

131070

UNITED STATES GENERAL ACCOUNTING OFFICE
Washington, D.C. 20548

FOR RELEASE ON DELIVERY
EXPECTED AT 10:00 a.m.
WEDNESDAY SEPTEMBER 24, 1986

STATEMENT OF
ELEANOR CHELIMSKY
DIRECTOR, PROGRAM EVALUATION AND METHODOLOGY DIVISION
BEFORE THE
ENVIRONMENT, ENERGY, AND NATURAL RESOURCES SUBCOMMITTEE
COMMITTEE ON GOVERNMENT OPERATIONS
HOUSE OF REPRESENTATIVES
ON
THE CONDITION OF INFORMATION ON HAZARDOUS WASTE



131070

086773 - 131070

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to be here today to report on the work that the Subcommittee has requested the General Accounting Office to undertake with respect to the central topic of this hearing: Whether future storage, treatment, and disposal capacity will be available to meet future hazardous waste production levels. The Subcommittee asked GAO to synthesize the information currently available on the volume of hazardous waste generated nationally and the capacity available to process that hazardous waste, now and in the future. In this work, we address four specific questions:

1. What is the amount, location, and source of known and expected future hazardous waste?
2. What treatment, storage, and disposal capacity currently exists and is projected for the future to manage and dispose of hazardous waste?
3. How have estimates of volume and capacity changed since the original enactment of the Resource Conservation and Recovery Act (RCRA) in October 1976?
4. What uncertainties and data gaps obscure the answers to the foregoing questions and what methodological problems

should be addressed in order to provide better information?

To answer these questions, we are performing an information synthesis to collect and analyze the major relevant information on this topic. Today I report on these efforts. We have reviewed approximately 90 studies and documents and present here our understanding of what is known about the volume of hazardous waste and the capacity to process waste as well as the problems associated with developing meaningful estimates of volume and capacity.

GAO's efforts have focused on studies that made national-level estimates of hazardous waste volume and capacity. Among the many studies that estimate hazardous waste volume at the national level, two groups emerge: national studies and national-sectoral studies. The first are national-level studies that provide estimates on total hazardous waste generated, such as the study prepared for the Environmental Protection Agency (EPA) by Westat which gives an estimate for all hazardous waste produced nationally in 1981. The second group of studies furnishes national estimates for a specific source or type of hazardous waste. An example is a study providing a national estimate for the chemical industry. These national-sectoral studies cannot be synthesized to provide national, total volume estimates because of definitional, methodological, or other variations across studies. Thus, in order to examine national,

total-volume estimates, one must concentrate on the first group of studies.

This group of studies has provided estimates that varied significantly over the last decade. However, the latest studies (those published since 1981) present estimates that are very close to each other. Upon review, we have found that these estimates are based on different definitions of hazardous waste, are methodologically diverse, contain different limitations, and, in fact, do not represent a consensual estimate on the current volume of waste produced nationally. Our conclusion is twofold: the studies we reviewed do not provide consistent information concerning the volume of hazardous waste currently being generated, and little information is available on future volume.

Fewer studies are available concerning hazardous waste management capacity. Very little information exists on total national capacity. GAO concludes that a serious data gap exists in the area of waste management capacity, especially at the national level.

Consequently, based on published information, we cannot determine whether quantitatively adequate treatment, storage and disposal capacity will be available to meet the hazardous waste volume that will be produced. In addition, several uncertainties-- for example, the amount of hazardous waste that will be produced

specifically from Superfund sites, the impact of the proposed ban on land disposal of some hazardous wastes, and the certification for compliance with groundwater monitoring and financial responsibility requirements of the Hazardous and Solid Waste Amendments of 1984--complicate this question still further. We conclude that the Congress does not have available the information needed to plan appropriately for the current or future management of hazardous waste.

Estimates of Known and Expected Hazardous Waste Volume (Question 1)

A number of studies have developed estimates for the amount of hazardous waste being produced nationally since the enactment of RCRA. However, a variety of problems exists. Not only have the published estimates varied significantly (from 9 to 266 million metric tons), but the most current data are inconsistent from one study to the next for a specific time period. To illustrate this, we shall discuss the national estimates provided by four studies for the period 1981 through 1984. (See table 1).

The point estimates in three of the studies are quite close together, and the mean of the three estimates is about 260 million metric tons (MMT). But the coincidence of the point estimates

Table 1

NATIONAL HAZARDOUS WASTE STUDIES
WITH SIMILAR ESTIMATES, 1981-84

<u>Source</u>	<u>Year of Measurement</u>	<u>Point Estimate (MMT)^d</u>	<u>Interval Estimate Range^d (MMT)</u>	<u>Approach</u>
Chemical Manufacturers' Association	1984	247	Not estimated	Survey of association members
EPA-Westat	1981	264	135-402 ^a	Statistical sample of generators and TSD ^c facilities
CBO	1983	266	223-308 ^a	Modeling estimate developed from disaggregated industry data
OTA	1981	N/A	255-275 ^b	Compilation of data reported from states

^aThese interval estimates are confidence intervals.
^bThe OTA estimate is an upper and lower bound range.
^cTSD: treatment, storage and disposal.
^dMMT: million metric tons.

may be misleading. Indeed, we noted a number of disparities and limitations associated with the methodologies that belie the similarity of these estimates.

The point estimate prepared by the Chemical Manufacturers' Association, 247 million metric tons for 1984, is seemingly close to the other point estimates, but represents only a portion of the total chemical industry. In turn, the chemical industry is only a subsector of the total hazardous waste generation sector (estimates we reviewed of the chemical industry's contribution to total waste volume ranged from 48 percent to 68 percent). Consequently, we conclude that the estimate from the Chemical Manufacturers' Association accounts for only part of the hazardous waste generated each year and that an extrapolated estimate for the remainder of the chemical industry and for the nation could be significantly greater.

The second point estimate, prepared for the Environmental Protection Agency (EPA) by Westat in 1981, is 264 million metric tons. The range provided in the study, 135 to 402 million metric tons, is a statistical confidence interval, and the authors stated that they are 95-percent confident that the true 1981 hazardous waste production level falls within this interval.

However, this confidence interval is so very wide (267 million metric tons, which is equal to a range of about plus or minus 50 percent), that it is an important limitation on the credibility of the estimate. In searching for an explanation of this considerable imprecision, we found that the study focused on RCRA regulated generators and treatment, storage and disposal (TSD) facilities. The TSD facility sampling scheme was designed to measure characteristics rather than quantities. The populations of RCRA regulated generators and TSD facilities were found to be highly skewed in terms of size; so skewed, in fact, that nearly all of the total quantities of the hazardous wastes generated and managed were accounted for by very small proportions of the respective populations. Inadvertently, the sample had not been designed for a skewed population, and this resulted in the estimates containing the high degree of sampling error that we have noted.

The third point estimate, prepared by the Congressional Budget Office (CBO), is similar to that of EPA-Westat (a point estimate of 266 million metric tons for 1983 versus 264 million metric tons by EPA-Westat for 1981). The confidence interval around the CBO point estimate is from 223 to 308 million metric tons with a statistical confidence level of 95 percent. In this case, the confidence interval is plus or minus 16 percent, much smaller than that of the EPA-Westat study. This estimate is the product of a national hazardous waste generation model developed

by CBO. The model is driven by two theoretical assumptions: (1) that specific industries generate characteristic wastes at measurable rates, and (2) that the overall quantity of waste produced is a function of industrial output (as measured by production employment), process technology, and production efficiency.

The CBO model uses employment data as a key variable to produce the hazardous waste estimates. But other studies have suggested that using employment data produces estimates that are in substantial disagreement with actual waste generation data obtained from surveys of generators. Therefore, there is some question concerning the use of employment data as an independent variable in deriving estimates of hazardous waste.

The Office of Technology Assessment (OTA) study (1981) took a different approach for developing its range estimate in that it did not generate a point estimate but asked the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) to collect data via a survey. The results indicated that approximately 250 million metric tons of hazardous waste were being produced annually by 40 states and Guam and Puerto Rico, with an estimated additional 5 to 25 million metric tons of waste being produced annually by the non-responding states and territories. This worked out to a volume estimate between 255 million and 275 million metric tons. The states' waste

generation data were derived using a number of different approaches: 19 states appear to have used state inventories; 5 states appear to have used data on manifested hazardous waste, thus underestimating waste generation unless extrapolation to account for waste managed onsite was done; and data from the remaining responses were derived through the use of EPA notifications and estimates of waste generated by industrial sectors receiving the notifications. Only nine states, plus Guam, Puerto Rico, and Washington, D.C., used a definition of hazardous waste consistent with that used by EPA at the time. Because of these within-study definitional and measurement differences, the accuracy of OTA's estimate, like that of the other studies, gives rise to some concern.

Comparing the definitions of hazardous waste used by the last three studies (EPA-WESTAT, CBO, and OTA), we found that the definitions used are also dissimilar across studies. The EPA-Westat study estimated the quantities of hazardous waste that were generated in 1981 and subject to control under the RCRA regulation. However, two categories of waste were not included in the EPA-WESTAT definition of hazardous waste:

- (1) Wastes that had been exempted or excluded from regulation under RCRA as hazardous waste (e.g., wastes generated in conjunction with ore and minerals extraction and beneficiation); and

- (2) RCRA regulated hazardous wastes that were generated in 1981 but that were not, at any point in the management process, treated, stored, or disposed of in processes subject to regulation under RCRA (e.g., hazardous wastes treated exclusively in wastewater-treatment tanks covered under the National Pollutant Discharge Elimination System).

The CBO study used a broader definition of hazardous waste than that established by the EPA under RCRA. It included wastes not regulated under RCRA such as waste oils, PCB's, industrial-scrubber sludges, air-pollution-control dusts, and certain liquid hazardous-waste streams.

The OTA study was a survey of states and the OTA estimate is based not only upon the federal regulatory definition, but upon the state definitions as well. The states sometimes defined hazardous waste differently and more broadly than the federal government, including many different types of waste which were not regulated under RCRA, such as additional chemical compounds, small-quantity generator wastes, RCRA exempted wastes, and various solid wastes. The definition used by states varied from one state to the next. Consequently, the basis for the OTA estimate is quite different from that of the two previous studies.

All of these definitional and measurement differences signify that the CMA, EPA-Westat, CBO, and OTA estimates must be considered separately. My point here is not to criticize the studies I have discussed, but only to point out that although four current, national estimates of hazardous waste did reach similar numerical estimates it should not be automatically assumed that they reinforce each other, given their differing qualitative bases, statistical precision, and approaches to definition and measurement.

In addition to the major studies discussed above, other studies exist that provide data and information about hazardous waste that is more narrowly scoped or at lower than national levels i.e., those studies which are national-sectoral studies. We reviewed some of these studies in order to determine whether the information contained in these reports can be synthesized to provide national-level estimates. Given various technical, methodological, and other factors (which will be discussed later), we believe it is not possible to derive a synthesis of national-sectoral studies that can provide accurate and reliable national estimates.

Very little information is available that can be used to make accurate estimates of the volume of hazardous waste generated by location. The CBO and OTA studies provide hazardous

waste estimates on a state-by-state basis. This state comparison is provided in table 2, and it is important to note that the state-level estimates provided by the two studies are very disparate. This, of course, is not surprising given the basic study differences already discussed, but we have not yet had the opportunity to determine precisely how much of this disparity is due to definitional, methodological, or other differences between the studies. On the other hand, what is clear is that the disparities in the OTA and CBO estimates at the state-level preclude any conclusive statements about how much waste is being generated within each state.

Other studies have attempted to provide estimates at various geographic levels. For example, studies were prepared for the New England region by Arthur D. Little and the New England Congressional Institute, and other data exist at the state level as well. Information for selected states is presented in table 3 to illustrate this. Here again, the variance between the studies' estimates for states is considerable. We conclude that the studies that we reviewed do not provide consistent information concerning the volume of hazardous waste generated by location.

National level information characterizing the amount or volume of hazardous waste attributable to specific sources is similarly disparate. Two studies that attempted to delineate the

TABLE 2

CONTRAST BETWEEN TWO STUDIES SHOWING ESTIMATED
HAZARDOUS WASTE VOLUME GENERATED
BY STATE IN MTS

<u>State</u>	<u>1981 OTA</u>	<u>1983 CBO</u>
Alabama	265,680	6,547,000
Alaska	360	52,000
Arizona	4,280,000	642,000
Arkansas	No data	3,729,000
California	15,000,000	17,284,000
Colorado	775,490	1,902,000
Connecticut	102,000	4,238,000
Delaware	272,000	894,000
Florida	No data	2,981,000
Georgia	38,500,800	3,338,000
Hawaii	No data	202,000
Idaho	No data	1,160,000
Illinois	1,810,000	14,810,000
Indiana	94,900,000	10,189,000
Iowa	No data	1,774,000
Kansas	45,300	2,564,000
Kentucky	415,000	4,647,000
Louisiana	38,800,000	13,801,000
Maine	5,290	337,000
Maryland	272,100	2,989,000
Massachusetts	172,000	4,536,000
Michigan	408,000	12,399,000
Minnesota	181,000	2,212,000
Missouri	658,930	6,046,000
Mississippi	1,810,000	1,816,000
Montana	91,200	662,000
Nebraska	1,250,000	739,000
Nevada	No data	379,000
New Hampshire	9,980	431,000
New Jersey	855,000	12,948,000
New Mexico	No data	619,000
New York	1,270,000	9,876,000
North Carolina	No data	3,954,000
North Dakota	125,000	269,000
Ohio	3,260,000	19,692,000
Oklahoma	3,570,000	2,673,000
Oregon	19,100	969,000
Pennsylvania	3,628,000	18,260,000
Rhode Island	1,600	1,745,000

<u>State</u>	<u>1981 OTA</u>	<u>1983 CBO</u>
South Carolina	1,587,000	3,669,000
South Dakota	1,590	159,000
Tennessee	4,300,000	12,159,000
Texas	29,146,960	34,866,000
Utah	558,000	1,139,000
Vermont	9,070	226,000
Virginia	181,000	4,038,000
Washington	616,000	5,523,000
West Virginia	No data	5,642,000
Wisconsin	81,600	3,297,000
Wyoming	No data	572,000
Other states	<u>5 to 25 million^a</u>	<u> </u>
Totals:	255-275 million	265,595,000

^aOTA's actual national estimate was 250 MMTs, but that total does not include 10 states. OTA estimates that inclusion of those states would result in an estimate of between 255 and 275 MMTs.

Table 3

RANGE OF HAZARDOUS WASTE VOLUME ESTIMATES
FOR SELECTED STATES FOR 1980-83
IN METRIC TONS

	<u>OTA</u>	<u>CBO</u>	<u>Gould</u>	<u>Arthur D. Little</u>	<u>New England</u>	<u>Other</u>
Connecticut	102,000	4,238,000	1,808,437	127,207	193,725	----
Maine	5,290	337,000	180,463	8,118	10,211	----
Massachusetts	172,000	4,563,000	1,851,208	158,816	111,017	----
New Hampshire	9,980	431,000	184,543	15,646	12,410	----
Rhode Island	1,600	1,745,000	524,369	34,421	3,989	----
Vermont	9,070	226,000	100,210	8,163	7,425	----
California	15,000,000	17,284,000	4,501,642	---	---	1,179,100
Illinois	1,810,000	14,810,000	5,149,737	---	---	2,503,320
Tennessee	4,300,000	12,159,000	2,588,475	---	---	644,877
Texas	29,146,960	34,866,000	6,337,588	---	---	57,125,071
Oklahoma	3,570,000	2,673,000	634,246	---	---	----

contribution of different sources are ones that have been cited already, the CBO and EPA-Westat studies. In these cases, however, the estimated contribution of various sources varies widely. The CBO study, for example, reports the contribution of the chemical industry at 48 percent of the total hazardous waste volume produced. The EPA-Westat study estimates the contribution of the same industry to be 68 percent. The incremental difference between these two estimates can result in an estimated difference of millions of metric tons of hazardous waste, depending, of course, on the base being used. In the case of the CBO study, the generation of approximately 127 million metric tons is attributed to the chemical industry. For the EPA-Westat study, it is approximately 180 million metric tons. Contrasting these estimates with that of the Chemical Manufacturers' Association for 1984--247 million metric tons for only a partial sector of the total chemical industry--we can readily see that, once again, significant variation exists. In sum, we found that estimates of the amount of waste contributed by different sources vary so much that we believe any conclusions about the relative contribution of different sources of hazardous waste should be highly qualified.

The Subcommittee also asked us to look at what is known about future hazardous waste volume estimates. Here we found only one study that provided future estimates, the 1983 CBO study, which furnishes an estimate of 229 to 280 million metric

tons in 1990. However, there are some methodological uncertainties that must be noted. Using the CBO model to predict future waste volume is subject to at least two kinds of error identified by CBO. First, the model may have underestimated waste generation in future years because of the use of production employees as a proxy for output by industry. Projections of employment growth by industry, obtained from the Bureau of Labor Statistics, were used by the CBO study because they were the only consistent set of industry-specific projections available. But the use of employee statistics might understate the estimate since growth in labor productivity over time will lead to increased output and, presumably, more waste per employee. Second, model projections might have overstated the amount of wastes produced by failing to account for turnover in the facilities, equipment, or both for those industries that generate waste. New industrial facilities may be more efficient and produce less waste per worker or per unit of output. Because there is no way to know which of these effects would be greater, there are uncertainties associated with these estimates. CBO does not discuss other possible kinds of errors such as uncertainties from forecasting employment growth.

Estimates of Hazardous Waste Treatment,
Storage and Disposal Capacity (Question 2)

The information on presently available and future capacity to treat, store, and dispose of hazardous waste is more limited

than that for hazardous-waste volume. We identified three studies that address, to some extent, capacity at the national level. The first two studies, conducted for EPA by Booz-Allen and Hamilton with Putnam, Hayes, and Bartlett (referred to in this testimony as the Booz-Allen study) and by Westat, provide such information for 1981. The third study, prepared by CBO, provides information for 1983 and 1990. I will briefly discuss the differences and limitations of these studies.

The Booz-Allen study is limited in scope in that it only addresses off-site capacity (i.e., of the commercial hazardous waste management industry). This study estimates that approximately 40 million metric tons of waste were managed in 1981, 31 million metric tons on-site and 9 million metric tons off-site. In examining whether sufficient off-site capacity was available to handle the amount of waste generated in that year, the study's conclusions were that, at the national level, excess off-site capacity would be available but, at the regional level, off-site capacity shortfalls do occur.

The Westat study is more extensive in scope, addressing both on-site and off-site treatment, storage, and disposal capacity. The volume of waste managed for 1981 was estimated by Westat to be 265 million metric tons; approximately 254 and 11 million metric tons were managed on- and off-site, respectively. The study's conclusions are that, for 1981, 23 percent of total

treatment capacity, 36 percent of total disposal capacity, and 64 percent of storage capacity were utilized. Concerning the Westat study, I have already noted that the precision of the volume estimate was not very high (plus or minus 50 percent). The estimate for the amount of hazardous waste being managed was similarly imprecise, plus or minus 49 percent. In both cases, the imprecision was at least partly a consequence of the highly skewed population being sampled.

Although the Booz-Allen and Westat studies provided estimates for the same year, their estimates for total waste volume managed and the proportion of waste processed off-site are quite different. In addition, the methodological approaches used for these two studies were also different. The Booz-Allen study was designed to summarize existing hazardous waste generation data and to undertake a survey of commercial hazardous waste management facilities. Booz-Allen used data bases from earlier industrial studies. Consequently, all variations and limitations in definitions and methodologies from these studies were incorporated. In addition, the data did not correspond to consistent time frames or to whole industry sectors. To compensate for these discrepancies, statistical adjustments were made. Finally, the Booz-Allen study (which looked only at off-site capacity) estimated that 23 percent of waste was processed off-site, while Westat (which addressed both off-site and on-site capacity) estimated that figure to be 4 percent.

A third study providing some information on capacity is the CBO study discussed earlier. However, the capacity information provided is limited because it only addresses how the amount of waste being generated is managed by the treatment, storage, and disposal facilities, not whether current or future excess capacity is available. It assumes that adequate storage, treatment, and disposal capacity is available to meet the volume-management requirement in 1983. The CBO's only position on future capacity concerns off-site capacity; the study notes that unless new off-site facilities are built by 1990, the demand could easily overwhelm capacity.

In summary, we found very little information on current and future national capacity. The one study that comprehensively addresses capacity (EPA-Westat) appears to have an important methodological limitation with regard to the degree of sampling error. EPA has recently acknowledged that a data gap exists in estimates of waste treatment, storage, and disposal capacity. As a result, the agency is currently conducting a census of treatment, storage, and disposal facilities to obtain national data on existing capacity.

Estimates of Volume Over the Years (Question 3)

The third question that the Subcommittee asked GAO to answer concerned identifying estimates of changes in volume and capacity over time and determining what estimates were cited when key legislative and regulatory actions were taken.

The changes in national estimates of volume since 1973 can be seen in table 4. The problem with giving much attention to changes over time is that the individual estimates may be accounted for as much by differences in scope, definition, and methodology as by true changes over time. With this caveat in mind, the point estimates reported range from 9 to 266 million metric tons over 15 years. One can readily see that the variation in estimates is substantial. In looking at point estimates for 1981 alone, the estimates range from 43 to 264 million metric tons, a factor of more than 6. For the period 1981 through 1984, the estimates appear to be coming closer together, but for the reasons we have given earlier, this closeness is not necessarily an indicator of accuracy.

To determine what estimates were cited when key legislative and regulatory actions were taken, we focused on hearings, records, and testimony related to four events:

--enactment of RCRA in 1976,

TABLE 4
ESTIMATES OF HAZARDOUS WASTE VOLUME
(1973-86)
IN MMTs

<u>YEAR OF PUBLICATION</u>	<u>YEAR ESTIMATED FOR</u>	<u>SOURCE</u>	<u>VOLUME^a</u>
1973	1970	EPA	9
1977	1974	EPA	29
1980	1980	FEDERAL REGISTER	54
1980	1980	EPA (BOOZ-ALLEN)	41
1980	1981	EPA (BOOZ-ALLEN)	43
1983	1981	PRELIMINARY EPA-WESTAT	150
1983	1981	OTA	255-275
1984	1981	EPA-WESTAT	264
1985	1983	CBO	266
1986	1984	CMA	247 ^b
1986	1980	GOULD	91

^aMost studies reported volume as million metric tons (MMTs). For studies reporting volume in different units, we converted the volume to metric tons units.

^bThis amount is for a subset of the chemical industry.

- implementation of RCRA notification requirements in 1980,
- passage of the Hazardous and Solid Waste Amendments Act in 1984, and
- implementation of RCRA certification requirements in 1985.

In our review, we found that EPA did not generate estimates specifically for these events. Rather, data on hazardous waste volume--that is, estimates that were prepared over a 12-year period--were used in association with these events. With regard to capacity, we found no estimates whatever--extant or otherwise--in our review of the legislative history.

EPA estimated in a 1973 report to Congress that 9 million metric tons of non-radioactive hazardous waste were generated by industrial sources nationally in 1970. EPA cited and used this estimate in hearings related to the enactment of RCRA and later in appropriations hearings. During the June 29, 1976, hearings on the RCRA enabling legislation, EPA provided a range of waste-volume estimates of 27.5 to 41.25 million metric tons. During the 1980 interim permitting notification requirements, EPA did not develop or cite specific estimates of volume or capacity and did not report estimates using data generated by the notification process. During congressional hearings prior to the enactment of the 1984 Hazardous and Solid Waste Amendments, OTA cited an EPA estimate of 150 million metric tons, which was a volume estimate made for 1981. For the appropriations hearings after the 1984

amendments, EPA did not provide an estimate for hazardous waste volume or capacity. Finally, EPA did not report estimates in conjunction with the 1985 certification process.

The fact that no capacity estimates were developed with regard to major RCRA program events is symptomatic of the problem presented earlier: that a data gap exists with regard to information on the national capacity to treat, store, and dispose of hazardous waste.

The Methodological State of the Art (Question 4)

Our work to date has uncovered a number of serious problems in and across the information available about hazardous waste. I now turn to a consideration of major methodological problems that need to be addressed if stronger information is to be developed. Based on our review of existing studies of the volume of hazardous waste and the national capacity for managing it, several categories of problems stand out as being important to address:

1. Variation in the scope of estimates.
2. Variation in the definition of hazardous waste.
3. Variation in measures for estimating the amount of waste generated or the capacity for storage, treatment, or disposal.

4. Sampling and response problems.

Variation in the scope of estimates

Some of the studies we reviewed focused on a particular waste stream or contaminant (e.g., solvent wastes), or a specific management approach (e.g., incineration, land filling), or a particular industrial or source sector (e.g., the petrochemical industry), or some geographic unit (e.g., New England). Given the many possible variations along these dimensions, it is virtually impossible to use a collection of such studies to derive accurate national estimates by aggregating across the studies. There are too many missing classes of information on the one hand and too much double-counting on the other.

Let me illustrate using two studies, the first of which focuses on hazardous waste solvents affected by land-disposal restrictions as well as solvent waste generated by small-quantity generators now covered by the 1984 RCRA amendments. The scope of the first study does not include solvent wastes that are disposed of in salt dome formations, salt bed formations, and underground mines and caves. The second study focuses exclusively on waste produced by 48 small-quantity generators. A number of questions would have to be addressed before the data contained in these two studies could be synthesized. For example, do the data on the 48 small-quantity generators include or exclude solvent wastes? Do

both studies address only those small-quantity generators covered by the 1984 RCRA amendments? Often, due to limitations in how studies' universes are described, it is very difficult, if not impossible, to answer the kinds of basic questions necessary for combining information across studies.

When the purpose of making volume and capacity estimates is for local or regional planning, or when the planning is limited along some other dimension such as the type of waste, the restricted scope of the available studies may not be a limiting factor. But when national estimates are needed for policy-making, we believe they cannot be obtained by combining multiple, limited-scope studies.

Variation in the definition of hazardous waste

In our review, we found that many different definitions of hazardous waste were used across studies and in some cases, definitions varied within a study, and we believe that those differences account for some of the uncertainty in volume and capacity estimates.

We have not yet formed a judgment about the net effect of variation in definitions on estimates, but our work to date confirms the conclusion reached by the Office of Technology Assessment (OTA) in 1983: that inadequate data, including the

problem of differing definitions, conceal the scope and intensity of the national hazardous waste problem and hinder effective implementation of government programs.

Variation in measures for estimating volume and capacity

The volume of hazardous waste and the capacity for dealing with it are described in various ways within and across studies, ranging from common measures such as tons, gallons, or cubic yards to more ill-defined indicators such as ponds or sites. Even when estimates are given in terms of standard measures such as gallons, there may be ambiguity because the concentration or form (e.g., liquid or solid) of hazardous material may vary or not be known. For example, 100 gallons of liquid may be contaminated in a concentration of 1000 parts per million or 10 parts per million. This variation in concentration may be important in terms of whether appropriate technologies are available to adequately manage the waste in the concentration in which it exists. Currently available estimates of the amount of hazardous waste frequently do not account for variations in concentration and form.

Sampling and response problems

Although estimates of volume and capacity can be made in different ways, an empirically based estimate ultimately depends

upon acquiring information using appropriately designed methods. Our preliminary review of studies causes us to be concerned about two kinds of problems: sampling errors and response errors. Neither of these problems is irremediable or intractable. Both can be greatly reduced, if not eliminated, through careful planning and skilled instrumentation.

There are thousands of waste generators and also thousands of facilities for storing, treating, or disposing of waste. As a practical and economic matter, it is difficult to acquire detailed information about all of these generators and facilities. Thus, for the national estimates of volume and capacity projected from samples of the universe, how those samples are chosen is important in determining the accuracy and precision of the resulting estimates.

For example, I have already discussed the EPA-Westat study of 1981 and noted the large degree of statistical uncertainty that accompanied that study's estimates of the volume of hazardous waste. In this case, there was a direct link between the sample chosen and the uncertainty of the estimates.

Our other concern beyond sampling error problems pertains to response errors, the errors that people make in responding to questions about volume and capacity. Some of these errors are derived from the problems of definition and measurement ambiguity

referred to earlier. That is, people who provide information may not correctly understand the request for data or may be unable to provide the information in the desired form. Given the large number of substances that constitute hazardous waste, the many generators and facilities involved, and the relatively recent attention given to measuring volume and capacity, we believe that response errors may lead to substantial inaccuracy and imprecision in estimates of volume and capacity. Reduction in response errors will require more precise and uniform definitions of terms and greater attention to data-collection techniques that minimize errors.

CONCLUSIONS

This Subcommittee is interested in whether treatment, storage, and disposal capacity for hazardous waste will be quantitatively sufficient to meet future hazardous waste management requirements. From our review to date, we have found that the Subcommittee's questions cannot be answered now because of significant data gaps, methodological problems, or both. Estimates of the current national volume of hazardous waste are inconsistent and limited; there is little information on treatment, storage, and disposal capacity; and few forecasts of future volume and capacity have been undertaken.

It is true that some sub-national studies of volume exist for certain geographic areas and source categories. However, we believe that these data cannot be synthesized to provide national estimates because of the many differences among the studies. Consequently, we cannot estimate the amount, location, and source of hazardous waste being produced either nationally or at the state level with confidence.

We have concluded that the Congress does not currently have the information base that it needs to plan appropriately for the management of hazardous waste, both now and in the future. But before the development of such an information base can be assured, we believe that certain methodological issues need to be addressed, including the ways in which hazardous waste is defined, estimates are scoped, and studies are designed (e.g., using a variety of approaches in which the weaknesses of some are offset by the strengths of others, and using data collection methods to minimize error).

Let us now turn to discussing other work at GAO that is relevant to the question that this Subcommittee is reviewing. In addition to the work conducted for this Subcommittee, we have addressed topics related to the volume-capacity relationship issue in prior reports or are doing so under ongoing assignments.

For example, in one report we recommended that EPA encourage other federal agencies to insist on a high degree of regulatory compliance at disposal facilities before sending their waste there, similar to EPA's policy for disposal of its Superfund cleanup wastes. EPA noted that one constraint to implementing this recommendation was possible commercial facility capacity limitations. Because of the lack of information, they were not sure what the effect of this initiative could be. In a second effort, we found that information on the types and quantities of hazardous waste generated is limited. The office now has an ongoing assignment examining this issue in detail. The focus of this current work is on determining why EPA has been unable to produce a report summarizing information required to be submitted periodically by hazardous-waste generators and TSD facilities on the types and quantities of waste that they handle.

In addition to currently generated hazardous wastes, the Superfund program's efforts to clean up past hazardous waste sites is also creating waste that must be disposed of. However, our past work has shown that EPA has not made a comprehensive effort to identify all such sites. Because EPA's inventory of potential Superfund sites is incomplete, estimates of the amount of wastes from these sites that must be destroyed or disposed of is also unknown. We have found that while EPA and the seven states that we reviewed had made varying efforts to discover sites and maintain an inventory, a comprehensive nationwide

inventory is non-existent. Although the states and EPA view site-discovery efforts as a low priority, EPA estimates that the inventory of potential Superfund sites could grow from the current figure of 23,000 to 400,000 and the number of priority sites from 880 to 4,000. We have an ongoing assignment reviewing federal agency early efforts to identify and clean up sites for which the federal government is responsible. Here again, the amount of waste to be generated and the capacity required and available to handle that waste is unknown.

This concludes my remarks. I will be happy to answer any questions that you or members of the Subcommittee may have.

BIBLIOGRAPHY

- Abt Associates, Inc. National Small Quantity Hazardous Waste Generator Survey. Cambridge, Mass.: February 1985.
- American Institute of Chemical Engineers. Technological Needs for Improved Management of Hazardous Wastes. Washington, D.C.: February 1986.
- Battelle. Report on Hazardous Waste Management Needs Assessment to the Tennessee Valley Authority. Columbus, Ohio: June 1984.
- Booz, Allen and Hamilton Inc. Hazardous Waste Management Capacity Development in the Delaware River Basin and New Jersey: A Program Strategy. Bethesda, Maryland: October 1980.
- . Review of Activities of Firms in the Commercial Hazardous Waste Management Industry: 1983 Update. Bethesda, Maryland: November 1984.
- . Review of Activities of Major Firms in the Commercial Hazardous Waste Management Industry: 1981 Update. Bethesda, Maryland: May 1982.
- . Review of Activities of Major Firms in the Commercial Hazardous Waste Management Industry: 1982 Update. Bethesda, Maryland: August 1983.
- Booz, Allen and Hamilton Inc. and Putnam, Hayes and Bartlett Inc. Hazardous Waste Generation and Commercial Hazardous Waste Management Capacity - An Assessment. Bethesda, Maryland: November 1980.

CBO (Congressional Budget Office). Empirical Analysis of U.S. Hazardous Waste Generation, Management, and Regulatory Costs, Staff Working Paper. Washington, D.C.: October 1985.

----- . Hazardous Waste Management: Recent Changes and Policy Alternatives. Washington, D.C.: May 1985.

CDM. Capacity and Capability of Alternatives to Land Disposal for Superfund Wastes: Waste Type and Quantity Projections - Review Draft. Boston, Massachusetts: September 1985.

Center for Economics Research. Supporting Statement for OMB Review: Screener Questionnaire for the Survey of Hazardous Waste Management Facilities. Research Triangle Park, North Carolina: October 1985.

Chemical Manufacturers Association and Engineering-Science, Inc. Results of the 1984 CMA Hazardous Waste Survey. Austin, Texas: January 1986.

Congressional Research Service (U.S. Library of Congress). Hazardous Wastes, IP0094. Washington, D.C.: February 1986.

----- . Hazardous Wastes: A Research Road Map. Washington, D.C.: 1985.

----- . Hazardous Waste Reduction in Industry: Preliminary Bibliography, 1980-1985. Washington, D.C.: September 1985.

Denison, Richard A. Testimony Before the Subcommittee on Oceanography House Committee on Merchant Marine and Fisheries on the Role of Ocean Incineration in the Management of Hazardous Wastes. Washington, D.C.: U.S. Congress Office of the Technology Assessment, December 1985.

"Directory of Commercial Hazardous Waste Management Facilities." The Hazardous Waste Consultant, 4:2 (March-April 1986), 4-13 - 4-46.

Drayton, William with Environmental Safety's Facts Committee. America's Toxic Protection Gap - The Collapse of Compliance With the Nation's Toxics Laws. Washington, D.C.: Environmental Safety, 1984.

Durso-Hughes, Katherine and James Lewis. "Recycling Hazardous Waste." Environment, 24:2 (March 1982), 14-41.

EPA (U.S. Environmental Protection Agency). Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes Background Report 111: Assessment of the Commercial Hazardous Waste Incineration Market. Washington, D.C.: March 1985.

----- . Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes Summary and Conclusions. Washington, D.C.: March 1985.

----- . Background Document for Solvents to Support 40 CFR Part 268, Land Disposal Restrictions. Volume III. Solvent Waste Volumes and Characteristics, Required Treatment and Recycling Capacity, and Available Treatment and Recycling Capacity. Washington, D.C.: January 1986.

- . "Hazardous Waste Generation Estimates." Memorandum
Prepared by E. Pappajohn, State Programs Branch.
Washington, D.C.: October 1982.

- . Hazardous Waste Generator Report for 1985. Washington,
D.C.: EPA Form 8700-13A (5-80) Revised (11-85).

- . Hazardous Waste Management System; Land Disposal
Restrictions; Proposed Rule. Federal Register 51:9
(January 14, 1986), 1602-1766.

- . Hazardous Waste Treatment, Storage and Disposal Facility
Report for 1985. Washington, D.C.: EPA Form 8700-13B
(5-80) Revised (11-85).

- . List of RCRA Land Disposal Facilities That Have
Submitted Certifications to Retain Interim Status Pursuant
to Section 3005(e)(2) of RCRA. Washington, D.C.: January
1986.

- . National Survey of Hazardous Waste Generators and
Treatment, Storage and Disposal Facilities Regulated Under
RCRA in 1981. Washington, D.C.: April 1984.

- . RCRA Land Disposal Facilities That Have Not Submitted
Certifications to Retain Interim Status Pursuant to Section
3005(e)(2) of RCRA. Washington, D.C.: January 1986.

- . Report to Congress: Disposal of Hazardous Wastes.
Washington, D.C.: 1974.

- . Report to Congress on Injection of Hazardous Waste.
Washington, D.C.: May 1985.

----- . Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works. Washington, D.C.: February 1986.

----- . "Waste Planning Pilot Project." Briefing Package Prepared by Debra Martin, Office of Policy Analysis Washington, D.C.: December 1985.

Feliciano, Donald V. The U.S. Environmental Protection Agency: An Analysis of its Controversies. Washington, D.C.: Congressional Research Service, June 1983.

Foster D. Snell, Inc. Potential for Capacity Creation in the Hazardous Waste Management Service Industry. Florham Park, New Jersey: August 1976.

GAO (U.S. General Accounting Office). Chemical Data: EPA's Data Collection Practices and Procedures on Chemicals, GAO/RCED-86-63. Washington, D.C.: February 1986.

----- . Cleaning Up Hazardous Wastes: An Overview of Superfund Reauthorization Issues, GAO/RCED-85-69. Washington, D.C.: March 1985.

----- . Efforts to Clean up DOD-Owned Inactive Hazardous Waste Disposal Sites, GAO/NSIAD-85-41. Washington, D.C.: April 1985.

----- . Environmental Protection Issues in the 1980s, CED-81-38. Washington, D.C.: December 1980.

- . EPA's Inventory of Potential Hazardous Waste Sites Is Incomplete, GAO/RCED-85-75. Washington, D.C.: March 1985.

- . EPA's Preliminary Estimates of Future Hazardous Waste Cleanup Costs Are Uncertain, GAO/RCED-84-152. Washington, D.C.: May 1984.

- . Hazardous Waste Disposal Methods: Major Problems With Their Use, CED-81-21. Washington, D.C.: November 1980.

- . Hazardous Waste: DOD's Efforts to Improve Management of Generation, Storage, and Disposal, GAO/NSIAD-86-60. Washington, D.C.: May 1986.

- . Hazardous Waste Facilities With Interim Status May Be Endangering Public Health and the Environment, CED-81-158. Washington, D.C.: September 1981.

- . Hazardous Waste: Federal Agency Hazardous Waste Disposal at Kettleman Hills, California, GAO/RCED-86-50. Washington, D.C.: December 1985.

- . Hazardous Waste: Federal Civil Agencies Slow to Comply With Regulatory Requirements, GAO/RCED-86-76. Washington, D.C.: May 1986.

- . Hazardous Waste Management Programs Will Not Be Effective: Greater Efforts are Need, CED-79-14. Washington, D.C.: January 1979.

- . Hazardous Waste: Review of Selected Air Force Hazardous Waste Reports, GAO/NSIAD-86-68BR. Washington, D.C.: March 1986.

- . Hazardous Waste Sites Pose Investigation, Evaluation, Scientific, and Legal Problems, CED-81-57. Washington, D.C.: April 1981.

- . How to Dispose of Hazardous Waste -- A Serious Question That Needs to Be Resolved, CED-79-13. Washington, D.C.: December 1978.

- . Illegal Disposal of Hazardous Waste: Difficult to Detect or Deter, GAO/RCED-85-2. Washington, D.C.: February 1985.

- . Information on Disposal Practices of Generators of Small Quantities of Hazardous Wastes, GAO/RCED-83-200. Washington, D.C.: September 1983.

- . Inspection, Enforcement, and Permitting Activities at New Jersey and Tennessee Hazardous Waste Facilities, GAO/RCED-84-7. Washington, D.C.: June 1984.

- . Interim Report on Inspection, Enforcement, and Permitting Activities at Hazardous Waste Facilities, GAO/RCED-83-241. Washington, D.C.: September 1983.

- . Siting of Hazardous Waste Landfills and Their Correlation With Racial and Economic Status of Surrounding Communities, GAO/RCED-83-168. Washington, D.C.: June 1983.

- . State Experiences With Taxes on Generators or Disposers of Hazardous Waste, GAO/RCED-84-146. Washington, D.C.: May 1984.
- . Status of Civilian Federal Agencies' Efforts to Address Hazardous Waste Problems on Their Lands, GAO/RCED-84-188. Washington, D.C.: September 1984.
- . Superfund: Status of Superfund Management Information Systems, GAO/RCED-86-98 FS. Washington, D.C.: February 1986.
- . The Evaluation Synthesis, Institute for Program Evaluation Methods Paper I. Washington, D.C.: April 1983.
- . Waste Disposal Practices: A Threat to Health and the Nation's Water Supply, CED-78-120. Washington, D.C.: June 1978.
- GCA Corporation. Preliminary Source Assessment for Hazardous Waste Air Emissions from Treatment, Storage and Disposal Facilities (TSDFs). Bedford, Massachusetts: February 1985.
- Gould, Jay M. Quality of Life in American Neighborhoods - Levels of Affluence, Toxic Waste, and Cancer Mortality in Residential Zip Code Areas. Boulder, Colorado: Westview Press, Inc., 1986.
- Greenberg, Michael R. and Richard F. Anderson. Hazardous Waste Sites: The Credibility Gap. New Brunswick, New Jersey: The Center for Policy Research, 1984.

- Grenfell, Adrienne. Hazardous Waste Issues: Selected References, 1983-1984. Washington, D.C.: Congressional Research Service, January 1985.
- "Hazardous Waste Tally Keeps on Growing". The New York Times. 132:45,791 (September 4, 1983).
- Hazardous Waste Treatment Council. Petition for Rulemaking by the Hazardous Waste Treatment Council for Adoption by EPA of Regulations Allowing Expeditious Permitting of Portable Hazardous Waste Treatment Units Under the Resource Conservation and Recovery Act. Washington, D.C.: January 1986.
- Helsing, Lyse Duhamel. "Managing Hazardous Wastes 1985." Chemical Week. 137:8 (August 21, 1985), 3-38.
- "How Much Hazardous Waste? Estimates Vary Widely." The Hazardous Waste Consultant, 2:2 (March-April 1984), 2-14 - 2-17.
- ICF Inc. Survey of Selected Firms in the Commercial Hazardous Waste Management Industry: 1984 Update. Washington, D.C.: September 1985.
- JT&A, Inc. Summary of Public Comments on the Proposed Research Permit for Incineration at Sea to U.S. Environmental Protection Agency. Washington, D.C.: Battelle, April 1986.
- Kiang, Yen - Hsiung and Amir A. Metry. Hazardous Waste Processing Technology. Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc., 1982.

McCarthy, James. Superfund: How Many Sites? How Much Money?
Washington, D.C.: Congressional Research Service,
February, 1986.

McCarthy, James E., Donald V. Feliciano, and Mark E. Anthony
Reisch. Capacity to Expand the Superfund: Labs,
Contractors, Qualified Personnel, and Waste Management.
Washington, D.C.: Congressional Research Service, April
1985.

National Research Council. Prospectus for an Evaluation of
Critical Aspects of the National Pollution Control
Program. Washington, D.C.: 1984.

New England Congressional Institute. Hazardous Waste Generation
and Management in New England. Washington, D.C.: February
1986.

"1986 Outlook for Commercial Hazardous Waste Management
Facilities: A Nationwide Perspective." The Hazardous Waste
Consultant, 4:2 (March-April 1986), 4-1 - 4-6.

"1986 State by State Outlook for Commercial TSD Facilities."
The Hazardous Waste Consultant, 4:2 (March-April 1986), 4-6
- 4-12.

Office of Technology Assessment. Nonnuclear Industrial
Hazardous Waste: Classifying for Hazard Management - A
Technical Memorandum. Washington, D.C.: November 1981.

----- Superfund Strategy. Washington, D.C.: April 1985.

----- Technologies and Management Strategies for Hazardous
Waste Control. Washington, D.C.: March 1983.

----- . Technologies and Management Strategies for Hazardous Waste Control. Volume 2. Working Papers. Part B. Application of Biotechnology to Hazardous Waste Disposal. Washington, D.C.: April 1983

----- . Technologies and Management Strategies for Hazardous Waste Control. Volume 2. Working Papers. Part C. Classification by Degree of Hazard for Selected Industrial Waste Streams. Washington, D.C.: April 1983.

----- . Technologies and Management Strategies for Hazardous Waste Control. Volume 2. Working Papers. Part D. Alternatives for Reducing End-Product Substitution. Washington, D.C.: April 1983.

Quarles, John. Federal Regulation of Hazardous Wastes: A Guide to RCRA. Washington, D.C.: The Environmental Law Institute, 1982.

Reisch, Mark E. Anthony. Superfund Reauthorization: Issues for the 99th Congress. Washington, D.C.: Congressional Research Service, January 1986.

"Revised Hazardous Waste Estimates Provides New Insight Into Magnitude of Problem." The Hazardous Waste Consultant, 2:4 (July-August 1984), 2-10 - 2-16.

Rich, Laurie A. "Drum Residue: A \$1 Billion Inch", Chemical Week, 138:10 (March 5, 1986), 12-16.

"Rollins Questions the Need for Ocean Incineration." The Hazardous Waste Consultant, 3:4 (September-October 1985), 2-25 - 2-26.

Sarokin, David J. and Warren R. Muir. "Too Little Toxic-Waste Data". The New York Times, 135:46,555 (October 7, 1985).

Shabecoff, Philip. "Hazardous Waste Exceeds Estimates". The New York Times, 132:45,787 (August 31, 1983).

Tobin, Patrick M. Hearing Officer's Report on the Tentative Determination to Issue the Incineration-at-Sea Research Permit (HQ-85-001). Washington, D.C.: Environmental Protection Agency, May 1986.

Toxics Assessment Group. Nowhere to Go: The Universal Failure of Class I Hazardous Waste Dump Sites in California. Sacramento, California: June 1985.

U.S. Congress, House of Representatives. Department of Housing and Urban Development - Independent Agencies Appropriations for 1978. Hearings Before a Subcommittee of the Committee on Appropriations Part 2, 95th Cong., 1st sess. Washington, D.C.: U.S. Government Printing Office, 1977.

----- Department of Housing and Urban Development - Independent Agencies Appropriations for 1986. Hearings Before a Subcommittee of the Committee on Appropriations Part 4, 99th Cong., 1st sess. Washington, D.C.: U.S. Government Printing Office, 1985.

----- Hazardous Waste Control and Enforcement Act, H.R. 2867 (Part 1 - Small Quantity Generators). Hearing Before the Subcommittee on Energy, Environment and Safety Issues Affecting Small Business of the Committee on Small Business, 98th Cong., 1st sess. Washington, D.C.: U.S. Government Printing Office, 1983.

----- . Hazardous Waste Control and Enforcement Act, H.R. 2867 (Part 2 - Innovative Technologies). Hearing Before the Subcommittee on Energy, Environment, and Safety Issues Affecting Small Business of the Committee on Small Business, 98th Cong., 1st sess. Washington, D.C.: U.S. Government Printing Office, 1984.

----- . Resource Conservation and Recovery Act of 1976. Hearings Before the Subcommittee on Transportation and Commerce of the Committee on Interstate and Foreign Commerce, 94th Cong., 2nd sess. Washington, D. C.: U.S. Government Printing Office, 1976.

----- . Waste Control Act of 1975. Hearings Before the Subcommittee on Transportation and Commerce the Committee on Interstate and Foreign Commerce, 94th Cong., 1st sess. Washington, D. C.: U. S. Government Printing Office, 1975.

U.S. Congress, Senate. Ocean Incineration. Hearings Before the Subcommittee on Environmental Pollution of the Committee on Environment and Public Works, 99th Congress, 1st session. Washington, D.C.: U.S. Government Printing Office, 1985.

----- . The Need for a National Materials Policy. Hearings Before the Panel on Materials Policy of the Subcommittee on Environmental Pollution of the Committee of Public Works Part 2, 93rd Cong., 2nd sess. Washington, D.C.: U.S. Government Printing Office, 1975.

----- . The Need for a National Materials Policy. Hearings Before the Panel on Materials Policy of the Subcommittee on Environmental Pollution of the Committee on Public Works Part 3, 93rd Cong., 2nd sess. Washington, D.C.: U.S. Government Printing Office, 1975.

Vajs, Kristin M. Hazardous Wastes: A Guide to Sources of Information. Washington, D.C.: Congressional Research Service, September 1983.