DRAFT

United States
Environmental Protection
Agency

Office of Solid Waste
and Emergency Response
Washington, DC 20460

EPA/530-SW88-034
September 1988

Solid Waste

EPA National Survey of Solid Waste (Municipal) Landfill Facilities

DRAFT

FINAL REPORT

NATIONAL SURVEY OF SOLID WASTE MUNICIPAL LANDFILL FACILITIES

Submitted to

The Environmental Protection Agency
Office of Solid Waste
401 M Street, S. W.
Washington, D.C. 20460

(Under Contract No. 68-01-7359)

Submitted by

Westat, Inc.
1650 Research Boulevard
Rockville, Maryland 20850

September 1988

ACKNOWLEDGMENTS

This survey was conducted by Westat, Inc. under the direction of the U.S. Environmental Protection Agency's (EPA) Office of Policy, Planning, and Information of the Office of Solid Waste. The EPA project manager for the survey was Jim Craig. Doug Ruby coordinated the review and comments on the final draft.

Many individuals at EPA contributed to the survey effort. Allen Geswein and Michael Flynn of the Special Wastes Branch and Ron Burke and Cliff Rothenstein of the Economic Analysis Staff made important contributions to the development of the survey forms and analysis of the results of the survey.

At Westat, the Project Manager was Dr. John Michael. The efforts of Steve Dietz, Margaret Pacious, David Hurwitz, Pat Leydig, Joan Bull, Sharon Gregory, Gary Brown, Lori Williams, and Elizabeth Gaughan are also appreciated.

The efforts of Mark Evans and Jenny Utz of SAIC are also acknowledged for providing technical expertise on landfill design.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

PART II: SURVEY RESULTS

List of Figures

List of Tables

EXECUTIVE SUMMARY

This report describes the methodology and results of a national survey of Subtitle D municipal landfill facilities. A landfill is classified as a *municipal* landfill if it receives primarily household refuse and commercial waste, and is not a hazardous waste landfill. The survey was administered for the Office of Solid Waste, United States Environmental Protection Agency (EPA) by Westat, Inc.

The survey was conducted in response to the Hazardous and Solid Waste Amendments (HSWA) of 1984. HSWA required that EPA (1) conduct a study to determine whether RCRA regulations are currently adequate to protect human health and the environment from ground-water contamination, (2) report the results of the study to Congress, and (3) revise these regulations for facilities that receive small quantity generator hazardous waste and household hazardous waste. Prior to this study, no comprehensive detailed information was available on municipal landfills.

A mail questionnaire was sent to a sample of 1,250 facilities in November, 1986. Completed questionnaires were received from 1,174 facilities of which 1,102 were determined to be eligible, that is members of the target population. Through a stratified design, large facilities were sampled with higher probability than small facilities. Detailed information was collected on ownership, operations, hydrogeology, waste characteristics, landfill unit construction, monitoring systems, and operating costs. A copy of the Questionnaire and the General Instructions mailed to each facility surveyed are given in Appendices A and B, respectively.

The target population was comprised of all municipal landfills in the United States and five territories. The target population was further limited to facilities that had at least one active landfill unit as of November 1, 1986. For the purposes of this survey, a landfill unit was defined as a solid waste disposal area within a landfill facility that has the same liner type (or no liner) throughout. Closed landfill units and planned landfill units were also surveyed, but only if they were located at a facility with at least one active landfill unit.

The number of active municipal landfill facilities (as of November 1986) is estimated to be 6,034. This is considerably less than the 9,284 facilities estimated by the Census of State and Territorial Non-Hazardous Waste Programs conducted by EPA during the fall and winter of 1985-86. The main reasons for the reduction in the estimate are the identification of non-municipal landfill facilities included in the previous count and recent closings of municipal landfills.

There are an average of 2.25 landfill units at each municipal landfill facility. Of these, an estimated 23 percent are closed, 49 percent are active, and 28 percent are planned. By definition, each facility surveyed had to have at least one active landfill unit. Only about 7 percent of facilities have more than 1 active landfill unit. About 25 percent of facilities have closed units and about 29 percent have planned units.

An estimated 209 million tons of waste is received annually by municipal landfill facilities. Of this amount, approximately 114 million tons (55%) is household and 58 million tons (28%) is commercial. A rough estimate of small quantity generator hazardous waste received by municipal landfills is about 150 thousand tons each year.

The distribution of the quantity of waste received by a facility was observed to be highly skewed to the right; that is, there were a relatively small number of large facilities that accounted for a substantial portion of the total waste received. With skewed distributions, the "typical" facility may be better represented by the median as opposed to the mean. Whereas the average amount of waste received by a facility was about 35 thousand tons, the median value was only about 3 thousand tons. Skewness was noted for most measures of quantity.

Several questions were posed concerning proximity to residences and drinking water sources. About 42 percent of municipal landfill facilities are located within one mile of private wells and about 6 percent are located within one mile of public wells. An estimated .7 million persons use these wells for drinking water.

About 36 percent of facilities monitor ground water, 15 percent monitor surface water, 7 percent monitor gas, and 3 percent monitor air. Leachate collection systems were reported for an estimated 8 percent of closed, 11 percent of active and 21 percent of planned landfill units.

Part I summarizes the survey methodology including statistical reliability and data accuracy. Part II presents selected statistical results primarily in a tabular and graphical form. Appendix A also presents statistical results but in a format similar to that of the questionnaire. Some readers may prefer to go directly to Appendix A for a systematic presentation of the results. Also statistics presented in this report are estimates and therefore are subject to error. See Chapter 5 for a discussion of the various types of error and the accuracy of the results.

PART I

SURVEY METHODOLOGY

1. INTRODUCTION

1.1 Overview

The Hazardous and Solid Waste Amendments (HSWA) of 1984 require that EPA (1) conduct a study to determine whether RCRA regulations are currently adequate to protect human health and the environment from ground-water contamination, (2) report the results of the study to Congress, and (3) revise these regulations for facilities that receive small quantity generator hazardous waste and household hazardous waste. In addition, HSWA gives EPA the authority to enforce the revised regulations should the States fail to enforce them adequately. In order to meet the Congressional mandate, EPA undertook several studies.

One of these studies was the Municipal Landfill Survey. This survey was of all active non-hazardous landfills that receive primarily household and commercial solid waste in the United States and five Territories. A mail questionnaire was sent to a sample of 1,250 facilities in November, 1986. Detailed information was collected on ownership, operations, hydrogeology, waste characteristics, landfill unit construction, monitoring systems, and operating costs. Statistical results are given in Part II of this report.

The data will be used by EPA to characterize the population of municipal landfills and to assess the risks of waste management on human health and the environment. Ultimately the results of this data collection effort will be used to determine the effectiveness of current Subtitle D guidelines and regulations, to examine the extent of any program deficiencies, and to recommend measures to Congress that would improve the effectiveness of the Subtitle D program. These data also will be used for regulatory impact analyses and decision-making.

A second area where EPA will use this information is the Subtitle C (hazardous waste) program. EPA is currently re-evaluating the list of hazardous wastes and will use the information from this survey in assessing the risks associated with waste management. Since wastes that are not classified as hazardous may be disposed in Subtitle D facilities, the information obtained in this survey is important to the continued development of the Subtitle C program as well as the Subtitle D program.

1.2 Congressional Mandate

Congress has passed a number of acts and amendments that deal with the management of solid waste. RCRA contained the first set of guidelines to address solid waste management practices. After the enactment of RCRA, EPA began to develop regulations under its authority.

In 1979, under the authority of Sections 1008(a)(3) and 4004(a) of Subtitle D of the Resource Conservation and Recovery Act (RCRA), EPA issued the "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (see 40 CFR Part 257, hereinafter referred to as "Criteria"). These Criteria addressed which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. The Criteria are used by States to classify solid waste disposal facilities as either open dumps or sanitary landfills. Facilities that violate any of the provisions of the Criteria are deemed "open dumps." A ban on open dumps is enforced by either the States or citizen suits. EPA has no direct enforcement authority for the current Criteria. Instead, the Federal role is limited to the development of the Criteria and to technical and financial assistance.

In 1979, EPA also issued guidelines for the development of State Solid Waste Management Plans (see 40 CFR Part 256). These guidelines require that States seeking EPA Subtitle D grant funds have the authority to prohibit, close, and upgrade open dumps. These grant funds were available from 1977 to 1981. Aside from approval of State plans and the disbursement of grant funds, EPA had no direct implementation authority for the Criteria. Subtitle D was, and still is, basically a State-administered program.

Subtitle D funding of State activities was terminated after 1981. Since then the focus of EPA's efforts has been on Subtitle C (hazardous waste) efforts. As a result of reduced involvement in Subtitle D activities, EPA has limited current information on the status of State non-hazardous waste programs and on the facilities themselves.

The Hazardous and Solid Waste Amendments (HSWA) of 1984, signed into law on November 8, 1984, states, in part, the following:

- "The Administrator shall conduct a study of the extent to which the guidelines and criteria under this Act...are adequate to protect human health and the environment from groundwater contamination."

- "..., the Administrator shall submit a report to the Congress setting forth the results of the study required under this section...."

- "..., the Administrator shall promulgate revisions of the Criteria promulgated under paragraph (1) of Section 4004(2) and under Section 1008(a)(3) for facilities that may receive hazardous household wastes or hazardous wastes from small quantity generators under Section 7001(d)."

And HSWA gives EPA the authority to enforce the revised Criteria should the States fail to enforce them adequately.

As a first step in meeting the Congressional mandate, EPA collected information on the number and basic characteristics of Subtitle D facilities in a census of U.S. State and Territorial governments[1]. (Hereafter, we will refer to this survey as the Subtitle D Census.) The purposes of the study were to evaluate the status of Subtitle D programs (organization, resources, enforcement, etc.) and to generate basic aggregated estimates on the numbers and types of Subtitle D facilities. Based on this information, EPA estimated that in 1984 there were a total of 227,127 Subtitle D facilities located throughout the 50 States and five Territories[2]. Of these facilities, about 9,000 were thought to be active residential or commercial (municipal) landfill facilities -- a key subset of Subtitle D facilities, because it is likely that they receive household hazardous waste and small quantity generator hazardous waste. Based on this survey, EPA now estimates that about one third of these sites are either closed or do not fit the definition of a Municipal Landfill. The estimate of the number of active municipal landfill facilities as of November 1986 is 6,034.

To meet the Congressional mandates, EPA is undertaking several studies to: (1) assess the impacts of non-hazardous municipal waste and industrial waste landfills, surface impoundments, and land application units on surface water, ground water, and air; (2) assess the implementation of the non-hazardous waste program by the States; and (3) make recommendations concerning possible changes to the Federal and State Subtitle D

---

[1]Census of State and Territorial Non-Hazardous Waste Programs prepared by Westat, Inc. for the U.S. Environmental Protection Agency, Contract No. 68-01-7047, April 1986.

[2]Territories were the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Marianas. The District of Columbia reported no Subtitle D facilities.

non-hazardous waste permitting and enforcement programs. The EPA Offices primarily responsible for this study are the Office of Solid Waste and the Office of Water.

Specifically, the Municipal Landfill survey is designed to gather information in each of the following areas from each individual municipal landfill:

- Landfill owner, operator, and permitting status;
- Facility jurisdiction, size, and operations;
- Hydrogeologic and water source information;
- Waste characteristics;
- Individual landfill unit information, e.g., liners, covers, leachate systems, and runoff systems;
- Monitoring systems; and
- Landfill operating costs and revenues.

EPA asked each State to provide a list of municipal landfills as part of the Subtitle D Census. EPA compiled these lists and used them as the initial population universe for the Municipal Landfill Survey data collection effort.

2. SURVEY DESIGN

2.1 Sample Frame

The Subtitle D Census of 1986 conducted by EPA was the first attempt to compile a comprehensive list of Municipal Landfills in the United States and Territories. The Subtitle D Survey instrument itself gave the following definitions:

- ***Municipal Waste Landfill*** - A Landfill that primarily receives household refuse and commercial waste. It may also receive a limited amount of other types of Subtitle D wastes, such as municipal sewage sludge and industrial wastes.
- ***Landfill*** - A part of an establishment at which waste is placed...
- ***Establishment*** - A single physical location where business is conducted or where services or industrial operations are performed by a municipality, corporation, or other public or private entity...

Question D2 of the Subtitle D Survey asked each respondent to estimate the number of active Municipal Waste Landfills. This provided a national estimate of 9,284 such landfills. Question F7 asked each respondent to attach a list of all Subtitle D facilities. These lists were keyed into a computer. The resulting data base of Subtitle D facilities was the starting point for the development of the sample frame for the Municipal Landfill Survey. (Hereafter, this data base will be referred to as the Subtitle D Census data base.)

An extensive and systematic *cleaning and data retrieval* effort was performed on the Subtitle D Census data base in 1986 prior to the selection of a sample. The lists of facilities provided by the states and territories differed in format, accuracy, temporal scope, and completeness. Respondents were contacted where key data were missing or suspect. For each respondent, the total number of Municipal Landfill facilities provided on the list submitted in response to the Subtitle D Survey was compared to the number given in the response to Question D2. Clarification was sought where there was a discrepancy. The reasons given for discrepancies fell into three general categories:

- ***Temporal differences.*** The Subtitle D Survey was conducted in the fall and winter of 1985-1986. The lists provided were sometimes dated much earlier. There were numerous instances of facilities on the list that had closed and therefore were not included

in the counts given in response to the Subtitle D Survey. There were fewer instances of openings.

- ***Definition***. Some lists contained unattended sites. There were numerous instances where the site was not at a location where "business is conducted or where services or industrial operations are performed by a municipality, corporation, or other public or private entity."

- ***Errors***. Counts by some states were estimates or judgement calls. Some states were unable to reconstruct the counts reported in the Subtitle D Survey, and still others were unable to reconstruct the lists. One state included closed facilities. Another state included Demolition Debris Landfills in the count of Municipal Landfills.

Multiple follow-up calls were made to most states/territories. A number of states resubmitted their lists. One submitted a list for the first time. Our data retrieval effort continued from March until October, 1986, by which time all major differences were satisfactorily resolved. The revised sample frame consisted of 8,343 facilities.

Supplemental data collection was also done in conjunction with the data cleaning and data retrieval effort. Each Subtitle D Survey respondent was asked to identify Municipal Landfills that received over 500 tons of waste per day. (Such sites will be referred to below as "large" sites.) This necessitated contacting almost all states as few had provided size information on the submitted lists of facilities. The purpose of this data collection effort was to sample "large" and "small" facilities separately. The stratified random sample design is described in Section 2.3 below.

2.2 Target Population

The definition of a Municipal Landfill facility was the same as the definition used in the Subtitle D Census. In particular, a facility had to have landfills that received primarily household and commercial waste, not be classified as a Subtitle C facility, and be at a location where business was conducted or where services or industrial operations were performed by a municipality, corporation, or other public or private entity. "Primarily" is interpreted to mean at least 50 percent. Thus at least 50 percent of the waste received must be household and/or commercial waste. Household waste is waste that typically comes from residential units. Commercial waste comes from office buildings, restaurants, and other retail and wholesale businesses.

The target population was limited to facilities that had at least one active landfill unit as of November 1, 1986. A landfill unit was defined as follows:

- ***Landfill Unit:*** a discrete area within a landfill facility used for disposing solid wastes. A landfill unit has the *same liner type (or no liner) throughout* and is bounded either by land on which no waste is placed or by another unit with a different liner type. A single landfill unit may have adjacent sections, but each will have the same liner type.

Closed landfill units and planned landfill units were also surveyed, but only if they were at a facility with at least one active landfill unit. EPA determined that a survey of active facilities would achieve all the objectives set down by Congress while avoiding the difficulties associated with including closed and planned facilities in the target population. It would have been very difficult to identify all closed facilities and to find parties who would acknowledge responsibility for these sites. Planned facilities would also be more difficult to identify and the anticipated characteristics of planned facilities, when available, would be subject to more uncertainty and potential bias.

In summary, the target population was defined as follows:

- ***Target Population:*** All non-hazardous solid waste landfills in the 50 states, District of Columbia and five territories (1) that had at least one active (or temporarily inactive) landfill unit on November 1, 1986; (2) that received primarily household and commercial waste; and (3) were part of an establishment where business was conducted or where services or industrial operations were performed by a municipality, corporation, or other public or private entity.

2.3 Sample Design

The sample design selected was a stratified random sample of facilities. The stratification was done on the basis of the estimated quantity of waste received per day. Stratification in this fashion will result in much improved national estimates of the quantities of waste with only a small loss of efficiency when estimating proportions. Specifically, EPA anticipated that for estimating quantities the stratified design would be up to two and a half times more efficient than a simple random sample. For estimating

proportions, the loss in efficiency of the stratified design would be no more than about five percent.

On the basis of the estimated quantity of waste received per day, the sample frame was broken down into two strata. Stratum 1 consisted of 406 "large" facilities on the sample frame, or those facilities that were estimated to receive at least 500 tons of waste per day. Stratum 2 consisted of the remaining 7,937 "small" sites, or those that were believed to receive less than 500 tons of waste per day. Further stratification was impractical because most states/territories had limited knowledge of the operating characteristics of individual facilities.

In order to receive 1,000 useable questionnaires, we estimated that 1,250 would have to be mailed. We expected to lose about 20 percent due to non-response and facilities being out of scope, i.e., not fitting the definition of a Municipal Landfill facility.

Table 2.1 gives the optimal stratified sampling plan for a sample size of 1,000. It is optimal in the sense that, for a fixed total sample size of 1,000, such an allocation minimizes the variance of the estimate of total quantity of waste received. This optimum plan was calculated using Neyman allocation which requires knowledge of the mean and standard deviation of the quantity to be estimated within each stratum. These parameters were estimated using the counts of facilities estimated to receive less than 30, 30-500, and at least 500 tons of waste per day (obtained from the Subtitle D State Census) and then fitting to them a distribution with a shape similar to the shape of the distribution of the population of cities in the United States.

The optimal allocation for a sample size of 1,000 completed questionnaires was 200 (52%) of the estimated 382 "large" facilities and 800 (13%) of the estimated 6,147 "small" facilities. Thus a "large" site was about four times as likely as a "small" site to be sampled.

Table 2.1 Optimal stratified sampling plan for estimating the total quantity of waste received by all facilities

Stratum	Optimal allocation of eligibles in sample	Number in Frame	Preliminary estimate of eligibles in Frame	Sampling fraction*
"Large"	200	406	382	.52
"Small"	800	7,937	6,147	.13
Total	1,000	8,343	6,529	.15

*Sampling Fraction = Eligibles in Sample / Eligibles in Frame.

The computation of the optimal allocation required knowledge of the numbers in each strata in the target population, or universe. The number in the universe is not the same as the number in the sample frame because the latter contains a considerable number of mis-classified sites. Therefore, a preliminary sample was taken and, through a screening procedure described below, the number of eligible facilities in each strata was estimated. These preliminary estimates are shown in the above table and formed the basis of the computations for optimal allocation. Note that a disproportionately higher percentage of "small" sites were mis-classified as being in the universe. This result is not surprising since the larger sites are better known and classification was therefore more reliable.

The sample size of 1,000 useable questionnaires was selected using the following procedure. Optimal variances for percentages and quantities were approximated using Neyman allocation for a number of different sample sizes. We then selected a sample size of 1,000 for the study because it held the respondent burden and cost to a minimum while still achieving acceptable levels of accuracy.

Note that the above discussion refers to the the number of completed questionnaires received from eligible facilities. In order to achieve this goal, a larger number of questionnaires were actually mailed, even after most of the ineligibles had been eliminated through the preliminary screening described below. Losses due to non-response and ineligibility were estimated to be as high as 20 percent. Thus the initial mailout was to 1,250 facilities. A total of 1,176 questionnaires were received of which 1,102 were from

eligible facilities. This exceeded the goal of 1,000 completed questionnaires from eligible facilities.

2.4 Preliminary Screening

A stratified random sample of 1,701 facilities was drawn from the sample frame. These 1,701 facilities constituted the pool from which the final sample would be selected. An attempt was made to contact each of these facilities in order to accomplish the following:

- To verify that the facility was indeed an active municipal landfill;
- To obtain the name and address of the person to whom the questionnaire should be sent;
- To alert that person to the survey so that he/she would be more likely to complete and return the mail questionnaire; and
- To obtain preliminary estimates of the percentage of facilities that were out of scope in order to determine optimal allocation and the size of the mailout.

In some cases, a contact person and telephone number had been provided by the state in response to the State Subtitle D census. In others, directory assistance was called in order to obtain an initial contact number.

At this preliminary screening stage, 336 sites were identified that didn't appear to fit the definition of a Municipal Landfill facility. For these sites, there was no evidence that business was being conducted or services provided, and no one could be located who would acknowledge responsibility for the site. These so-called "promiscuous" sites were classified as ineligible.

Screening calls were conducted to determine names and addresses. Only eight facilities could not be contacted after repeated attempts. There were seven instances or duplication where a facility was listed twice. A total of 336 facilities were classified as ineligible. This left 1,350 eligible facilities for the mailout, of which 1,250 were selected.

2.5 Questionnaire Design

The survey instrument was developed over several months by EPA staff responsible for regulation development with review by technical experts. Because detailed instructions were required for questions of a technical nature, we decided to design a separate booklet of General Instructions. In order to provide technical assistance to respondents, the General Instructions listed a toll-free telephone number to call.

2.6 Pretest

There were two major differences between the pretest and the actual survey. The first was that the pretest required initial contact with respondents to determine if they were willing to participate in the pretest. The other difference was that after completing the pretest questionnaire, EPA followed up with extensive discussions with each respondent in order to identify any potential problems in completing the questionnaire. The major emphasis in these discussions was on question clarity, format, and ease of response.

EPA contacted nine municipal landfill facilities by phone in early August 1986, and asked them to participate in the pretest. In selecting sites, attention was first focused on selecting diverse facilities in the neighboring states of Maryland, Pennsylvania, Virginia, and West Virginia. Their close proximity to EPA offices in Washington, D.C. would facilitate site visits, should such visits become necessary. (As it turned out, none were visited.) EPA selected nine facilities that represented different states, different types of ownership (public and private), different sizes (an estimated 4 tons to 4500 tons received per day), and different operating characteristics (presence or absence of monitoring and/or leachate collection systems).

Each of the nine selected facilities was mailed Questionnaire and General Instruction booklets on August 14. A cover letter gave a background summary and explained the purpose of the pilot study. Shortly thereafter, each facility was contacted to ensure that the materials had been received and that work on the Questionnaire was planned or in progress. Approximately two and four weeks later, follow-up calls were made to nonrespondents.

Eight of the nine facilities returned completed questionnaires. One facility decided not to participate in the pretest on advice of legal counsel because it did not have a permit and was then in litigation with the state. EPA contacted each of the eight participating facilities and asked the following general questions:

- Were there parts of the General Instructions that were difficult to understand?
- Can you think of better ways to work the General Instructions?
- Were there any questions that you had difficulty understanding?
- Were there any questions that you had difficulty answering?
- Can you think of better ways to word any questions?
- How long did it take you to complete the questionnaire?

The pattern observed was that the data were relatively complete for large facilities compared to small facilities, particularly regarding design capacity and hydrogeologic data. The complexity of certain questions tended to be a problem only for the smaller less sophisticated sites. Respondents felt that additional definitions of terms would help, but only to a limited degree. Most of the missing data occurred because the respondent didn't know the answer, not because he didn't understand the question. Instances of failure to complete a question, or failure to follow instructions, appeared unrelated to the length of the questionnaire. The average length of time to complete the questionnaire was about two hours, as predicted.

As a result of the pretest, only minor changes were made in the survey instrument. These included the rewording of some questions and the addition of several others.

3. DATA COLLECTION

3.1 Initial Mailout

The initial mailout of 1,250 questionnaires was conducted in mid-November, 1986. Each Questionnaire was accompanied with a set of General Instructions, a cover letter from EPA which explained the purpose of the survey, and a postage-paid return envelope. Each package was sent via certified mail.

3.2 Follow-up of Nonrespondents

The first follow-up action took place approximately two weeks after the initial mailout. In early December, a confirmation letter from EPA was mailed to each facility surveyed. The letter confirmed the mailing of the questionnaire package and urged to facility manager to complete and return the questionnaire as soon as possible.

Two telephone prompts were conducted later in an attempt to increase the response rate and the quality of the responses. In mid-December, telephone calls were made to 819 facilities that had neither returned the completed questionnaire nor contacted the Questionnaire Assistance Center. The caller reminded the respondent of the importance of the survey and asked for a date by which the questionnaire would be completed and returned. If the respondent needed technical assistance, the caller arranged for a return call by a technical specialist. In late January, 1987, a second series of telephone prompts were made to 345 nonrespondents.

Finally, in April, a package was sent from EPA to each of the 167 remaining nonrespondents. Each package contained a letter from EPA urging cooperation, a copy of the letter that was included in the original mailing in November 1986, and another copy of the Questionnaire and General Instructions. At that time, 24 of the 167 nonrespondents had expressed their intention not to participate in the survey. These 24 so-called "refusals" were sent a different version of the cover letter. By the end of the data collection effort, all but 7 of the initial 24 "refusals" had been "converted" by the Data Retrieval team and returned completed questionnaires.

A summary of the contact with survey respondents is given in Table 3.1. A summary of the number of questionnaires received over time is shown in Figure 3.1. The primary data collection effort ended on June 30 when the last questionnaire was received.

A total of 1,176 questionnaires were either received by mail or completed over the phone for an overall response rate of 94 percent. Of the 74 nonrespondents, 7 were classified as "refusals" who informed a telephone interviewer that they would not complete and return the questionnaire. Of the 1,176 respondents, 74 (coincidentally) were determined to be ineligible. This left a total of 1,102 eligibles which exceed our goal of 1,000 These results are summarized in Table 3.2 below.

Table 3.1 Summary of contact with survey respondents

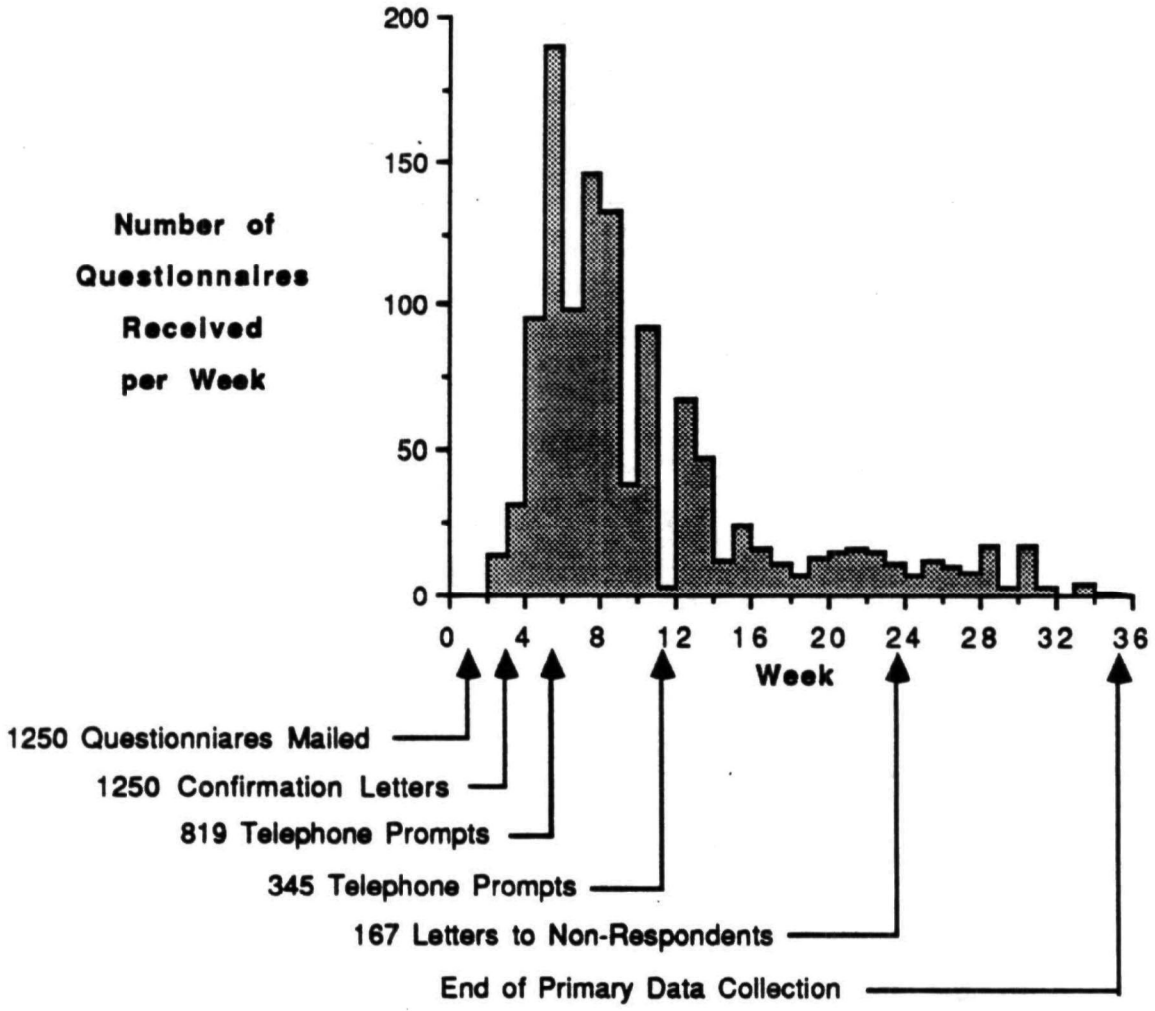
Type of contact	Number contacted	Date of contact
Initial mailout	1,250	November 1986
Confirmation letter	1,250	December 1986
First telephone prompt	819	December 1986
Second telephone prompt	345	January 1987
Nonrespondent letter	167	April 1987

Table 3.2 Summary of the number of questionnaires received

Stratum	Total mailed	Total received	Response rate	Eligibles received
"Large"	250	238	95.2%	227
"Small"	1,000	938	93.8	875
Total	1,250	1,176	94.1	1,102

Figure 3.1

Summary of the Number of Questionnaires Received Over Time



4. DATA PREPARATION

4.1 General Approach

The major steps in the data preparation process are shown in Figure 4.1. At the center of the activity was the Coding operation. The Coding staff received data in the form of incoming questionnaires, supplementary data from the Data Retrieval staff, and computer printouts that summarized edit checks. The Coding staff also forwarded data to Data Retrieval and Key Entry for processing. The data preparation manager and the receipt control operation were also co-located with Coding. The data preparation manager monitored the data flow in Coding, Data Retrieval, and Key Entry. In addition, the data preparation manager supervised the receipt control system which tracked each questionnaire from mailout through the data cleaning stage.

Some questionnaires cycled through the the Error Checking stage several times. An effort was made to limit to one the number of times a questionnaire was passed to Data Retrieval because of the cost of initial contact and the burden of multiple calls on the respondent.

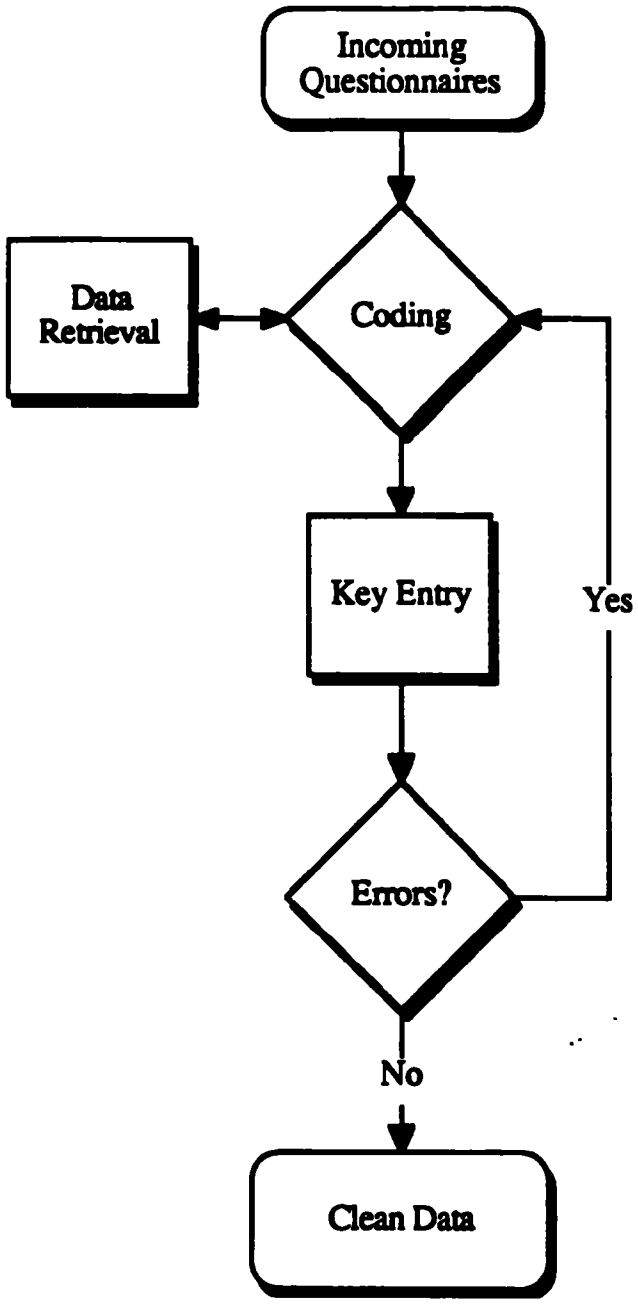
4.2 Coding and Data Entry

The term *coding* is usually used to describe the process of transcribing responses written on the questionnaire into a consistent form suitable for direct Key Entry. For some data fields, no transcription was necessary. For others the response was circled, abbreviated or *coded* with a special value. Coders also prepared the Data Retrieval sheets, entered new data from Data Retrieval on questionnaires and data update sheets, collated related responses in order to reconcile apparent inconsistencies, and interpreted computer-generated edits.

A team of eight coders received special training by the data preparation manager. A key reference document was the *code book.* The code book names all the variables, defines codes, indicates skip patterns, and gives acceptable values and ranges for each variable. The data preparation manager along with certain coders also functioned in a quality control

Figure 4.1

Flow Chart of Steps in Data Preparation



capacity by checking the work of others coders. All coding was 100 percent verified before it was passed to Key Entry.

The first time a questionnaire was coded, it was sent to Key Entry in its entirety. All keyed data were 100 percent verified. Updates were made by running special update programs on the computerized data.

4.3 Editing

The editing of the data consisted of a series of five edits: (1) scan edits, (2) standard machine edits, (3) custom logic edits, (4) mass edits and (5) special edits.

Scan edits were performed by Coding when the questionnaire was initially coded. Often apparent errors were rectified by reference to other related responses. In other cases, rules were applied to convert a response into an acceptable value.

Standard machine edits were computerized edits that checked to see that ranges and codes specified in the code book were adhered to for each field. This included skip patterns which specified conditions under which fields should be left blank.

Custom logic edits primarily checked across fields for consistency. Whereas the standard machine edit was derived automatically from the code book and looked primarily within fields, custom logic edits required logical consideration across fields.

Mass edits procedures apply descriptive statistics to collections of cases. Usually these descriptive statistics took the form of frequency distributions, cross-tabulations, or scattergrams. Descriptive statistics helped to identify errors that caused a value to stand out from the rest. Frequency distributions were generated and studied for every field. Distributions across fields were also examined for consistency and reasonableness.

Special edits were conducted because of the significance of certain questions. These included the following:

- Any facility that reported being out of scope (Q1.2) was contacted by telephone and its status was verified.
- The reported average annual quantity of waste received was compared to the stratification variable and large differences were verified by telephone.
- Because of a typographical error in Question 4.3, responses to this question were either verified by telephone when the respondent was contacted for data retrieval or dropped from the data base.

4.4 Confidential Business Information (CBI)

In the cover letter that accompanied each questionnaire, EPA explained why the data were being collected, how the data would be used, and identified the contractors and subcontractors to whom the data would be transmitted for regulatory development. Each respondent was apprised of his/her right to assert a claim of CBI covering all or part of the information furnished to EPA and was instructed as to how to make such a claim. Questionnaires declared to be CBI were and continue to be handled in accordance with 40 CFR Part 2.

5. STATISTICAL RELIABILITY AND DATA ACCURACY

5.1 Types of Error

It is important to keep in mind that the estimates provided in this report are subject to errors of various kinds. Errors in sample survey estimates can usually be classified into two major categories: sampling errors and non-sampling errors. Sampling errors result from the fact that estimates are based on only a sample of the population and not the entire population. Nonsampling errors include all other sources of error. Each of these major types of error are discussed below.

5.2 Sampling Error

In order to quantify the variability of the estimates presented in this report, the standard errors of the estimates were also estimated. The standard error is a measure of the variability of an estimate due to sampling error. On the average, estimates will be within one standard error of the true population parameters about 68 percent of the time, and within two standard errors of the true population parameters about 95 percent of the time.

Indication of the variability of estimates are given in two ways in this report. In Part II, standard errors and corresponding 95 percent confidence intervals are given for selected estimates. A 95 percent confidence interval is constructed by adding and subtracting 1.96 standard errors from estimates. A 95 percent confidence interval will contain the true parameter about 95 percent of the time. In the appendix, a second method is used to caution the reader of high variability. One or two asterisks (*) following a statistic are used to indicate when the estimated standard error is greater than 25 percent or 50 percent, respectively, of the estimate itself. One asterisk indicates high relative variability, and two asterisks indicate very high relative variability. In the latter case, a 95 percent confidence interval would contain values as low as 0 and as high as twice the estimate.

5.3 Non-sampling Error

Sources of error in a survey other than sampling error are referred to as *non-sampling errors*. Non-sampling errors by the respondent include mistakes in interpreting questions, researching answers, and writing down responses. Non-sampling errors in the processing stage include errors in coding, key entry, programming, and reporting. Nonresponse bias errors occur if nonrespondents differ systematically from respondents. The incompleteness of the sample frame can also result in biased estimates of averages and percents and in underestimates of population totals.

Although respondent and processing errors probably occurred during the course of this survey, there is no evidence to suggest that they introduced significant amounts of bias or error into the survey results. Intensive quality control efforts are summarized below in Section 5.5 that were utilized to minimize nonsampling errors.

The possible incompleteness of the sample frame is always a possibility in a survey designed around a frame compiled from lists. Whereas the percentage of ineligibles on the sample frame can be estimated and adjusted for using the survey results, it is difficult to estimate the number of eligible facilities that do not appear on the sample frame. The quality of the frame used in this survey depends on the quality of the data provided by the states. The process of contacting the states in order to reconcile the aggregate numbers reported on the Subtitle D Census afforded EPA the opportunity to assess the quality of the data on a state-by-state basis. While some omissions were discovered for some states, these errors were not substantial or widespread. The effect of any incompleteness in the sample frame would be to deflate estimates of totals for the population.

Seven instances of duplicate pairs of entries were discovered in the screening sample. Duplicates were eliminated and the sample weights on the retained members of the pairs were halved. Other yet undiscovered duplicates may exist, although they are estimated to comprise no more than .5 percent of the sample frame. The effect of any such duplicates would be to inflate estimates of totals for the population.

5.4 Maximizing Response Rates

A major reason for maximizing the number of responses to a question is that one can never be sure if nonrespondents have the same characteristics as respondents. If nonrespondents are systematically different from respondents, estimates based on the survey data can be biased. The degree of bias depends on the extent to which nonrespondents differ from respondents *and* the response rate.

Participation in the survey was mandatory under Section 3007(a) of RCRA. The mandatory nature of the survey contributed to the high response rates achieved. As given earlier in Table 3.2, the response rate for this survey was 94.1 percent. Given the nature of most municipal landfills -- small operations run by a town official with little technical background and many other responsibilities, EPA chose not to pursue enforcement against nonrespondents.

EPA also used a number of measures to maximize the number of facilities that returned completed questionnaires. Some of the measures are discussed in Section 3.2. EPA also utilized a number of diverse techniques in order to maximize the *item* response rate. The key to high initial item response rates was careful questionnaire design, making sure that each question was easy to understand and easy to answer. Closed-ended questions were used whenever possible; and skip patterns were used extensively in order to reduce the burden on the respondents and speed them through the questionnaire. The General Instructions contained a set of definitions of important terms, a diagram of a typical landfill facility, and gave examples of each major question/response format.

For respondents who had questions or problems, the toll-free telephone number of the Questionnaire Assistance Center was given in both the General Instructions and the cover letter. Incoming calls were channeled to a technical specialist who was very familiar with the questionnaire. In addition, telephone numbers for the EPA Project Manager, Jim Craig, and the RCRA-Superfund Hotline were given in the cover letter.

A second way in which item response rates were increased was through the data retrieval process -- the process of re-contacting the respondent by telephone in order to fill data gaps and resolve inconsistencies. The degree of data retrieval that was done for a particular item depended on how the item was answered and the importance of the item. In

some cases the respondent left the space for the answer "blank" and in other cases wrote "unknown" next to it. For some items data retrieval was done on "blanks" but not "unknowns." Certain critical items were deemed "trigger" items in that a data gap would cause a data retrieval call to be made. For other items, data retrieval was done on the item only if some other more important item triggered a data retrieval call. For still others items, no data retrieval was attempted, even if a data retrieval contact was made. Figure 5.1 gives the degree of data retrieval done for each item in the questionnaire.

The item response rate varied with the technical level of the question. Most questions required only general knowledge of the facility and their response rates were typically above 90 percent. But for some technical questions the response rate was low. For example only about 261 or 24 percent gave an answer to Question 3.7c which asked for the hydraulic gradient of the uppermost aquifer at the facility. The response rates to questions about closed and planned landfill units were also low - only about 45 percent. With these exception, the response rates were typically quite high - over 90 percent.

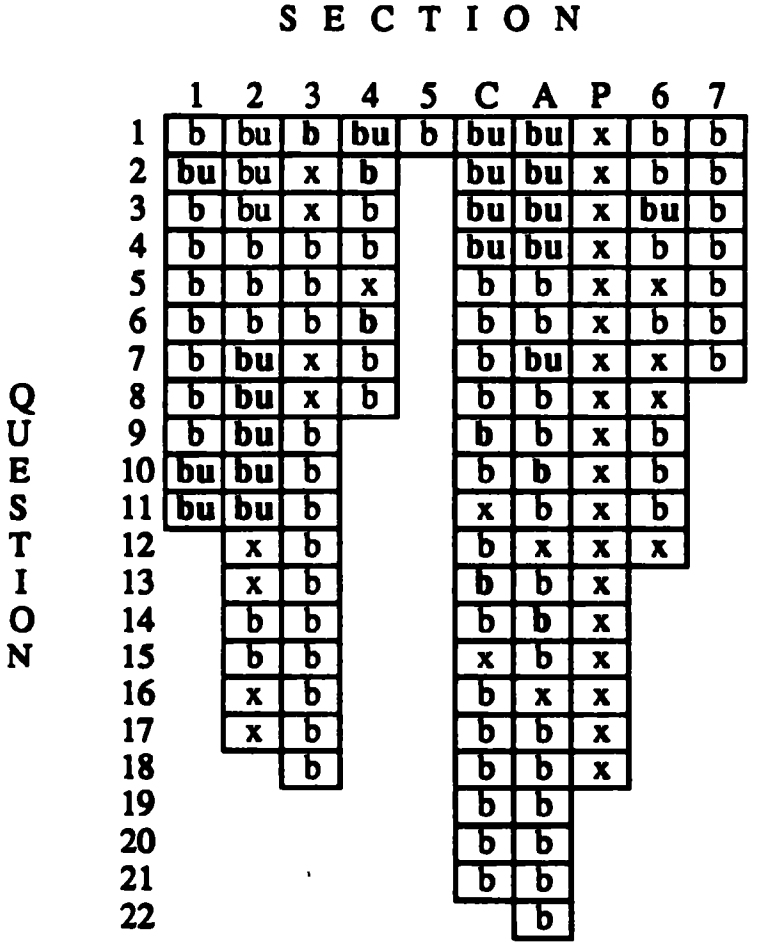
5.5 Quality Assurance

Quality assurance procedures touched every aspect of the study, from the coding of each data item to estimation of the variances of estimates. Below we summarize quality assurance procedures, many of which are discussed in more detail in other parts of this report.

- The Questionnaire and General Instructions were carefully designed and went through numerous revisions;
- The Questionnaire and General Instructions were reviewed by numerous EPA staff as well as representative from the National Solid Waste Management Association (NSWMA), the American Public Works Administration (APWA), Governmental Refuse Collection and Disposal Association (GRCDA), and trade associations;
- A pretest was conducted with extensive follow-up discussions (see Section 2.6);
- Efforts were made to maximize the response rate (see Section 5.4);

Figure 5.1

Data Retrieval Criteria



The following table entries indicate when data retrieval was performed, given that a call was made:

- b: when answer is blank;
- u: when unknown is written in as an answer;
- bu: when answer is blank or unknown;
- x: no data retrieval.

Table entries in bold print indicate problems that triggered a data retrieval call.

- Thorough training was given to coders (see Section 4.2) and data retrieval specialists;
- Coding and key entry work was 100 percent verified (see Section 4.2);
- Extensive error checking was conducted which included scan edits, standard machine edits, custom logic edits, mass edits, and other special edits (see Section 4.3);
- Estimates were computed manually to double-check the logic of computer programs; and
- The data were reviewed independently by EPA over a period of several months prior to the release of this report.

PART II

SURVEY RESULTS

6. NUMBERS OF LANDFILL FACILITIES AND UNITS

6.1 Number of Landfill Facilities

Based on this survey, there were an estimated 6,034 active Municipal Landfill facilities in the United States and territories in November, 1986. Table 6.1 shows this result and presents the estimated standard error of the estimate along with the corresponding 95 percent confidence interval. With 95 percent confidence, we can say that the total number of landfill facilities ranges from 5,882 to 6,186 facilities. (See Chapter 5 for a discussion of sampling and nonsampling error, standard error and confidence intervals.)

Table 6.1 Total number of landfill facilities

	Total number in population	Standard error	95% Confidence interval
Active municipal landfills	6,034	77.5	5,882 - 6,186

6.2 Number of Landfill Units

A landfill *unit* is defined as a discrete area within a landfill facility that is used for disposing solid wastes. A landfill unit has the same liner type (or no liner) throughout and is bounded either by land on which no waste is placed or by another unit with a different liner type. A single landfill unit may have adjacent sections, but each must have the same liner type. (A cluster of naturally occurring pits that had been filled with solid waste and had the same liner type may also have been classified as a single landfill unit.)

Table 6.2 summarizes the estimated numbers of landfill units by type; closed, active and planned. In November, 1986, there were an estimated 6,585 active

landfill units in the United States and territories. This averages to 1.09 active units per facility. Table 6.2 also includes numbers for closed and planned units. The estimates for closed and planned units are less reliable than that for active units because many current facility operators do not have a good idea of past or future activities at a site and thus did not complete survey questions on these types of units. At landfill facilities with active landfill units, there were a total of 3,152 closed and 3,847 planned landfill units:

Table 6.2 Reported numbers of landfill units

Landfill unit type	Total number in population	Average number per landfill facility
Active landfill units	6,585	1.09
Reported closed landfill units	3,152	.52
Reported planned landfill units	3,847	.64
TOTAL	13,564	2.25

7. QUANTITIES OF WASTE

7.1 Annual Quantity of Waste Received

An estimated 208.8 million tons of waste is received annually by active Municipal Landfill facilities in the United States and Territories (as of November, 1986). Table 7.1 shows this result and presents the estimated standard error of the estimate along with the corresponding 95 percent confidence interval.

Table 7.1 Total annual quantity of waste received

	Total amount (millions of tons)	Standard error	95% Confidence interval
TOTAL	208.8	12.6	184.1 - 233.6

The distribution of the annual quantity of waste across facilities is also of interest. The majority of facilities receive small quantities of waste and relatively few facilities receive very large quantities of waste. The average annual quantity of waste received by a facility is estimated to be 34.6 thousand tons per year. But 83.7 percent of all facilities are estimated to receive less than this average amount. The "typical" site is perhaps better represented by the median amount of waste received annually which was 2,830 tons per year.

Table 7.2 gives the distribution of the average annual quantity of waste received by a facility. The first column gives ranges of amounts of waste received annually by a facility. The second and third columns list the numbers and percentages of facilities estimated to fall in the range. The fourth column gives the estimated percentage of waste accounted for by all facilities in that range. Based on the sample, we estimate that the largest 21 of the 6,034 facilities in the population received 23.2 percent of all municipal waste, and the largest 491 facilities received 73.6 percent of all municipal waste.

Table 7.2 Distribution of the average annual quantity of waste received

Amount of waste per facility (tons)		Number of facilities in population	Percentage of facilities	Percentage of waste
1-	10	65	1.1%	.0%
10-	100	597	9.9	.0
100-	1,000	1,514	25.1	.3
1,000-	10,000	1,994	33.0	4.3
10,000-	100,000	1,373	22.8	21.8
100,000-	1,000,000	470	7.8	50.4
1,000,000-	10,000,000	21	.3	23.2
TOTAL		6,034	100.0%	100.0%

7.2 Categories Of Waste Received

Table 7.3 gives the total annual quantity of waste broken down by waste category. Active municipal landfills are estimated to receive 113.86 million tons of household waste annually. (Note that the figures in Table 7.3 do not estimate all waste generated in each category since not all waste is disposed of in landfills, and not all landfills that receive such waste are classified as municipal landfills.)

By definition, household and commercial waste comprised at least 50 percent of the total waste received by each Municipal Landfill facility. From Table 7.3, household and commercial waste accounts for about 82 percent of the total waste received. If, on the other hand, we average the percentages reported by facilities, we find that household and commercial waste comprises about 89 percent of incoming waste for the typical facility. This second percentage, 89 percent, is different because it is not weighted by the total amount received. Apparently, small facilities tend to receive higher proportions of household and commercial waste than do large facilities.

Table 7.3 Total annual quantity of waste received by category

Category of waste	Total amount (million tons)	Standard error	95% Confidence interval
Household wastes	113.86	.84	112.22 - 115.50
Commercial wastes	58.17	.44	57.30 - 59.04
Construction/demolition wastes	18.18	1.47	15.30 - 21.06
Industrial process wastes	8.87	.78	7.35 - 10.39
Sewage sludges	4.42	1.74	1.02 - 7.83
Other wastes	2.39	.35	1.71 - 3.07
Asbestos-containing materials	1.26	.39	.50 - 2.03
Non-municipal incinerator ash	.94	.34	.28 - 1.60
Municipal incinerator ash	.51	.15	.22 - .81
Small quant. gen. hazard. wastes	.15	.04	.07 - .24
Infectious wastes	.07	.02	.04 - .11
TOTAL	208.82	12.63	184.06 - 233.56

7.3 Capacity of Landfill Facilities

The estimates of used, remaining and total design capacities as measured in cubic yards are shown in Table 7.4. Of the reported 15,980 million cubic yards total capacity, 9,503 million cubic yards or 59 percent is still remaining. However, this percentage is hard to interpret because it is likely that there is additional capacity in closed units that were not reported. Furthermore, the capacity of potential future units may have been underreported because not all such units were reported as "planned". Many facilities will plan a new unit, thus increasing capacity, only when it becomes apparent that more capacity is needed.

Table 7.4 Total capacity of all municipal landfills facilities

Capacity status	Total capacity (million cubic yards)	Standard error	95% Confidence interval
Already used (reported)	6,477	607	5,287 - 7,667
Remaining (currently planned)	9,503	654	8,220 - 10,786
TOTAL	15,980	1,080	13,864 - 18,096

The distribution of capacity across facilities is also of interest. Table 7.5 gives average and median capacities for individual landfills. As with quantity of waste received, the distribution of capacity is highly skewed. This is evidenced by the fact that the average value is much larger than the median value.

Table 7.5 Average capacity of a municipal landfill facility

Capacity status	Average capacity (million cubic yards)	Median capacity (million cubic yards)
Already used (reported)	1.08	.14
Remaining (currently planned)	1.57	.16
TOTAL	2.65	.39

The above statistics on capacity were taken from responses to Questions 2.10 and 2.11 which asked for the total design capacity and total remaining design capacity of the landfill facility in units of cubic yards. Another measure of capacity is in terms of estimated remaining years of operation which takes into account factors such as remaining capacity, projected amounts of waste to be received in future years, and early closings because of legal or economic considerations. Question 1.11 asked for the year in which the facility was expected to be completely filled. The average remaining life and median remaining life are estimated to be 21.3 and 12.4 years, respectively.

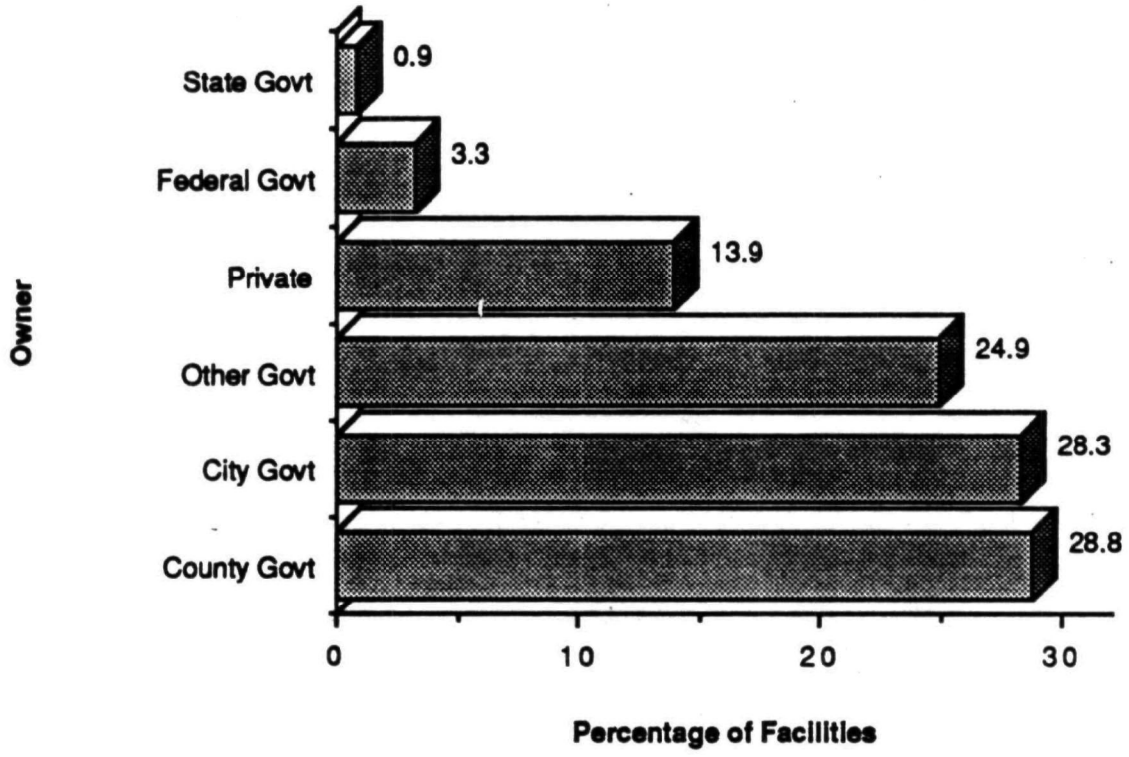
8. FACILITY CHARACTERISTICS

8.1 Ownership, Permitting and Age

An estimated 86.1 percent of the Municipal Landfill Facilities are owned by government entities leaving only 13.9 percent privately owned. Figure 8.1 shows the distribution of landfill ownership.

Figure 8.1

Distribution of Landfill Ownership



An estimated 91.2 percent of Municpal Landfill facilities have permits. Most of the permitting was done by state governments. Engineering plans were reviewed for about 78 percent of the permitted facilities. The average age of a facility is estimated to be 18.6 years.

8.2 Proximity to Residences and Drinking Water Sources

The mean distance from the property line to the nearest residence is 2,686 feet. The median distance is 1,310 feet.

Questions were asked concerning the proximity of water sources to the landfill facility. Table 8.1 summarizes some of the key results: 41.7 percent of all facilities are estimated to be located within one mile of private wells; 6.3 percent within one mile of public wells; .36 percent within one mile of a river or stream; and .6 percent within one mile of a lake or reservoir. Table 8.2 gives estimates of the numbers of persons to drinking from such water sources.

Table 8.1 Percentages of landfill facilities within one mile of drinking water sources

Water source type	Percentage of facilities within one mile
Private wells	41.7%
Public wells	6.3%
River/streams	3.6%
Lake/reservoirs	1.3%

Table 8.2 Total number of persons in the population drinking from water sources within one mile of a landfill facility

Water source type	Total number of persons (thousands)	Standard error	95% Confidence interval
Private wells	67	13	42 - 92
Public wells	666	357	104 - 1,365
River/streams	852	341	423 - 1,521
Lake/reservoirs	424	203	177 - 822

Some respondents may have had problems determining the number of wells, lakes or reservoirs within one mile of their facility, whether they are used for drinking water, and estimating how many persons use these water sources for drinking water. Moreover, the problem is especially difficult for rivers and streams since the intake point may be hundreds of miles away. When clarifications were sought by respondents, they were instructed to include a river or stream as a drinking water source only if the intake point was within five miles of the landfill facility. Because of the difficulties in answering these questions and possible variablity in the assumptions made by respondents when answering this question about rivers and streams, these results should be interpreted with caution.

8.3 Hydrogeology

Hydrogeological questions were concerned with the flow of water through the facility and the geology of the area. Table 8.3 lists percentages of facilities with certain hydogeological location characteristics.

Among specific types of soils, the most common type mentioned was clay followed by sandy clay, sand, clayee soil and silt. Table 8.4 gives the estimated percentages of facilities that have various soil types. Each facility was asked to list the single most predominant (primary) soil type and all other (secondary) soil types that occurred between bedrock and the bottom of the landfilled waste. Figure 8.2 presents these results graphically.

Table 8.3 Percentages of facilities with certain location characteristics

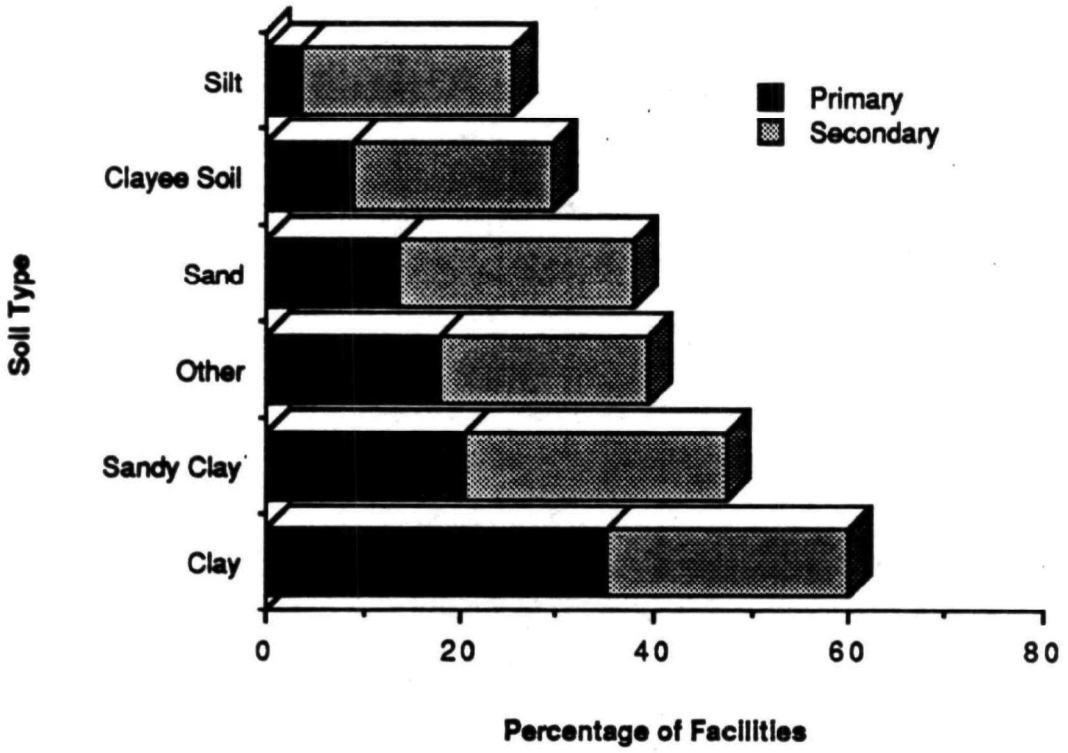
Location characteristic	Percentage of facilities
Located in a 100-year floodplain	12.8%
Located in an area designated as a wetland	5.6
Located in karst terrain	3.8
Not located completely above the seasonal high water table	7.3

Table 8.4 Soil types between bedrock and the bottom of landfilled wastes

Soil type	Percentage of time listed as:		
	Primary	Secondary	Total
Clay	35.1%	24.9%	60.0%
Sandy clay	20.7	26.9	47.6
Sand	13.8	24.2	38.0
Clayee soil	9.1	20.6	29.7
Silt	3.6	21.8	25.4
Other	17.8	21.7	39.5
TOTAL	100.0%	(Multiple responses allowed)	

Figure 8.2

Soil Types Between Bedrock and the Bottom of Landfilled Wastes



8.4 Monitoring

Table 8.5 summarizes the percentages of facilities that monitored ground water, surface water, air and gas. The most common type of monitoring is the monitoring of ground water with an estimated 35.8 percent of facilities conducting this type of monitoring. Next came the monitoring of surface water (15.3% of facilities), gas (6.7% of facilities) and air (2.7% of facilities).

Table 8.5 Percentages of facilities that monitor water, gas and air

Type of monitoring	Percentage of facilities
Ground Water	35.8%
Surface Water	15.3
Gas	6.7
Air	2.7

A number of questions were directed at the frequency of ground-water monitoring. Table 8.6 summarizes the results. Among facilities that reported conducting ground-water monitoring, there were a average of 2.1 ungradient and 3.8 downgradient wells. Well were sampled about three times per year with about two samples taken for each sampling period. On the average, sampling had been conducted for about five years.

Table 8.6 Number of wells and amount of sampling at facilities that monitor ground water

Characteristic	Upgradient wells	Downgradient wells
Number of wells	2.1	3.8
Sampling periods per year well	3.3	3.2
Samples per well per sampling period	1.9	2.1
Years wells have been sampled	5.0	5.1

9. UNIT CHARACTERISTICS

9.1 Size and Capacity

Table 9.1 summarizes the average surface area and average capacity of closed, active, and planned landfill units. An active landfill unit is estimated to cover an average of 32.5 acres and to have an average capacity of one and a half million cubic yards of waste.

Table 9.1 Average surface area and capacity for closed, active and planned landfill units

Characteristic	Type of landfill unit		
	Closed	Active	Planned
Surface area (acres)	9.1	32.5	18.8
Capacity (million cubic yards)	.4	1.5	1.0

9.2 Liners

Table 9.2 gives estimated percentages of landfill units that were reported to have specific liner types and Table 9.3 gives the estimated thickness for each type. For example, for active sites, we estimate that 27.5 percent of all active landfill units have In-Situ Clay liners with an average thickness of 29.6 feet.

Table 9.2 Liner types for closed, active and planned landfill units

Liner type	Percentage of landfill units with liner type		
	Closed	Active	Planned
In-situ clay	33.8%	27.5%	30.2%
Re-compacted clay	16.8	18.6	20.2
Soil	17.9	20.7	15.4
Synthetic membrane	.4*	1.1	6.4
Asphalt	.1*	.1**	.1
Other	7.6	6.6	8.0
None or unknown	39.0	39.7	34.5

* Estimated standard error of estimate exceeds 25 percent of estimate
** Estimated standard error of estimate exceeds 50 percent of estimate

Table 9.3 Liner thickness by liner type for closed, active and planned landfill units

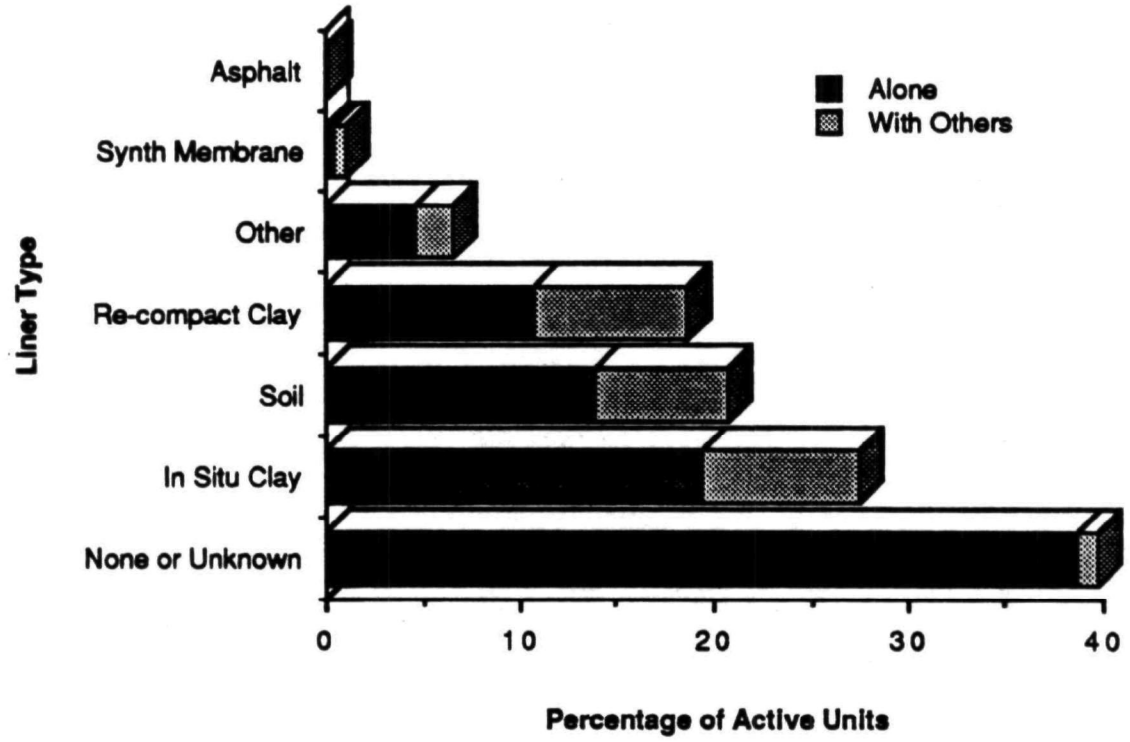
Liner type	Type of landfill unit		
	Closed	Active	Planned
In-situ clay (feet)	17.1	29.6	11.9
Recompacted clay (feet)	2.8	4.0	3.5
Soil (feet)	20.8*	17.5*	24.6*
Synthetic membrane (mils)	20.0*	44.8	52.8
Asphalt (inches)	.1**	7.6**	1.0**
Other (feet)	22.3	25.6*	28.5*

* Estimated standard error of estimate exceeds 25 percent of estimate
** Estimated standard error of estimate exceeds 50 percent of estimate

Figure 9.1 below shows the percentages of active landfill units with specific liner types. The column chart is stacked in order to show separately the percentages where a liner type is reported alone or in combination with other liner type or types. Multiple responses were permitted for liner types.

Figure 9.1

Liner Types for Active Landfill Units:
Alone and in Combination with Other Liner Types



9.3 Final Covers

Table 9.4 gives estimated percentages of landfill units that were reported to have specific final cover types and Table 9.5 gives the estimated thickness for each type. For example, for active sites, we estimate that 49.8 percent of all active landfill units have soil final covers with an average thickness of 2.0 feet.

Table 9.4 Final cover types for closed, active and planned landfill units

Final cover type	Percentage of landfill units with final cover type		
	Closed	Active	Planned
Soil	50.8%	49.8%	49.5%
Sand or gravel	11.7	14.2	10.4
Re-compacted clay	32.3	32.4	32.9
Synthetic membrane	1.4*	1.7	2.5
Topsoil	33.6	37.3	37.3
Other	9.8	5.2	10.2
Unknown	2.8	6.0	4.3

* Estimated standard error of estimate exceeds 25 percent of estimate

Table 9.5 Final cover thickness by final cover type for closed, active and planned landfill units

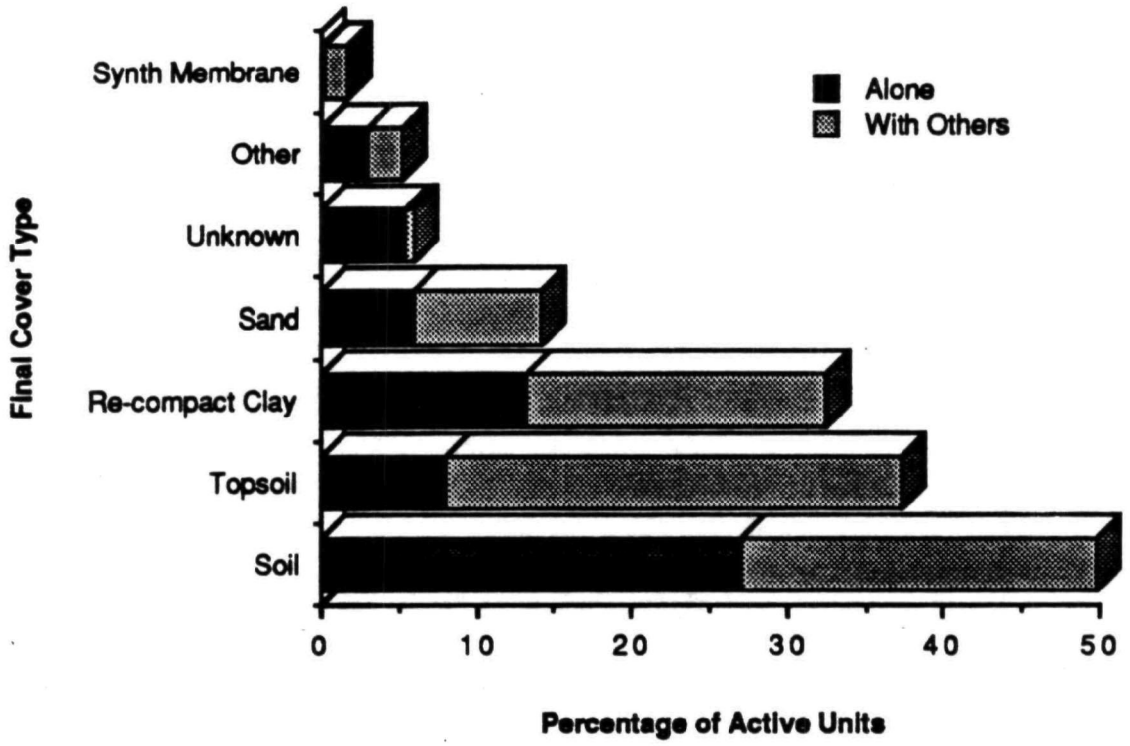
Final cover type	Type of landfill unit		
	Closed	Active	Planned
Soil (feet)	2.0	2.0	2.1
Sand or gravel (feet)	2.0	2.0	2.5
Re-compacted clay (feet)	2.2	2.1	1.8
Synthetic membrane (mils)	34.5	36.2	32.4
Topsoil (feet)	1.3	1.2	1.1
Other (feet)	2.8	2.0	2.6

Figure 9.2 below, analogous to Figure 9.1 for liners, shows the percentages of active landfill units with specific final cover types. The column chart is

stacked in order to show separately the percentages where a final cover type is reported alone or in combination with other liner type or types. Multiple responses were permitted for liner types.

Figure 9.2

Final Cover Types for Active Landfill Units:
Alone and in Combination with Other Final Cover Types



9.4 Leachate Collection

Leachate collection systems were reported for an estimated 7.8 percent of closed, 11.5 percent of active, and 21.2 percent of planned landfill units. These increasing percentages suggest that such systems are becoming more common over time. Table 9.6 shows estimated percentages of landfill units that use, or will use, specific leachate disposal methods. Multiple responses were permitted for a unit.

Table 9.6 Leachate disposal methods for closed, active and planned landfill units

Leachate disposal method	Type of landfill unit		
	Closed	Active	Planned
Recirculate			
Spray on active landfill area	17.2%*	21.0%	30.4%
Injection	4.3**	5.1*	1.9**
Other	4.4**	5.1*	3.2*
Land application, spread. or treatment	4.7**	12.6*	9.1*
Truck to POTW or Sewer	14.5*	21.6	39.5
Discharge through sewer to POTW	18.4*	16.8	16.2
Discharge to surface water	16.0*	13.5*	3.4**
Other or unknown off-site treatment	.4**	2.7**	3.2**
On-site treatment			
Biological	17.5*	14.2*	16.6
Physical/chemical	13.2**	7.0*	7.3*

* Estimated standard error of estimate exceeds 25 percent of estimate
** Estimated standard error of estimate exceeds 50 percent of estimate

APPENDIX A

SUMMARY STATISTICS FOR SELECTED QUESTIONS

Statistics are presented in this appendix in a question and answer format similar to the Solid Waste Landfill Survey Questionnaire (see Appendix A). Some questions have been reworded slightly. Estimates are reported for approximately half of the questions asked in the questionnaire.

Two types of statistics are reported: averages and percents. In most cases averages are for all landfill facilities or units; exceptions are noted or can be gleaned from wording of the question. Percents reported for subparts to a question may not add up to 100 because (1) there was rounding, (2) multiple responses were allowed or (3) the set of respondents varied by subpart.

Stratified estimates were computed for all results presented. All estimates are subject to error. An indication is given of the sampling variability of the estimates. For ***averages***, asterisks following the estimates have the following interpretation:

- * One asterisk indicates that the estimated standard error of the average is greater than 25 percent of the estimate; and
- ** Two asterisks indicate that the estimated standard error of the average is greater than 50 percent of the estimate.

A similar convention is used for *percentages*:

- * One asterisk indicates that the estimated standard error of the percentage is greater than either 25 percent of the estimate or 25 percent of 100 minus the estimate, whichever is less; and
- ** Two asterisks indicate that the estimated standard error of the percentage is greater than either 50 percent of the estimate or 50 percent of 100 minus the estimate, whichever is less.

With one asterisk, a 95 percent confidence interval for an estimate (an average or percentage less than 50 percent) will be at least as wide as an interval ranging from half the estimate to one and a half times the estimate. With two asterisks, the confidence interval will be at least as wide an interval ranging from zero to twice the estimate.

Part 1: Landfill Facility, Owner, and Operator

Q1.5 Which one of the following categories best describes the *landfill facility owner*? (Only one response allowed.)

Percent

3.3	Federal
.9	State
28.8	County
28.3	City
24.9	Other government
13.9	Private

Q1.7 Does this landfill facility have a solid waste *permit or license*?

Percent

91.2	Yes

Q1.8 Who issued the solid waste permit or license? (Multiple responses allowed.)

Percent (computed for facilities that report having a permit or license)

90.9	State Government
10.4	County Government
1.8	City Government
6.1	Other government

Q1.9 Did the authority that issued the permit or license review any engineering plans before issuing the permit or license?

Percent (computed for facilities that report having a permit or license)

78.4	Yes

Q1.10 In what year was waste first placed in any of the landfill units at this landfill facility?

Average

1967	Year

Q1.11 In what year do you expect all active (and planned) landfill units at this facility to be completely filled?

Average

2007 Year

Part 2: Facility Jurisdiction, Size, and Operations

Q2.7 What is the shortest distance from the edge of the *property line* to a residence?

Average

2,686 Feet

Q2.8 What is the shortest distance from the edge of the *landfill unit* to a residence?

Average

3,194 Feet

Q2.9 What is the *total area* of this landfill facility? Include all buildings, buffer areas, lagoons and holding ponds, and roads on the property as well as landfill areas.

Average

86.5 Acres

Q2.10 What is the *total design capacity* of this landfill facility? Include the combined total amount of waste that the active, closed, and planned landfill units will hold. Do not include the volume of cover material in your estimate.

Average

2,648,292 Cubic Yards

Q2.11 What is the *total remaining design capacity* of this landfill facility? Include the *additional* waste volume that all active, unused, and planned landfill units can hold. Total remaining design capacity is the total design capacity (provided in Question 2.10), minus the amount of waste currently in the landfills.

Average

1,574,877 Cubic Yards

Q2.12 Which landfill method(s) does this facility use? (Multiple responses allowed.)

Percent

48.4	Area Fill Method
66.9	Trench or Cell Method
5.5	Other Method

Q2.13 Which waste processing technique(s) does this facility use prior to landfilling? (Multiple responses allowed.)

Percent

2.1	Baling
1.7	Shredding
38.8	Other Technique

Q2.16 What is the ratio of waste to cover material at this landfill facility?

Average

4.4 to 1 Ratio.

Part 3: Hydrogeologic and Water Source Information

Q3.1 Is any part of this landfill facility located in any of the following? (Multiple responses allowed.)

Percent

12.8	a 100-year floodplain.
5.6	an area designated as a wetland
3.8	karst terrain

Q3.2 Identify the single most predominant type of soil between bedrock and the bottom of the landfilled wastes. (Only one response allowed.)

Percent

13.8	Sand
9.1	Clayee Sand
3.6	Silt
20.7	Sandy Clay
35.1	Clay
17.8	Other
100.0	

Q3.3 Identify all other soil types occurring between bedrock and the bottom of the landfilled wastes. (Multiple responses allowed.)

Percent

24.2	Sand
20.6	Clayee Sand
21.8	Silt
26.9	Sandy Clay
24.9	Clay
21.7	Other

Q3.4 Is this landfill facility located completely above the seasonal high water table?

Percent

92.8	Yes

Q3.5 What is the average distance from the bottom of the landfilled wastes to the seasonal high water table?

Average (computed for facilities located above the seasonal high water table)

85.7 Feet

Q3.9 What sources of information did you use to answer hydrogeologic question 3.1 - 3.8 above? (Multiple responses allowed.)

Percent

29.0	Site-Specific Hydrogeologic Study
18.4	General Literature Sources (e.g., County Report)
14.3	State Agency
69.3	No Hydrogeologic Data Available; "Best Estimates" Provided

Q3.10 How many downgradient private and public *drinking water wells* are within one mile of the edge of any landfill unit?

Average

6.99	Private Wells
.14	Public Wells

Also estimate the number of people using drinking water wells within one mile of the edge of any landfill unit.

Average

11.1	People Use Private Wells for Drinking Water
110.3**	People Use Public Wells for Drinking Water

Q3.11 How far away from the edge of any landfill unit are the *closest* downgradient drinking water wells? Give the distance separately for the closest private and public well (if within 1 mile).

Average (computed for facilities that report having such a well)

1,835	Feet to Closest Private Well
2,327	Feet to Closest Public Well

Q3.13 How many downgradient *rivers/streams* and *lakes/reservoirs* that *are used for drinking water* are within one mile of the edge of any landfill unit?

Average

.040	Rivers/Streams
.017*	Lakes/Reservoirs

Also, estimate the number of people who use these sources for drinking water.

Average (computed for facilities that report having these sources)

141.2*	People Who Use Rivers/Streams for Drinking Water
70.3*	People Who Use Lakes/Reservoirs for Drinking Water

Q3.14 How far away from the edge of any landfill unit are the *closest* downgradient river/stream and lake/reservoir that *are used for drinking water*? Give the distance separately for the closest river/stream and lake/reservoir (if within 1 mile).

Average (computed for facilities that report having such a source)

1,936	Feet to Closest River/Stream
3,397	Feet to Closest Lake/Reservoir

Q3.18 What sources of information did you use to answer water source questions 3.10-3.17 above? (Multiple responses allowed.)

Percent	
19.0	Site-Specific Water Source Study
11.1	Local Water Department
72.8	No Water Source Data Available; "Best Estimates" Provided
16.0	Other

Part 4: Waste Characteristics

Q4.1 What is the *average annual quantity of waste* received at this landfill facility?

Average	
34,604	Tons Per Year

Q4.2 Estimate the *average annual percent of the waste* received at this landfill facility in each of the waste categories listed.

Percent	
71.8	Household Wastes
17.3	Commercial Wastes
.1	Small Quantity Generator Hazardous Wastes
.2	Asbestos-Containing Materials
5.9	Construction/Demolition Wastes
2.7	Industrial Process Wastes
.1*	Infectious Wastes
.1*	Municipal Incinerator Ash
.2	Other Incinerator Ash
.5	Sewage Sludges
1.2	Other Wastes

Also, for which categories does this facility refuse to accept waste?

Percent

.1**	Household Wastes
5.5	Commercial Wastes
71.5	Small Quantity Generator Hazardous Wastes
55.9	Asbestos-Containing Materials
15.4	Construction/Demolition Wastes
43.5	Industrial Process Wastes
67.9	Infectious Wastes
53.8	Municipal Incinerator Ash
51.5	Other Incinerator Ash
54.1	Sewage Sludges
2.7	Other Wastes

Q4.3 Of the total amount of *industrial process wastes* received at this landfill facility, estimate the percent received from each of the industrial categories listed below.

Percent (computed for facilities that report receiving industrial process waste)

.4**	Electric Power Generation
3.2*	Fertilizer/Agricultural Chemicals
21.5	Food and Related Products and Byproducts
1.7*	Inorganic Chemicals
5.9*	Iron and Steel Manufacturing
2.6**	Leather and Leather Products
4.2*	Non-Ferrous Metals Manufacturing/Foundries
.3*	Organic Chemicals
.2*	Petroleum Refining Industry
8.9*	Plastics and Resins Manufacturing
9.3	Pulp and Paper Industry
7.5	Rubber and Misc. Plastic Products
9.4	Stone, Glass, Clay, and Concrete Products
14.4	Textile Manufacturing
.7*	Transportation Equipment
.8*	Water Treatment
9.1	Other

Also, for which categories does this facility refuse to accept waste?

Percent (computed for facilities that report receiving industrial process waste)

27.8	Electric Power Generation
32.8	Fertilizer/Agricultural Chemicals
7.1*	Food and Related Products and Byproducts
32.0	Inorganic Chemicals
16.7	Iron and Steel Manufacturing
15.9	Leather and Leather Products
16.3	Non-Ferrous Metals Manufacturing/Foundries
32.9	Organic Chemicals
30.0	Petroleum Refining Industry
16.9	Plastics and Resins Manufacturing
18.4	Pulp and Paper Industry
14.1	Rubber and Misc. Plastic Products
10.4*	Stone, Glass, Clay, and Concrete Products
15.9	Textile Manufacturing
22.5	Transportation Equipment
24.2	Water Treatment
.9**	Other

Q4.4 What percent of the total facility wastes received by this landfill facility are bulk liquids and drummed/containerized wastes?

Percent

.14	Bulk Liquids (not containerized)
.05*	Drummed/Containerized Liquids
.09*	Drummed/Containerized Other Waste Forms

Also, for which categories does this facility refuse to accept waste?

Percent

65.7	Bulk Liquids (not containerized)
65.8	Drummed/Containerized Liquids
62.5	Drummed/Containerized Other Waste Forms

Q4.7 Does this landfill facility have *separate disposal or management areas* for specific wastes?

Percent (computed for facilities that report having a liner of the given type)

46.0	Yes

Q4.8 Does this landfill facility have a *separate disposal or management area for asbestos*?

Percent

6.9 Yes

Part 5 Individual Landfill Unit Information

Q5.1 How many closed, active, and planned landfill units are there at this facility?

Average

.52 Number Closed
1.09 Number Active
.64 Number Planned

Closed Landfill Units

QC3. What is the *total area* of the landfill unit?

Average

9.1 Acres

QC4. What is the *total volume* of the landfill unit?

Average

358,070 Cubic Yards

QC9. What *types of liners* are used? (Multiple responses allowed.)

Percent

33.8 In-Situ Clay
16.8 Re-compacted Clay
17.9 Soil
.4* Synthetic Membrane
.1* Asphalt
7.6 Other
39.0 None or Unknown

QC10. What is the *layer thickness* for each type of liner used?

Average

17.1	Feet, In-Situ Clay
2.8	Feet, Re-compacted Clay
20.0*	Feet, Soil
20.0*	Mils, Synthetic Membrane
1.0**	Inches, Asphalt
22.3	Feet, Other

QC13. What *types of final cover* are used? (Multiple responses allowed.)

Percent

50.8	Soil Layer
11.7	Sand or Gravel Layer
32.3	Re-compacted Clay Layer
1.4*	Synthetic Membrane
33.6	Topsoil Layer
9.8	Other
2.8	Unknown

QC14. What is the *layer thickness* for each type of cover used?

Average

2.0	Feet, Soil Layer
2.0	Feet, Sand or Gravel Layer
2.2	Feet, Re-compacted Clay Layer
34.5	Mils, Synthetic Membrane
1.3	Feet, Topsoil Layer
2.8	Feet, Other

QC17. Does this landfill unit have a *leachate collection system*?

Percent

7.8	Yes

QC20. What is done with any leachate collected in this landfill unit? (Multiple responses allowed.)

Percent

17.2*	Recirculate - Spray on active landfill area
4.3**	Recirculate - Injection
4.4**	Recirculate - Other
4.7**	Land Application, Spreading or Treatment
14.5*	Truck to POTW or Sewer
18.4*	Discharge through Sewer to POTW
16.0*	Discharge to Surface Water
.4**	Other or Unknown Off-site Treatment
17.5*	On-site Treatment - Biological
13.2**	On-site Treatment - Physical/Chemical

Active Landfill Units

QA3. What is the *total area* of the landfill unit?

Average

32.5	Acres

QA4. What is the *total volume* of the landfill unit?

Average

1,528,274	Cubic Yards

QA10. What *types of liners* are used? (Multiple responses allowed.)

Percent

27.5	In-Situ Clay
18.6	Re-compacted Clay
20.7	Soil
1.1	Synthetic Membrane
.1**	Asphalt
6.6	Other
39.7	None or Unknown

QA11. What is the *layer thickness* for each type of liner used?

Average

29.6	Feet, In-Situ Clay
4.0	Feet, Re-compacted Clay
17.5*	Feet, Soil
44.8	Mils, Synthetic Membrane
7.6**	Inches, Asphalt
25.6*	Feet, Other

QA14. What *types of final cover* are planned? (Multiple responses allowed.)

Percent

49.9	Soil Layer
14.2	Sand or Gravel Layer
32.5	Re-compacted Clay Layer
1.7	Synthetic Membrane
37.3	Topsoil Layer
5.2	Other
6.0	Unknown

QA15. What will be the *layer thickness* for each type of cover planned?

Average

2.0	Feet, Soil Layer
2.0	Feet, Sand or Gravel Layer
2.1	Feet, Re-compacted Clay Layer
36.2	Mils, Synthetic Membrane
1.2	Feet, Topsoil Layer
2.0	Feet, Other

QA18. Does this landfill unit have a *leachate collection system*?

Percent

11.5	Yes

QA21. What is done with any leachate collected in this landfill unit? (Multiple responses allowed.)

Percent	
21.0	Recirculate - Spray on active landfill area
5.1*	Recirculate - Injection
5.1*	Recirculate - Other
12.6*	Land Application, Spreading or Treatment
21.6	Truck to POTW or Sewer
16.8*	Discharge through Sewer to POTW
13.5*	Discharge to Surface Water
2.7**	Other or Unknown Off-site Treatment
14.2*	On-site Treatment - Biological
7.0*	On-site Treatment - Physical/Chemical

Planned Landfill Units

QP3. What is the *total area* of the landfill unit?

Average	
18.8	Acres

QP4. What is the planned *total volume* of the landfill unit?

Average	
1,026,630	Cubic Yards

QP6. What *types of liners* are planned? (Multiple responses allowed.)

Percent	
30.2	In-Situ Clay
20.2	Re-compacted Clay
15.4	Soil
6.4	Synthetic Membrane
.1	Asphalt
8.0	Other
34.5	None or Unknown

QP7. What will be the *layer thickness* for each type of liner planned?

Average

11.9	Feet, In-Situ Clay
3.5	Feet, Re-compacted Clay
24.6*	Feet, Soil
52.8	Mils, Synthetic Membrane
1.0**	Inches, Asphalt
28.5*	Inches, Other

QP10. What *types of final cover* are planned? (Multiple responses allowed.)

Percent

49.5	Soil Layer
10.4	Sand or Gravel Layer
32.9	Re-compacted Clay Layer
2.5	Synthetic Membrane
37.3	Topsoil Layer
10.2	Other
4.3	Unknown

QP11. What will be the *layer thickness* for each type of cover planned?

Average

2.1	Feet, Soil Layer
2.5	Feet, Sand or Gravel Layer
1.8	Feet, Re-compacted Clay Layer
32.4	Mils, Synthetic Membrane
1.1	Feet, Topsoil Layer
2.6	Feet, Other

QP14. Will this landfill unit have a *leachate collection system*?

Percent

21.2	Yes

QP17. What will be done with any leachate collected in this landfill unit? (Multiple responses allowed.)

Percent

30.4	Recirculate - Spray on active landfill area
1.9**	Recirculate - Injection
3.2**	Recirculate - Other
9.1*	Land Application, Spreading or Treatment
39.5	Truck to POTW or Sewer
16.2	Discharge through Sewer to POTW
3.4**	Discharge to Surface Water
3.2**	Other or Unknown Off-site Treatment
16.6	On-site Treatment - Biological
7.3*	On-site Treatment - Physical/Chemical

Part 6: Monitoring Systems

Q6.1 Does all or part of this landfill facility have any of the following, either completed or under construction? (Multiple responses allowed.)

Percent

6.7	A Landfill Gas Monitoring or Detection System
2.1	A Landfill Gas Recovery System

Q6.3 Is the ground water monitored at this landfill facility?

Percent

35.8	Yes

Q6.4 How is the ground water is monitored at this landfill facility? (Multiple responses allowed.)

Percent (computed for facilities that monitor ground water)

39.1	Individual Landfill Units Have Monitoring Wells
83.0	Overall Facility Has a Monitoring System

Q6.6 Describe the *upgradient ground-water monitoring wells* at this landfill facility.

Average (computed for facilities that monitor ground water)

2.1	Number of wells
63.2	Feet, depth of wells from ground surface
3.3	Number of times wells are sampled per year
1.9	Number of samples per well per sampling period
5.0	Years, longest time any of these wells have been sampled?

Describe the *downgradient ground-water monitoring wells* at this landfill facility.

Average (computed for facilities that monitor ground water)

3.8	Number of wells
54.2	Feet, depth of wells from ground surface
3.3	Number of times wells are sampled per year
2.1	Number of samples per well per sampling period
5.1	Years, longest time any of these wells have been sampled?

Q6.7 Has this landfill facility ever been found to be a *source of ground-water contamination* by any government authority?

Percent

2.1 Yes

Q6.9 Does this landfill facility *monitor air emissions*?

Percent

2.7 Yes

Q6.10 Does this landfill facility *monitor surface water*?

Percent

15.3 Yes

Q6.11 How many *times per year* is *surface water sampled* at this facility?

Average (for facilities that monitor surface water)

3.5 Times per year

Part 7: Landfill Operating Costs and Revenues

Q7.2 What is the approximate *total annual operating cost* of this landfill facility?

Average

$270,030 Per year
$51.70 Per ton

Q7.5 What is the average *tipping fee* per ton of waste disposed at this landfill facility for each of the categories below?

Average (computed for facilities that reported a tipping fee by the ton, cubic yard, or no fee at all)

$1.77 Per Ton, for Commercial and Residential Wastes
.39 Per Ton, for Sewage Sludges
.22 Per Ton, for Municipal and Other Incinerator Ash
1.56 Per Ton, for Non-hazardous Industrial Process Waste

Average (computed only for facilities that reported a tipping fee by the carload)

$7.48 Per Carload or Truckload, for Commercial and Residential Wastes