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Overview

Newly established Federal regulations for hazardous waste management facilities may not effectivel y detect, prevent, or control hazardous releases, especially over the longer term. Moreover, some regulatory standards and controls will be set by State authorities, who may not have the resources to make technically complex decisions, Consistent levels of protection nationwide are not assured.

In less than a decade the Federal program has advanced State efforts, cleaned up some uncontrolled sites, and assisted industry in improving its waste management. Nevertheless, data inadequacies conceal the scope and intensity of hazardous waste problems, especially those related to health and environmental effects, and impede effective regulation of wastes and waste management facilities.

About 255 million to 275 million metric tons (tonnes) of hazardous waste under Federal and State regulation are generated annually. Some States have stricter definitions for hazardous waste than the Federal program, which regulates about 40 million tonnes annually, Millions of tonnes of federally exempted hazardous waste disposed in sanitary landfills pose substantial risks. Such exemptions cover most hazardous waste from generators producing less than 1 tonne a month. In addition, large volumes of relatively low-hazard waste such as mining waste and waste generated by the burning of fossil fuels are exempt from Federal regulation.

Land disposal is used for as much as 80 percent of regulated hazardous waste, some of which may remain hazardous for years or centuries. Inappropriate disposal of hazardous waste on land creates the risk of contaminating the environment, particularly ground water, which could cause adverse health effects. Federal policies may inadvertently reduce private costs of land disposal by shifting some long-term cleanup and monitoring costs to Government or to society as a whole; the effect may be to retard the adoption of alternatives such as waste reduction and waste treatment. A key policy issue is: Can unnecessary risks and future cleanup costs be eliminated by limiting the use of land disposal and by making alternatives to it more attractive?

As their responsibilities mount, States fear reductions in Federal support and seek a stronger policy role. States sometimes cannot raise even the required minimum 10 percent of initial Superfund cleanup costs—and they must assume all future operation and maintenance costs. Because there are no specific Federal technical standards for the extent of cleanup, and because there is an incentive to minimize initial costs, remedial actions may be taken that will prove ineffective in the long term. When Superfund expires in 1985, many uncontrolled sites still will require attention.

Actions that enhance public confidence in the equity, effectiveness, and vigorous enforcement of Government programs may reduce public opposition to siting hazardous waste facilities. Opposition also may be reduced by improvement in the dissemination of accurate technical information on issues such as waste treatment alternatives to land disposal,

Five policy options are examined:

1, Continue with the current program.
2. Extend Federal controls to more hazardous waste, and establish national regulatory standards based on specific technical criteria, Also, restrict disposal of high-hazard waste on land, and improve procedures for permitting facilities and deregulating waste.
3. Establish Federal fees on waste generators as an economic incentive to reduce the generation of waste and discour-

age land disposal; impose higher fees on generators of high-hazard waste that are land disposed; provide assistance for capital investments and research and development (R&D) for waste reduction and waste treatment.

4. Study the costs and advantages of classifying wastes and waste management facilities by degree-of-hazard to match hazards and risks with levels of regulatory control.
5. Examine the need for greater integration of Federal environmental programs to remove gaps, overlaps, and inconsistencies in the regulation of hazardous waste, and to make better use of technical data and personnel.

Substantial Risks and Damages

Uncontrolled and careless disposal of industrial waste became a national concern in the mid and late 1970's. It became evident at many waste sites that mismanagement and indiscriminate dumping of waste were causing harmful substances to be released into the land, water, and air. Waste handlers and the general public alike were threatened with direct exposure to hazardous waste.

It also became increasingly clear that even well-intentioned and presently accepted waste management practices, particularly the use of landfills, surface impoundments, and lagoons, might still constitute substantial threats. These threats arise from the potential slow leakage of waste constituents or leachate* through the soil and into ground water, which is a source of drinking water for many communities.

Before Congress enacted the Resource Conservation and Recovery Act (RCRA) in 1976, relatively few States had regulatory programs dealing with hazardous waste. Experience with conventional forms of industrial and municipal solid waste had given the States little preparation for dealing with hazardous waste, many of which are chemically stable and thus extremely persistent under most conditions.

Studies across the Nation revealed that the disposal of hazardous waste decades earlier had left undetermined, but possibly very large, amounts of dangerous substances in and on the land. Moreover, wastes were leaking from many hazardous waste sites, some of which were closed. RCRA did not effectively deal with these old, often abandoned, sites because it was primarily concerned with proper management and permitting of present and future hazardous waste. In order to deal with the many substantiated and potential hazards posed by uncontrolled hazardous waste sites, Congress passed the Comprehensive Environmental, Response, Compensation, and Liability Act of 1980 (CERCLA), better known as Superfund.

Adverse health effects attributable to hazardous waste remain inadequately documented. However, a 1980 survey by the Environmental Protection Agency (EPA)[1] of 350 uncontrolled hazardous waste sites indicated substantial threats to the public. At the time, these were essentially all the sites for which there was detailed information. There are currently more than 15,000 uncontrolled sites in EPA's Emergency and Remedial Response Information System. The survey found:

- contamination of ground waters and reservoirs, affecting water supplies of 168 communities;
- contamination of drinking water wells leading to closure of at least 468 individual wells; and
- a total of 108 other adverse incidents, including damage to human health, natural

*Leachate is liquid resulting from the interaction of water with waste. The source of the water may be rain, inflow of ground or surface waters, or other waste.

[1] "Damages and Threats Caused by Hazardous Waste Sites" (Washington, D, C.: Environmental Protection Agency, 1980).

habitats, fish and livestock, crops, sewer systems, and soils.

Furthermore, an unreleased EPA study, in progress for several years, indicates there are 80,263 sites in the Nation with contaminated surface impoundments (pits, ponds, and lagoons).[2] Ninety percent are believed to pose at least a potential threat of ground water contamination, Another unreleased EPA study reports that testing of underground drinking water supplies in 954 cities found contamination in 29 percent. All the affected areas had populations of more than 10,000.[3] Leaching of toxic substances from waste landfills is believed to be a contributory factor in these cases.

Long-term health effects from exposure to hazardous waste are uncertain, but they may be serious. For example, in one case of contaminated drinking water (associated with a hazardous waste dump in Hardeman County, Term.), the levels of carbon tetrachloride were so high that they exceeded proposed water quality criteria by a factor of 10,000.[4] EPA has said that of the 418 uncontrolled hazardous waste sites in the Nation that need priority attention, 347 pose direct threats to drinking water supplies and could cause birth defects, cancer, and other diseases.[5]

[2] As reported in *The New York Times*, Dec. 30, 1982.
[3] As reported in *Engineering Times*, September 1982.
[4] Samuel S. Epstein, et al., *Hazardous Waste in America*, Sierra Club Books, 1982.

Although information is scanty on the amounts and types of releases, many hazardous wastes are persistent, mobile, and highly toxic. It is possible that large segments of the population are being exposed to releases of hazardous waste constituents. As much as 80 percent of federally regulated hazardous waste—at least 30 million tonnes per year—are being placed in or on the land. An even greater percentage of the 255 million to 275 million tonnes of hazardous waste under Federal and State regulation may be land disposed. Therefore, under current practice, 1 tonne of hazardous waste is added to the environment for every person in the Nation every year. The accumulation from past decades of industrial activity is equivalent to several tonnes of hazardous waste for every person in the Nation. Furthermore, waste management techniques other than land disposal, such as the burning of waste in boilers, cement kilns, and incinerators, may be releasing hazardous substances into the environment.

[5] As reported in *The Washington Post*, Dec. 21, 1982.

The Tradeoff Between Near- and Long-Term Costs

The economic costs of hazardous waste are substantial. Industry and governments are currently spending $4 billion to $5 billion annually to manage regulated hazardous waste. Assuming a continuation of present Federal RCRA and CERCLA programs and modest increases in hazardous waste generation, annual costs are estimated to rise to more than $12 billion (in 1981 dollars) in 1990. If more wastes are regulated, if more major cleanup actions are required, and if compensation is required for damages to health and environment, then future costs could be much greater. Government spending will increase substantially as RCRA and CERCLA implementation becomes more intensive.

The cost of cleaning up uncontrolled sites and compensating for damages to human health and the environment calls for consideration of the full "lifecycle" costs of managing hazardous waste. From an economic perspective, the overriding hazardous waste issue of today is: Would it be more prudent and effective in the long term to increase the stringency of current land disposal regulations and encourage the use of alternatives to land disposal, even though near-term costs might be increased? Attempting to minimize present costs will almost certainly lead to a transfer of greater costs to the future. Moreover, failure to improve waste management in the near term would surely lead to unacceptable health and environmental effects in the long term. It should be stressed that the language of RCRA precludes balancing costs and risks; rather, it places sole emphasis on the protection of public health and the environment.

The cost to assess and clean up an uncontrolled site ranges from several hundred thousand dollars to tens of millions of dollars. For example, the cost to clean up one site in Seymour, Ind., has been estimated at $22.7 million. To clean up four sites in St. Louis, Mich., one company has agreed to spend $38.5 million. Hydrogeologic investigations to define the extent of ground water contamination can cost from $25,000 to $250,000. The average cost for cleaning up and containing contaminated ground water ranges from $5 million to $10 million a site; the cost of totally restoring a badly contaminated aquifer to potable quality could be 10 times the average cost.

To cleanup a substantial fraction of the more than 15,000 presently known uncontrolled hazardous waste sites is likely to cost, in public and private spending, a total of $10 billion to $40 billion. This should be compared with the estimated $1.6 billion to be collected under CERCLA by 1985. CERCLA funds are meant to be used for cleaning up uncontrolled sites where no responsible party can be identified, and for advancing funds for cleanup before recovery from responsible parties is made. The cost of cleaning up known sites is not likely to be the end of the expense. Still more uncontrolled sites are being discovered, and probably some are being created by current practices and exemptions.

It is generally acknowledged that, even with the new stricter RCRA regulations in place, eventual releases of hazardous constituents from land disposal facilities are highly probable. Greater use of waste treatment alternatives is, therefore, a major issue, although they too, if not regulated effectively, can release hazardous constituents to the environment. Yet greater use of alternatives to land disposal—treatment, recycling, and especially more investment in waste reduction—could increase industry's near-term costs significantly, perhaps by as much as 50 to 100 percent. But years or decades from now, cleaning up a site from which there are hazardous releases, and compensating victims, might cost 10 to 100 times the additional costs incurred today to prevent releases of hazardous materials.

For example, in the case of Love Canal, it has been estimated that disposal of the waste dumped there decades ago—according to the standards and practices of today—would have cost $2 million (in 1979 dollars)* versus $36 million for remedial action already spent through 1980. Ultimate costs for remedial action are expected to exceed $100 million; in addition about $2 billion in lawsuits have been filed by persons claiming damages.

EPA estimates that the average cost of disposing of hazardous waste in compliance with the new RCRA regulations is about $90 per tonne. The EPA estimate of the cost of cleaning up improperly dumped waste is up to about $2,000 per tonne, In addition, much of the burden of future costs would likely fall on the general public. Costs incurred today by improved management of hazardous waste would be borne, more equitably, by waste generators and by consumers of "hazardous waste-intensive" products.

*This is not to suggest that the technical factors alone were responsible for the Love Canal problems.

Scope of This Study

As requested by Congress, this assessment focuses on:

1. information and analysis on the use and development of technologies that can improve hazardous waste management through:
   a. reduction of the volume and hazard level of waste generated;
   b. better management of the risks associated with waste treatment and disposal; and
   c. the cleanup of uncontrolled waste sites;
2. analysis of the potential benefits and costs of a framework based on scientific criteria to judge the relative degree of hazard of wastes and risks from management facilities; and
3. evaluation of current regulatory programs, particularly with regard to technical information and issues.

The primary focus of this assessment is on management strategies, technological options, and the technical components of a Federal hazardous waste regulatory program that would protect human health and the environment. More attention has been given to issues and problems related to RCRA than to CERCLA, This assessment is an analytical study to provide a basis for policy discussion and examination of legislative options by Congress; it is not an attempt to write new regulations for the executive branch or the individual States. Strictly administrative issues and problems, such as enforcement, permitting, and delegation of authority to States, are considered only to the extent that they relate to the study's primary technical focus. Transportation and accidental spills of waste are not considered in any substantial way. Nor has it been possible to examine issues and problems unique to Federal hazardous waste facilities, A part of this analysis is concerned with examining the procedures for better assessing the nature and intensity of, and monitoring for, adverse effects on human health and the environment from releases of hazardous waste or their constituents into the air, land, and/or water. Major attention, however, is not given to substantiating, documenting, or critically evaluating health and environmental data.

Key Issues and Findings

The following "issues and findings" section is a partial summary of the full report, emphasizing issues of particular interest to Congress and areas of special concern in the development of the Federal hazardous waste program. It presents the major analytical findings of chapters 4 through 7. A summary of chapter 3 (Policy Options) follows this section.

ISSUE 1

Is the existing health, environmental, and management information an adequate basis for an effective national hazardous waste control program? To what extent are currently generated hazardous wastes subject to regulation by Federal and State programs?

FINDING

Although EPA and the States are improving data collection, there are major uncertainties on how much hazardous waste is generated, the types and capacities of existing waste management facilities, the number of uncontrolled waste sites and their hazard levels, and on health and environmental effects of hazardous waste releases. Data inadequacies conceal the scope and complexity of the Nation's hazardous waste problems, and impede effective control. Large-scale exemptions from the Federal program make the coverage of Federal regulation much narrower than that of the States (see ch. 4).

Waste Definition.—An adequate definition of hazardous waste is crucial to an effective hazardous waste management effort. EPA regulations currently define a subset of "solid wastes" * that are controlled under RCRA as "hazardous wastes." In addition, some hazardous wastes are regulated under environmental statutes other than RCRA. EPA's definition of "hazardous waste" covers only these federally regulated wastes. Some States, perceiving inadequacies in the Federal definition of hazardous waste, use different and broader definitions for purposes of their own control programs. This leads not only to significant differences in perceived types and quantities of waste that pose hazards to human health and the environment, but also to confusion as to the degree and focus of efforts required to manage hazardous waste.

Waste Generation .—EPA has estimated that 28 million to 54 million tonnes of federally regulated hazardous waste were generated in the United States in 1980. The average value of 41 million tonnes is the amount that is generally quoted. A survey conducted for OTA assembled data on waste generation based on the different definitions of hazardous waste used by States. The survey indicated that approximately 255 million to 275 million tonnes of hazardous waste generated per year are recognized by the States. Much (although not all) of the "extra" waste regulated by States are of relatively low-hazard level, such as mining waste and fly ash. Other wastes which escape the Federal definition and regulation, such as wastes from small quantity generators, pose substantial hazards. These and other wastes currently exempted from control under RCRA by Congress and EPA total several hundred million tonnes per year. They are summarized in table 1. In general, the large-volume exempted wastes are those of lower hazard, although the quantities of high-hazard wastes may be very substantial (the volumes of many of these wastes are unknown). In addition, cleanup actions at uncontrolled sites produce several million tonnes of hazardous waste and contaminated materials annually which must be managed. These have not been included in EPA's estimates.

Generators and Storage, Treatment, and Disposal Facilities. -It is possible to collect accurate data on individual hazardous waste generators, management facilities, and methods of waste disposal. However, the national data base is generally recognized to be incomplete, and in some respects inaccurate, even by EPA. These data must serve as the basis for permitting efforts, and must be progressively updated as that effort proceeds. Most wastes—generally 70 to 85 percent nationwide—are managed on the sites where they are generated. Accurate data on the use of different waste management methods are not available; however, it is clear that on a volume basis most hazardous waste (as much as 80 percent according to early EPA data) are land disposed. Use of land disposal varies among States; for example, in Louisiana about 97 percent of waste managed onsite and 50 percent of those managed offsite are land disposed. In Texas, 95 percent of hazardous waste are land disposed. In Massachusetts, only 7 percent is land disposed, and all of that is sent to other States for disposal.

Uncontrolled Sites.-The CERCLA program has made some progress in identifying the number and location of uncontrolled sites requiring remedial action, particularly for known problem sites. EPA now has a list of more than 15,000 sites, and 418 sites have been selected for the National Priority List. However, the inventory of uncontrolled sites in the Nation is still incomplete, and the severity of the hazards posed by many of the priority sites is uncertain (which is true as well for the thousands of sites not on the priority list). The model used to evaluate hazards has serious inadequacies (see issue 5),

Health and Environmental Effects.-Data on potential health and environmental effects are critically needed for the Federal hazardous waste program as a basis for establishing appropriate levels of regulatory control. The current situation is not satisfactory. There are very few data on the short- and long-term health and environmental effects of exposure to actual hazard-

*In RCRA, solid waste refers to a general class of wastes that may be solid, liquid, gases, or complex mixtures of a number of phases.

Table 1.—Examples of Exemptions From Federal Regulation as Hazardous Waste

Waste type	Estimated annual generation (million metric tons)	Possible hazard	Determined by
Fly and bottom ash from burning fossil fuels[a]	66	Trace toxic metals	RCRA
Fuels gas emission control waste	Unknown	Toxic organics, and inorganic	RCRA
Mining waste, including radioactive waste[b]	2,100	Toxic metals; acidity; radioactivity y	RCRA
Domestic sewage discharged into publicly owned treatment works	5	Uncertain, toxic metals likely	RCRA
Cement kiln dust[a]	12	Alkalinity, toxic metals	RCRA
Gas and oil drilling muds and production waste; geothermal energy waste	Unknown	Alkalinity, toxic metals, toxic organics, salinity	RCRA
NPDES permitted industrial discharge	Unknown	Toxic organics, heavy metals	RCRA
Irrigation return flows	Unknown	Pesticides, fertilizers	RCRA
Waste burned as fuels[c]	19	Unburned toxic organics	EPA
Waste oil	Unknown	Toxic organics, toxic metals	EPA
Infectious waste	Unknown	Infectious materials	EPA
Small volume generators	2.7-4.0	Possibly any hazardous waste	EPA
Agricultural waste	Unknown	Variable	EPA
Waste exempted under delisting petitions	Unknown	Presumably insignificant	EPA
Deferred regulations	Unknown	Unknown	EPA
EPA deregulation	Unknown	Presumably insignificant	EPA
Toxicity test exemptions	Unknown	Organics	EPA
Recycled waste	Unknown	Improper application of various materials	EPA

†Wastes may be delisted on the basis of a petition that is concerned only with the constituent(s) which have determined the original listing, however, other hazardous constituents may be present which have previously been unrecognized administratively

‡Wastes not identified as toxic by the EPA extraction procedure test and not otherwise listed by EPA

††Legitimate recycling is exempt from RCRA regulations except for storage However, there have been numerous incidents (e g., the dioxin case in Missouri) involving recycled materials which are sti I I hazardous

SOURCES [a]Federal Register, vol 43, No. 243, 12/16/78.
b" Technical Environmental Impact of Various Approaches for Regulating Small Volume Hazardous Waste Generators" (Washington, D C. Environmental Protection Agency, contract No 68-02.2613, TRW, December 1979)
c"A Technical Overview of the Concept of Disposing of Hazardous Wastes in Industrial Boilers" (Cincinnati, Ohio Environmental Protection Agency, contract No 68-03-2567, Acurex Corp., October 1981)
d, The RCRA Exemption for Small Volume Hazardous Waste Generators, Staff Memorandum" Washington, D C U S congress, Off ice Of Technology Assessment, July 1982

ous waste. The considerable scientific data that exist are useful, but the data usually must be extrapolated from animal to human health effects, from high to low concentrations of hazardous constituents, and from exposure to pure chemicals to exposure to complex waste mixtures. The disease registry and health survey required by CERCLA, to provide more data on health effects of hazardous waste, have not been implemented satisfactorily.

Priorities for Data Acquisition.—A major obstacle to assessing the long-term effectiveness of RCRA and CERCLA implementation by EPA and States is inadequate health and environmental effects data. Substantial efforts are needed in this area. Other data priorities include: hazardous waste generators (who and where they are, and their types and quantities of wastes) and management facilities (technology types and capacities); the performance of different kinds of facilities and technologies and degree of risk associated with each; alternative industrial processes for waste and hazard reduction; uncontrolled sites; capital and operating costs of waste management facilities; and regulatory compliance costs.

Institutional Factors.—There is a need for a long-term, systematic EPA plan—for which a congressional mandate does not yet **exist—** for obtaining more complete and reliable data on hazardous wastes, facilities, sites, and exposures to and effects from releases. The likely consequences of devoting inadequate resources to obtain accurate information include the following:

- Federal and State programs to protect the public from hazardous waste may be inappropriate or misdirected and long-term risks to public health and the environment may not be properly assessed.

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- Over time it will be difficult to evaluate the effectiveness of the large funds spent by Federal and State regulatory programs and the private sector.
- Eventual costs of protecting public health and the environment may escalate because wastes, facilities, and sites may not have been properly identified and, therefore, may be receiving either inadequate or excessive attention under RCRA or CERCLA. The costs to provide remedies where waste facilities were omitted from or inadequately managed under present programs will increase markedly over time as sites deteriorate and releases enter the environment.

ISSUE 2

Can the amount of hazardous waste that is generated be further reduced, and does the Federal regulatory program provide incentives or disincentives for waste reduction?

FINDING

Several technological approaches can be used to reduce the amount of waste requiring treatment or disposal. The current Federal program indirectly provides more disincentives than incentives for waste reduction (see ch. 5). -

An important way to reduce threats to public health and the environment from hazardous waste and to lessen the cost of waste management is to reduce the amount of waste generated. Generators of waste can accomplish this by segregating waste more carefully or recycling them, or sometimes by changing manufacturing processes or products. Whether they will in fact do so depends on the economic costs and savings involved. The generator's costs are influenced by government regulations. A generator may, for example, recycle a waste even though it adds to his costs, if the cost is less than treating or disposing of the waste in the manner required by government regulations.

Some initiatives undertaken by the private sector indicate that there are opportunities for waste reduction which, in the right circumstances, can lead to economic benefits for the waste generator. First, the cost of changes that reduce waste generation may be more than offset by lower waste management costs. Then, materials or energy recovered from materials before discard or from wastes can in some cases be used or sold for profit. Sometimes, changes in processes motivated by waste management concerns may help introduce innovative new technologies.

Table 2 presents a summary of the advantages and disadvantages of the major approaches to waste reduction. There is considerable evidence based on practical experience that these approaches are technically feasible, to different degrees, for many hazardous wastes. Specific findings concerning the current state of usage of the four major approaches to waste reduction are:

- Source segregation or separation is usually the easiest and cheapest method of reducing waste before they require management as hazardous waste. This method has been widely used in industry and offers further opportunities for application. The basic principle is to keep waste in concentrated, isolated forms rather than to form large volume indiscriminate mixtures that must be separated later.
- Hazardous waste reduction by process modification is usually a secondary benefit; the changes are motivated by other engineering and economic considerations, such as improving process efficiency and yield. The benefits are usually specific to individual plants and processes. Impacts on hazardous waste reduction industry-wide have been limited.
- End-product substitution appears to offer long-term benefits. However, full realization of the benefits depends on its application to many industrial sectors and markets. Changing one product, or one application of a product, is likely to have only a relatively small effect on hazardous waste generation. Here, too, waste reduction is usually a secondary benefit, with product performance improvements being the main driving force for change. However, as hazardous waste management becomes more expensive and costs are

Table 2.—A Comparison of the Four Waste Reduction Methods

Advantages	Disadvantages
Source ***segregation or separation***	
1) Easy to implement; usually low investment 2) Short-term solution	1) Still have some waste to manage
Process *modification*	
1) Potentially reduce both hazard and volume 2) Medium-term solution 3) Potential savings in production costs	1) Requires R&D effort; capital investment 2) Usually does not have industrywide impact
End product substitution	
1) Potentially industrywide impact—large volume, hazard reduction	1) Relatively long-term solutions 2) Many sectors must be affected to achieve significant benefits 3) Usually a side benefit of product improvement 4) May require change in consumer habits 5) Major investments required—need growing market
Recovery/recycling	
In-plant	
1) Medium-term solution 2) Potential savings in manufacturing costs 3) Reduced liability compared to commercial recovery or waste exchange	1) May require capital investment 2) May not have wide impact
Commercial recovery (offsite)	
1) *No* capital investment required for generator 2) Economy of scale for small waste generators	1) Liability not transferred to operator 2) If privately owned, must make profit and return investment 3) Requires permitting 4) Some history of poor management 5) Must establish long-term sources of waste and markets 6) Requires uniformity in composition
Waste exchange	
1) Transportation costs only	1) Liability not transferred 2) Requires uniformity in composition of waste 3) Requires long-term relationships—two-party involvement

SOURCE: Office of Technology Assessment

passed onto consumers, the awareness of the "hazardous waste-intensiveness" of products may contribute more to end-product substitutions,

- In-plant recycling has been widely used in industry for waste reduction, Onsite recycling and recovery can be done before materials are discarded and managed as hazardous waste, thereby reducing the volume and perhaps the hazard level of the waste that are eventually generated. Commercial *or* offsite recovery operations have had varying degrees of success, depending on problems with contamination of waste, consistency of waste composition and supply, and market factors. All these greatly influence profitability. Generally, commercial recovery is more attractive to small- to medium-sized waste generators that do not have the capital for in-plant installations. Waste exchanges have not yet become a major influence because larger generators cannot transfer their liability for the waste (imposed by RCRA) to the waste user, and small generators have too little waste to pay the costs of exchange, or, in some cases, to assure consistent types and volumes to users.

Institutional Factors.—The Federal hazardous waste regulatory structure does not now provide direct incentives for use of any of the approaches mentioned above: segregation of waste components at the source of generation, modifications in manufacturing processes, development of end-product substitutions, and greater use of in-plant and commercial recycling and recovery operations. In part, this is because the emphasis in RCRA is not on reducing waste generation but on management of waste once they are generated, and EPA has not generally pursued the resource recovery aspects of RCRA. Moreover, a number of current regulatory policies and practices may actually act as disincentives for waste reduction and treatment activities. In some instances, process intermediates containing recoverable materials or energy are defined as waste even though they are not discarded. This can act as a disincentive to some recycling.

An important disincentive is the policy of keeping landfill costs low, even under the new RCRA regulations by:

- not requiring comprehensive, stringent monitoring at landfills;
- not requiring retrofitting of existing, active landfills;
- a liberal interpretation of "existing" in exempting, from some of the new regulations, portions of existing landfills that do not yet contain waste;
- limiting post-closure monitoring requirements to 30 years; and
- not requiring location of waste management facilities to protect drinking water sources,

As discussed further in the next section, the defects of the land disposal method may be postponing cleanup costs to the future, and it is likely that these costs will be borne by government or society in general. Externalizing such costs away from the private market to the public sector provides an indirect incentive for land disposal. Nevertheless, to a limited extent, for some waste generators, increasing costs under the current program and the perceived liabilities of land disposal are indirectly promoting more use of waste reduction methods.

A common question is: How much of the Nation's hazardous waste could be eliminated by the various approaches to waste reduction? Any estimate of what could be done technically and economically can be only a crude approximation. Theoretically, the generation of almost every hazardous waste might be affected to some extent by one or more of the approaches discussed previously. A 1981 California study of future hazardous waste generation concluded that new industrial plants will produce only half the amount of hazardous waste currently produced. Other estimates for potential waste reduction range from 30 to 80 percent. Waste reduction efforts, however, are more difficult to make in existing plants than in new ones. In addition to regulatory factors, capital and R&D needs—particularly for smaller hazardous waste generators—are important obstacles to implementing waste reduction efforts. General economic and market factors play a crucial role in raising and committing capital.

ISSUE 3

Are alternatives to land or ocean disposal of wastes available and used? How do Federal regulatory programs affect their use? Are concerns about the risks of land disposal of hazardous waste well founded?

FINDING

Not all of the technically feasible management options for hazardous waste are being used to their full potential. On the whole, Federal programs indirectly provide more incentive for disposal options than for alternatives. Land disposal, even if in compliance with RCRA, probably poses some preventable risks both in the near term and for the future. But land disposal is appropriate and necessary for many wastes (see chs. 5 and 7).

Management Alternatives.--Once hazardous waste are generated, they can be managed by one of two broad categories of technologies:

1. treatment by one or more steps to reduce the hazard level of the waste, or
2. disposal through containment or dispersal on land or in the oceans.

Treatment technologies reduce the hazard level directly or facilitate reduction in other steps by changing the physical or chemical nature of the waste, by separating waste constituents, by reducing the waste volume, or by reducing the concentration of hazardous substances in the waste. The treatment technologies include chemical, thermal, and biological treatments.

Containment technologies hold waste in a manner intended to inhibit release of hazardous components into the environment or keep releases to acceptable levels. These technologies include landfills, surface impoundments, and underground injection wells. With most containment options, it is probable that releases will occur at some time. Some surface impoundments are designed, in fact, to transfer material to the ground. Dispersal techniques, such as land treatment (spreading waste on the land) or ocean dumping, rely on naturally occurring processes to reduce the hazard level of waste constituents, or to transport them into and through the environment thereby diluting concentrations to acceptable levels, or both. Some geographical locations are generally understood to make exceptionally good sites for land disposal facilities because their hydrogeological characteristics make releases unlikely and because the probability that people or sensitive elements of the environment would be exposed to releases is extremely low.

The degree of feasibility and appropriateness of a specific management technology for a specific waste depends on many factors, including the characteristics of the waste and the environmental features of the facility site. Regulatory requirements and the goals and economic calculations of waste generators and handlers will also influence technology choices. A summary comparison of the major waste management alternatives (hazard reduction through treatment or disposal) is given in table 3.

Technology Selection and Waste Type.—Waste type is an **important determinant of** the technology chosen for waste management. For example, some wastes are technically incompatible with a specific technology because they would damage equipment. For wastes characterized as hazardous because of their reactivity, corrosiveness, and ignitability, there are well-established chemical and physical treatments available. However, for a waste in which toxicity is the major hazardous characteristic, the choices are not clear. Toxic constituents may be organic, inorganic, or metallic, and many technologies could be used. The major issue is whether to use a treatment or containment approach. For the most toxic waste, the preferred choice is treatment when it is technically feasible.

In general, the kinds of waste most suitable for land-based containment are residuals from treatment operations, pretreated (or stabilized) waste, untreatable waste, and relatively low-hazard (and often high-volume) waste. However, some untreatable waste are so highly toxic that land disposal should not be used, and waste elimination is the only acceptable alternative (exemplified by the statutory prohibition on the use of polychlorinated biphenyls (PCBS). Appropriate use of the

Table 3.—Comparison of Some Hazard Reduction Technologies

	Disposal		Treatment		
	Landfills and impoundments	Injection wells	Incineration and other thermal destruction	Emerging high-temperature decomposition [a]	Chemical stabilization
Effectiveness How well it contains or destroys hazardous characteristics	Low for volatlies, questionable for liquids, based on lab and field tests	High, based on theory, but limited field data available	High, baaed on field tests, except little data on specific constituents	Very high, commercial. scale tests	High for many metals, based on lab tests
Reliability issues"	Siting, construction, and operation Uncertainlties long-term integrity of cells and cover, Ilner life less than life of toxic waste	Site history and geology, well depth, construction and operation	Monitoring uncertainties with respect to high degree of DRE; surrogate measures, PICS, Incinerability[c]	Limited experience Mobile units; onsite treatment avoids hauling risks Operational simplicity	Some inorganic still soluble Uncertain leachate test, surrogate for weathering
Environmental media most affected	Surface and ground water	Surface and ground water	Air	Air	Ground water
Least compatible	Liner reactive; highly toxic, mobile, persistent, and bioaccumulative	Reactive; corrosive; highly toxic, mobile, and persistent	Highly toxic and refractory organics, high heavy metals concentration	Some Inorganic	Organics
Costs" Low, Mod, High	L-M	L	M-H (Coincln. - L)	M-H	M
Resource recovery: potential	None	None	Energy and some acids	Energy and some metals	Possible building material

[a]Molten salt, high-temperature fluid wall, and plasma arc treatments
[b]Vastes for which this method may be less effective for reducing exposure, relative to other technologies Wastes listed do not necessarily denote common usage
[c]DRE = destruction and removal efficiency PIC = product of Incomplete combustion

SOURCE Off Ice of Technology Assessment

oceans for disposal has not been resolved. For some hazardous waste, dumping in certain ocean locations appears to offer acceptable levels of risk for both the ocean environment and human health. However, there is generally inadequate scientific information to decide what the locations are for specific wastes.

Comparisons of Technologies.-Several technical factors make it difficult to compare treatment and disposal alternatives (see table 3). The goal for each technology is to reduce the probability of release of hazardous constituents, but no technology can offer zero release. Performance capabilities for different technologies must be considered in relative terms; releases that do occur vary in location, quantity, and time. For example, landfills inhibit releases through containment but will eventually (and usually gradually) leak and may contaminate ground water. Incinerators destroy most of the waste, but some air pollution will occur. Stabilization of waste immobilizes hazardous constituents but often allows some hazardous constituents to be dissolved (leached), albeit at slow rates. Chemical treatment, such as dechlorination, detoxifies but may produce some residue requiring disposal. An important issue in making comparisons, and for regulatory purposes, is to describe the nature and impact of potential releases, not merely what the technology accomplishes. For example, a technology may destroy or detoxify 99.99 percent of a waste constituent input, but it is necessary to consider the total amounts released and their toxic effects.

Another factor influencing comparisons is that different technologies achieve their objective with differing efficiencies, such as degree of destruction, degree of containment, and degree of stabilization. Another factor to consider is the variation in potential routes of releases, such as air for incinerators and ground water for landfills. These are important qualitative differences that influence the character of risks. The reliability of different technologies is also important, Reliability depends, for example, on the degree of direct process control available, the effectiveness and accuracy of surrogate (indirect) process monitoring measures, and the opportunity to correct emissions prior to environmental discharge. Finally, opportunities for energy and material recovery vary among alternative technologies.

Comparison of Direct Costs .—Costs are generally considered on some volume or weight basis for a particular management technique. It is not possible at present to compare costs of treatment and disposal alternatives on the basis of comparable levels of control because:

1. consensus is lacking about what constitutes comparable levels of control across technologies;
2. there are regulatory uncertainties in the evolving Federal program;
3. cost data are specific to applications, locations, and wastes; and
4. costs are changing as generators find lower cost alternatives in response to regulatory and market conditions.

An important conclusion, however, is: even though RCRA regulations will increase land disposal costs, land disposal is still likely to be the low-cost option under the current regulations for most hazardous waste. In addition, costs for treatment technologies are more sensitive to waste type than are land disposal options.

Table 4 summarizes direct costs for commercial, offsite treatment, and disposal alternatives on a per tonne basis (as received wet or dry). Generally, different technologies compete at the low end and in the middle of the price spectrum, but in some cases the exact character of the waste, not the cost, determines the applicability of different technologies and therefore the management choice. There are greater price differences among the technologies for managing the most hazardous waste, with incineration markedly more costly than land disposal, and some chemical treatments being as costly as incineration.

It should be noted that transportation costs to waste management facilities can be quite substantial, with long distances increasing direct costs by as much as 50 to 100 percent. In some locations, there may be no nearby

Table 4.— Representative Unit Costs for Commercial Hazardous Waste Treatment and Disposal

Category	$/tonne
Typical ranges:	
Land disposal	
Landfills (low to high hazard drummed waste)	$13-$240
Deep well injection—oily waste waters . . .	$16-$40
Land treatment, farming or spreading.	$5-$24
Chemical treatment—acids or alkalines	$21-$92
Incineration (clean combustible liquids to highly toxic and refractory solids or drummed waste)	$53-$800
Most costly:	
Landfills (extremely hazardous waste) . .	$168-$240
Deep well injection—toxic rinse waters .	$132-$264
Chemical treatment—cyanides, toxic metals, highly toxic wastes	$66-$791
Incineration (solid or drummed highly toxic waste)	$400-$800

SOURCE Office of Technology Assessment, based on various published sources

alternatives to land disposal, and the added cost for transportation makes land disposal even more attractive economically. Also, the smaller the quantity of waste handled, the greater the per-unit treatment or disposal costs. There are, however, new commercial enterprises aimed particularly at the small generator market. Various techniques can be used to reduce handling costs, including using trucks that deliver chemical feedstocks to pick up carefully labeled and separated hazardous waste.

Land Disposal Risks .—All treatment and disposal options for hazardous waste inescapably pose some risks to public health and the environment. Technical experts and the public are concerned because land disposal facilities can release hazardous constituents at some indeterminate time in the future. Although the likelihood of some releases is high, there are considerable uncertainties about:

1. the likely quantity and timing of releases of particular constituents,
2. the rates of transport of released hazardous constituents through the environment and their rates of degradation in the environment,
3. the extent of possible exposures of people and the environment to persistent hazardous constituents and their degradation products, and
4. the probability of damages.

The uncertainty of the risks, the fact that people are unable to control their own exposure to the risks, the as yet unproven ability of RCRA regulations to detect or minimize releases, and the uncertainties about effective cleanup of old waste dumps that are a legacy of past land disposal practices all contribute to a widespread belief by technical experts and the public that land disposal of many types of waste poses unacceptable risks. As with most public debates over perceived risky situations, it is not only the technical aspects of the risk that matter. In addition, public perceptions of the risk levels and their acceptability influence priorities. In the case of land disposal, the issue appears to be when and how, rather than if the use of land disposal is to be reduced.

Use of Land Disposal v. Its Alternatives.-AVailable information indicates that land-based disposal methods are used for most wastes (as much as 80 percent according to early EPA data, see issue 1), including many that are treatable or recyclable. There is insufficient information to determine exactly the extent to which land disposal options may be used nationwide for waste that could be treated or recycled,

In 1981, a study on California waste managed offsite concluded that:

1. 75 percent of the hazardous waste disposed in landfills (classified as the most secure by the State) could be recycled, treated, or destroyed,
2. almost 40 percent of all land disposed hazardous waste were highly toxic and very persistent,
3. most of the additional waste management capacity needed to recycle, treat, or destroy hazardous waste could be developed in less than 2 years; and
4. the additional cost of recycling, treating, or incinerating highly toxic waste would have a minimal effect on industry.

Nationally, a recent study for EPA of nine major commercial waste management companics showed that capacity utilization for incineration in recent years was about 80 percent, for chemical treatment just over 50 percent, and for recycling it was 24 percent. These data indicate that available capacity for offsite management of wastes is not a barrier to shifting management choices away from land disposal.

Even more technological alternatives to traditional land disposal could be developed in the years ahead. Only about 10 percent of EPA's current R&D efforts for hazardous waste are devoted to alternatives to land disposal. Emerging thermal, physical, and chemical treatment technologies are at a point where they could substantially benefit from more R&D support. Certain physical/chemical processes now being developed offer unusual benefits with regard to preventing emissions of hazardous constituents, providing resource recovery, and reducing toxicity,

Institutional Factors.—The current regulatory structure does not directly encourage consideration of alternative, safer, and more permanent solutions to problems posed by the very complex nature of hazardous waste. Indirectly, the increased stringency of RCRA regulations for land disposal facilities, increased emphasis on financial liability and future legal actions, increased public concerns, and increasing costs for land disposal have all contributed to greater consideration of treatment alternatives to disposal where they are technically feasible.

The current Federal program, however, also presents indirect, and probably inadvertent, disincentives for treatment alternatives to disposal. The following recent statement by EPA's senior official for hazardous waste regulation signals the continuing acceptance of land disposal options:

> We believe that most wastes can be satisfactorily managed in the land and that it can be done with a reasonable margin of safety more cheaply in this manner, . . . it may be that recycling or destruction is preferable from a strictly health and environmental protection standpoint, but for many wastes, the reduction in risk achieved is probably marginal and may not be worth the cost."

However, EPA has made technical statements of a more cautious nature about disposal: ". , , the regulation of hazardous waste land disposal must proceed from the assumption that migration of hazardous wastes and their constituents and by-products from a land disposal facility will inevitably occur.'" In the final land disposal regulations where stringency depends, in part, on the use of liners beneath wastes, EPA has also said ". . . any liner will begin to leak eventually.'" The regulations also state that a landfill liner must completely "prevent" migration during the active life of a landfill, and that it must "minimize" migration thereafter. There are substantial differences of opinion in interpreting what these requirements mean, and how to implement them technically, Concerns over who will pay for actions necessary to deal with expected and unexpected releases of hazardous constituents are heightened by the absence of any financial responsibility requirements for the operator to take corrective action if there are releases of hazardous constituents from land disposal facilities. There are, however, RCRA closure and post-closure financial responsibility requirements, and a CERCLA Post-Closure Liability Trust Fund, but there are uncertainties about the long-term effectiveness of these approaches. The net effect is that current RCRA regulatory policies continue to make land disposal attractive economically, despite uncertainties over long-term safety, although much less so than before these regulations. Thus, long-term risks and costs, to some extent, are transferred to government or society in general, Without the full internalization of costs, land disposal options retain a competitive advantage against treatment alternatives and, therefore, an indirect disincentive for such alternatives exists.

'Testimony of Rita M. Lavelle, Assistant Administrator for Solid Waste and Emergency Response, EPA, U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment, Dec. 16, 1982.

[7]Federal Register, vol. 46, No, 24, Feb. 5, 1981.

eFederal Register, vol. 47, No, 143, July 26, 1982.

Until the private sector perceives the regulatory structure as not containing a bias in favor of land disposal technologies, investment in new treatment technology R&D and commercial development may be limited. Equally important are the size and certainty of the total waste management market, which is also dependent on Federal hazardous waste policies, particularly those concerning the universe of waste regulated. The use of direct Federal incentives for alternatives to land disposal has not been pursued by EPA thus far. EPA has, however, commented favorably on the use by some States of tax and fee systems that can raise revenues to offset a loss in Federal grants that support State hazardous waste control programs. In some cases, the State tax and fee systems are structured to promote alternatives to land disposal.

ISSUE 4

Can the various kinds of hazardous waste be differentiated by estimates of hazard potential? Could waste and facility classification play a useful role in the regulation of hazardous waste?

FINDING

Waste can be differentiated into at least three categories of hazard. Waste classes can be combined with facility classes to form a technical base for Federal regulatory policies. Developing the details of waste and facility classification would require substantial work (see ch. 6).

Hazard classification models are available that differentiate among the variety of industrial waste based on measures of potential hazard posed to human health or to the environment. Criteria used to rank hazards differ. Some models use only measures of acute toxicity and carcinogenicity. Some consider toxicological criteria and estimate environmental fate of waste constituents. Others include safety factors, toxicity measures, and concentration levels for major constituents. Although each model has drawbacks, a case study performed for OTA of selected RCRA waste treated by EPA regulations as equally hazardous, indicates that waste can be differentiated into at least three categories of hazard.

Certain problems, however, emerge in the attempt to classify wastes:

1. criteria must be chosen carefully to maximize protection of public health and the environment, and to identify sensitive species which may be exposed;
2. ranges of measurements must be used that reflect expected doses and exposures; and
3. incomplete data bases, including problems of variability and interpretation, can hamper classification of some wastes.

Classification of any particular waste can vary depending on the system used; the choice and weighting of technical criteria are critical. Concerns over the determination of boundaries for classes should be addressed by developing technical justifications and working for a consensus among industry, government, the scientific community, and public interest groups.

Classification of wastes can be combined with facility classification to serve as the technical basis for a regulatory program. Facility classes would distinguish among different designs of a particular type of facility and among different physical locations. The risk potential of a facility depends on the environment surrounding the facility, meteorological conditions, the impact of facility operation on the waste (e.g., treatment or containment), and the technological limitations of facility design and operating conditions. For example, two or three classes of incinerators could be developed with different destruction and removal efficiencies. Several landfill classes might be formulated relating permeability potential of liners to the environmental conditions of a site such that wastes would be contained for specified periods. Different facility classes would require different types and levels of monitoring.

Waste and facility classes must be matched so that consistent risk levels are obtained across both waste and facility classes. For example, the risk from a waste class I and facility class I combination should be substantially the same as from a waste class 11 and facility class II combination.

Although there are technical limitations that must be recognized, the use of classification systems for wastes and facilities offers certain advantages over the current regulatory program.

ISSUE 5

To what extent can risk assessment be used in the regulation and management of hazardous waste?

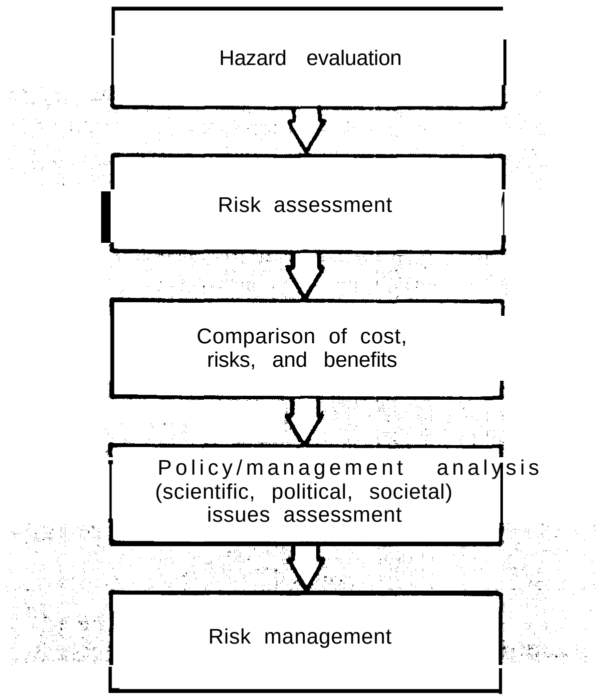
FINDING

The technical limitations of risk models, assumptions, and data require careful attention. However, risk assessment has a useful role as an analytical tool in the total risk management and decisionmaking framework (see chs. 6 and 7).

Risk assessment involves two steps: risk estimation and validation of the estimate (too often omitted or deemphasized). Risk estimates are based on evaluations of the hazard potential of wastes and identification of relationships between the potential hazard and health and environmental effects. In some instances, risk estimation is calculated using mathematical models to extrapolate from high doses, used in laboratory situations, to low doses, which may be detected in the environment. Individual estimates generated by different models can vary considerably, even when the same data are used.

Risk assessment can assist in making a variety of decisions, including establishing regulatory standards, setting priorities for R&D, identifying risk levels associated with treatment and disposal options, and determining appropriate locations for waste management facilities. But risk assessment is only one component in a risk management framework, as shown in figure 1. Several models are available for analyzing tradeoffs between costs, risks, and benefits. It should be emphasized, however, that RCRA precludes balancing costs and risks. Risk assessment is best regarded as an analytical tool and not as the final decision process. Decisionmakers evaluate the results of risk assessments in the context of many nonquantitative factors, including all the uncertainties of the risk analysis, value judgments made in the assessment, special interests that have been recognized (or not), and sociopolitical factors of importance to the issue. In risk management, conflicts among these factors always will exist. Such conflicts represent differences in societal interests and perspectives and, thus, must be considered in the decisionmaking process,

Figure l.— Risk Management Framework



SOURCE: Off Ice of Technology Assessment

Because better data and information are critical to risk management decisions, it is often implied that tradeoffs must be made between expeditious protection of the public and the need to obtain improved data. However, considerable data exist to allow some reasonable risk assessments to be made, bearing in mind the previously noted limitations. RCRA requires protection of the public from hazardous waste in the near term on the basis of known (or presumed) toxic and other harmful substances in such waste, and on the basis of documented adverse incidents. A scientifically certain link between disposal of hazardous waste at a specific location and resulting health or environmental effects, particularly long-term ones, is usually not possible.

Recently, EPA developed two risk assessment models for CERCLA and RCRA applications. While the concept of using risk models for regulatory purposes has merit, the assumptions used by EPA as the basis for these particular models are so simplistic that their usefulness is questionable. For example, both models incorporate a concept that can result in unequal protection of some segments of the public. In these models, estimates of risk depend on population density close to the site. Areas of low population density will receive lower risk estimates than areas with high population densities, but this is not necessarily as sensible as it first appears. Actual risks depend on where and how releases of hazardous constituents move through the environment, the ultimate fate of the materials, and, most importantly, the doses or exposures received by particular people or elements of the environment. Population density by itself is a poor indicator of actual individual exposures and risks (i.e., "per capita risk"), and risks may be high or low, independent of overall population density. In addition to the problems in the way population density is used, there are problems in these models with the criteria used to determine hazard potential. These and other problems lead to considerable uncertainty in the final risk estimates.

ISSUE 6

What contribution can monitoring make to effective risk management and is such a contribution required by the current RCRA program?

FINDING

Current monitoring practices and requirements under RCRA do not lead to a high level of confidence that releases will be detected and responsive action quickly taken (see chs. 6 and 7).

Monitoring can generate data to serve as a technical basis for regulatory action and as verification that public health and the environment are being protected. There are several closely related functions for monitoring: establishing baseline or background data, developing data for setting regulatory standards, verifying compliance with regulations, identifying R&D priorities, and assessing contamination.

Two different monitoring strategies can provide information about the operation of hazardous waste management facilities. Surveillance monitoring can verify compliance with regulatory requirements and provides limited data about changes in environmental quality. Assessment monitoring is used to determine the extent of deterioration in environmental quality and also provides data that indicate cause-effect relationships for specific hazards. Regulatory programs should employ both strategies—with surveillance monitoring required for all facilities, and assessment monitoring used when the results of the former indicate an emerging problem.

Both monitoring strategies pose problems including sampling procedures, data comparability, and limitations in available analytical methodologies. For example, difficult choices must be made regarding the location and number of sampling sites and the frequency with which samples are taken, A poor choice of sampling location could miss the detection of "hot spots" of contamination. Data comparability is possible only if standardized sampling and analytical protocols are used. Variances can occur among results if different laboratories and equipment are used, and even if different personnel perform the same test. Greater attention should be given to these "practical" aspects of the national hazardous waste monitoring program and to the development of an adequate analytical infrastructure nationwide.

Of the five types of monitoring (visual, process, source, ambient, and effects), only visual, process, and source are incorporated into RCRA regulations to any significant degree. Limited ambient monitoring is required of land disposal facilities but collection of effects data is not required. If effectively conducted, visual, process, and source monitoring can reduce the amount of ambient monitoring that may be needed by minimizing the release of hazardous constituents into the environment. However, they cannot serve as a substitute for ambient monitoring.

Ambient monitoring provides information on the appearance of statistically significant levels of contaminants in air, soil, water, and biota. Ambient monitoring holds the greatest potential for minimizing risks that might result from hazardous waste mismanagement. Only by taking representative samples from potentially affected locations and environmental media and then analyzing them for a broad spectrum of potential contaminants is it possible to control risks reliably. Minimization of releases of hazardous constituents ultimately provides the greatest protection of public health. Furthermore, environmental media, and the processes that influence the movement and fate of hazardous releases, are protective barriers against human exposure. If contamination of air, water, or land can be detected sufficiently early (before widespread contamination and actual damage) and corrective action taken, then human exposure will be reduced. Ambient monitoring, therefore, should be given a greater role in the RCRA regulatory program.

The full potential of monitoring is not required by the RCRA regulations. Specific but limited monitoring activities are required only for incinerators and land disposal facilities. Land disposal facilities are required to conduct limited ambient monitoring (i.e., four samples taken twice a year). However, there are exemptions to ground water monitoring requirements for land disposal facilities that have a double liner and a leak detection system between the liners. This could lead to delays in detecting the release of contaminants. Furthermore, even if ambient monitoring is conducted, EPA's guidelines for locating sampling wells will not provide adequate representations of the quality of an aquifer in all cases because of the possibility of complex aquifer shapes and flows. Contamination limits established for ground water protection for land disposal facilities have serious inadequacies.

With regard to discharges to air and water, waste treatment facilities must comply only with monitoring requirements of the Clean Air and Clean Water Acts. Because these acts do not cover the broad range of hazardous constituents that are of concern in RCRA, reliance solely on monitoring required by the Clean Air and Clean Water Acts appears risky.

There are also serious concerns over the possible lack of routine reporting of monitoring data obtained by facility operators to, and verification by, State programs, and accessibility of monitoring information to the general public. Therefore, limited monitoring requirements established for treatment, incinerator, and land disposal facilities will not likely provide adequate protection of either public health or the environment, particularly over the long term.

ISSUE 7

How effectively is CERCLA addressing the problem of uncontrolled hazardous waste sites?

FINDING

Some progress is being made toward cleaning up some of the worst uncontrolled sites. However, many sites will not have received attention when collection of the CERCLA tax expires in 1985. There is still incomplete information on the long-term effectiveness of cleanup techniques (see chs, 5 and 7).

Uncontrolled sites may be either operational, inactive, or abandoned. A recent survey of 348 uncontrolled sites, which have received some remedial action, indicated that various types of land disposal techniques were used originally in 97 percent of the cases, There is no question that uncontrolled sites are a large problem for the Nation, EPA's inventory now contains more than 15,000 sites and the total is increasing steadily. Costs of remediation vary greatly, from several hundred thousand to ten to twenty million dollars per site. Through fiscal year 1982 only $88 million of $452 million collected under CERCLA had been spent for cleanups, no cleanup funds had been allocated or expended on 97 of the initial 160 priority sites determined by EPA, and only three sites had been totally cleaned up (one entirely with State funds). The first complete National Priority List contained 418 sites. But the model used to rank sites according to their hazards has important inadequacies (see issue 5).

A major problem is that the National Contingency Plan does not provide specific standards, such as concentration limits for certain toxic substances, to establish the extent of cleanup. Consequently, there is little assurance that cleanups provide protection of health and environment over the long term. However, another perspective is that flexibility and site-specific standards are both appropriate and effective.

Although the approach being used stresses cost effectiveness, there has not been time for a history of effectiveness to accumulate. Thus, it is not yet possible to quantify and compare technologies. The long-term effectiveness of remedial technologies is uncertain because many remedial technologies are containment approaches and these require long-term operation and maintenance.

Technical approaches for remedial control consist either of actions on the waste, such as drum and contaminant removal, contaminant treatment, and incineration; or of actions on the route of release, such as ground water pumping, encapsulation, and gas control. In recent remedial actions, removal of wastes and contaminants (e. g., soil) accounted for about 40 percent of the cases. Usually, removed materials are land disposed, and are beginning to constitute a significant added management burden in RCRA facilities,

There will be many uncontrolled hazardous waste sites requiring attention when collection under Superfund expires in 1985, perhaps even more than when it was enacted because:

1. not all of the 418 priority sites will be cleaned up; EPA has indicated that perhaps half will be totally cleaned up;
2. the national inventory of uncontrolled sites is as yet incomplete;
3. active sites will continue to be closed under circumstances that may shift cleanup responsibility to CERCLA, and this process may be accelerated by final RCRA regulations and the difficulty of compliance by some facilities;
4. a potentially large number of sanitary landfill (subtitle D) facilities for solid, nonhazardous waste may be closed, and may be contaminated by hazardous waste received in the past and currently (e.g., because of the small generator exemption, exempted recycling facilities, and from household discards of hazardous materials);
5. some States may be unable to provide their matching share for cleanup of sites (10 percent for private sites and 50 percent for government-owned sites); this has already prevented about one-third of the original 160 priority sites from receiving remedial action;
6. States and private parties will have difficulty in securing sufficient funds to clean up sites not selected early in the Superfund program, and these may become more hazardous over time;
7. the lifetimes and performance levels of remediation technologies (particularly containment systems) under either RCRA or CERCLA are limited;
8. corporate financial responsibility for some closed RCRA sites will expire; and
9. "ancient" sites not yet documented will continue to be unearthed (often accidentally) and identified.

ISSUE 8

To what extent can technical means be used to address public opposition to siting of hazardous waste facilities?

FINDING

Improving the scope, quality, and dissemination of technical information and using technical siting criteria could prove useful; however, nontechnical institutional remedies that improve public confidence in government programs may be more effective (see ch. 6).

A paradox exists wherein the same public that calls for safer hazardous waste management frequently opposes the siting of specific hazardous waste facilities, The public generally views risks associated with a specific facility as unacceptable at worst, and uncertain and out of its control at best. Risks and potential damages (direct effects resulting from releases of hazardous constituents, as well as indirect effects resulting from potential problems, such as losses in property values) are borne largely by local communities. There is usually little prospect of timely compensation. In contrast, benefits associated with the myriad of activities that generate hazardous waste are more equally distributed over society as a whole. Furthermore, perceptions of future risks are shaped almost entirely by the public's understanding of health and environmental effects from past hazardous waste management practices and failures. The public remembers problems with uncontrolled sites and risks from transportation accidents and spills of hazardous material rather than of hazardous waste. A key issue is the degree of public confidence in new government programs to control hazardous waste, and in contemporary, improved management approaches. Whatever the causes, continued public opposition poses a substantial obstacle to siting hazardous waste management capacity of any type. The uncertainties and costs related to public opposition make private sector commitments of capital difficult.

Both technical and institutional approaches can be used to address public concerns, but these concerns will never completely be eliminated, In the technical area, public confidence and understanding can be increased by:

1. improving the quality of information disseminated to the public to better describe facility needs, uses, characteristics, and risks;
2. using siting processes based on sound technical criteria to ensure that specific locations have been chosen to reduce present and future risks as well as to satisfy waste generator and management needs; and
3. increasing efforts to promote the development and use of alternatives to land disposal.

However, nontechnical or institutional approaches, mostly at the State level, may be more effective, These include:

1. measures to ensure meaningful and effective public participation in siting and permitting of facilities;
2. programs to provide assurance that in the event of any release of hazardous constituents there will be quick and effective emergency and remedial actions;
3. programs to provide assurance that in the event of damages to health or the environment, or indirect economic effects, injured parties will be able to obtain equitable compensation expeditiously; and
4. programs that provide assurance of continued compliance with stringent regulatory requirements, particularly for monitoring.

Currently, there is little direct Federal involvement in facility siting, other than the permitting of facilities. However, there are a number of possibilities being discussed for greater Federal involvement, including:

- providing technical siting criteria either as a model for States to consider, or as mandatory;
- providing assessment of hydrogeological characteristics of importance in deciding the acceptability of sites;
- providing technical assistance to States, local governments, and the public;
- providing information exchange programs;
- assisting in formal or informal mediation of siting disputes;
- providing use of Federal lands;
- legislative sanctioning of interstate hazardous waste management compacts to ensure adequate hazardous waste management capacity in a regional context; and
- mandating that States engage in hazardous waste planning, based on a hierarchy of waste management alternatives, and then provide adequate management capacity for all waste generated in their States.

Whatever actions are taken to address public opposition to hazardous waste facilities, there is little likelihood of any "quick fixes. " Current difficulties with the economy may, in some instances, alleviate public concerns by, for example, making waste management activities more attractive as sources of employment, or as a means to keep or attract industrial plants. However, dampened public concern caused by a depressed economy should not be relied on as a widespread or lasting solution to siting problems. In the longer term, successful experience with the RCRA and CERCLA programs could improve public confidence substantially, but lack of success would cause further erosion in public confidence. The potential loss of Federal funding of State programs, which EPA is discussing, and uncertainties over alternate sources of money will likely exacerbate public concerns.

ISSUE 9

Is the congressional intent that the States become partners in implementing the Federal hazardous waste program being met?

FINDING

The States are being given increasing responsibilities by the Federal program without matching technical and financial resources (see ch. 7).

An important element of the congressional mandate to regulate hazardous waste was the eventual shifting of administration of the programs to the States. The States have had difficulties because the Federal program has experienced changes in direction and delays, and is still incomplete. Nevertheless, it is generally accepted that RCRA has greatly improved the number and quality of effective State hazardous waste programs, few of which existed before RCRA.

However, an element of confrontation has developed between the Federal program and the States. At a critical time when the program is just beginning to be fully implemented, some States believe that there are substantial impediments to providing adequate protection to the public. In fact, some States may refuse the responsibility of taking over administration of the RCRA program.

1. States are not receiving increases in financial assistance from the Federal Government corresponding to increased responsibilities for implementing the RCRA program; EPA has indicated its desire to eliminate RCRA grants to the States altogether; and States face uncertainties and delays in attempts to obtain alternative sources of funds.
2. Many States do not have an adequate technical information base or enough technically skilled personnel to carry out their regulatory responsibilities. Data obtained by EPA have often been incomplete, and the level of detail has sometimes been inadequate for use by the States to implement Federal regulations; this has resulted because of statistical sampling rather than total inventory approaches to collecting data, States are hampered in their efforts to obtain necessary information by a lack of funds and a lack of certainty concerning the RCRA regulations. Moreover, a number of RCRA and CERCLA regulations transfer considerable technical standard-setting and decisionmaking to the permit writing stage. However, the complex technical requirements of these areas are substantial, as in hydrogeology, and there may be shortages of State personnel to adequately perform these required functions.
3. Many State officials feel that States are not being given sufficient opportunities to influence the formulation of Federal regulations and policies that they are expected to adopt and implement.
4. States do not have policy guidance or support for regional approaches to dealing with hazardous waste problems.
5. States are not being given sufficient latitude by EPA to develop their own programs that might deviate from the Federal program but lead to the same result—i.e., programs that are consistent with and equivalent to the Federal program in terms of protection of public health and the environment, but are not identical to it in terms of the language in regulations and statutes,
6. In some cases, EPA policies concerning hazardous waste have shifted burdens to the States in the area of solid waste (under Subtitle D of RCRA). At the same time, however, Federal funds for support of State solid waste activities have been

eliminated. Such is the case when wastes that are hazardous are granted exemptions (e.g., from small generators) under subtitle C and can be disposed of in subtitle D sanitary landfills.

7. Problems associated with CERCLA (Superfund) implementation are substantial. States must provide substantial matching funds (10 percent for privately owned sites and 50 percent or more for State or municipally owned sites) to obtain Federal assistance for remedial actions at uncontrolled sites, as well as assuring all future operating and maintenance costs. They must also perform a number of activities, such as assessments of potential Superfund sites and enforcement activities, for which no continued CERCLA funding is available. Hence, many States have found it necessary to use funds from Federal RCRA subtitle C grants for Superfund activities at a time when activities under RCRA are mounting,

One important area of development at the State level are policies and programs to supplement regulation of facilities such as greater use of insurance requirements, civil liability, taxes and tax incentives, and negotiated agreements for dealing with problems posed by hazardous waste. Such means have some potential to improve the overall effectiveness of State and Federal waste programs, In many cases, the major motivation for the use of fee and tax systems is to increase revenues for State hazardous waste programs (or in some instances for general purposes), and secondarily to provide incentives for waste reduction and treatment alternatives to land disposal. States' use of these approaches are not generally in conflict with EPA regulations or RCRA. EPA's State authorization program has generally not focused on State nonregulatory initiatives that could supplement the Federal program, or on efforts to develop acceptable alternative regulatory approaches such as State degree-of-hazard systems,

Policy Options

The current Federal hazardous waste program presents a dilemma. On the one hand, there is a sense of urgency and impatience, derived from 6 years of difficulties in dealing with an extremely broad and complex area of threats to public health and the environment. Suggesting changes in Federal policies, therefore, creates concerns over the possibility of still more delays and uncertainties. Those who support the current Federal program (both RCRA and CERCLA) believe there is a need to allow more time before conclusions concerning effectiveness are drawn and possibly disruptive changes are made.

On the other hand, there is also a widespread belief that current policies and programs could be technically, economically, and socially more effective. Waiting for the determination of the current program's effectiveness, it is argued, may lead to the development of outright crises, such as widespread ground water contamination. There is consensus that we are now acting more effectively than in the past to protect the public from improper management of hazardous waste. But there is also considerable evidence (concerning, e.g., the technical limitations and uncertainties of land disposal techniques) that we may be acting in ways which:

1. are too temporary in nature;
2. may lead to greater risks to the public in the future; and
3. may increase ultimate costs to industry, government, and the public.

Furthermore, this dilemma must be considered in the context of reduced allocations for government programs. Such conditions may prompt industry, State and Federal Governments, and the general public to avoid additional near-term costs associated with a cleaner environment in order to cope with immediate economic difficulties, Thus, options that defer costs, that do not jeopardize current industrial activities, that shift risks to the future may appear more attractive than in the past. Such tradeoffs pose formidable choices for policymakers, made more difficult by current uncertainties concerning the degrees of effectiveness of laws and programs not yet fully implemented.

Five policy options are evaluated in terms of overall goals:

- Option I: Continuation of the Current Program.
- Option II: A More Comprehensive and Nationally Consistent RCRA Program.
- Option 111: Use of Economic Incentives for Alternatives to Disposal or Dispersal of Hazardous Waste.
- Option IV: Development and Potential Use of a Hazard Classification Framework.
- Option V: Planning for Greater Integration of Environmental Protection Programs.

The first, "status quo" policy option is not compatible with option II; however, the options are not mutually exclusive for the most part. The four "new direction" options, taken together, can be viewed as a series of complementary changes to improve and reorient the current program.

Four scenarios are also presented to indicate how several options may be combined. For example, one scenario (a combination of options I and III) responds both to the desire to prevent delays and uncertainties resulting from changes in the current regulatory program and to the need to promote greater use of alternatives to land disposal.

The General Accounting Office, among others, has focused on several administrative aspects, including the critical area of enforcement, in a number of reports to Congress. Most recently, a House study has documented critical concerns in the enforcement of both RCRA and CERCLA statutes and regulations.[9] There are indications of an increased administrative reliance on voluntary compliance and settlements with responsible parties, which by themselves may be effective, but which appear to be linked to substantial reductions in funding for enforcement activities. OTA'S study of technical issues and problems, such as the effectiveness of pollution control regulations or the exemption of wastes from RCRA regulation, cannot substitute for congressional examination of the administration of the Federal program. The policy actions discussed below, regardless of their merits, are not likely to produce favorable results unless enforcement of regulations is effective.

[9]U.S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, report on enforcement of hazardous and toxic substances regulations during fiscal year 1982, October 1982.

Common Goals for Policy Options

It is helpful to define specific goals for policy options for purposes of comparison and evaluation, Eight such goals for any practical congressional option are presented below. These goals have been used to evaluate each of the policy options.

GOAL 1

Improved protection of public health and the environment, without undue delays and uncertainties by:

- **reducing the magnitude and hazardous nature of potential releases of waste constituents from all types of waste generation and management facilities,**
- **improving monitoring programs to quickly detect such releases, and**
- **improving corrective actions to mitigate releases.**

GOAL 2

Expand the kinds of hazardous waste federally regulated, recognizing that different levels of regulation under RCRA may be appropriate and desirable.

GOAL 3

Encourage development and use of technological alternatives to land disposal (land disposal includes land and ocean dispersal), such as waste reduction and treatment, to reduce risks resulting from releases of hazardous waste constituents into the environment.

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GOAL 4

Improve and expand data and information on hazardous wastes, facilities, and health and environmental offects which are necessary for more reliable risk assessments and for the implementation of RCRA and CERCLA by both EPA and the States.

GOAL 5

Improve and expand participation in RCRA and CERCLA by the States through improved definition, implementation, and support of both Federal and State rasponsibilities.

GOAL 6

Moderate the inevitable increases in the costs of Fedaral and State program administration and regulatory complianca by industry; and minimize costs associated with site remediation and compensation for further damages to public health and the environment which may result from current practices that could be Improved.

GOAL 7

Reduce risks transferred to the future, whether several years or to future generations, and reduce costs of waste management which are externalized and shifted to society in general.

GOAL 8

Reduce public concerns over the Sitting of hazardous waste management facilities of all types through, for ● xampb, improved implementation and enforcement of, government programs.

The Five Policy Options

OPTION i

Continuation of Current Program.

This option assumes that the mandates of both RCRA and CERCLA may be met by the current Federal hazardous waste program. It should be recognized that the present program is not static. EPA has indicated several plans for changes and improvements in the near term.

Unlike the other policy options, no unusual implementation problems and costs are associated with this "status quo" option. Criticisms of the option are generally based on perceptions of current problems or point to unacceptable risks and costs involved in waiting for the program to "prove itself."

OPTION II

A More Comprehensive and Nationally Consistent RCRA Program.

The purpose of this option is to expand the scope and increase the effectiveness of the current RCRA program. The changes discussed below would be carried out by amendment to RCRA, possibly including a schedule for EPA implementation within approximately 6 months to 1 year of enactment. For convenience, all changes in RCRA are presented as one congressional option, although each could be acted on independently, and any combination is possible.

Wastes Regulated .—This change concerns the universe of regulated hazardous waste and the extent of such regulation. The findings of this assessment support consideration of the following measures to regulate, in appropriate ways, more high-priority waste which pose significant threats.

1. Closing the gap created by the blanket exemption of hazardous waste generated in relatively small quantities. The objective is to avoid having hazardous wastes managed as nonhazardous, solid wastes in sanitary landfills. In the near term, if a quantity cutoff is used, the prudent approach would be to use a relatively low cutoff, such as 100 kilograms per month (kg/me) instead of the current 1,000 kg/mo value. In the longer term, however, some measure of the level of hazard of the waste could be used instead. The degree-of-hazard approach does not imply adoption of any particular, or complex, methodology for assessing level of hazard. Regulation would be based on known characteristics of the waste that indicate potential harm to human health and the environment on release of the material into the environment and with significant exposure. However, if it could be demonstrated that relatively small quantities of hazardous waste do not present significant threats (either on a generic or waste-specific weight cutoff basis),

then there could be minimal regulatory control, e.g., notification and reporting requirements, or modification of the RCRA regulations which govern waste generators.

2. Ending the total exemption for hazardous waste burned as fuels, or as fuel supplements, which may, in some instances, be dispersing unacceptable amounts of hazardous substances into the environment. Instead, there would be notification requirements for records of what wastes are being burned and where. Also, there would be standards for acceptable levels of releases into the environment, and perhaps some monitoring requirements.

3. Ending the total exemption from RCRA coverage of liquid hazardous waste sent to publically owned waste water treatment facilities. There would be instead notification requirements and standards for acceptable amounts of releases and residuals in effluent waters and sludges, supplementing gaps in pretreatment coverage under the Clean Water Act. These requirements and standards would be defined for specific hazardous constituents in a manner consistent with types and concentrations of constituents.

4. Establishing a category of "special" hazardous waste consisting of high-volume relatively low-hazard waste to be minimally regulated under RCRA. There may only be notification requirements for generators of such waste.

5. Developing minimal regulations for the recycling of hazardous waste (or hazardous materials that could become wastes), applicable to all operations, not just "third party" recyclers as is currently proposed. Due consideration would be given to avoiding the creation of disincentives for recycling, e.g., by only requiring notification of what wastes are being recycled.

6. Developing lists of hazardous waste to be prohibited from management in landfills, surface impoundments, and deep wells. These lists should be correlated with technical criteria regarding particularly high risks from possible releases into the environment.

7. Establishing regulatory criteria for hazardous waste which, although substantial scientific information indicates their hazardous character, have not yet been so defined. They have not been listed and, when subjected to current EPA tests and procedures, they do not exhibit any of the currently identified hazardous waste characteristics. For example, a number of industrial wastes containing significant levels of dioxins, chlorinated organics, or pesticides are not now regulated as hazardous waste and cannot be shown to be toxic by EPA's test for toxicity (see ch. 4).

8. Making delisting of hazardous waste more expeditious without, however, compromising protection of the public. This could be done by using clearer, specific criteria for delisting and by limiting times for evaluation by EPA. To some extent, this action could balance the effects of the preceding actions, which lead to more wastes being regulated. Delisting provides a means whereby site-specific factors or previously unavailable information might mitigate prior estimates of potential hazard. However, one problem that has become apparent in delisting processes should be controlled. Although constituents causing a waste to be originally defined as hazardous may have been removed, the waste may still contain other hazardous constituents in significant concentrations. Such waste should not be delisted, pending further testing. The sole or inappropriate use of the EPA toxicity test should be examined, Adopting a procedure for verification of submitted data should also be examined.

Limited Class Permits.-The engineering design and performance characteristics of some hazardous waste management facilities may be largely independent of location. Class permits may be appropriate for such facilities. However, such facilities should have little probability of release of hazardous constituents, and possible releases should be easily observable through minimal, and required, inspection or monitoring. There is some concern over whether permitting by rule would lead to sufficient protection of the public, such that the loss of public participation in the permitting process is justified. Furthermore, while use of class permits for tanks and containers may be reasonable, these may have to be limited to aboveground facilities because of the difficulty of detecting leaks in underground facilities. Limited class permits may have to be based on detailed technical criteria, in order to avoid permitting of older facilities having unacceptable design and performance features. (For example, construction materials in older facilities may lack adequate corrosion resistance). If Congress is to sanction class permitting without sacrificing protection of the public, then the limited nature of the policy should be carefully defined through legislation. Class permitting need not involve a cutoff of all public participation. Expedited and minimal permit review can be combined with appropriate notification and an opportunity for the public to be heard as part of the permitting process.

Specific Technical Criteria in Regulations .–There are **a** number of critical components to the RCRA and CERCLA regulations that include little if any specific technical criteria to guide permitting. If Congress is to ensure protection of the public in a consistent way nationwide, then it is necessary to direct EPA to establish specific technical criteria through rulemaking (in contrast to reliance on guidance documents). This would correct the current emphasis on allowing Federal or State permit writers to make critical decisions without either such guidance, or the resources (financial, technical, and human) necessary for making decisions and formulating criteria about extremely complex technical matters. Two areas of particular concern are the RCRA regulations dealing with monitoring for land disposal facilities and the CERCLA regulations dealing with the determination of the extent of cleanup at a remedial site. This is not to imply that EPA is unaware of the problem. Several relevant activities should be noted: draft guidance documents have been prepared by EPA and may lead to specific criteria being used; EPA was under judicial order to promulgate final regulations; and regulations can and may be revised in the future to add more detailed standards.

OPTION III

Use of Economic Incentives for Alternatives to Disposal and Dispersal of Hazardous Waste.

The objective of this option is to shift the balance from disposal and dispersal of hazardous waste into the land or oceans to the reduction of waste at the source, recycling, and treatment. Direct economic incentives would be used to accomplish this objective.

This option is designed to provide direct incentives. There are, within the current program, opportunities to promote the use of alternatives to disposal and dispersal through regulatory incentives, including: streamlining of permitting procedures for alternative and perhaps innovative facilities; requirements to use certain alternatives for specific wastes; and increasing the required level of control for disposal and dispersal approaches. Moreover, the current system is significantly increasing the costs of land disposal, compared to a few years ago. While these factors may have beneficial effects, they are often rendered less effective than they could be by uncertainties, ambiguities, and contradictions in the regulatory system as perceived by the regulated community or because they limit choices in too general a fashion. The use of direct economic incentives can be viewed as a complement to regulatory incentives and to the use of the legal system. While legal actions may motivate the use of alternatives to land disposal, the perceived effects are often uncertain and may not occur until long after the adverse effects of land disposal practices occur.

This policy option should be viewed in the context of current legislation concerning hazardous waste management. CERCLA was enacted because of the recognition that unacceptable risks have been inherited from certain past waste management efforts that were too shortsighted. The connection between CERCLA and RCRA has received insufficient attention. Too often they are viewed as separate programs, rather than as two components of the Federal hazardous waste program. The need for future expenditures of public funds to clean up hazardous waste sites should be minimized,

Congressional action to implement this option could occur through an amendment to RCRA or CERCLA or as new legislation. There are no apparent technical or institutional obstacles to adoption, but a major issue would be what types of incentives to provide. Before discussing several types of economic incentives, the concept of a hierarchy of alternative management strategies is examined to provide a context for considering this option.

A Hierarchy of Alternative Management Strategies

A major purpose of chapter 5 is to demonstrate the applicability of a relatively large number of alternative technological approaches to hazardous waste management. Such technologies provide means for the reduction of waste generation, the destruction of waste, and the disposal or dispersal of waste in the environment. Different alternatives are appropriate for different wastes and locations. In chapter 4, it is noted that, nationwide, land disposal continues to be used for most hazardous waste (although it varies substantially among States), and in chapter 5 the uncertainties concerning the use of ocean disposal are discussed,

The following hierarchy provides a useful framework for understanding the potential use of alternatives to disposal and dispersal of hazardous waste, consistent with good engineering practice and sound economics:

1. waste reduction at the source through, for example, process modifications;
2. waste separation, segregation, and concentration through available engineering approaches in order to facilitate identification of the waste and the application of the remaining steps;
3. material recovery, either onsite or offsite, to make use of valuable materials, including the use of waste exchanges so that a (potential) waste for one generator can be made available as a resource for another operation;
4. energy recovery from (potential) waste or its components, perhaps as a fuel supplement;
5. waste treatment to reduce the hazard level and possibly the amount of waste requiring disposal; and
6. ultimate disposal or dispersal (preferably of residues from previous steps, of materials pretreated to reduce mobility after land disposal, and of untreatable wastes) in a manner that holds release of hazardous constituents into the environment to acceptable levels.

Such a systematic ordering of waste management options presents a number of advantages. For example, permanent solutions to waste problems are more likely to occur at some stage prior to disposal and dispersal. Consequently, fewer risks and costs are shifted to the future. An initial emphasis on waste reduction could significantly reduce costs of waste management and, in some instances, avoid them altogether, Using materials as resources, rather than discarding them, at once prevents them from becoming wastes and provides direct economic benefits. If less hazardous wastes are produced and regulated by promoting the use of alternatives 1 through 5 of the hierarchy, and if there are reduced administrative activities (such as inspection) for treatment and disposal facilities, then the costs of administering a regulatory program and of remediating uncontrolled sites could be reduced.

Specific factors concerning waste, plants, and companies should play their normal role in economic evaluations of alternatives. Moreover, for some waste only management alternatives 5 or 6 will be technically feasible or cost effective. The above listing does not imply that alternatives 2 through 5 do not involve any potential release of waste or their constituents into the environment, Techniques for these options require some regulatory coverage to monitor and hold such releases to acceptable levels. For example, energy recovery through the burning of waste as fuels poses problems of releases of hazardous constituents into the environment. Such regulation can provide information useful in enforcement efforts and for understanding how generic types of waste can be managed other than by disposal and dispersal approaches.

The idea of the hierarchy presented above did not originate with OTA. It has been recognized for some time by those concerned with waste management in industry and government. In 1976, before the passage of RCRA, EPA offered a position statement on effective hazardous waste management that included the above hierarchy as a ranking of preferred alternatives. As recently as 1982, EPA reiterated its support of the 1976 position.[10]

Nonetheless, there has been little programmatic support of the concept of a waste management hierarchy. Although RCRA gave some attention to reuse, recovery, and recycling, there have been few programs providing incentives to waste generators, nor have there been transfers of technology and information encouraging this strategy. As for EPA's R&D activities, in fiscal year 1983 the total effort related to alternatives to land disposal amounts to about 10 percent of all hazardous waste R&D, or $4.4 million. From another perspective, 10 years of such funding for this purpose would only be equivalent to the costs of cleaning up several major uncontrolled land disposal sites. (See ch. 7 for a discussion of all current EPA expenditures.)

Types of Incentives

Considering the generally accepted objective of minimizing government expenditures, OTA believes that it is impractical to suggest major incentive programs based on direct, budgeted expenditures. Also, the use of economic incentives raises questions concerning the appropriate placement of burdens on industry. For such reasons, this option consists of three components: a fee system on generated wastes to influence management choices, procedures addressing capital needs of alternatives to disposal and dispersal, and consideration of R&D problems that might prevent the development of alternatives.

A Fee System.–There is a trend toward State use of fee systems, some of which are based on wastes, both to raise revenues and to influence choices among hazardous waste management alternatives, although results of these relatively new programs are mixed. California, Kentucky, Missouri, and New York impose fees on waste generators. The CERCLA program, at the Federal level by comparison is based on the collection of a fee or tax on the production of petroleum feedstocks and specified chemicals, raising 87.5 percent of the $1.6 billion fund. Many critics of this approach believe that the fund should have been financed through a "tail-end" fee or tax on actual waste generated, rather than on "front-end" feedstock materials that only indirectly, and to different degrees, lead to hazardous waste generation. A strong disincentive is thus inadvertently established which penalizes those generators choosing to minimize waste generation. However, there was insufficient information on waste generators originally available to facilitate such an approach. When collection under CERCLA expires in 1985, it is likely that substantial sums will continue to be required to clean up uncontrolled sites. EPA's original estimate of several years ago was that $44 billion might be required. There have also been indications from the administration that it is currently disinclined to seek reauthorization of the tax collection program. Continuation of the current CERCLA fee system offers no direct incentive to alternatives to land disposal, although continued experience with CERCLA may prove to be an effective indirect influence on use of such alternatives.

An approach that would satisfy several objectives could be based on the use of the CERCLA funding mechanism for RCRA purposes, using the tail-end fee system. This would involve shifting the collection of CERCLA moneys (including the post-closure liability trust fund to start in 1983) to hazardous waste generators. For such an approach to be effective, fees would have to be reduced, on a unit-

[10] Federal *Register,* vol. *41, No.* 161, pp. 35050, 35051, 1976; U.S. House of Representatives, *EPA Journal,* July-August, p. 19, 1982; and testimony of Rita M. Lavelle, U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment, Dec. 16, 1982.

weight basis, when: 1) alternatives to disposal and dispersal were used by the generator, either onsite or offsite, and 2) the hazard level of the waste or residue finally disposed of was relatively low.

The critical feature of such a system is that such a fee should be substantially greater (perhaps double) for disposal and dispersal options and substantially lower for low-hazard or treated waste (perhaps by half). A fee discrimination would provide the desired economic incentives for alternatives to disposal and dispersal. Moreover, the discriminatory ratios and/or the amounts of the fees on land-disposed waste might be increased over time, as waste volumes decline and after ample time has been given for adopting alternatives. A zero tax for those wastes (or portions of them) recycled for materials or energy that would otherwise become hazardous wastes would appear equitable and desirable. However, there is a need for carefully determined definitions for recycling (as well as for what is a hazardous waste), otherwise a waste-fee approach could lead to inappropriate removal of waste from the system,

Can fees on generated hazardous waste raise sufficient revenues? If one accepts the currently quoted figure of 41 million tonnes per year of RCRA-defined hazardous waste generation, an average fee of $10 per tonne would raise about the same annual revenues as CERCLA now does. If total waste generation is much higher, as it may be (see ch. 4), or if more wastes are brought under the RCRA program, then fees might be reduced somewhat.

For disposal and dispersal options, with high fees of perhaps $10 to $20 per tonne, costs would increase by less than 10 to 40 percent for a disposal cost range of $50 to $200 per tonne, and perhaps by less if the national waste stream is found to be much greater than the current estimate. However, there are low-hazard high-volume wastes for which disposal or treatment may only cost $10 to $20 per tonne, and for which fees should be lower than the average. Table 5 illustrates a waste-fee system which has been proposed in Minnesota. The structure of this system is strongly biased against land disposal, particularly for liquid wastes. It also favors onsite over offsite management, a bias often defended because of advantages associated with not transporting hazardous materials, rather than on any intrinsically superior level of management at onsite facilities.

Suggesting a national waste fee system is likely to raise a number of problems and concerns. A summary of the key issues is presented in table 6.

The underlying philosophy of this approach would be to reward those who minimize future risks and costs to society through the use of preferred alternatives which permanently reduce the risks involved in hazardous waste management. As existing uncontrolled sites are cleaned up, future uncontrolled sites made less likely, and hazardous waste generation reduced, the fees for non-land-disposed wastes could eventually be decreased. Morever, such an incentive system would encourage efforts to reduce the amounts of waste generated. The uses of the fees collected could be expanded, as has been recommended, perhaps to deal with injuries and damages directly associated with mismanagement of hazard-

Table S.—illustration of a Hazardous Waste Generator Tax Structure

Waste management category	Tax on solid waste ($/tonne)	Tax on Ilquid waste ($/tonne)
Land disposal.	42	85
Off site:		
Land disposal after treatment	21	42
Treatment	11	21
Onsite:		
Land disposal after treatment	11	21
Treatment	5	11
Recycling/reuse;		
used crankcase 011	0	0

NOTE In addition to this tax to support a State Superfund, a hazardous waste generator fee (a minimum fee plus a fee dependent on the quantity of waste generated) was also proposed to support State administrative costs for hazardous waste programs A prows ion was Included to exempt small generators

SOURCE" Minnesota Conference Report H F No 1176, Mar 19, 1982

Table 6.—A National Waste Fee System: Summary of Key Problems and Concerns

Problem or concern	Comments
Use of the legal system and insurance requirements could be used as nonregulatory approaches instead of the fee system.	They are useful; but affect management choices slowly because of time delays and uncertainties.
There is insufficient capacity for treatment alternatives to land disposal.	Unused capacity now exists; a fee system would remove market uncertainties and stimulate investments. Waste reduction efforts do not face this problem.
Industry and consumers may face heavy economic burdens.	Programs to address capital and R&D needs are required. Action soon would provide time for planning. Small effects on consumer prices would be equitable.
Illegal dumping would be increased.	Both regulatory enforcement and policing efforts remain necessary.
It would be more efficient to rely on State fee systems.	Not all States will or can adopt waste fee systems. Nor will they have similar programs. For consistency and equity nationwide, a Federal system is necessary, Otherwise pollution havens may form.
Eventually, there may be extremely high fees on remaining and, perhaps, unavoidably land-disposed waste.	Abrupt changes in management choice not likely. More waste may be regulated with lower fees. CERCLA and administrative needs will eventually decline. Fees can be lower for high-volume, low-hazard wastes.
International competitiveness of some industries may be reduced.	Capital and R&D assistance, and time for planning are necessary. Some industrialized nations already use more treatment options.
A national waste fee system distorts the marketplace.	Such a system is a corrective action; presently costs and risks are transferred to people (now and in the future) who do not receive corresponding benefits.

SOURCE: Office of Technology Assessment (see ch 3 for a complete discussion)

ous wastes.[11] Fees could be collected by States, and it might be advantageous to distribute a specified percentage of the moneys collected by a State to its program. This could promote the replacement of varying State fee programs with a uniform national system, at least for federally regulated waste. A uniform system could minimize potential effects on interstate commerce (e.g., States with fees which are high relative to other States are less able to attract industrial activities producing hazardous waste).

Capital Needs.–A major obstacle to the adoption of measures to reduce waste generation or hazard levels is the need for capital investment for new or modified equipment or facilities, either by waste generators or commercial waste managers. A Federal loan program could be instituted, which offered low interest rates, and perhaps long terms for repayment, for capital expenditures on existing or new facilities directly related to waste or hazard reduction, Alternatively, the Federal program might guarantee private sector loans, or make available tax free bonds to finance loans. Technical guidelines could be established and the administration of loan evaluations and approvals could be shifted, for the most part, to the State level. CERCLA funds not spent for cleanups, or more likely a designated portion of moneys collected under a new fee system, might be used as a source of funds for loans, A fixed fraction of such fee- or tax-generated funds might be designated for these types of loans. One recent study that examined using government loan incentives for resource recovery equipment for hazardous waste generated in the electroplating industry concluded that such a program could be quite effective.

Another means of addressing capital needs is the use of tax credits. A special, time-limited investment tax credit to spur capital investments could be offered for those uses directly related to reduction of waste amounts or hazard levels, Although this is a traditional approach to achieving a desired goal of society, it has received criticism due to the loss of revenues to the government. However, the case

[11]''Injuries and Damages From Hazardous Wastes—Analysis and Improvement of Legal Remedies, " a report to Congress in compliance with sec. 301(e) of the CERCLA, September 1982. (By an independent group of attorneys.)

of hazardous waste presents a particularly good example of how spending promoted by a tax benefit could, in the long-term, markedly reduce government expenditures. Moreover, a special tax credit of 10 percent (in addition to any broad investment tax credit) likely would lead to reductions in government revenues of several hundred million dollars annually over perhaps a 5- to 10-year period. An interesting possibility would be to use some portion of the funds collected under a waste generator fee system to compensate the U.S. Treasury for all or part of the lost tax revenues. This would be consistent with a philosophic commitment to rewarding those who reduce the magnitude of the hazardous waste problem, while requiring those who continue to place a burden on society to pay the costs of that burden. The study mentioned above concerning the electroplating industry also concluded that a special investment tax credit for resource recovery investments could be effective.

Assistance for R&D Efforts.-Alternatives to disposal and dispersal meet with another obstacle in that often technologies for, say, process modification or for treatment of particularly difficult wastes require applied R&D efforts before they can be commercially feasible. Increased Federal support of private sector R&D, including pilot plant efforts, could therefore be very useful—relatively small sums might produce very large benefits. In order to allay objections to using Federal funds, it might be possible to structure R&D assistance so as to recover the Federal investment, perhaps through long-term low-interest loans to be repaid upon successful commercialization of the technology. Profit-sharing and exclusive licensing arrangements with payments to the government are also possible, Illinois commits a portion of the revenues obtained from fees on waste for R&D projects.

OPTION IV

Development and Potential Use of a Hazard Classification Framework.

This option provides for the development of a hazard classification framework for risk management that, if feasible and beneficial, would be introduced into the RCRA regulatory program. The framework would be based on detailed technical criteria establishing several different ranges (or classes) of hazard levels. There would also be a corresponding classification system for facilities. The waste and facility classification would provide means to:

1. set priorities, such as determining what areas need to be addressed first in obtaining more accurate and reliable data;
2. establish different levels of monitoring requirements; and
3. establish appropriate levels of regulatory control, including restrictions on certain management technologies and types of facilities, exemptions from full regulatory coverage, and different levels of performance standards for RCRA regulations covering the operation of waste management facilities.

Although using classifications seem to suggest considerable complexity and drastic changes in the regulatory structure; neither is required. What is envisioned is using an improving scientific base to structure the evolving RCRA regulatory program. For example, some solid wastes addressed under subtitle D of RCRA would be brought under subtitle C control, but, for almost all these wastes, there would be minimal regulatory requirements (such as reporting and notification requirements). Similarly, some low-hazardous waste currently under subtitle C might receive less regulation than they now receive, and perhaps be removed from the hazardous category altogether. Some high-hazardous waste would receive more stringent regulation than they now receive. For most hazardous waste, however, the classification approach would have little effect.

Congressional action could be accomplished by amendment to RCRA, by initially directing EPA, or another agency, to develop a waste and facility classification system and a plan for its implementation, Such an analytical effort could take several years and would require additional Federal appropriations of perhaps $5 million to $10 million. Presumably, no new data would be acquired for this initial study phase (which for health and environment effects data is an expensive undertaking), but rather existing data bases would be used. The second level of congressional action would consist of an evaluation of the study, and a decision: I) to either move ahead with implementation; or 2) to pursue a second, more detailed study, possibly involving the acquisition of new data, followed by integration of the hazard classification framework into the RCRA program; or 3) to discontinue the option. Implementation, or a second study, could take several years, and the costs are difficult to estimate.

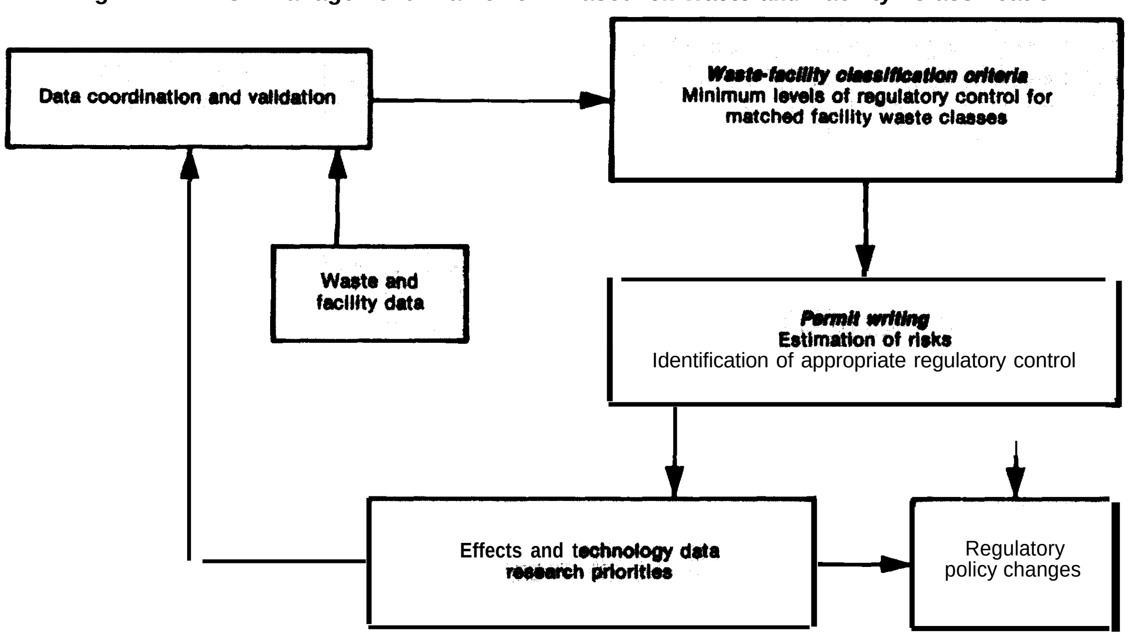
Brief Summary of a Hazard Classification Framework

The key elements of this particular application of the hazard classification concept are presented in figure z. The approach is compatible with the hierarchy of alternative management strategies presented earlier, particularly the goal of reducing the amount and hazard level of wastes.

Several important elements, each requiring reliable information to be obtained by the Federal program, form the basis of this scheme. Some of the information may be currently available in varying degrees of completeness and accuracy. The collection of other necessary data may require substantial efforts. There are three elements of the system:

1. The critical characteristics of those constituents of the waste that largely determine its hazard classification. Classifying wastes is a major undertaking that requires a carefully designed analytical framework and substantial amounts of information on a broad variety of factors, including concentrations of hazardous constituents, toxicities, nobilities through various environmental media, environmental persistence or bioaccumulation, and various safety characteristics. It is not sufficient merely to use information on the most hazardous constituent, or the one present in the largest amount, to fully assess a particular waste. There currently is no standard procedure to describe the hazard level for a physically and chemically complex waste, although there are indications that it is technically feasible to develop one (see ch. 6).

Figure 2.— Risk Management Framework Based on Waste and Facility Classification



SOURCE" Office of Technology Assessment

2. Consideration of those factors used to determine facility classes:
   - The chemical and physical characteristics of the waste that limit treatment and disposal options. This information would indicate whether the waste is aqueous or nonaqueous, inorganic or organic, and whether it is a liquid, sludge, or bulk waste with a high-solid content. It also would be necessary to know if the waste contains toxic metals, particular types of known toxic organics, corrosive acids, explosives, or highly ignitable substances.
   - Information on the broad range of technology options that are commercially available and technically feasible. Considerable information is needed on the designs of technologies, actual performance characteristics, problems related to operation and maintenance, and requirements for trained personnel. Problems related to patented and proprietary information may have to be addressed.
   - Performance standards for various technology options, used for setting the level of effectiveness (risk reduction) of the technology, or the level of acceptable release of hazardous constituents from the facility. For waste treatment operations, performance standards may be given in terms of changes to be effected in various critical characteristics of the waste, After incineration, for example, the percent of one or more waste constituents destroyed, perhaps in conjunction with acceptable levels of emissions, can be used. (This is similar to what is used now.) It is important that waste classification and its linkage to facility class be technically sound in order to avoid "technology forcing" when, in fact, available technology can achieve desired levels of protection. For disposal operations, performance standards may be given in terms of acceptable levels of release over specified periods of time, Standards would vary with levels of hazard.

   In general, different types of performance standards will be required for different disposal and treatment technologies and may be required for different levels of hazard. Selection of performance standards depend on the regulatory functions deemed most important. What is attractive from the perspective of ease of enforcement or compliance may not be as attractive to those concerned with risk management.
3. Matching of waste and facility classes. This is the key step—ensuring that levels of risk are consistent across both waste and facility classes. For a particular waste class, different technologies within the same facility class should offer similar risks. It must be emphasized that all suggested uses of hazard classification assume that only a few classes would be required and are practical. Usually high, medium, low, and no hazard (essentially a decision to consider the waste as an ordinary solid waste) waste classes, and corresponding facility classes, are envisioned.

An Illustration of the Classification Approach .—Two types of questions are usually raised concerning the hazard classification approach. What types of data are used to distinguish different waste hazard classes? What are the regulatory implications of establishing different waste hazard classes? Table 7 provides examples of how the classification approach can be developed and used, but it should be emphasized that the examples shown are strictly for illustrative purposes and do not constitute any endorsement or recommendation by OTA.

OPTION V

Planning for Greater Integration of Environmental Protection Programs,

The purpose of this option is to integrate administratively (and, if necessary, statutorily) a number of existing environmental programs that affect hazardous waste management and regulation, Policies and programs that lead to inefficient overlapping regulations, gaps in regulatory coverage, and inconsistent regula-

Table 7.—illustrative Examples of a Potential Hazard Classification Framework[a]

Examples of scientific criteria for waste definition	Examples of varying levels of regulatory control, and restrictions on waste management practices
High hazard	
1) Acute toxicity:	
Oral rat LD_{50} < 5 mg/kg	Limited to Class I facilities; cannot be placed in surface impoundments, landfills, injection wells, land farms
Aquatic LC_{50} < 1 mg/kg	
2) Chronic toxicity:	No monitoring exemptions
Equivalent concentration of persistent compounds > 1.O%	Incineration DRE > 99.99; as fuel, can only be burned in industrial boilers
Toxic metals 100 to 10,000 x DWS	Cannot be stored more than 30 days without permit
Suspected bioaccumulative carcinogens	No exemptions for small generators
	Recycling facilities to be permitted
Medium hazard	
1) Acute toxicity:	Limited to Class I and II facilities; cannot be disposed above or within 5 miles of a ground water aquifer
Oral rate LD_{50} 5 to 500 mg/kg	
Aquatic LC_{50} 1 to 100 mg/kg	Incineration DRE > 99.9; cannot be burned in residential boilers
2) Chronic toxicity:	Can be stored up to 90 days without permit
Equivalent concentration of persistent compounds 0.01-1.O%	Small generators exempted up to 10 kg/month
	Recycling facilities to be permitted
Toxic metals 100 x DWS	
Suspected nonbioaccumulated carcinogens	
3) Corrosive, reactive, ignitable	
Low hazard	
1) Acute toxicity:	Limited to Class Ill facilities, and to Class I and II facilities for which no reactions with wastes are likely
Oral rat LD_{50} >500 mg/kg	
Aquatic LC_{50} > 100 mg/kg	Incineration DRE > 99.0; can be burned in industrial and residential boilers
2) Chronic toxicity:	
Equivalent concentration of persistent compounds < 0.01%	Can be stored up to 180 days without permit
	Small generators exempted up to 100 kg/month
Toxic metals 100 x DWS	Only reporting requirement for recycled waste and recycling facilities
3) Corrosive, reactive, ignitable	

DWS—drinking water standards
[a]The examples shown are strictly for illustrative purposes only, and do not constitute any endorsement or recommendation by OTA
[b]Source: Adapted from system in Washington; see discussion in ch. 6.
[c]Source: Off Ice of Technology Assessment.

tions would be addressed. Insufficient integration among different EPA programs and other executive agencies may be leading to duplication of effort or unawareness of the extent of data and technical resources that are available.

A number of hazardous waste activities are now regulated under different statutes, and within EPA several different groups administer activities related to hazardous waste. There are also programs in several other executive agencies related to hazardous waste; these do not appear to be highly integrated. The language in RCRA that mandates integration with other acts has proven to be too inexact, and EPA's efforts in this area do not appear to have a high priority. Ocean disposal or dispersal of hazardous waste falls under the Marine Protection, Research and Sanctuaries Act. Some injection wells that may be used for waste disposal fall under the Safe Drinking Water Act and others under RCRA. Hazardo-us waste streams destined for municipal water treatment plants fall under the Clean Water Act. A number of aspects of regulating releases into the air or water from hazardous waste management facilities fall under the Clean Air and Clean Water Acts. Some wastes are and may be regulated under the Toxic Substances Control Act (TSCA). A recent study for EPA concluded:

> A number of Federal statutes govern aspects of the hazardous waste problem. The statutes in combination do not cover many of the major sources and types of hazardous waste releases, however.[12]

Congressional action for this option would consist, first, of mandating a comprehensive

[12]"Evaluation of Market and Legal Mechanisms for Promoting Control of Hazardous Wastes," draft, Industrial Economics, Inc., September 1982.

study of integration by EPA or some other agency, including formulation of an integration plan, The second phase would consist of congressional examination of the study and plan. If deemed necessary, legislative action would then implement the plan.

The existence of overlapping jurisdiction to regulate hazardous waste activities is not necessarily counterproductive, confusing, or undesirable. The goal should be twofold:

1. ensuring that hazardous wastes that might pose significant risks to human health and the environment do not escape regulation, and
2. promoting the integration of hazardous waste control and other pollution control with legislation so that they can support each other, consistent with the statutory requirements and goals of each program.

There is now no mechanism for ensuring: 1) that facilities disposing of similar wastes but regulated under different acts will be consistently regulated; or 2) that a facility permitted under RCRA is not also disposing, without a permit, other hazardous wastes regulated under other acts.

Moreover, although both RCRA and CERCLA are managed within the same division of EPA, there appears to be little coordination of efforts between the two programs. Chapter 7 presents three examples that illustrate additional problems associated with inadequate integration in the current Federal program.

Two Steps Toward Integration of Environmental Programs

There are two phases to this option, both of which should anticipate the need for effective public participation in order to address concerns over changes that might lead to delays. First, EPA (or perhaps some independent body) could develop a plan for the improved integration of programs related to hazardous waste. The plan would focus on statutory changes required to implement a comprehensive integration, with emphasis on the permitting of facilities. " The study also should examine obstacles to integration which occur at the State level, the costs of integration incurred at Federal and State levels, probable improvements in protection of human health and the environment, and impacts on waste generators.

The second phase would include congressional examination of the study and plan, and an examination of how administrative and statutory changes could be achieved. Congress could also examine changes in EPA's organization that would be necessary to integrate, and if integration would require legislation.

*These statutory changes need not—and probably would **not**—involve integrating the various environmental laws themselves.

Summary Comparison of the Five Policy Options

This section presents the relative benefits of all five options-in a convenient form and is intended to facilitate the comparison of the five options apart from the consideration of costs and time involved. Options II through V can be viewed as a series of complementary actions, taken progressively over time, or as separate individual actions offering particular benefits relative to one or more of the eight goals. Moreover, while option I (status quo] and option II (modifications in RCRA) are mutually exclusive, options III, IV, and V are compatible with option I.

Options II through IV appear to require approximately the sa-me level of initial congressional appropriations, about $5 million to $10 million each. There are, however, no means of reliably estimating longer term costs, or cost savings for government, industry, or the general public. The five options have been presented in order of increasing time required for preliminary studies and implementation. If immediacy of implementation is an important consideration for some policy makers, then clearly options I, II, and III are the most attractive.

The policy options have been compared in two ways. In neither comparison, however, has any attempt been made to demonstrate that any one option is "best," or even that one option is better than another. In addition to the eight goals, considerations of time and cost, along with specific objections to particular options, can make any option either more or less attractive.

Table 8 summarizes in brief narrative form the key advantages and disadvantages of each option. Table 9 presents an evaluation of how each option, relative to the others, satisfies each of the eight goals. This evaluation is necessarily somewhat subjective and judgmental.

In presenting the five policy options, OTA is aware of the need to justify additional Federal expenditures and possible increases in short-term costs to the private sector. Current public and private sector costs for hazardous waste management are substantial, approximately $4 billion to $5 billion annually. Regardless of any policy action, these costs will increase markedly in the future as both the RCRA and CERCLA programs become more fully implemented and possibly as the expected economic recovery leads to an upturn in hazardous waste generation.

The total appropriated funds for options II through V might be $50 million. This represents about 25 percent of annual total Federal and State expenditures for hazardous waste activities. It also represents about 1 percent of the current total public and private sector annual costs of administering and complying with RCRA and CERCLA.

There are considerable uncertainties concerning longer term costs to public and private sectors for implementing options II through V. Nonetheless, there is reason to believe that both the short- and long-term costs of carrying out all four policy options may be more than offset by the potential benefits, only some of which can be viewed in strictly economic terms. The chief areas of potential cost savings are: reductions in the number of haz-

Table 8.—Key Advantages and Disadvantages of the Five Policy Options

Key advantages	Key disadvantages
***1. Continue** current program*	
• Current program stabilized and resources already invested utilized	. Protection of public health and environment may be weaker than possible and desirable
• Participation by States improved	• Risks and costs may be unnecessarily transferred to the future
• Short-term private and public sector costs moderated	• Land disposal continues to be used extensively
II. A ***more comprehensive and nationally consistent RCRA program***	
• Protection of health and environment improved and made more consistent nationally	• Short-term private and public sector costs increased
• More hazardous waste controlled	• Progress of present program could be slowed unless additional resources are provided
• Data base improved	• Technical resources and data may be insufficient
Ill. ***Economic incentives for alternatives to land disposal***	
• More waste reduction and treatment	• Near-term costs to industry increased
Ž Costs for improved protection more equitably distributed	• Uncertain effects on firms, communities, and international competitiveness
• Public concerns over siting alleviated	Ž Illegal dumping may increase
IV. ***Development and potential use of a hazard classification framework***	
• More waste regulated at levels consistent with hazards posed	• Major effort needed to improve data base
• Fewer risks and less costs transferred to the future	• Unnecessary complexity may be introduced
• Improved technical support for State programs	• Long-term costs for implemenentation uncertain
V. ***Planning for greater integration of programs***	
• Gaps, overlaps, and inconsistencies in regulatory coverage reduced	• Considerable administrative and institutional difficulties
• Reduced transfer of risks and costs to the future	• Possible interruptions i n ongoing programs
• Public confidence in Federal program improved	• Congressional action on necessary legislative changes may be complex

Sorce: Office of Technology Assessment.

Table 9.—Comparative Ranking of Policy Options for Each Policy Goal

Goals	Most effective				Least effective
1. Improve protection of human health and the environment without undue delays and uncertainties	II	III	I	IV	V
2. Expand universe of federally regulated hazardous waste	II	IV	V	I	III
3. Encourage alternatives to land disposal	III	IV	II	I	V
4. Improve data for risk assessment and RCRA/CERCLA implementation	II	IV	I	V	III
5. Improve and expand RCRA/CERCLA participation by States	III	II	I	IV	V
6. Moderate increases in costs to governments for administration and industry for compliance	I	IV	V	II	III
7. Reduce risks and costs transferred to the future; reduce costs of management shifted to society in general	III	II	IV	V	I
8. Reduce public concerns over siting facilities	III	II	V	IV	I

Policy options
I Continuation of current program
II A more comprehensive and nationally consistent RCRA program
III Economic Incentives for alternatives to land disposal
IV Development and potential use of a hazard class! fication framework
V Planning for greater integration of environmental protection programs
[a]Least effective does not imply total lack of effectiveness, all rankings are strictly for ordering OPtiOnS and do not imply any absolute level of effectiveness

SOURCE Off Ice of Technology Assessment

ardous waste sites requiring very expensive cleanup and reductions in damages to people and to the environment which entail substantial costs for treatment, remediation, and compensation. Relatively small percentage savings imply substantial absolute dollar savings. For example, if all four options led to a net savings of only 1 percent in the future annual national costs associated with hazardous waste (currently about $4 billion to $5 billion and rising), the savings in one year would exceed the initial costs of implementing the options. It is possible that in the long-term, implementation of the options could lead to considerably greater economic benefits,

Four Scenarios

As discussed in the previous section, it is possible to implement various combinations of the five policy options. The purpose of the following discussion is to illustrate four such combinations. The four scenarios have been developed by making certain simplified assumptions about varying perspectives on the need and methods for improving the current Federal waste program.

SCENARIO I

Current RCRA regulations are adequate, but alternatives to land disposal need encouragement. Options I and III are adopted.

Many believe that the current RCRA regulations are satisfactory and should be given an opportunity to prove themselves effective. Changes in the regulatory program, it is argued, are unnecessary and would be counterproductive to the extensive efforts made since the passage of RCRA. Nonetheless, it is also generally recognized that from a long-term perspective, unnecessary risks and costs may be transferred to the future by disposing of many hazardous wastes in the land, There is equal concern that congressional action in this critical period of development should be expeditious and well defined.

Accordingly, this scenario consists of adopting option I (maintaining the current RCRA regulatory program) and also adopting option 111 (providing direct economic incentives for alternatives to land disposal). Option 111 is compatible with option I, since it involves nonregulatory "market" methods of reducing future releases of hazardous constituents. Option III consists of three critical components:

1. a system of fees or taxes on waste generators (to replace the current funding mechanism for CERCLA) based on quantity of waste, level of hazard, and management practices, in order to promote management choices of alternatives to land disposal;
2. methods for meeting the initial capital needs of those waste generators and commercial facilities that decide to reduce waste generation and to implement treatments reducing hazard or volume levels; and
3. support for R&D efforts that may be necessary before waste and hazard reduction can be accomplished commercially.

SCENARIO II

Specific changes are needed to strengthen RCRA, and an effort is needed to integrate and streamline the entire Federal hazardous waste program which has evolved in a piecemeal fashion. Options II and V are adopted.

The choice of option 11 is based on the desire to modify and improve the existing RCRA regulatory program. The specific actions included in option II would close a number of existing gaps in regulatory coverage of waste, restrict certain wastes from land disposal facilities, and introduce more technical criteria to set nationwide standards, improve the delisting process, and introduce limited class permitting. However, to address broader concerns over gaps, overlaps, and inconsistencies in regulatory coverage, option V would also be adopted. Option V moves beyond the analysis of RCRA regulations to examine problems related to insufficient integration between RCRA and CERCLA, among the various environmental protection statutes, and among the various executive agencies having programs associated with hazardous waste. These two options combine both short- and long-term approaches to obtaining a more effective, efficient hazardous waste program.

SCENARIO III

The current RCRA program needs improvement and a nonregulatory approach is also needed to shift waste management choices away from land disposal toward waste reduction and treatment efforts. The most expeditious congressional actions are required. Options II and III are adopted.

Option II would result in the improvement of RCRA regulations to better provide short- and long-term protection of human health and the environment. However, uncertainties concerning the effect of the regulations on shifting management choices away from land disposal, along with enforcement problems, would probably remain. To complement the regulatory approach of option II, option III is used to introduce direct economic incentives for alternatives to land disposal, The combination of these options would reinforce the connection between RCRA and CERCLA. Federal fees on hazardous waste, increased for land disposal and for waste with higher hazard levels, can be used to fund CERCLA and State hazardous waste programs. With a fee system, the life-cycle costs of waste management could be internalized by increased costs to responsible parties and to consumers of hazardous waste-intensive products.

SCENARIO IV

The current RCRA regulatory program should be maintained, but some long-term efforts to improve the program should also be pursued. Adopt options 1, IV, and V.

Options IV and V are compatible with the current program in the near term, since both initially involve studies before changing the current program. The introduction of hazard classification at some future time does not imply any fundamental change in the RCRA regulatory structure. Similarly, a plan for regulatory integration resulting from option V would not require a restructuring of RCRA regulations. Both options IV and V can be viewed as evolutionary refinements of the current program, and this adoption would not necessarily jeopardize the stability of the present program,