible for all safety procedures and operations.
- Command Post Supervisor—serves as a means of communication and never enters the exclusive area except for emergencies.
- Work Party—performs the on-site tasks necessary to fulfill the objectives.

2. *Site characterization.* The Site Safety Plan will describe the risks associated with working on the site. Using the profile developed from information gathered during an off-site survey (preliminary site evaluation) and limited on-site surveys, hazards at the site will be identified and worker protection methods selected. Site characterization is a continuous process. As new information is gathered from various on-site activities, this portion of the Site Safety Plan must be updated and used to develop the health and safety plan for the next phase of site work.

3. *Personnel training.* The Site Safety Plan must confirm that the assigned site workers have completed a certified hazardous waste training program. Depending on the type of site, the necessary training may involve from 24 to 40 hours of instruction.

4. *Personal protective clothing and equipment.* The Site Safety Plan must describe the personal protective clothing and equipment (collectively referred to as PPE) to be worn by workers on the site. PPE, which shields sampling personnel and other individuals from site hazards, must be worn as needed to conduct site activities. The level of PPE necessary to protect a worker in a particular circumstance can only be determined by a qualified health and safety professional.

EPA has established four levels of protection (A, B, C, and D) consisting of certain ensemble components. Level A affords the highest available level of respiratory, skin, and eye protection, and should be used when substances with a high degree of hazard are present. Level A protection is often worn by contractors who clean up major hazardous waste sites. For most sites considered by highway officials, Level D protection may be sufficient since activities such as soil sampling may present the only potential exposure to a hazardous substance.

5. *Medical program.* Workers handling hazardous wastes may be exposed to stressful and risky situations. Depending on the site and the type of wastes present, a medical program may need to be developed to assess and monitor worker health prior to and during the assessment, and to deal with unexpected medical emergencies. The Site Safety Plan must describe the site-specific medical surveillance program to be used.

6. *Site sampling and monitoring plans.* This part of the Site Safety Plan describes the sampling plan and methods to be employed. It also describes the program for periodic air and personnel monitoring.

7. *Site control.* The Site Safety Plan must also specify guidelines for the control of the site and for the use of equipment engaged in the operations. Procedures and practices must be described that will be used to ensure the area and prevent the contamination of personnel and the public. Workers on the site must be trained to understand and practice safe and acceptable drum and container handling procedures.

8. *Decontamination procedures.* All personnel, equipment, samples, and protective clothing that come into contact with potentially hazardous materials must be decontaminated to remove or neutralize any hazardous contaminants that may have adhered to them. The first step in decontamination is to establish *standard operating procedures* that minimize the likelihood of contact with waste. These procedures include using disposable equipment whenever possible; protecting sampling instruments by bagging them, being sure to leave openings for sampling ports and sensors; stressing work practices that minimize contact with hazardous substances; encasing the source of contaminants with plastic sheeting or overpacks; covering equipment and tools with a strippable coating that can be removed during decontamination; and testing to determine decontamination effectiveness.

Decontamination methods can pose hazards under certain circumstances. Some decontamination solutions are incompatible with the material being decontaminated or with the hazardous substances being removed. To check for incompatibility, tests should be conducted to determine whether a decontamination method permeates, degrades, or otherwise damages personal protective clothing and other equipment.

9. *Standard operating procedures.* The Site Safety Plan will also set forth standard operating procedures (SOPs) for the site. Standard operating procedures will be appropriate for those activities, like decontamination, where uniform procedures can be developed for use by all site personnel. All personnel should be trained in the SOPs before entering a site, and the procedures should be enforced throughout all site activities.

For a detailed description of the elements of a Site Safety Plan, see the "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities," October 1985, prepared for the National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Coast Guard (USCG), and the U.S. Environmental Protection Agency (EPA).

Quality Assurance and Quality Control

Comprehensive quality assurance and quality control procedures are essential to a detailed site investigation. These include documentation and sample control procedures.

Documentation

Proper documentation and document control can: (1) help ensure that field data are of high quality; (2) substantiate any potential legal actions; and (3) provide the rationale for precautions taken in future on-site investigations. The best way to document site inspections is to record pertinent field information, sampling locations, and site conditions in a log book. Also, keep track of maps, graphs, drawings, photographs, project work plans, field and laboratory data sheets, sample labels, and analytical records. Appendix B contains a sample form used by the EPA to document sampling activities at hazardous waste sites.

Document control procedures will ensure that all pertinent documents are accounted for when the project is completed. These procedures include activities such as numbering each

document and listing each document in a document inventory; recording the location of each document and the name of the person in charge of the document in a document registry; collecting all documents at the end of each work period; and making sure that waterproof ink is used to record all document entries.

Sample Control

When samples are taken, chain-of-custody procedures must be set up to document the identity of samples and to trace their progress through all handling, transportation, and laboratory analysis steps. Chain-of-custody procedures also are necessary to document measures taken to prevent or detect tampering with samples or equipment.

As part of a QA/QC program, all samples should be analyzed by certified laboratories with the most up-to-date sample analysis protocols and methodologies, and with well-established quality assurance, chain-of-custody, and document control procedures. A laboratory can be licensed to perform different kinds of analyses, such as chemical analysis of drinking water, bacteriological analysis of drinking water, pesticide/herbicide analysis of drinking water, PCB/dioxin analysis under the Toxic Substances Control Act (TSCA), volative organic compound analysis under the Safe Drinking Water Act (SDWA), and hazardous waste analysis under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

When a laboratory says it is licensed or certified, it must be made certain that it is licensed to perform the testing that is desired. Expertly trained personnel should be relied upon to not only analyze the sample but also collect it in the proper manner.

3. HAZARDOUS WASTE REMEDIATION TECHNOLOGIES

This section describes the types of hazardous waste remediation technologies that are presently available or under development. It defines the kinds of hazardous wastes for which different technologies are applicable and the conditions under which they are appropriate. The information in this section will be useful in evaluating the appropriateness of clean-up alternatives that may be recommended by contractors under highway agency supervision.

In the hazardous waste field, the term "remediation technologies" is used to describe a wide range of techniques, from those that do not truly fall into a definition of technology (e.g., digging up contaminated soil with a backhoe), to sophisticated or complicated activities (e.g., plasma arc and certain landfill systems). Over the last 15 to 20 years, hazardous waste has become a widely recognized problem of national concern. Thus, social, scientific, and engineering ideas about "acceptable" technologies have moved from a reliance on the simpler and more general to an emphasis, mandated by law and regulation, on the more sophisticated and thorough.

Since the reauthorization of SARA and the 1984 Hazardous and Solid Waste Amendments to RCRA, EPA has emphasized treatment or destruction of contaminants where possible, and more stringently guaranteed containment (disposal) where treatment is not possible. In practice, this encourages use of technologies with high destruction efficiency such as incineration (both stationary and mobile units) and of on-site treatment of various types (e.g., thermal treatments, solidification and stabilization, and biological treatments).

In principle, hazardous waste remediation can be considered a three-step process: control, treatment, and disposal. In practice, however, steps may be performed concurrently and/or eliminated. For example, on-site solidification can be both a treatment and a disposal process, and may eliminate the need for a control step. Tables C-1 through C-7 in Appendix C outline specific methods and treatments available for these three steps, including their advantages and disadvantages and the types of contaminants they are suited and unsuited for.

Control Technologies

Control technologies are used to keep wastes in place, or to move them from the source area to another place for treatment, storage, or disposal. Control technologies are generally physical barriers or mechanical means of moving contaminated material, such as a subsurface barrier which prevents waste from leaching into vulnerable areas (for example, drinking water sources such as wells, rivers, streams, or ground water). Pumping/dredging is a technique used to bring liquids or sediments to the surface for further treatment. Other technologies include mechanical devices (e.g., bulldozers, front-end loaders, and backhoes) for moving wastes (generally soils or contaminant-filled drums). Most control technologies are well developed and have been time-tested and used for related types of treatment, such as treatment of industrial wastewater. Refer to Table C-1, "Selected Control Methods," for descriptions of typical technologies.

Treatment Technologies

Treatment technologies actually change the waste in some crucial way. Waste may be rendered less hazardous or inert; waste constituents can be separated; or waste may be totally destroyed. For some wastes, especially those with many hazardous constituents, several means of sequential treatment may be needed.

Treatment can be divided into five categories based on the primary mode of action: biological, chemical, physical, solidification and stabilization, and thermal. Each category includes a number of technologies. These technologies vary along several dimensions, such as their effectiveness, the contaminants they can treat, their expense, their commercial availability, and their track records (both in the hazardous waste field and in allied areas). No single technology is the answer to all hazardous waste problems, although some technologies are more comprehensive than others.

Biological treatments use biological organisms (e.g., bacteria, algae, fungi, other microorganisms) to destroy contaminants. These organisms essentially consume contaminants as part of their growth process. These treatments are most frequently, although not exclusively, used for organic compounds. Treatment can be performed either by placing waste in on-site or off-site engineered reactors that are designed to foster the growth of colonies of microorganisms, or by placing microorganisms into waste which has remained in place on the site because of inaccessibility or bulkiness (e.g., ground water, large amounts of soil). Engineered reactors using microorganisms have a long history in wastewater treatment. Although the treatment process

is more easily controlled in reactors, biological treatment of the waste in place (also known as in-situ treatment) is a commercially available technique with a promising future. Genetically engineered organisms are being developed with increased powers to degrade a variety of contaminants. In-situ biological treatment is particularly appealing for ground water, because it is cost-effective compared to pumping and treating techniques, and is also relatively nondisruptive to the environment. Refer to Table C-2, "Selected Treatment Method: Biological," for a description of these technologies.

Chemical treatments alter wastes by chemical reactions. These may either destroy contaminants or make them less hazardous. Chemical treatments may also be used to separate the contaminant from the larger body of waste. Some chemical treatments both separate and degrade (e.g., chemical reduction, gas-phase stripping). Examples of chemical treatment include neutralization, oxidation, ion exchange, ozonation, and electrolysis. There are a wide variety of these treatments; various technologies may treat different contaminants, such as organics, inorganics, metals, or combinations of these. Most chemical treatments deal with one waste or one stage of contaminant reduction. A disadvantage of some chemical treatments is that they can generate by-products that are as hazardous as, or even more hazardous than, the original contaminants. Refer to Table C-3, "Selected Treatment Methods: Chemical," for a description of these technologies.

Physical treatments generally reduce the volume of wastes (separation processes) or render hazardous constituents inert (immobilization techniques). Separation processes have been adapted from wastewater treatment technologies, which have used them for many years. In these processes, hazardous constituents are removed from a larger body of waste. This is often done by separation of phases, such as solids or gases from liquid waste. The concentrated amount of hazardous residue that remains must then undergo further treatment. Examples of separation processes include carbon adsorption, sedimentation, and reverse osmosis. Immobilization techniques, which include chemical as well as physical treatments, are considered important enough in practice to warrant a separate description (as discussed under "Solidification and Stabilization" below.) Refer to Table C-4, "Selected Treatment Methods: Physical," for a description of these technologies.

Solidification and Stabilization processes (also known as immobilization processes) mix hazardous wastes with reagents or absorbents to produce an inert material (usually a hardened mass of soil-like material) that contains the contaminants, renders them less toxic and more easily handled and disposed of, and reduces or eliminates the possibility of leaching. Common agents for these processes include portland cement, fly ash, slag, and lime. Chemical fixation (for example, pozzolanic solidification), which involves allowing lime, silaceous materials, and water to react to produce a concrete-like mass, is particularly useful for wastes containing metals. Vitrification, a solidification technique that combines wastes with molten glass, is extremely effective, but is very expensive and requires special equipment. Although solidification and stabilization processes are improving because of commercial development, they nevertheless have certain drawbacks. They are more successful with inorganic substances; some wastes (both organic and inorganic) interfere with solidification processes; and if these techniques are used as end-treatment processes, monitoring is generally necessary. Refer to Table C-5, "Selected Treatment Methods: Solidification and Stabilization," for a description of these processes.

Thermal treatments are in the forefront of current techniques because of their efficiency in destroying a variety of contaminants in a variety of media. Thermal treatments use combustion to induce chemical reactions that destroy contaminants. These treatments either can use oxygen (e.g., incineration of various types) or they can be performed in the absence of oxygen (pyrolysis). The most widely used thermal treatment is incineration. Incineration can treat a potentially wide variety of wastes; several types of incinerators meet national levels for destruction and removal efficiency (DRE) of organic hazardous constituents of greater than 99.99 percent by mass. Incinerators are also being manufactured in portable mobile versions. The disadvantages of incinerators include their relative expensiveness and their emission into the air of residual contaminants, sometimes termed products of incomplete combustion (PICs). Refer to Table C-6, "Selected Treatment Methods: Thermal," for a description of these treatments.

Disposal Technologies

Disposal methods are employed to store wastes, either temporarily (until they can be treated), or permanently (after treatment). Disposal units essentially are containment units for waste and residues of waste treatment, either on or below the ground. Such units can be designed landfills, surface impoundments (which may be pits, ponds, or lagoons), injection wells, or storage depositories (either man-made or natural; above or under the ground).

In principle, these systems are designed to place a relatively impermeable barrier between the waste or residue and the surrounding area to ensure that contaminants do not leach into soil or water or disperse into the air. In addition, because total impermeability is currently an ideal, rather than a real-life occurrence, most disposal systems require some form of ongoing monitoring. The amount and relative strength of barrier components (such as liners, leachate collection systems, covers, walls, and so forth) are keyed to a series of site-specific factors, including the types of contaminants, the nature of the soil and underlying rock, the height of the water table, water use, and general weather conditions.

For example, clay soil is relatively impermeable. Suppose a landfill in clay soil is placed over unfractured rock; over an aquifer that does not supply drinking water; and far from an ecologically vulnerable area. This landfill would provide a high assurance of relative impermeability (provided that the contaminants placed within the landfill were minimized or rendered immobile). In contrast, suppose a landfill is located in sandy soil; in an area with a high water table; close to drinking water and ecologically vulnerable areas; and above fractured or otherwise permeable rock. This landfill would be much more prone to leaching if the containment system were breached. Thus, much elaborate precautions might have to be taken.

Operationally, disposal and control methods overlap to a large extent. In this compendium, the systems themselves are listed under Table C-7, "Selected Disposal Methods," while specific system components or tools are generally listed under Table C-1, "Selected Control Methods."

Underground Storage Tanks

Underground storage tanks (USTs) may be closed by either abandoning them in place or by removing them altogether.

Whether to abandon a tank in place or remove it for disposal will depend on the age and condition of the tank, its salvage value, and government regulations.

Abandoning the tank involves removing the product (usually by pumping), disconnecting all plumbing and controls, filling the tank with an inert solid (e.g., sand, gravel, or concrete) to prevent ground subsidence, and securing against tampering by capping and locking all plugged lines, or by erecting a locked fence around the tank area.

Removing the tank involves removing the liquid product, disconnecting and capping all plumbing and controls, venting all vapors (e.g., using nonsparking fans, blowers or pumps, or by applying steam or dry ice), excavating all piping and the tank, and transporting the tank from the site.

If the tank is leaking and wastes have contaminated the surrounding environment, it may be necessary to clean up the soil, ground water, or nearby bodies of water. A leak or spill might also occur during excavation. At present, the most widely used cleanup technique for leaks and spills is excavation of the leaking tank and any contaminated soil. Excavation is a quick and effective first step for removing wastes before they reach the water table. Soil removal is possible, however, only if the waste has penetrated just a few feet below the surface. The tank is then repaired or properly disposed of, along with the contaminated soil, at a landfill. More extensive cleanup methods may be needed, however, when ground water is threatened or when a large soil mass is contaminated. These include:

- *Sorbents*—these are natural materials (such as straw or sawdust) or synthetic products (such as foam plastics) that are spread over a spill to absorb it. Sorbents should be capable of absorbing the spill, and should not react with the contaminants to form toxic substances or hazardous fumes.
- *Trenching*—in some instances, ditches, trenches, or pits can be used to control the flow of contaminated ground water and to recover spilled product. Trenching may be used as the prime cleanup method or as a supplement to other methods.
- *Recovery wells*—a pumping well may be used to remove wastes from the ground when the water table is too deep to use trenches and ditches. The product is often withdrawn through a dual pump system in which one pump reaches down to the contaminated ground water and creates a cone of depression into which the product flows. A second pump transfers the product to the surface where it can be collected and separated from the ground water.

Which technologies are chosen for cleaning up tank spills depend on several factors, including the mobility of the wastes, the feasibility of on-site containment or in-situ treatment, and the cost of disposing of the waste (or tank) or decontaminating it once it has been excavated.

Emerging Technologies

The hazardous waste field is relatively new. Approaches to developing cost-effective sampling plans and techniques for collecting samples are still under development. For example, demonstration programs funded by EPA are actively looking for new field analysis techniques that can be used to detect and monitor hazardous substances at waste sites while out-performing laboratory analysis. Special attention is being given to developing immunochemical testing methods that are quick, highly sensitive, and inexpensive, but have not previously been applied to hazardous wastes.

Extensive research is also ongoing in the area of remediation technologies. Under EPA's Superfund Innovative Technology Evaluation Program, microbiological degradation, chemical fixation, and mobile plasma arc systems are being tested and evaluated. Innovative soil melting technologies, called in-situ vitrification, are also being examined more closely. These processes simplify treatment and eliminate excavation and reburial. Thus, waste generators can avoid the liabilities associated with disposing of waste in an authorized landfill. Additional research and commercial development are sure to be fostered as the full force of recent regulations are felt.

While the information summarized in the previous sections represents the current state of the art, it is rapidly changing. Hazardous waste consultants are being challenged to stay abreast of developments in the field. Highway staff responsible for overseeing and evaluating the work of hazardous waste contractors will be similarly challenged to maintain a familiarity with new developments that may affect their approaches to hazardous waste site assessment and remediation.

Selecting and Implementing a Remediation Technology

Factors Influencing Selection

Several factors influence the selection of the most approximate remedial action technology for a particular situation. Table 13 lists site-specific characteristics (waste, surface, and subsurface) that can affect the choice of cleanup technologies.

Technology-related and other factors important in evaluating alternative technologies include the following:

- *Performance.* How effective is the technology in performing its intended function, and how long is its useful life?
- *Reliability.* Has reliability been demonstrated at other sites? What are the chances and consequences of failure? How complex are operation and maintenance requirements? How available will labor and materials be?
- *Dependability.* How easily can the technology be installed? How soon will it begin working? How soon will an acceptable level of contaminant reduction be attained?
- *Health and safety.* What are the possibilities of fire, explosion, hazardous substance release, or other problems that might affect workers and surrounding communities? What is the technology's potential to remove or minimize exposures?
- *Regulatory requirements.* What effect will federal, state, and local regulations have on the installation and use of the technology?
- *Environmental concerns.* What, if any, adverse effect will the technology have on the environment and on environmentally sensitive areas?
- *Costs.* What are the estimated capital and operational costs of the technology? What effects might varying sets of assumptions have on these costs?
- *Public reaction.* Will the technology or its use create adverse public reaction? What can be done to respond to or deal with this reaction?

Table 13. Important site characteristics and considerations affecting the selection of remedial measures.

SITE CHARACTERISTICS	CONSIDERATIONS
Waste Considerations	
Quantity	- Determines volume and size of area; affects costs
Chemical make-up	- Determines transport paths, materials of construction
Toxicity	- Calls for immediate action, worker safety
Persistence/ biodegradability	- Resists decomposition/can be treated by biodegradation
Radioactive	- Requires special construction materials; worker safety; site security
Ignitable	- Explosion hazard
Reactivity/ corrosiveness	- Requires special construction materials; potential for explosion
Infectiousness	- Calls for immediate action; worker safety
Solubility	- Affects hydrology migration
Volatility	- Affects migration in gaseous state
Climate	
Precipitation	- Humid areas--abundant surface water, shallow ground-water table
	- Arid areas - high wind and water erosion potential, deep ground-water table
Temperature	- Affects physical processes such as rates of reaction, volatilization, and sealed container pressure, as well as microbial degradation and transformation processes
Surface Temperature	
Soil texture and permeability	- Coarse-textured (sandy) soils have greater permeability and transmit liquid and gases faster than fine-textured (clay) soils
Soil moisture content	- Wet soils are less permeable to gases than dry soils
Slope	- Steeper slopes gave greater runoff, less infiltration
	- Very steep or unbroken slopes have high erosion potential
Vegetation	- Increases filtration, decreases erosion

Table 13. Continued

SITE CHARACTERISTICS	CONSIDERATIONS
Subsurface Characteristics	
Depths to ground water	- Deep--higher pumping costs
	- Shallow--may require lowering water table
Permeability	- Permeable soils readily transmit water and gases
	- Lower permeability causes difficulty in pumping; drainage
Depths to bedrock	- Shallow--impermeable bedrock may cause leachate surface seepage; shallow or deep permeable bedrock may cause rapid and extensive contaminant migration
	- Deep--limit on trench excavation depth
Direction of ground-water flow and points of discharge	- Direction of flow toward point of use presents a significantly adverse impact; points of discharge must be known to assess areal extent of contamination and degree of impact
Receptors	- Nearby working and residual populations, farms, orchards, grazing lands, natural lands, critical habitats may require immediate relief
Existing land use	- Maintenance of site security; protection of equipment and soil cover from accidental abuse; vandalism

Table 14. Items included in a remedial design package.

- Site Description
- Selected Remedy
  - Description of technologies and rationales for selection
  - Performance expectations
  - Site topographic map and preliminary layouts
  - Preliminary design criteria and rationale
  - Preliminary process diagrams
  - General operation and maintenance (O&M) requirements
  - Long-term monitoring requirements
- Remedial Investigation and Impact on Selected Technology
  - Field studies (air, surface water, ground water, geology)
  - Laboratory studies (bench scale, pilot scale)
- Design/Implementation Issues
  - Special technical problems
  - Additional engineering data required
  - Permits and regulatory requirements
  - Access, easements, rights-of-way
  - Health and safety requirements
  - Community relations activities
- Cost Estimates and Schedules
  - Implementation cost estimate (order of magnitude, +50%/-30%)
  - Preliminary estimate of annual O&M cost and duration
  - Project schedule (design, construction, permits, and access)
- Appendices
  - Reports, data summaries, etc.

Source: EPA Superfund Federal-Lead Remedial Project Management Handbook, December 1986. EPA/540/6-87/001. U.S. EPA, Washington, D.C.

Remedy Design

Once appropriate technologies have been identified, a statement of work is prepared describing the proposed project scope, and a remedial design package is developed by one or more contractors. This package consists of detailed plans and specifications for conducting the remedial action. Table 14 summarizes the items included in a remedial design package.

Closure

Site closure occurs when acceptable cleanup levels have been achieved. For sites that are considered disposal sites, monitoring may extend indefinitely. At this time, most remedial technologies do not totally destroy all contaminants; for this reason, some form of disposal and monitoring is generally needed before site closure.

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Chapter 5

CONCLUSION

Highway agencies throughout the United States are experiencing first-hand the problems associated with the unexpected discovery of hazardous wastes. For some, the discovery has been made early in project planning, allowing the agency to take steps to avoid the contaminated parcels. In other cases, the problem has not been easily or always identified early enough and avoided by design modifications. The discovery of wastes on currently or previously owned property has exposed agencies to considerable liabilities and risks. Highway budgets have been impacted because of project delays and overruns. Agency staff and funding resources have also been diverted to unfamiliar hazardous waste cleanup activities and time-consuming litigation as well.

As the present or previous owner of a contaminated parcel of land, the liability faced by a highway agency is potentially enormous. Under current statutes, a highway agency becomes exposed to considerable liability when it decides to knowingly purchase a parcel of land contaminated with hazardous wastes. The agency may also be responsible if it owned property when hazardous wastes were placed there inadvertantly by past agency practices, by third-party illegal disposal practices, or by the activities of lessers of the property.

Claims against a highway agency and its officials can be made for a variety of cleanup costs, as well as personal or property damages. Under different circumstances, suit can be brought

against the agency by a number of plaintiffs—the Federal Government, a local government, or an individual. The agency can be sued under such federal laws as the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), or the Clean Water Act (CWA); under similar state environmental statutes; and under state nuisance, negligence, and trespass laws.

Agency personnel can also be exposed to harmful risks if hazardous wastes are suspected or discovered on a property. During the preliminary site investigation, it is usually not necessary for agency personnel to enter the site. Maps, photographs, databases, and other information services can be examined offsite to determine the potential for discovering wastes. However, if contaminants are determined or suspected based on the preliminary site investigation, a detailed site investigation must be conducted, and this can expose personnel to considerable risks.

The state of the art in conducting hazardous waste site assessments and cleanup activities is fraught with technical and legal uncertainty. Hidden or buried underground, many wastes are not detectable by sight or other physical evidence. If inexperienced in identifying and handling hazardous wastes, workers investigating potential hazardous waste sites are at risk, as are the general public and visitors to the site. Even with a comprehensive site sampling plan and state-of-the-art detection techniques, there is no guarantee that wastes will be found on a site when they actually exist. Changing regulations, limited information on the effectiveness of existing cleanup technologies, the fast-paced development of new cleanup technologies, and the need for the multiple treatments at a single site, also introduce risk into site remediation activities.

The Highway Trust Fund and individual project budgets are not designed to absorb the large costs associated with hazardous waste site assessments and cleanup. In addition, because most highway departments are self-insured, payments for hazardous waste claims come from highway program funds. Payments for hazardous waste-related cleanups and tort claims only defer or cancel important highway projects, and should be avoided wherever possible. While some cleanups are cheaper than others, they are all expensive when they are unexpected, nonbudgeted items that must be assigned to a project.

Because of the ever-present threat of encountering a hazard-

Table 15. Activities of selected highway agencies in developing hazardous waste programs.

Minnesota Department of Transportation

The Minnesota Department of Transportation (Mn/DOT) established an internal Hazardous Waste Task Force in 1985 to provide its District Offices with guidance on hazardous waste issues they were confronting. Since its formation, the Task Force has adopted a policy concerning "Hazardous Waste Considerations in Route or Facility Site Selection." In support of this policy, the Task Force has defined the term "hazardous waste," and contacted offices of those state agencies that maintain lists of hazardous waste sites. Specific procedures have been developed for route or facility site selection (location studies), the preparation of environmental documents, right-of-way acquisition, and site cleanup.

To date, Mn/DOT has also developed a draft policy describing how to respond to releases or abandonment of hazardous materials on department rights-of-way. More detailed information, policy, and procedures are being developed to deal with:

- Underground storage/waste oil tanks.
- Site investigations.
- Options for acquisition.
- Leasing of Mn/DOT property.

Pennsylvania Department of Transportation

The Pennsylvania Department of Transportation has developed a diagram identifying the process for considering hazardous waste sites encountered during highway project development. This diagram describes:

- Procedures to be followed by department staff during preliminary design.
- Specific sources of information on potential hazardous waste sites.
- Options for dealing with different contingencies.
- The role of different federal, state, and local agencies.
- The procedures to be followed when hazardous wastes are discovered during final design and construction.

ous waste site, highway officials should develop operational plans to deal with this problem. Staffing and organizational changes needed to implement this plan should also be made. Every highway agency is unique in its priorities, its internal organization, its staff capabilities, and its resources. An agency must examine its situation, and take steps to train and hire needed in-house staff, coordinate with other agencies, and establish relationships with qualified contractors and consultants. Several state highway agencies have already begun developing operational hazardous waste programs that minimize the potential impact a hazardous waste discovery can have on day-to-day operations. Table 15 summarizes the efforts in four states. Other highway agencies are encouraged to develop operational programs that address their needs.

Having to clean up an unexpected hazardous waste site can have a devastating impact on a state highway program. Preventive measures taken now to improve the management of its real estate can provide highway officials with important assurances that its primary mission to deliver transportation services will not be undermined by the unexpected discovery of a hazardous waste site.

Table 15. Continued

California Department of Transportation

The California Department of Transportation (CALTRANS) has developed a detailed flow chart describing the hazardous waste process during project development. Specific responsibilities are assigned to specific units of the agency, including the Divisions of Engineering Services, Project Development, Facilities Construction, and the Transportation Districts.

Specific guidance has been developed in the following areas and incorporated into the Department's Policy Manual and Procedural Handbooks:

- Property Appraisal: Guidance is provided on how to identify hazardous wastes, notification procedures that should be followed, and how to factor the presence of hazardous wastes into property appraisal.
- Property Acquisition: Procedures to follow when hazardous wastes are encountered are defined. How to obtain permission to enter a property is also discussed.
- Property Management: Information is presented on the definition of hazardous wastes; possible sources of surface contamination; procedures for "tracking" hazardous waste sites that are found; policy and procedures regarding the treatment of underground tanks; and precautions to take when leasing a property.

Florida Department of Transportation

The focus of policy development in the Florida Department of Transportation has been on site assessment and acquisition activities. The department has provided district personnel with hazardous waste site procedures for pre- and post-acquisition activities when acquiring title by taking or settlement for both tank sites and hazardous waste sites. Procedures cover obtaining permission to enter property, site assessment, hazardous waste evaluation, and the abandonment or removal of underground tanks.

To establish a comprehensive hazardous waste site management program, Florida DOT has adopted:

- Contractor specifications for on-site activities.
- Contract provisions for the removal of underground fuel storage tanks.
- Project management training for district personnel covering the policies and procedures.
- Procedures for acquisition where no site assessment has been conducted on potentially contaminated property.

Appendix A

DEFINITION OF HAZARDOUS WASTE

Hazardous wastes are the by-products of a wide variety of manufacturing and service industries. They can be solid, liquids, or gases. They may appear in a variety of forms: in barrels or drums; in pits, ponds, or lagoons; in sludges; as part of contaminated soil; in bottles or other fragile or nondurable containers; in aboveground or underground storage tanks; and as part of building materials (e.g., asbestos).

From a practical point of view, a hazardous waste is any discarded or abandoned substance that may endanger human health or safety. The legal definition of hazardous waste is, however, very important because it determines which substances a highway agency must be concerned about from a liability and regulatory point of view. Congress defined the term "hazardous waste" in Sec. 1004(5) of the Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S.C. § 6901, *et seq.*) as follows:

> The term 'hazardous waste' means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may:
>
> (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or,
>
> (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

The term "solid waste" is further defined in RCRA Sec. 1004(27) as follows:

> The term 'solid waste' means any garbage, refuse, sludge, from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gascous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

EPA has expanded RCRA's definition of a hazardous waste to mean a solid waste that meets one of four conditions:

- It is ***listed*** as a hazardous waste by EPA (see below).
- It is a ***mixture*** of solid waste and one or more of the listed hazardous wastes.
- It exhibits one or more of four ***characteristics:*** ignitability, corrosivity, reactivity, or toxicity.
- It is not ***excluded*** from regulation as a hazardous waste.

EPA HAZARDOUS WASTE LIST

The Environmental Protection Agency maintains a list of hazardous wastes. Most wastes on the list are process residues, emission control dusts, or wastewater treatment sludges. They have been placed on the list and assigned an EPA Hazardous Waste Number because they have been found to be either ignitable, corrosive, reactive, or toxic. EPA periodically adds or deletes substances from the list. In addition, through a process called delisting, a listed waste can be excluded from regulation upon petition to EPA.

The list is divided into three categories: (1) Nonspecific source wastes—listed in 40 C.F.R. § 261.31—these are generic wastes produced by manufacturing and industrial processes. (2) Specific source wastes—listed in 40 C.F.R. § 261.32—this list consists of wastes from specific industries such as petroleum refining and chemical manufacturing. (3) Discarded commercial chemical products—found in 40 C.F.R. §§ 261.33(e) and (f)—this list consists of specific commercial chemical products or chemical manufacturing intermediates.

If a discovered material is identifiable and appears on one of these lists, it is automatically deemed hazardous and will require attention. It is therefore, important that those conducting hazardous waste evaluations become familiar with the EPA lists. These same lists are referred to frequently by EPA and others when promulgating or modifying federal hazardous waste management regulations.

MIXTURES

Any waste mixture containing one or more hazardous wastes that appear on the EPA lists is also considered a hazardous waste. Normally, this applies regardless of the percentage of the mixture that is listed as hazardous waste. However, there are exemptions to this mixture rule, such as those noted in the discussion that follows.

HAZARDOUS WASTE CHARACTERISTICS

If the solid waste is *not* included in the EPA list of hazardous wastes, or is *not* a mixture that contains one of these wastes, it may still be a hazardous waste if testing shows it to be ignitable, corrosive, reactive, or toxic. EPA's definition of these characteristics is contained in 40 C.F.R. §§ 261.20 to 261.24. The standard measures specified by EPA to test for these properties are summarized in Table A-1.

WASTES EXCLUDED FROM REGULATION

EPA has excluded a number of wastewaters, hazardous waste mixtures, and solid wastes from regulation because they do not present a significant threat to human health or the environment. For example, certain mixtures of nonhazardous wastewaters with small amounts of listed hazardous wastes that are discharged into a plant's wastewater treatment unit are exempt. Residues of hazardous wastes in empty containers, discarded arsenical treated wood product wastes, certain tannery wastes, agricultural wastes, and household wastes are among the solid wastes exempt. Secondary materials that are reclaimed and returned to the original process and samples collected for testing and analysis are also exempt from regulation under RCRA. A complete description of substances exempt from RCRA can be found in 40 C.F.R. 261.

Table A-1. Characteristics of hazardous wastes defined by EPA.*

Ignitability

EPA considers wastes with the following characteristics of ignitability to be hazardous:

- Liquids with a flash point (the temperature at which the vapor easily ignites in air) less than 140° F. (The only exceptions are aqueous alchohol solutions containing 24 percent by volume or less of alcohol.)
- Materials that are not liquids and are capable, under standard temperature and pressure, or causing a fire by means of friction, absorption of the moisture, spontaneous chemical changes.
- Materials that burn so vigorously and persistently when ignited that they create a hazard.
- Ignitable compressed gases.
- Oxidizers.

Corrosivity

EPA considers wastes with the following characteristics of corrosivity to be hazardous:

- Aqueous wastes with a pH less than or equal to 2 or greater than or equal to 12.5.
- Liquid wastes that corrode steel at a rate equal to or greater than 0.25 inches per year at a test temperature of 130° F.

Reactivity

EPA considers wastes with the following characteristics of reactivity to be hazardous:

- Materials that are normally unstable and readily undergo violent change without detonating.
- Materials that react violently with water.
- Materials that form potentially explosive mixtures with water.
- Materials that, when mixed with water, will generate toxic gases, vapors, or fumes in quantities sufficient to endanger human health or the environment.
- Cyanide- or sulfide-bearing materials that, when exposed to a pH between 2 and 12.5, can generate sufficient quantities of toxic gases, vapors, or fumes to present a danger.
- Materials capable of detonation or explosive reaction if subject to a strong initiating source or if heated under confinement.

Reactivity (continued)

- Materials that are readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
- Forbidden explosive of Class A (primers, dynamite, and other high-energy explosives) and Class B (propellants, and other low-energy explosives).

Toxicity

EPA defines as toxic those wastes that qualify under the terms of EPA's Extraction Procedure, a test that identifies hazardous concentrations of a constituent in ground water, and the National Interim Primary Drinking Water Standards (NIPDWS). The following steps summarize the determination procedures:

- Constituents are extracted from the wastes in a manner designed to simulate the leaching action that occurs in landfills.
- This extract is analyzed to determine whether it possesses any toxic contaminants identified in NIPDWS.
- If the extract contains any of the contaminants in concentrations 100 times greater than that specified in NIPDWS, the waste is considered hazardous.
- If the original solid waste stream contains less than 0.5% solid matter, then technicians analyze the original solid waste stream rather than the leachate.

Source: Code of Federal Regulations, Title 40, Part 261, Subpart C, Section 261.24.

*Note: EPA issued a "supplemental notice of proposed rulemaking" on May 18, 1987 stating its plan to define some industrial wastes as hazardous based on the type of unit in which they are managed. If adopted, the plan would represent a change in EPA's usual method of identifying wastes as hazardous through their chemical and physical properties.

Appendix B

SAMPLE HAZARDOUS WASTE SITE EVALUATION FORM

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 1 - SITE INFORMATION AND ASSESSMENT

I. IDENTIFICATION

01 STATE	02 SITE NUMBER

II. SITE NAME AND LOCATION

01 SITE NAME *(Legal, common, or descriptive name of site)*	02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER				
03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE	08 CONG DIST
09 COORDINATES LATITUDE ___ ___ ___.___ LONGITUDE ___ ___ ___.___					

10 DIRECTIONS TO SITE *(Starting from nearest public road)*

III. RESPONSIBLE PARTIES

01 OWNER *(If known)*	02 STREET *(Business, mailing, residential)*			
03 CITY	04 STATE	05 ZIP CODE	06 TELEPHONE NUMBER ( )	
07 OPERATOR *(If known and different from owner)*	08 STREET *(Business, mailing, residential)*			
09 CITY	10 STATE	11 ZIP CODE	12 TELEPHONE NUMBER ( )	

13 TYPE OF OWNERSHIP *(Check one)*

☐ A. PRIVATE ☐ B. FEDERAL: _____ *(Agency name)* ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL

☐ F. OTHER: _____ *(Specify)* ☐ G. UNKNOWN

14 OWNER/OPERATOR NOTIFICATION ON FILE *(Check all that apply)*

☐ A. RCRA 3001 DATE RECEIVED: ___/___/___ MONTH DAY YEAR ☐ B. UNCONTROLLED WASTE SITE *(CERCLA 103 c)* DATE RECEIVED: ___/___/___ MONTH DAY YEAR ☐ C. NONE

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 ON SITE INSPECTION

☐ YES DATE ___/___/___ MONTH DAY YEAR
☐ NO

BY *(Check all that apply)*

☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. STATE ☐ D. OTHER CONTRACTOR
☐ E. LOCAL HEALTH OFFICIAL ☐ F. OTHER: _____ *(Specify)*

CONTRACTOR NAME(S): _____

02 SITE STATUS *(Check one)*	03 YEARS OF OPERATION
☐ A. ACTIVE ☐ B. INACTIVE ☐ C. UNKNOWN	___ BEGINNING YEAR ___ ENDING YEAR ☐ UNKNOWN

04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED

05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION

V. PRIORITY ASSESSMENT

01 PRIORITY FOR INSPECTION *(Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)*

☐ A. HIGH *(Inspection required promptly)* ☐ B. MEDIUM *(Inspection required)* ☐ C. LOW *(Inspect on time available basis)* ☐ D. NONE *(No further action needed, complete current disposition form)*

VI. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF *(Agency/Organization)*			03 TELEPHONE NUMBER ( )
04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER ( )	08 DATE ___/___/___ MONTH DAY YEAR

EPA FORM 2070-12 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- _ A SOLID
- _ B POWDER, FINES
- _ C SLUDGE
- _ D OTHER _____ (Specify)
- _ E SLURRY
- _ F LIQUID
- _ G GAS

02 WASTE QUANTITY AT SITE

Measures of waste quantities must be independent

TONS _____

CUBIC YARDS _____

NO. OF DRUMS _____

03 WASTE CHARACTERISTICS (Check all that apply)

- _ A TOXIC
- _ B CORROSIVE
- _ C RADIOACTIVE
- _ D PERSISTENT
- _ E SOLUBLE
- _ F INFECTIOUS
- _ G FLAMMABLE
- _ H IGNITABLE
- _ I HIGHLY VOLATILE
- _ J EXPLOSIVE
- _ K REACTIVE
- _ L INCOMPATIBLE
- _ M NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE			
SOL	SOLVENTS			
PSD	PESTICIDES			
OCC	OTHER ORGANIC CHEMICALS			
IOC	INORGANIC CHEMICALS			
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for most frequently cited CAS Numbers)

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS			FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

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EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☐ A. GROUNDWATER CONTAMINATION 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ B. SURFACE WATER CONTAMINATION 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ C. CONTAMINATION OF AIR 03 POPULATION POTENTIALLY AFFECTED:	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ D. FIRE/EXPLOSIVE CONDITIONS 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ E. DIRECT CONTACT 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ F. CONTAMINATION OF SOIL 03 AREA POTENTIALLY AFFECTED: _____ (Acres)	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ G. DRINKING WATER CONTAMINATION 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ H. WORKER EXPOSURE/INJURY 03 WORKERS POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED
01 ☐ I. POPULATION EXPOSURE/INJURY 03 POPULATION POTENTIALLY AFFECTED: _____	02 ☐ OBSERVED (DATE: _____) 04 NARRATIVE DESCRIPTION	☐ POTENTIAL	☐ ALLEGED

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EPA

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER

II. HAZARDOUS CONDITIONS AND INCIDENTS *(Continued)*

01 ☐ J. DAMAGE TU FLORA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION *(Include name(s) of species)*

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES *(Spills/runoff/standing liquids/leaking drums)* — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

III. TOTAL POPULATION POTENTIALLY AFFECTED: _____

IV. COMMENTS

V. SOURCES OF INFORMATION *(Cite specific references, e.g., state files, sample analysis reports)*

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POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT

General Information

The Potential Hazardous Waste Site, Preliminary Assessment form is used to record information necessary to make an initial evaluation of the potential risk posed by a site and to recommend further action.

The Preliminary Assessment form contains three parts:

Part 1 – Site Information and Assessment

Part 2 – Waste Information

Part 3 – Description of Hazardous Conditions and Incidents

Part 1 – Site Information and Assessment contains all of the data elements also contained on the Site Identification form required to add a site to the automated Site Tracking System (STS). It is therefore possible to add a site to STS at the Preliminary Assessment stage. Instructions are given below.

Part 2 – Waste Information and Part 3 – Description of Hazardous Conditions and Incidents are used to record specific information about substances, amounts, hazards, and targets, e.g., population potentially affected, that are used in determining the priority for further action. Parts 2 and 3 are also contained in the Potential Hazardous Waste Site, Site Inspection Report form where they may be used to update, add, delete, or correct information supplied on the Preliminary Assessment.

An Appendix with feedstock names and CAS Numbers and the most frequently cited hazardous substances and CAS Numbers is located behind the instructions for the Preliminary Assessment.

General Instructions

1. Complete the Preliminary Assessment form as completely as possible.

2. Starred items (*) are required before assessment information can be added to STS. The system will not accept incomplete assessment information.

3. To add a site to STS at the Preliminary Assessment stage, write "New" across the top of the form and complete items II-01, 02, 03, 04, and 06, Site Name and Location, and item III-13, Type of Ownership.

4. Data items carried in STS, which are identical to those on the Site Identification form and which can be added, deleted, or changed using the Preliminary Assessment form, are indicated with a pound sign (#). To ensure that the proper action is taken, outline the item(s) to be added, deleted, or changed with a bright color and indicate the proper action with "A" (add), "D" (delete), or "C" (change).

5. There are two options available for adding, deleting, or changing information supplied on the Preliminary Assessment form. The first is to use a new Preliminary Assessment form, completing only those items to be added, deleted, or changed. Mark the form clearly, using "A", "D", or "C", to indicate the action to be taken. If only data carried in STS are to be altered, the Site Source Data Report may be used. Using the report, mark clearly the items to be changed and the action to be taken.

Detailed Instructions

Part 1 Site Information and Assessment

I. **Identification**: Identification (State and Site Number) is the site record key, or primary identifier, for the site. Site records in the STS are updated based on Identification. It is essential that State and Site Number are correctly entered on each form.

*I-01 State: Enter the two character alpha FIPS code for the state in which the site is located. It must be identical to State on the Site Identification form.

*I-02 Site Number: Enter the ten character alphanumeric code for sites which have a Dun and Bradstreet or EPA "user" Dun and Bradstreet number or the ten character numeric GSA identification code for federal sites. The Site Number must be identical to the Site Number on the Site Identification form.

II. **Site Name and Location**: If Site Name and Location information require no additions or changes, these items are not required on the Preliminary Assessment form. However, completing these items will facilitate use of the completed form and records management procedures.

#II-01 Site Name: Enter the legal, common, or descriptive name of the site.

#II-02 Site Street: Enter the street address and number (if appropriate) where the site is located. If the precise street address is unavailable for this site, enter brief direction identifier, e.g., NW intersection I-295 & US 99; Post Rd, 5 mi W of Rt. 5.

#II-03 Site City: Enter the city, town, village, or other municipality in which the site is located. If the site is not located in a municipality, enter the name of the municipality (or place) which is nearest the site or which most easily locates the site.

#II-04 Site State: Enter the two character alpha FIPS code for the state in which the site is located. The code must be the same as in item I-01.

#II-05 Site Zip Code: Enter the five character numeric zip code for the postal zone in which the site is located.

#II-06 Site County: Enter the name of the county, parish (Louisiana), or borough (Alaska) in which the site is located.

#II-07 County Code: Enter the three character numeric FIPS county code for the county, parish, or borough in which the site is located. (The regional data analyst will furnish this data item.)

#II-08 Site Congressional District: Enter the two character number for the congressional district in which the site is located.

II-09 Coordinates: Enter the Coordinates, Latitude and Longitude, of the site in degrees, minutes, seconds and tenths of seconds. If a tenth of a second is insignificant at this site, enter "0".

II-10 Directions to Site: Starting from the nearest public road, provide narrative directions to the site.

III. **Responsible Parties**

#III-01 Site Owner: Enter the name of the owner of the site. The site owner is the person, company, or federal, state, municipal or other public or private entity, who currently holds title to the property on which the site is located.

#III-02 -03 -04 -05 Site Owner Address: Enter the current complete business, residential, or mailing address at which the owner of the site can be reached.

III-06 Site Owner Telephone Number: Enter the area code and local telephone number at which the owner of the site can be reached.

#III-07 Site Operator: If different from Site Owner, enter the name of the operator at the site. The site operator is the person, company, or federal, state, municipal or other public or private entity, who currently, or most recently, is, or was, responsible for operations at the site.

#III-08 -09 -10 -11 Site Operator Address: Enter the current complete business, residential, or mailing address at which the operator of the site can be reached.

III-12 Site Operator Telephone Number: Enter the area code and local telephone number at which the operator of the site can be reached.

#III-13 Type of Ownership: Check the appropriate box to indicate the type of site ownership. If the site is under the jurisdiction of an activity of the federal government, enter the name of the department, agency, or activity. If Other is indicated, specify the type of ownership and name.

III-14 Owner/Operator Notification On File: Check the appropriate box(es) to indicate that the notification required by RCRA (3001) and/or CERCLA (103c, Superfund) have been received. If received, enter the date(s) received. Check none if not received.

IV **Characterization of Potential Hazard**

IV-01 On Site Inspection: Check the appropriate box to indicate that the site has been inspected or visited by EPA, a state or local official, or a contractor representative of EPA or a state or local government. Enter the date of the inspection. Check the appropriate box(es) to indicate who visited the site or performed the inspection. If the site visit was performed by a contractor, enter the name of the company.

*IV-02 Site Status: Check the appropriate box(es) to indicate the current status of the site. Active sites are those which treat, store, or dispose of wastes. Check Active for those active sites with an inactive storage or disposal area. Inactive sites are those at which treatment, storage, or disposal activities no longer occur.

IV-03 Years of Operation: Enter the beginning and ending years (or beginning only if operations at the site are on-going), e.g., 1878/1932, of waste treatment, storage, and/or disposal activities at the site. Check Unknown if the years of operation are not known.

IV-04 Description of Substances Possibly Present, Known, or Alleged: Provide a narrative description of hazardous, potentially hazardous, or other substances present, or claimed to be present, at the site.

IV-05 Description of Potential Hazard to Environment and/or Population: Provide a narrative description of the potential hazard the site poses to the environment and to exposed population or wildlife. If no hazard, or potential hazard, exists, provide the basis for that determination.

V. **Priority Assessment**

*V-01 Priority for Inspection: Check the appropriate box to indicate the priority for further action or inspection. If no further action is required, complete the Potential Hazardous Waste Site, Current Disposition form. The Priority for Inspection assessed must be supported by appropriate data in Part 2 – Waste Information and Part 3 – Description of Hazardous Conditions and Incidents of this form. If no hazardous conditions exist, Part 3 is not required.

VI. **Information Available From**

VI-01 Contact: Enter the name of the individual who can provide information about the site.

VI-02 Of: If appropriate, enter the name of the Public or private agency, firm, or company and the organization within the agency, firm, or company of the individual named as Contact.

VI-03 Telephone Number: Enter the area code and local telephone number of the individual named as contact.

VI-04 Person Responsible for Assessment: Enter the name of the individual who made the site assessment and assigned the priority rating to the site. The person responsible for the assessment may be different from the individual who prepared the form.

VI-05 Agency: Enter the name of the Agency where the individual who made the assessment is employed.

VI-06 Organization: Enter the name of the organization within the Agency.

VI-07 Telephone Number: Enter the area code and local telephone number of the individual who made the assessment.

VI-08 Date: Enter the date the assessment was made.

Part 2 Waste Information

*I. **Identification**: Refer to Part 1–I.

II. **Waste States, Quantities, and Characteristics**: Waste States, Quantities, and Characteristics provide information about the physical structure and form of the waste, measures of gross amounts at the site, and the hazards posed by the waste, considering acute and chronic health effects and mobility along a pathway.

*II-01 Physical States: Check the appropriate box(es) to indicate the state(s) of waste present, or thought to be present, at the site. If Other is indicated, specify the physical state of the waste.

*II-02 Waste Quantity at Site: Enter estimates of amounts of waste at the site. Estimates may be in weight (Tons) or volume (Cubic Yards or Number of Drums). Use as many entries as are appropriate; however, measurements must be independent. For

example, do not measure the same amounts of waste as both tons and cubic yards.

*II-03 **Waste Characteristics:** Check all appropriate entries to indicate the hazards posed by waste at the site. If waste at the site poses no hazard, check Not Applicable.

III. **Waste Category:** General categories of waste typically found are listed here. Enter the estimated gross amount of the category of waste next to the appropriate substance name and enter the unit of measure used with the estimate.

*III-01 Gross Amount: Gross Amount is the estimate of the amount of the waste category found at the site. Estimates should be furnished in metric tons (MT), tons (TN), cubic meters (CM), cubic yards (CY), drums (DR), acres (AC), acre feet (AF), liters (LT), or gallons (GA). Enter the estimated amount next to the appropriate waste category.

*III-02 Unit of Measure: Enter the appropriate unit of measure: MT (metric tons),TN (tons), CM (cubic meters), CY (cubic yards), DR (number of drums), AC (acres), AF (acre feet), LT (liters), or GA (gallons), next to the estimate of gross amount.

III-03 Comments: Comments may be used to further explain, or provide additional information, about particular waste categories.

IV. **Hazardous Substances:** Specific hazardous, or potentially hazardous, chemicals, mixtures, and substances found at the site are listed here. This information may not be available at the Preliminary Assessment stage. Substances for which information is available are to be listed here. For each substance listed those data items marked with an "at" sign (@) must be included.

@IV-01 Category: Enter in front of the substance name the three character waste category from Section III which best describes the substance, e.g., OLW (Oily Waste).

@IV-02 Substance Name: Enter one of the following: the name of the substance registered with the Chemical Abstract Service, the common or accepted abbreviation of the substance, the generic name of the substance, or commercial name of the substance.

@IV-03 CAS Number: Enter the number assigned to the substance when it was registered with the Chemical Abstract Service. Refer to the Appendix for most frequently cited CAS Numbers. CAS Numbers must be furnished for each substance listed. If a CAS Number for this substance has not been assigned, enter "999".

@IV-04 Storage/Disposal Method: Enter the type of storage or disposal facility in which the substance was found: SI (surface impoundment, including pits, ponds, and lagoons), PL (pile), DR (drum), TK (tank), LF (landfill), LM (landfarm), OD (open dump).

IV-05 Concentration: Enter the concentration of the substance found in samples taken at the site.

IV-06 Measure of Concentration: Enter the appropriate unit of measure for the measured concentration of the substance found in the sample, e.g., MG/L, UG/L.

V. **Feedstocks**

V-01 Feedstock Name: If feedstocks, or substances derived from one or more feedstocks, are present at the site, enter the name of each feedstock found. See the Appendix for the feedstock list.

V-02 CAS Number: Enter the CAS Number for each feedstock named. See the Appendix for feedstock CAS Numbers.

VI. **Sources of Information:** List the sources used to obtain information for this form. Sources cited may include: sample analysis, reports, inspections, official records, or other documentation. Sources cited provide the basis for information entered on the form and may be used to obtain further information about the site.

Part 3 Description of Hazardous Conditions and Incidents

*I. **Identification:** Refer to Part 1—I.

II. **Hazardous Conditions and Incidents:**

II-01 Hazards: Indicate each hazardous, or potentially hazardous, condition known, or claimed, to exist at the site.

II-02 Observed, Potential, or Alleged: Check Observed and enter the date, or approximate date, of occurrence if a release of contaminants to the environment, or some other hazardous incident, is known to have occurred. In cases of a continuing release, e.g., groundwater contamination, enter the date, or approximate date, the condition first became apparent. If conditions exist for a potential release, check potential. Check Alleged for hazardous, or potentially hazardous, conditions claimed to exist at the site.

II-03 Population Potentially Affected: For each hazardous condition at the site, enter the number of people potentially affected. For Soil enter the number of acres potentially affected.

II-04 Narrative Description: Provide a narrative description, or explanation, of each condition. Include any additional information which further explains the condition.

II-05 Description of Any Other Known, Potential, or Alleged Hazards: Provide a narrative description of any other hazardous, or potentially hazardous, conditions at the site not covered above.

III. **Total Population Potentially Affected:** Enter the total number of people potentially affected by the existence of hazardous, or potentially hazardous, conditions at the site. Do not sum the numbers shown for each condition.

IV. **Comments:** Other information relevant to observed, potential, or alleged hazards may be entered here.

V. **Sources of Information:** List the sources used to obtain information for this form. Sources cited may include: sample analysis, reports, inspections, official records, or other documentation. Sources cited provide the basis for information entered on the form and may be used to obtain further information about the site.

APPENDIX

I. FEEDSTOCKS

CAS Number	Chemical Name
1. 7664-41-7	Ammonia
2. 7440-36-0	Antimony
3. 1309-64-4	Antimony Trioxide
4. 7440-38-2	Arsenic
5. 1327-53-3	Arsenic Trioxide
6. 21109-95-5	Barium Sulfide
7. 7726-95-6	Bromine
8. 106-99-0	Butadiene
9. 7440-43-9	Cadmium
10. 7782-50-5	Chlorine
11. 12737-27-8	Chromite
12. 7440-47-3	Chromium
13. 7440-48-4	Cobalt
14. 1317-38-0	Cupric Oxide
15. 7758-98-7	Cupric Sulfate
16. 1317-39-1	Cuprous Oxide
17. 74-85-1	Ethylene
18. 7647-01-0	Hydrochloric Acid
19. 7664-39-3	Hydrogen Fluoride
20. 1335-26-7	Lead Oxide
21. 7439-97-6	Mercury
22. 74-82-8	Methane
23. 91-20-3	Napthalene
24. 7440-02-0	Nickel
25. 7697-37-2	Nitric Acid
26. 7723-14-0	Phosphorus
27. 7778-50-9	Potassium Dichromate
28. 1310-58-3	Potassium Hydroxide
29. 115-07-1	Propylene
30. 10588-01-9	Sodium Dichromate
31. 1310-73-2	Sodium Hydroxide
32. 7646-78-8	Stannic Chloride
33. 7772-99-8	Stannous Chloride
34. 7664-93-9	Sulfuric Acid
35. 108-88-3	Toluene
36. 1330-20-7	Xylene
37. 7646-85-7	Zinc Chloride
38. 7733-02-0	Zinc Sulfate

II. HAZARDOUS SUBSTANCES

CAS Number	Chemical Name
1. 75-07-0	Acetaldehyde
2. 64-19-7	Acetic Acid
3. 108-24-7	Acetic Anhydride
4. 75-86-5	Acetone Cyanohydrin
5. 506-96-7	Acetyl Bromide
6. 75-36-5	Acetyl Chloride
7. 107-02-8	Acrolein
8. 107-13-1	Acrylonitrile
9. 124-04-9	Adipic Acid
10. 309-00-2	Aldrin
11. 10043-01-3	Aluminum Sulfate
12. 107-18-6	Allyl Alcohol
13. 107-05-1	Allyl Chloride
14. 7664-41-7	Ammonia
15. 631-61-8	Ammonium Acetate
16. 1863-63-4	Ammonium Benzoate
17. 1066-33-7	Ammonium Bicarbonate
18. 7789-09-5	Ammonium Bichromate
19. 1341-49-7	Ammonium Bifluoride
20. 10192-30-0	Ammonium Bisulfite
21. 1111-78-0	Ammonium Carbamate
22. 12125-02-9	Ammonium Chloride
23. 7788-98-9	Ammonium Chromate
24. 3012-65-5	Ammonium Citrate, Dibasic
25. 13826-83-0	Ammonium Fluoborate
26. 12125-01-8	Ammonium Fluoride
27. 1336-21-6	Ammonium Hydroxide
28. 6009-70-7	Ammonium Oxalate
29. 16919-19-0	Ammonium Silicofluoride
30. 7773-06-0	Ammonium Sulfamate
31. 12135-76-1	Ammonium Sulfide
32. 10196-04-0	Ammonium Sulfite
33. 14307-43-8	Ammonium Tartrate
34. 1762-95-4	Ammonium Thiocyanate
35. 7783-18-8	Ammonium Thiosulfate
36. 628-63-7	Amyl Acetate
37. 62-53-3	Aniline
38. 7647-18-9	Antimony Pentachloride
39. 7789-61-9	Antimony Tribromide
40. 10025-91-9	Antimony Trichloride
41. 7783-56-4	Antimony Trifluoride
42. 1309-64-4	Antimony Trioxide
43. 1303-32-8	Arsenic Disulfide
44. 1303-28-2	Arsenic Pentoxide
45. 7784-34-1	Arsenic Trichloride
46. 1327-53-3	Arsenic Trioxide
47. 1303-33-9	Arsenic Trisulfide
48. 542-62-1	Barium Cyanide
49. 71-43-2	Benzene
50. 65-85-0	Benzoic Acid
51. 100-47-0	Benzonitrile
52. 98-88-4	Benzoyl Chloride
53. 100-44-7	Benzyl Chloride
54. 7440-41-7	Beryllium
55. 7787-47-5	Beryllium Chloride
56. 7787-49-7	Beryllium Fluoride
57. 13597-99-4	Beryllium Nitrate
58. 123-86-4	Butyl Acetate
59. 84-74-2	n-Butyl Phthalate
60. 109-73-9	Butylamine
61. 107-92-6	Butyric Acid
62. 543-90-8	Cadimium Acetate
63. 7789-42-6	Cadmium Bromide
64. 10108-64-2	Cadmium Chloride
65. 7778-44-1	Calcium Arsenate
66. 52740-16-6	Calcium Arsenite
67. 75-20-7	Calcium Carbide
68. 13765-19-0	Calcium Chromate
69. 592-01-8	Calcium Cyanide
70. 26264-06-2	Calcium Dodecylbenzene Sulfonate
71. 7778-54-3	Calcium Hypochlorite
72. 133-06-2	Captan
73. 63-25-2	Carbaryl
74. 1563-66-2	Carbofuran
75. 75-15-0	Carbon Disulfide
76. 56-23-5	Carbon Tetrachloride
77. 57-74-9	Chlordane
78. 7782-50-5	Chlorine
79. 108-90-7	Chlorobenzene
80. 67-66-3	Chloroform
81. 7790-94-5	Chlorosulfonic Acid
82. 2921-88-2	Chlorpyrifos
83. 1066-30-4	Chromic Acetate
84. 7738-94-5	Chromic Acid
85. 10101-53-8	Chromic Sulfate
86. 10049-05-5	Chromous Chloride
87. 544-18-3	Cobaltous Formate
88. 14017-41-5	Cobaltous Sulfamate
89. 56-72-4	Coumaphos
90. 1319-77-3	Cresol
91. 4170-30-3	Crotonaldehyde
92. 142-71-2	Cupric Acetate
93. 12002-03-8	Cupric Acetoarsenite
94. 7447-39-4	Cupric Chloride
95. 3251-23-8	Cupric Nitrate
96. 5893-66-3	Cupric Oxalate
97. 7758-98-7	Cupric Sulfate
98. 10380-29-7	Cupric Sulfate Ammoniated
99. 815-82-7	Cupric Tartrate
100. 506-77-4	Cyanogen Chloride
101. 110-82-7	Cyclohexane
102. 94-75-7	2,4-D Acid
103. 94-11-1	2,4-D Esters
104. 50-29-3	DDT
105. 333-41-5	Diazinon
106. 1918-00-9	Dicamba
107. 1194-65-6	Dichlobenil
108. 117-80-6	Dichlone
109. 25321-22-6	Dichlorobenzene (all isomers)
110. 266-38-19-7	Dichloropropane (all isomers)
111. 26952-23-8	Dichloropropene (all isomers)
112. 8003-19-8	Dichloropropene-Dichloropropane Mixture
113. 75-99-0	2-2-Dichloropropionic Acid
114. 62-73-7	Dichlorvos
115. 60-57-1	Dieldrin
116. 109-89-7	Diethylamine
117. 124-40-3	Dimethylamine
118. 25154-54-5	Dinitrobenzene (all isomers)
119. 51-28-5	Dinitrophenol
120. 25321-14-6	Dinitrotoluene (all isomers)
121. 85-00-7	Diquat
122. 298-04-4	Disulfoton
123. 330-54-1	Diuron
124. 27176-87-0	Dodecylbenzenesulfonic Acid
125. 115-29-7	Endosulfan (all isomers)
126. 72-20-8	Endrin and Metabolites
127. 106-89-8	Epichlorohydrin
128. 563-12-2	Ethion
129. 100-41-4	Ethyl Benzene
130. 107-15-3	Ethylenediamine
131. 106-93-4	Ethylene Dibromide
132. 107-06-2	Ethylene Dichloride
133. 60-00-4	EDTA
134. 1185-57-5	Ferric Ammonium Citrate
135. 2944-67-4	Ferric Ammonium Oxalate
136. 7705-08-0	Ferric Chloride

II. HAZARDOUS SUBSTANCES

CAS Number	Chemical Name
137. 7783-50-8	Ferric Fluoride
138. 10421-48-4	Ferric Nitrate
139. 10028-22-5	Ferric Sulfate
140. 10045-89-3	Ferrous Ammonium Sulfate
141. 7758-94-3	Ferrous Chloride
142. 7720-78-7	Ferrous Sulfate
143. 206-44-0	Fluoranthene
144. 50-00-0	Formaldehyde
145. 64-18-6	Formic Acid
146. 110-17-8	Fumaric Acid
147. 98-01-1	Furfural
148. 86-50-0	Guthion
149. 76-44-8	Heptachlor
150. 118-74-1	Hexachlorobenzene
151. 87-68-3	Hexachlorobutadiene
152. 67-72-1	Hexachloroethane
153. 70-30-4	Hexachlorophene
154. 77-47-4	Hexachlorocyclopentadiene
155. 7647-01-0	Hydrochloric Acid (Hydrogen Chloride)
156. 7664-39-3	Hydrofluoric Acid (Hydrogen Fluoride)
157. 74-90-8	Hydrogen Cyanide
158. 7783-06-4	Hydrogen Sulfide
159. 78-79-5	Isoprene
160. 42504-46-1	Isopropanolamine Dodecylbenzenesulfonate
161. 115-32-2	Kelthane
162. 143-50-0	Kepone
163. 301-04-2	Lead Acetate
164. 3687-31-8	Lead Arsenate
165. 7758-95-4	Lead Chloride
166. 13814-96-5	Lead Fluoborate
167. 7783-46-2	Lead Fluoride
168. 10101-63-0	Lead Iodide
169. 18256-98-9	Lead Nitrate
170. 7428-48-0	Lead Stearate
171. 15739-80-7	Lead Sulfate
172. 1314-87-0	Lead Sulfide
173. 592-87-0	Lead Thiocyanate
174. 58-89-9	Lindane
175. 14307-35-8	Lithium Chromate
176. 121-75-5	Malthion
177. 110-16-7	Maleic Acid
178. 108-31-6	Maleic Anhydride
179. 2032-65-7	Mercaptodimethur
180. 592-04-1	Mercuric Cyanide
181. 10045-94-0	Mercuric Nitrate
182. 7783-35-9	Mercuric Sulfate
183. 592-85-8	Mercuric Thiocyanate
184. 10415-75-5	Mercurous Nitrate
185. 72-43-5	Methoxychlor
186. 74-93-1	Methyl Mercaptan
187. 80-62-6	Methyl Methacrylate
188. 298-00-0	Methyl Parathion
189. 7786-34-7	Mevinphos
190. 315-18-4	Mexacarbate
191. 75-04-7	Monoethylamine
192. 74-89-5	Monomethylamine
193. 300-76-5	Naled
194. 91-20-3	Naphthalene
195. 1338-24-5	Nephthenic Acid
196. 7440-02-0	Nickel
197. 15699-18-0	Nickel Ammonium Sulfate
198. 37211-05-5	Nickel Chloride
199. 12054-48-7	Nickel Hydroxide
200. 14216-75-2	Nickel Nitrate
201. 7786-81-4	Nickel Sulfate
202. 7697-37-2	Nitric Acid
203. 98-95-3	Nitrobenzene
204. 10102-44-0	Nitrogen Dioxide
205. 25154-55-6	Nitrophenol (all isomers)
206. 1321-12-6	Nitrotoluene
207. 30525-89-4	Paraformaldehyde
208. 56-38-2	Parathion
209. 608-93-5	Pentachlorobenzene
210. 87-86-5	Pentachlorophenol
211. 85-01-8	Phenanthrene
212. 108-95-2	Phenol
213. 75-44-5	Phosgene
214. 7664-38-2	Phosphoric Acid
215. 7723-14-0	Phosphorus
216. 10025-87-3	Phosphorus Oxychloride
217. 1314-80-3	Phosphorus Pentasulfide
218. 7719-12-2	Phosphorus Trichloride
219. 7784-41-0	Potassium Arsenate
220. 10124-50-2	Potassium Arsenite
221. 7778-50-9	Potassium Bichromate
222. 7789-00-6	Potassium Chromate
223. 7722-64-7	Potassium Permanganate
224. 2312-35-8	Propargite
225. 79-09-4	Propionic Acid
226. 123-62-6	Propionic Anhydride
227. 1336-36-3	Polychlorinated Biphenyls
228. 151-50-8	Potassium Cyanide
229. 1310-58-3	Potassium Hydroxide
230. 75-56-9	Propylene Oxide
231. 121-29-9	Pyrethrins
232. 91-22-5	Quinoline
233. 108-46-3	Resorcinol
234. 7446-08-4	Selenium Oxide
235. 7761-88-8	Silver Nitrate
236. 7631-89-2	Sodium Arsenate
237. 7784-46-5	Sodium Arsenite
238. 10588-01-9	Sodium Bichromate
239. 1333-83-1	Sodium Bifluoride
240. 7631-90-5	Sodium Bisulfite
241. 7775-11-3	Sodium Chromate
242. 143-33-9	Sodium Cyanide
243. 25155-30-0	Sodium Dodecylbenzene Sulfonate
244. 7681-49-4	Sodium Fluoride
245. 16721-80-5	Sodium Hydrosulfide
246. 1310-73-2	Sodium Hydroxide
247. 7681-52-9	Sodium Hypochlorite
248. 124-41-4	Sodium Methylate
249. 7632-00-0	Sodium Nitrate
250. 7558-79-4	Sodium Phosphate, Dibasic
251. 7601-54-9	Sodium Phosphate, Tribasic
252. 10102-18-8	Sodium Selenite
253. 7789-06-2	Strontium Chromate
254. 57-24-9	Strychnine and Salts
255. 100-420-5	Styrene
256. 12771-08-3	Sulfur Monochloride
257. 7664-93-9	Sulfuric Acid
258. 93-76-5	2,4,5-T Acid
259. 2008-46-0	2,4,5-T Amines
260. 93-79-8	2,4,5-T Esters
261. 13560-99-1	2,4,5-T Salts
262. 93-72-1	2,4,5-TP Acid
263. 32534-95-5	2,4,5-TP Acid Esters
264. 72-54-8	TDE
265. 95-94-3	Tetrachlorobenzene
266. 127-18-4	Tetrachloroethane
267. 78-00-2	Tetraethyl Lead
268. 107-49-3	Tetraethyl Pyrophosphate
269. 7446-18-6	Thallium (I) Sulfate
270. 108-88-3	Toluene
271. 8001-35-2	Toxaphene
272. 12002-48-1	Trichlorobenzene (all isomers)
273. 52-68-6	Trichlorfon
274. 25323-89-1	Trichloroethane (all isomers)
275. 79-01-6	Trichloroethylene
276. 25167-82-2	Trichlorophenol (all isomers)
277. 27323-41-7	Triethanolamine Dodecylbenzenesulfonate
278. 121-44-8	Triethylamine
279. 75-50-3	Trimethylamine
280. 541-09-3	Uranyl Acetate
281. 10102-06-4	Uranyl Nitrate
282. 1314-62-1	Vanadium Pentoxide
283. 27774-13-6	Vanadyl Sulfate
284. 108-05-4	Vinyl Acetate
285. 75-35-4	Vinylidene Chloride
286. 1300-71-6	Xylenol
287. 557-34-6	Zinc Acetate
288. 52628-25-8	Zinc Ammonium Chloride
289. 1332-07-6	Zinc Borate
290. 7699-45-8	Zinc Bromide
291. 3486-35-9	Zinc Carbonate
292. 7646-85-7	Zinc Chloride
293. 557-21-1	Zinc Cyanide
294. 7783-49-3	Zinc Fluoride
295. 557-41-5	Zinc Formate
296. 7779-86-4	Zinc Hydrosulfite
297. 7779-88-6	Zinc Nitrate
298. 127-82-2	Zinc Phenolsulfonate
299. 1314-84-7	Zinc Phosphide
300. 16871-71-9	Zinc Silicofluoride
301. 7733-02-0	Zinc Sulfate
302. 13746-89-9	Zirconium Nitrate
303. 16923-95-8	Zirconium Potassium Fluoride
304. 14644-61-2	Zirconium Sulfate
305. 10026-11-6	Zirconium Tetrachloride

Appendix C—REMEDIAL ACTION TECHNOLOGIES

Table C-1. Selected control methods.[a]

TYPE	PURPOSE	ADVANTAGES	DISADVANTAGES
Capping/Sealing (e.g., clay, cement, asphalt, synthetics, fly ash, rock, sand, gravel, multimedia, chemical sealants/ stabilizers)	As part of a containment system (e.g., landfill), prevents and restricts surface water infiltration and leachate formation. Controls erosion and contains contaminated wastes. Preferred material depends on waste type, hydrogeologic conditions, and cost.	When local soils can be used, expense is lessened. Blending soils can create effective seals with low permeability.	Caps and seals subject to damage by weather, erosion, and burrowing animals. Rigid barriers (e.g., concrete) are vulnerable to cracking and chemical deterioration. Effective life of these methods is limited; maintenance, repairs, and eventual replacement is necessary.
Containment Barriers (e.g., grout curtains, slurry walls, steel sheet piling, vibrating beams)	A variety of methods which employ walls or diversions to contain, capture, or redirect ground-water flow at or near a site of contamination. Slurry walls are the most commonly used. Bottom sealing techniques (e.g., block displacement, grout injection) are still being developed.	Some methods are relatively inexpensive and are relatively impermeable. Once installed, most methods require no operation and little maintenance.	Some techniques or designs may not be suitable for certain soils, wastes, or geologic formations. Potential for soil disruption, dust hazards, increase or decrease of ground-water heads, ground-water contamination. Monitoring necessary.
Diversion/ Collection Systems (e.g., dikes, berms, terraces, benches, chutes, downpipes, seepage basins, sedimentation basins and ponds, levees, floodwalls)	Divert and collect surface water and leachate. Isolate waste site from surface infiltration. Some methods used during excavation and removal to temporarily segregate incompatible wastes.	Reduce rates of surface run-off and control erosion of cover material. Most materials are generally found on-site. Most design and construction techniques are well-established.	Generally a temporary measure. Construction may disturb wastes in soils.

Table C-1. Continued

TYPE	PURPOSE	ADVANTAGES	DISADVANTAGES
Excavation and Removal (e.g., backhoe, dragline, clamshell bucket, industrial vacuums, drum grapplers, forklifts)	Remove hazardous waste from an uncontrolled site for further on-site or off-site treatment.	Equipment readily available. Used for large areas. May be used as an emergency control measure.	Disturbed soils may release pollutants into surface or ground water. These techniques are only capable of reaching a limited depth for removal activities.
Gas Migration Systems (e.g., pipe vents, trench vents, gas barriers, collection systems)	Restrict the lateral movement and buildup of flammable and volatile toxic gases, and control emissions of volatile toxic compounds from a hazardous waste site.	Passive systems channel subsurface gas flows without using mechanical components.	Improper installation may cause surface water infiltration. Monitoring required.
Grading (e.g., contour furrowing, scarification, tracking, compaction)	Reshapes landfill surfaces in order to restrict surface water infiltration and runoff, and to control erosion.	Economical method of control. Suitable for preparation of cover soils for vegetation.	Transportation costs for off-site cover soils may be high; periodic regrading and maintenance may be necessary.
Ground-Water Pumping (e.g., suction wells, ejector wells, well points)	Restrict and prevent dispersal of contaminated plume in ground water. Remove contaminated water for treatment and disposal.	Good flexibility in design and operation. May have lower costs than ground-water barriers.	Not effective in fine silty soils. Pumping must be maintained over time. Equipment breakdown and power failure can jeopardize operation.
Liners (e.g., clay soil, synthetic)	Used for lining landfills, surface impoundments, and other disposal systems.	Helps to provide control of leachate in conjunction with other methods.	Liners may tear, leak, or be corroded by chemicals. Monitoring and repair necessary. Liner life generally limited.

Table C-1. Continued

TYPE	PURPOSE	ADVANTAGES	DISADVANTAGES
Revegetation	Planting of a range of flora (e.g., grasses, legumes, shrubs, trees), depending on site needs, can be used to provide a cover for a hazardous waste site or disposal site. Stabilizes the surface of the site, controls infiltration of rain and other water, prevents other plants from rooting and breaking caps or transporting wastes to the surface. Reduces runoff. Can also be used to reclaim wetlands where sediments have been dredged.	Relatively inexpensive. Serves multiple purposes. Minimal disruption of the environment. Aesthetically appealing.	Plants must be carefully selected. Long-term monitoring needed. Plants should not be used as food for humans or livestock. Fertilizers and agricultural schemicals used for revegetation may pollute surface and ground water.
Sediment Removal Systems	These methods remove sediment for further treatment.		
Mechanical Dredging	Methods using excavation equipment (e.g., backhoes, clamshells, fraylines), which can be vessel- or track-mounted or land-based. Good for shallow waters with low velocity rates.	Good density removal; maximizes solids content, and minimizes scale of facilities needed for material transport, treatment and disposal.	Sediment resuspension and turbidity often high. Relatively ineffective for removing free or unabsorbed liquid contaminants. Low production rate.
Hydraulic Dredging	These methods remove and transport sediments in liquid slurry form. Removal of slurries with 10-20% solids by net weight common. Research being done to minimize water content. Usually barge-mounted. Cutterhead (to assist in cutting) may be used.	May be pumped thousands of feet to treatment/storage area. Can be used in water with high flow velocity. May have high production rates. Portable, hand-held, and specially designed dredges are available.	Large flow rate necessitates large land areas for setting and de-watering of dredged material.

Table C-1. Continued

TYPE	PURPOSE	ADVANTAGES	DISADVANTAGES
Sediment Removal Systems			
Pneumatic Dredging	A type of hydraulic dredge using compressed air and hydrostatic pressure to draw sediments to a collection head and through piping. May be operated in shallow or deep water with no theoretical maximum depth.	Relatively easily dismantled and transported by truck or air. May be able to yield denser slurries with lower levels of turbidity and resuspension than conventional/hydraulic dredges. Extremely deep application may be possible with some methods.	Not in widespread use in the United States; may not be readily available. Only modest production rates.

[a]Control methods include techniques that are used both as control before or during treatment and/or as part of a disposal system (e.g., landfill). Depending on-site conditions, control methods may be needed at various stages of hazardous waste management.

Table C-2. Selected treatment methods—biological.[a]

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Activated Sludge System	Microbial organisms in sludge are aerated in a tank and clarification unit system to treat liquid wastes. Efficient for removing alcohols, phenols, phthalates, cyanides, and ammonia. Process sensitive to concentration levels of metals and suspended solids.	O,S	Proven wastewater treatment technology. Tolerates high organic loads. Applicable to simple and complex organics. Reliable and adaptable to different waste streams. Can handle higher organic loads than many biotreatment processes.	Relatively inexpensive. Toxic gases may be released during aeration. Energy requirements high. Sensitive to shock loads and disruption by suspended solids and other matter. Pretreatment and post-treatment may be required. Possible difficulty in removing highly chlorinated organics, aliphatics, amines, and aromatic compounds. Resulting sludge may be hazardous.
Bioreclamation	Decontaminates ground water by enhancing indigenous microbes. Microorganisms may also be injected. The treatment system generally consists of injection and extraction wells. Infiltration galleries (treatment units built directly in the soil) may be used as well. Surface-based reactors may also be part of the process. Most proven utility for readily degradable nonhalogenated organics, primarily gasoline.	I	Cost-effective. Minimally disruptive to the environment. Where effective, preferable to costly excavation and/or treatment methods.	Effectiveness dependent on rate of biodegradation, hydrogeologic conditions, and the recycling rate. Not useful for some organics.

Table C-2. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Composting	A land treatment option that degrades organics using microbes that thrive in moderate to high temperatures. Fundamental process involves placing waste or soil in windrow piles. Applicable wastes include phenols, cyanides, chlorinated hydrocarbons, and oil wastes with metal contents.	I,O,S	Low energy consumption. No sludge or brine disposal required. High tolerance to microbially toxic chemicals (e.g., metals). Most organics can be microbially degraded with this method.	Long degradation periods required. Leachate from composting may require treatment. Acclimation needed for microorganisms. Best for low concentrations of toxic wastes. Needs favorable soil moisture and temperature levels.
Fixed Film Systems				
Rotating Biological Disks	Decomposes organic components in wastewater using rotating disks to which microorganisms are attached. Pretreatment and clarification needed.	O,S	Removes toxics such as solvents and halogenated organics. Conventional wastewater treatment.	Some contaminants above low concentrations are toxic to microorganisms. Not yet demonstrated for hazardous waste sites. May require aeration. Sensitive to changes in weather temperature.
Trickling Filters	Biological film grown on a fixed bed of crushed rock or other support medium. Short retention time for pass-through.	O,S	Suitable for removal of suspended and colloidal material. Low sensitivity to shock loads.	Generates odors. Only for liquids. Limited flexibility and control. Temperature-sensitive. One-pass-through operation. Effluent not low in toxic compounds.
Lagoons/Ponds	Organics are decomposed in wastewater using aerobic or anaerobic microbes in surface impoundments or ponds; may be aerated by wind or with mechanical devices. Most efficient for removing alcohols, phenols, phthalates, cyanides, and ammonia. Anaerobic lagoons sensitive to waste composition,	I,O,S	Low operating costs require minimal energy. Suitable for organics with low rate of biodegradation. Energy requirements low. Effective final-phase method for treatment.	Unsuitable for large concentrations of suspended solids and metals. Requires large land areas. Susceptible to disruption by low temperatures. May release volatile gases. Limited flexibility. Only for low-strength wastes.

Table C-2. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Sequencing Batch Realtors	Degrades wastewater contaminants in an encasement using microbes. Suitable for toxics such as phenols, chlorinated hydrocarbons, amines, and alcohols.	M,O	Can be completely monitored by computer. High feed volumes possible.	Production of sludge can impair efficiency.

[a]These treatment methods have been selected because they are commonly used or are promising in innovative techniques. For more information about these and other techniques, the reader should consult the information sources cited in this chapter.

[b]Key to Location:
I = In Situ (treatment takes place directly in the contaminated medium [soil, ground water] without excavation or removal).
M = Mobile (portable treatment unit or systems which can be set up on site).
O = Off-site (waste must be transported to treatment plant system).
S = On-site (nonportable treatment unit on site).

Table C-3. Selected treatment methods—chemical.[a]

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Dechlorination	Decomposes chlorinated molecules or rearranges them to form less toxic compounds. Usually used with a catalyst. Has been used for pesticides. May be suitable for wastes with PCBs as an initial treatment prior to biodegradation. Promising treatment for dioxin-containing wastes.	I,O,S	Best potential use as a pretreatment to minimize some PIC potential prior to incineration.	Not totally effective in removing chlorine.
Hydrolysis	Degrades a range of organics through element bond cleavage, typically by acid- or base-catalyzed reactions.	I,O,S	Suitable for compounds such as amides, carbamates, organophosphorous, esters, and certain pesticides.	Wastes have to be carefully screened to prevent toxic by-product formation.
Ion Exchange	Removes hazardous materials, primarily inorganics, by exchanging with ions on a resin or by dissolution in an immiscible organic liquid. Suitable for removal of waste components such as chromium, selenium, arsenic, halides, sulfates, cyanides, and phenols.	I,M,O,S	Can recover metals at high efficiency.	Expensive resins may be damaged by waste stream components. Pretreatment may be necessary. Produces by-products (in sludge) which can cause contamination if not properly disposed of.
Neutralization	Adjusts pH level to neutral by adding acidic or basic agents (as the waste requires). May be used alone or as a pre- or post-treatment process in step with other processes. May also be used during treatment to prevent the formation of toxic gases. Important for separating out heavy metals in hazardous wastes.	I,M,O,S	Wide range of applications. Suitable for acidic and basic wastes and some organic liquids. Well understood process.	Reagents may be corrosive. Hazardous by-products (in sludge) produced and must be disposed of.

Table C-3. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Oxidation	Alters the oxidation state of a compound through removal of electrons. May be used to detoxify, precipitate, or solubilize metals, and decompose, detoxify, or solubilize organics. May be used as pretreatment to biodegradation.	M,O,S	Potential use in in situ detoxification of organics in ground waters and soils using hydrogen peroxide, ozone, or hypochlorites as agents.	Toxic byproducts may be formed. Some agents (e.g., ozone) are unstable and reactive.
Permeable Treatment Beds (e.g., limestone, activated carbon, zeolites)	Removes wastes in ground water by passage through layers of chemically reactive substances (e.g., limestone which neutralizes acids) and/or physical retention (e.g., of metals).	I,O	Some agents are readily available, have good permeability, and are inexpensive.	Subject to plugging and cementation over time. At present considered a temporary treatment option because of unresolved technical problems.
Precipitation	Separates soluble components from solutions in solid or colloidal form. Can be applied to almost any liquid waste stream containing a hazardous constituent. Technique of choice to remove metals from aqueous hazardous wastes. Produces a wet sludge that must be processed further.	I,M,O,S	Required equipment commercially available. Associated costs low. Can be applied to large volumes of liquid. Energy consumption relatively low.	Organic components may form complexes with precipitation substances. Sensitive to flow rates, pH, and metal concentrations.
Reduction	Reduces oxygen state of compound by adding electrons. Can perform same functions as oxidation, but does not appear as primarily a treatment. Well demonstrated for some metals. No practical applications for organic compounds.	I,M,O,S	Promising for treatment of some metals in soil and ground water. Required equipment commercially available. Associated costs low. Can be applied to large volumes of liquid. Energy consumption relatively low.	Not suitable for organics. May degrade non-targeted compounds. Chemicals used may create pollution. Reagents may be expensive.

Table C-3. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Soil Flushing (a.k.a. solvent flushing, ground leaching, solution mining)	Solubilizes contaminants in place by injecting liquids such as water, water and surfactants, or dilute acid solutions. Leachate is then pumped to the surface for further treatment. Suitable for some metals and organics. Widely used in chemical processing and mining.	I,M,O	May present an economical alternative to excavation and treatment.	Not suitable for soils or leachate with low contaminant levels or complex waste mixtures. Not practical for large volumes of contaminated material. In situ use for hazardous waste is still being tested.

[a]These treatment methods have been selected because they are commonly used or are promising in innovative techniques. For more information about these and other techniques, the reader should consult the information sources cited in this chapter.

[b]Key to Location:
I = In Situ (treatment takes place directly in the contaminated medium [soil, ground water] without excavation or removal).
M = Mobile (portable treatment unit or systems which can be set up on site).
O = Off-site (waste must be transported to treatment plant system).
S = On-site (nonportable treatment unit on site).

Table C-4. Selected treatment methods—physical.[a]

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Activated Carbon Adsorption	Removes hazardous components in a waste stream by passage through a bed of activated carbon. A well developed technology. Carbon, once saturated, must be replaced. High efficiency for removal of organics such as chlorinated hydrocarbons and phenol.	M,O	Well suited for removal of mixed organics from aqueous wastes. Some metals and inorganics have shown excellent to good adsorption potential. Good for low solubility organics. Well suited to mobile treatment. Easily operated. Not sensitive to changes in concentration and flow rates.	Sensitive to concentrations of suspended solids, oil and grease, and dissolved inorganics. Polarity of waste and solubility determine effectiveness of process. Economy of this process varies depending on field conditions.
Air Stripping	A mass transfer process in which volatile organic contaminants in water or soil are transferred to gas. Several designs available, e.g., packed column, diffused air basin, cross-flow tower.		Cost-effective for low concentrations of volatile organics as a pretreatment to activated carbon. Equipment and operation relatively simple.	Feed stream must be low in suspended solids. Often only partially effective. Most widely used equipment at hazardous waste sites (tower) has high energy costs.
De-watering De-watering beds Vacuum pumping Centrifugation Belt filter presses	Removes liquids from solid/liquid mixtures to facilitate handling and prepare material for final treatment or disposal. Methods include gravity thickness, centrifuges, filters, and lagoons. Selection of methods depends on volume, solids, content, space availability, and degree of de-watering needed.	M,O,S	Makes processing of solids easier. Many methods very effective. A variety of methods available. Proven technology.	Liquids separated during de-watering may contain hazardous components. Solids often not deep enough to meet disposal requirements. Contaminated water residue may require further treatment.

Table C-4. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Dissolved Air Flotation	Removes insoluble suspended particulates by saturating an aqueous waste mixture with air at high pressure, reducing pressure, and skimming contaminants from the surface. Chemicals and pH adjusters may be added to enhance the process. Conventional and demonstrated technique.	M,O,S	Suitable for sludges, slurries, and solid mixtures in aqueous solutions. Removes toxics such as inorganics, organics, and heavy metals.	Limited to treatment of wastes that have a specific gravity close to that of carrying fluid. Air emission controls may be needed for volatile constituents.
Filtration	Removes suspended solids from waste streams. Often used as a pretreatment or a final treatment step. Process involves forcing fluid through a bed of porous medium (e.g., sand and coal); an underdrain collects the filtrate. Filter media must eventually be cleaned.	I,O,S	Economical for streams with low concentration of suspended solids. Small space requirements and simple operation. Suitable for waste recovery processes, and a wide range of waste streams. Reliable and effective in its treatment range.	Subject to clogging and blocking. Liquid effluent may need further treatment. Not very effective for colloidal sized particles.
Flocculation/ Coagulation	Agglomerates fine suspended particles in a liquid into larger particles that can settle out. Flocculating agent(s) (e.g., alum, lime, polymers) are added to a waste stream and mixed. Resulting particles may be removed by sedimentation.	M,O,S	Suitable for a range of organic and inorganic waste components; will handle large volumes of wastes. Simple equipment, readily available and easy to operate. Can be integrated into more complex treatment systems. Minimal safety and health hazards.	Not suitable for highly viscous wastes; sensitive to flow rates and composition of waste streams. Generates a large volume of sludge. Performance and reliability depend on variability of waste composition.

Table C-4. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Gravity Separator	A system to treat two-phase aqueous wastes, e.g., to remove oil and grease from water (wastewater or contaminated ground water). An emulsion-breaking chemical may need to be added. Several designs are possible for equipment.	M,O,S	Batch and continuous operations possible. Small, simple design can reduce costs. Operational requirements minimal. Straightforward, effective means of phase separation.	Separation efficiency affected by flow rates and temperature. Extracted waste constituents must be disposed of.
Reverse Osmosis	Pressure is used to reverse the osmotic flow and allow contaminants in a solvent (e.g., water) to be built up on one side of a membrane and then removed. Removes dissolved organic and inorganic materials, as well as reduce concentrations of soluble metals, total dissolved solids, and dissolved carbon. Has not been widely used for hazardous wastes.	O,M,S	Effective for removal of dissolved solids. Simple equipment.	Units subject to chemical attack, fouling, and plugging. Not reliable for high organic content wastes. Generates sludge that must be disposed. Extensive pretreatment of waste streams may be necessary. Membrane design crucial.

[a]These treatment methods have been selected because they are commonly used or are promising in innovative techniques. For more information about these and other techniques, the reader should consult the information sources cited in this chapter.

[b]Key to Location:
I = In Situ (treatment takes place directly in the contaminated medium [soil, ground water] without excavation or removal).
M = Mobile (portable treatment unit or systems which can be set up on site).
O = Off-site (waste must be transported to treatment plant system).
S = On-site (nonportable treatment unit on site).

Table C-5. Selected treatment methods—solidification and stabilization.[a]

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Cement-Based	Physically or chemically (based on waste characteristics) binds wastes with Portland cement and soil into a solid mass or a soil-like product. Most suitable for metals; not suitable for organics. Because of disadvantages, generally used as a setting agent in combination with other solidifiers.	M,O	Inexpensive, readily available material. Mixing equipment also commonly available.	Most wastes will not be chemically bound and therefore are subject to leaching. Not acceptable for disposal without secondary containment. Some wastes require pretreatment. Heavy weight and large volume increase transportation and disposal costs.
Macroencapsulation	Seals large amounts of wastes in inert jacketing material or in polyethylene-liner drums or containers. Several methods available. May be used for both organic and inorganic wastes. Some methods still being investigated.	M,O	Can be used for very soluble toxics. Extremely effective method; waste completely isolated. Leaching can be eliminated for life of jacketing. Waste may be pretreated so that jacket acts as final barrier.	Process and materials are costly (e.g., custom-fabricated molds) and require skilled labor. Process may carry risks of release of volatile toxics and/or reactions at high temperatures.
Silicate-based	A broad range of methods which employ a silicate material plus lime, cement, gypsum, and other setting agents. Many types use proprietary additives. Some processes are established; others in the research stage. Can stabilize a wide range of contaminants, including metals, waste oil, and solvents.	M,O	Versatile; costs vary but may be inexpensive, depending on material used. Readily available equipment.	Particular mix must be determined on a site-specific basis. Reactions may prevent bonding of materials. Leaching (a major limitation of this technique) necessitates secondary containment (disposal) and monitoring.

Table C-5. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Sorbents	Variety of natural and synthetic solids (e.g., fly ash, clays, vermiculite, proprietary mixtures) used to eliminate free liquid in waste. May produce a soil-like material. Used before or together with other treatment methods.	M,O	Improves handling of wastes. May limit escape of volatile organics and limit some waste solubility. Material and mixing equipment widely available.	Does not necessarily prevent leaching; secondary containment (disposal) required. Must match sorbent to waste for several reasons, especially to prevent undesirable reactions (e.g., toxic gas release, production of new toxic substances).
Thermoplastic	These methods bind wastes in a matrix such as asphalt, polyethylene, or paraffin. Waste must be carefully matched to binder; a number of waste types are incompatible with these methods. Can be buried with or without a container. Widely used in nuclear waste disposal. Can be adapted to special industrial wastes.	I,M,O	Can solidify very soluble, toxic materials. Slower loss of contaminants through leaching than cement- or lime-based methods; helps reduce landfill volume.	High energy consumption; complex equipment and high costs. Plasticity of product may require containerization, thus increasing transportation and disposal costs. Compatibililty of waste and matrix a major consideration.
Vitrification	Combines wastes with molten glass at high temperatures to form stable non-crystalline solids on cooling. Mainly used for radioactive wastes.	I,M,O	Often more effective than other solidification methods; solids have very low leaching rates.	Process is costly and requires specialized equipment and skilled labor. Limited application to mixed wastes.

[a]These treatment methods have been selected because they are commonly used or are promising in innovative techniques. For more information about these and other techniques, the reader should consult the information sources cited in this chapter.

[b]Key to Location:
I = In Situ (treatment takes place directly in the contaminated medium [soil, ground water] without excavation or removal).
M = Mobile (portable treatment unit or systems which can be set up on site).
O = Off-site (waste must be transported to treatment plant system).
S = On-site (nonportable treatment unit on site).

Table C-6. Selected treatment methods—thermal.[a]

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Fluidized Bed Reactor	Destroys waste at high temperatures by passing waste stream through a chamber lined with heated turbulent inert granular material. Bed may be fixed or circulating. Applicable to wastes such as halogenated organics, pesticides, and PCBs. Relatively new design. Handles same wastes as the rotary kiln; limited data available on the treatment of hazardous wastes.	M,O	Simple design and operation. Long life. High efficiency. Relatively low capital and maintenance costs. Emission control less costly than some other systems. Well suited for wastes with high moisture, sludges, and waste with large amounts of ash.	Some wastes (e.g., solids) require pretreatment. Difficulty removing residue and ashes. Relatively low throughput capacity. Relatively high operating costs.
Flares	Waste is exposed to an open flame; no special features to control temperature or time of combustion. Commonly used for waste oil and gas fumes and gases, landfill gas, and sewage treatment gas.	M,O	Suitable for flaring low toxicity gases (e.g., simple hydrocarbons). System simple to fabricate and install.	Does not meet current environmental regulatory destruction removal efficiency standards for hazardous wastes for most substances. Operating costs high. Inconsistent performance because not controllable.
High Temperature Fluid Wall Reactor	Changes organic wastes to their elemental states through pyrolysis using high temperatures in patented reactor. Developmental. Has been used for PCBs and dioxin.	M,O	Low residue formation; high destruction of efficiency.	Not suitable for gases or bulky solids. High use of energy. Some preparation of feed material. Post-treatment may be needed.

Table C-6. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Liquid Injection	Incineration process which atomizes wastes with high pressure air or steam and burns them in suspension. Used for liquids and pumpable slurries. Good for almost all organic wastes. Units have been used to destroy wastes such as PCBs, solvents, polymer wastes, and pesticides. Commercially available.	M,O	Can destroy virtually any pumpable waste or gas. Does not need a continuous ash removal system except for pollution control. No moving parts; requires least maintenance of any incinerator.	Not useful for heavy metals or wastes high in inorganics. Highly sensitive to waste composition and flow changes. Needs storage and mixing tanks to ensure steady flow. Only for wastes which can be atomized in burner nozzle. Burner can clog. Needs supplemental fuel.
Molten Salt	Incineration process which destroys hazardous liquids and solids using molten salt maintained at high temperature. Demonstrated to be effective for chlorinated hydrocarbons, including PCBs, chlorinated solvents, and malathion.	O	Can be used for a variety of waste forms. May have good emission control.	May not be suitable for wastes with high ash or chlorine content. Supplemental fuel may be required. Molten salt can be very corrosive.
Multiple Hearth	Allows wastes to descend through several grates to be burned in increasingly hotter combustion zones. Applicable to sludges, gases, liquids, and solids. Can treat some wastes as rotary kiln providing solid waste is pretreated.	O	Good for sludge destruction. Can evaporate large amounts of water. High fuel efficiency; can use a variety of fuels.	Solid waste must be shredded/sorted before insertion. Susceptible to thermal shock. Fuses wastes containing ash. Cannot handle wastes requiring very high temperatures. High maintenance and operating costs.
Plasma Systems	Plasma technologies destroy wastes at extremely high temperature by directly breaking chemical bonds.	M,O	High destruction of very toxic chemicals. Compact system.	Pre-treatment of wastes necessary; limited to liquids or fluidized materials. Low throughput.

Table C-6. Continued

TYPE	PROCESS/PURPOSE CONTAMINANTS CONTROLLED	TREATMENT LOCATION[b]	ADVANTAGES	DISADVANTAGES
Pyrolysis	Destroys organic wastes by application of heat in the absence of oxygen. Units typically designed to process specific types of chemicals rather than as multipurpose waste processing units. Limited use to date in hazardous waste treatment facilities.	M,O	Applicable to a variety of wastes. Potential for by-product recovery. Sludge volumes may be reduced with large amounts of supplementary fuel. Air emissions usually less than conventional incinerators.	May produce toxic by-products. Some methods may be costly.
Rotary Kiln	An incineration process in which waste is burned in a rotating, refractory cylinder. Can be used for any combustible solid, liquid, or gas. Wastes treated include PCBs, PVC wastes, dioxins, contaminated soils, halogenated organics, and pesticides. Conventional and commercially available.	M,O	Capable of burning waste in any physical form. High incineration efficiency. Preferred method for treating hazardous solid residues. Can incinerate solids and liquids independently or together. Can accept waste feed without any preparation.	Not suitable for some wastes with high inorganic salt or heavy metal content. Susceptible to thermal shock. Need careful maintenance. Low thermal efficiency. Portable version cannot accept containerized or oversized wastes.
Wet-Air Oxidation	Aqueous phase oxidation of dissolved or suspended organic substances at high temperatures and pressures. Especially applicable to wastes such as pesticides, herbicides, or other not readily biodegradable complex organic compounds. Used primarily for waste streams with organic and oxidizable inorganic wastes.	M,O	Usable where biological treatment is ineffective. May be more cost effective than incineration in some cases.	Generally limited to aqueous wastes.

[a]These treatment methods have been selected because they are commonly used or are promising innovative techniques.

[b]Key to Location:
I = In Situ (treatment takes place directly in the contaminated medium [soil, ground water] without excavation or removal).
M = Mobile (portable treatment unit or systems which can be set up on site).
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S = On-site (nonportable treatment unit on site).

Table C-7. Disposal methods.[a]

TYPE	PURPOSE	ADVANTAGES	DISADVANTAGES
Chemical Vault	Stores wastes in secure chambers above ground.	Provides interim storage for wastes that cannot be disposed of otherwise. (Long-term storage vaults are being investigated.)	At present, suitable for short-term storage only. Long-term storage may present licensing problems; must be monitored.
Deep Well Injection	Isolates waste streams by injecting them into wells drilled below any known drinking water sources and below an impervious rock layer. Pretreatment and stabilization may take place. Suitable for a variety of wastes; particularly suited to heavy metals which can be rendered insoluble or otherwise non-migratory.	Economical isolation of wastes from the surface environment.	Site-dependent, relative to subsurface geology. Operational and technical problems exist for pre-treatment of wastes and installation and maintenance of wells. Long-term fate of wastes unknown.
Land Application	Decomposes sludge waste by spreading it over land surfaces and allowing microbial decomposition. Depending on type of waste, may be used on agricultural lands, forest lands, to reclaim damaged land, or on land dedicated to disposal only.	Can improve characteristics of the land. In some cases, suitable for providing plant nutrients (e.g., as a partial replacement for chemical fertilizers) after careful screening.	Constituents of sludge waste limit usage options (e.g., metal concentrations may not be suitable for agricultural applications). Siting may conflict with land-use options; improper siting may contribute to pollution by run off and seepage to ground water.
Landfill	These are generally excavated on-land systems which serve as long-term repositories for hazardous substances. Components include protective materials (liners, bases, covers), leachate collection systems, gas venting devices, and monitoring systems. Suitable for many waste types.	Provides disposal method for dewatered sludges, solid materials, and contaminated soils; stores residuals from processes such as incineration, solidification, and chemical treatment.	May release pollutants into soil, ground water, and/or air. Requires long-term operation and maintenance. Increasingly problematic option due to environmental, regulatory, and social reasons.
Surface Impoundment (e.g., lagoons, pits, ponds)	Man-made or natural excavations which store hazardous wastes for the short term or for pre-treatment. May be above, below, or partially in the ground. Some have liner systems.	May be used as a pretreatment step in disposal of some types of materials.	May release contaminants into the environment. Chemicals in wastes may breach the impermeability of liners.
Underground Storage (e.g., salt domes, hard-rock mines)	Natural or man-made subsurface cavities that store wastes for long periods of time. Not in use currently for hazardous wastes in the United States.	Some excavations (e.g., caves), because of natural impermeability and size, may require minimal construction and protective systems.	Fractures and permeable rocks may allow contaminant transport. Long-term operation and maintenance needed.

[a]A disposal method may utilize a range of control techniques as part of a total system. See Table C-1, Control Methods, for components.

Appendix D

GLOSSARY OF TERMS

ABBREVIATIONS AND ACRONYMS

CAA	Clean Air Act
CALTRANS	California Department of Transportation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (42 U.S.C. 9601)
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability System
C.F.R.	Code of Federal Regulations
CWA	Clean Water Act
DEP	Department of Environmental Protection
DNR	Department of Natural Resources
DOT	Department of Transportation
ECRA	Environmental Cleanup Responsibility Act
EIS	Environmental Impact Statement
EMI	Electromagnetic induction
EMSL-LV	Environmental Monitoring Systems Laboratory, Las Vegas
EPA	United States Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ERNS	Emergency Response Notification System
FHWA	Federal Highway Administration
HRS	Hazards Ranking System
HSWA	Hazardous and Solid Waste Amendments of 1984
HWDMIS	Hazardous Waste Data Management Information System
LUST	Leaking Underground Storage Tank Program
NCIC	National Cartographic Information Center
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NIPDWS	National Interim Primary Drinking Water Standards
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyls
PIC	Products of incomplete combustion
PRP	Potentially responsible party
QA/QC	Quality assurance and quality control
RCRA	Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901)
RFP	Requests for Proposals
RFQ	Requests for Qualifications
RI/FS	Remedial Investigation/Feasibility Study
ROW	Right-of-way
SARA	Superfund Amendments and Reauthorization Act of 1986
SCAP	Superfund Comprehensive Accomplishments Plan
SDWA	Safe Drinking Water Act
SIC	Standard Industrial Classification
SLAR	Side Looking Airborne Radar
SWDA	Solid Waste Disposal Act
TSCA	Toxic Substances Control Act
TSD	Treatment, storage or disposal facility
Title III	Emergency Planning and Community Right-to-Know Act (Superfund Amendments and Reauthorization Act of 1986)
USGS	U.S. Geological Survey
UST	Underground storage tank
WPCA	Water Pollution Control Act

TERMS

Acquifer. An underground geologic formation containing water which may be a source of public drinking water.

ARAR. Under the Superfund Amendments and Reauthorization Act of 1986, the Environmental Protection Agency is directed to select remedial actions that will satisfy "applicable, relevant and appropriate requirements" (ARAR) set forth under federal or state standards. SARA requires that preference be given to remedial actions that permanently reduce the toxicity, mobility, or volume of hazardous substances, and meet specified federal or state standards, whichever is more stringent.

Environment. Any surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air.

Facility. Any building, structure, installation, equipment, storage container, motor vehicle, rolling stock, aircraft, site, or area where a hazardous substance has been deposited, stored, disposed of, or placed.

Generator. Any person, by site, whose act or process creates hazardous waste, or any person who first makes the waste subject to regulation under the Resource Conservation and Recovery Act (RCRA).

Hazardous substance. Any element, compound, mixture, solution, or substance which, when released to the environment, may present substantial danger to public health or welfare, or to the environment (CERCLA, § 101(14)). This definition is broader than the definition of hazardous wastes under the Resource Conservation and Recovery Act, and has been used to regulate substances not regulated by RCRA (for example, asbestos and mining wastes). A hazardous substance under CERCLA also includes: any substance designated under § 311(b)(2)(A) or any toxic pollutant listed under § 307(a) of the Federal Water Pollution Control Act; any hazardous air pollutant listed under

§ 112 of the Clean Air Act; or any imminently hazardous chemical substance or mixture for which the government has taken action under § 7 of the Toxic Substances Control Act. Petroleum, natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel are all excluded from the CERCLA definition of hazardous substances.

On August 10, 1987, OSHA proposed to adopt EPA's definition of hazardous waste, and to define hazardous substance as any hazardous waste defined under RCRA, any hazardous substance defined under CERCLA, and any hazardous substance listed by the U.S. Department of Transportation under 49 C.F.R. 172.101 and appendixes.

Hazardous waste. Wastes that are regulated or "listed" under RCRA (40 C.F.R. 261), or are ignitable, corrosive, reactive, or toxic. (See Appendix A for a more complete description of the RCRA definition of a hazardous waste.) The definition of hazardous waste under state law may differ from that under federal law. State law definitions may be broader, regulations may apply to smaller quantities and site sizes, and restrictions and site monitoring requirements may differ. In view of the lack of uniformity among state laws, state statutes concerned with hazardous wastes should be consulted carefully by highway agency staff.

Hazardous waste site. This term is used to mean any area containing hazardous wastes. An area suspected of containing wastes is called a potential hazardous waste site.

Hazardous waste site management process. All of the activities associated with the investigation and cleanup of hazardous waste sites. For the purpose of this compendium, the process consists of the following five activities: (1) preliminary hazardous waste site evaluation; (2) detailed hazardous waste site investigation; (3) alternatives analysis and selection; (4) remedy design; and (5) treatment or disposal.

Hazards Ranking System (HRS). A mathematical rating system that results in a numerical score reflecting the degree of risk to human health and the environment posed by a hazardous waste site. Sites receiving high HRS scores are placed on the National Priorities List and targeted for remedial action. Section 105(c) of SARA requires EPA to amend the present HRS by April 1988 to include more risks than are presently factored in the scoring system. The HRS is part of the National Contingency Plan.

Highway agency. That unit of state government (including central office, field office, and district staffs) responsible for the planning, design, construction, operation, and maintenance of its highway system. It is recognized that most states have departments that encompass several transportation modes. Only a few states still have exclusive highway departments or agencies.

Highway development process. All the activities associated with the planning, design, construction, operation, and maintenance of highway systems.

Liability. An obligation or responsibility imposed on a highway agency or other party as the result of legislative or attendant regulatory requirements.

National Contingency Plan (NCP). A federal directive that establishes procedures and standards for responding to releases of hazardous substances, pollutants, and contaminants. Codified at 40 C.F.R. 300, NCP establishes the Hazards Ranking System and designates the roles of federal, state, local, and private parties in effectuating a cleanup plan.

National Priorities List (NPL). A list of hazardous waste sites across the country targeted for enforcement action or cleanup under CERCLA. This list serves as the basis for allocating the limited financial resources of the federal Superfund, and is revised at least once a year. At present, a site is placed on the NPL when it receives a hazards ranking system score greater than 28.5, or is designated by a state as a top priority. With the most recent update, there are 802 NPL sites across the United States, with an additional 149 sites proposed.

Owner/operator. A term used by EPA to include the United States Government, a state, municipality, a commission, a political subdivision of a state, or an interstate body.

Potentially responsible party (PRP). Those identified by EPA as potentially liable for cleanup costs under CERCLA. PRPs include: generators of hazardous wastes; present or former owners and operators of sites where hazardous wastes have been stored, treated, or disposed of; or those who accepted hazardous wastes for transport and selected the disposal site.

Release. Any spilling, leaking, pumping, poring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment.

Remedial action. Cleanup actions designed to result in a permanent remedy. Remedial actions may be taken instead of, or in addition to, a removal action.

Removal action. The cleanup or removal of a released hazardous substance so as to prevent, minimize, or totally mitigate damage to the environment.

Right-of-way. The area (including land, buildings, and structures) needed to construct and safely maintain a highway facility.

Risk. A term that refers to the probability and severity of a loss, where the loss may be economic or financial; environmental or health-related; ethical; personal; psychological; or organizational.

Uncontrolled waste site. Abandoned dumps or other hazardous waste sites for which responsible parties are difficult to identify.