United States
Environmental Protection
Agency

Office of Solid Waste
and Emergency Response
Washington, DC 20460

EPA/530-SW-86-054
October 1986

Solid Waste

EPA

Subtitle D Study
Phase I Report

DISCLAIMER

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ACKNOWLEDGEMENT

This report was prepared by a team of individuals from several organizations. The EPA Office of Solid Waste, Special Wastes Branch directed Alliance Technologies Corporation (formerly GCA Technology Division, Inc.) in organizing and managing the report preparation. Those who contributed to the report include:

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EXECUTIVE SUMMARY

The Hazardous and Solid Waste Amendments (HSWA) of 1984 require EPA to conduct a study of the adequacy of Subtitle D Criteria to protect human health and the environment from ground water contamination and to recommend whether additional authorities are needed to enforce them. This report presents the results of data collection for the first phase of that study, and identifies key areas to be addressed in Phase II data collection efforts.

BACKGROUND

Subtitle D of the Resource Conservation and Recovery Act (RCRA) established a cooperative framework for Federal, State, and local governments to control the management of solid waste. As part of this framework, EPA developed Criteria that set minimum performance standards for all solid waste disposal facilities. These "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (40 CFR Part 257), were promulgated by EPA in 1979. They consist of eight environmental performance standards for solid waste management.

These Criteria are implemented and enforced by State and local governments or through citizen suits. Prior to 1981, EPA provided financial assistance to the States to implement the Criteria. That assistance ceased in 1981 and, since that time, States have managed the Subtitle D programs without Federal financial assistance. The scope and status of State programs are quite variable, as described in Section 5.

The Hazardous and Solid Waste Amendments of 1984 direct the EPA to revise the Criteria for facilities that may receive household hazardous waste (HHW) or hazardous waste from small quantity generators (SQG). The HSWA specify that the Criteria "shall be those necessary to protect human health and the environment," and at a minimum "should require ground water monitoring as necessary to detect contamination, establish criteria for the acceptable location of new or existing facilities, and provide for corrective action as appropriate." The statute further states that the EPA may consider the "practicable capability" of facilities and that the revised Criteria must be promulgated by March 31, 1988.

The HSWA also directed the EPA to conduct a study to determine whether the current Criteria are adequate to protect human health and the environment. This Subtitle D study is being conducted in two phases: Phase I involves collection of existing data; and Phase II includes additional data collection efforts. Results of the Subtitle D study are to be submitted in a report to Congress by November 1987.

PHASE I PROJECTS

The EPA identified three categories for data collection in the Subtitle D study:

- Subtitle D waste characterization
- Subtitle D facility characterization
- State Subtitle D program characterization

During Phase I, EPA undertook numerous projects to collect readily available information in these three categories. The key projects are described in Table ES-1 and described in further detail in Section 2. The projects cited in this table include the Subtitle D Census,[1] the State regulation reviews,[2] the municipal solid waste (MSW) characterization study,[3] the industrial nonhazardous waste study,[4] the HHW study,[5] and the SQG survey.[6] The Census results are limited by inaccuracies and response errors, but they present previously unavailable data. Most of the other studies are reviews, compilations, or analyses of previously available data.

SUBTITLE D WASTE

Subtitle D wastes are all solid wastes regulated under the RCRA not subject to hazardous waste regulations under Subtitle C. These wastes are defined in 40 CFR Part 257 (see Appendix A).

The Phase I data collection efforts gathered readily available existing information on characteristics, generation volumes, and management of the following Subtitle D wastes:

- Municipal solid waste
- Household hazardous waste (HHW)
- Industrial waste
- Small quantity generator hazardous waste (SQG)

Less extensive reviews were performed for municipal sludge, municipal waste combustion ash, construction and demolition waste, agricultural waste, oil and gas waste, and mining waste. Phase I data for these waste categories are summarized in Table ES-2 and addressed further below.

Municipal Solid Waste

Municipal solid waste is generated from residential, institutional, and commercial sources. The MSW characterization study[3] determined that, as a national annual average, over 50 percent of MSW is composed of paper and

TABLE ES-1. PHASE I DATA COLLECTION PROJECTS

1. Subtitle D Waste Characterization Studies

   a. Source, Availability and Review of RCRA Subtitle D Land Disposal Data Published Since 1980

      - Reviews and abstracts of recent literature relevant to the Subtitle D study.

   b. Characterization of Municipal Solid Waste in the United States, 1960 to 2000

      - Inventory and forecast of municipal solid wastes in the U.S.

   c. Summary of Data on Industrial Nonhazardous Waste Disposal Practices

      - Summary of non-state data on solid waste characteristics and solid land disposal practices.

   d. A Survey of Household Hazardous Wastes and Related Collection Programs

      - Review of existing data on the characteristics of HHW and analysis of HHW collection programs.

   e. National Small Quantity Generator Survey

      - Survey to characterize SQG waste volumes and disposal practices.

   f. Hazardous Waste Generator Data and Characteristics of Sanitary Landfills in Selected Counties in Florida.

      - Case history of Florida disposal of small quantity generator hazardous wastes.

2. Subtitle D Facility Characterization Studies (in addition to studies noted above)

   a. Census of State and Territorial Subtitle D Nonhazardous Waste Programs

      - Mail survey of data on State Subtitle D programs and Subtitle D facilities.

   b. Critical Review and Summary of Leachate and Gas Production from Landfills.

      - Summary and evaluation of data on quality of leachate from municipal landfills.

   c. Evaluation of a Landfill with Leachate Recycle.

      - Case study of the Lycoming County, PA landfill with a major emphasis on experiences with leachate recirculation.

   d. Gas Characterization, Microbiological Analysis and Disposal of Refuse in GRI Landfill Simulators.

      - GC/MS analysis of landfill gas samples from the Center Hill lysimeters.

   e. Landfill Gas Update: Summaries of Technical Reports.

      - Summaries of six studies relating to landfill gas production, characteristics and recovery.

   f. Evaluation of NPL/Subtitle D Landfill Data

      - Summary of data on former Subtitle D facilities that are now on the NPL or are candidates for the NPL.

   g. Municipal Landfill Case Studies

      - Preliminary studies of facility characteristics and environmental impacts at 127 municipal waste landfills.

   State Subtitle D Program Studies (in addition to studies noted above)

   a. State Subtitle D Regulations on Municipal Waste Landfills, Surface Impoundments and Land Application Units.

      - Review of State Subtitle D regulations.

   b. National Solid Waste Survey

      - Mail survey of data on State Subtitle D programs.

TABLE ES-2. CHARACTERISTICS, QUANTITIES, AND MANAGEMENT PRACTICES OF SUBTITLE D WASTES

	Waste	Major characteristics	Annual quantities	Management practice
1.	Municipal Solid	37% Paper and paperboard 18% Yard waste 10% Glass 10% Metals 8% Food waste 7% Plastics 10% Others	133 million tons[3]	Landfill (94.7 wt. percent)[3] Ocean disposal, incineration recycle, and other (5.3 wt. percent)
2.	Household Hazardous	Drain openers, cleaners/strippers, oil and fuel additives, solvents, refrigerants, adhesives, pesticides	10^{-5} to 10^{-3} times the weight of MSW[15,16]	Disposed with MSW (mostly landfilled)
3.	Municipal Sludge	Water and wastewater treatment sludges. Constituents are highly variable and often contain cadmium, copper and zinc	wastewater-8.4 million tons (dry basis)[19]	Landfill Surface impoundment Land application units Ocean disposal Incineration
4.	Municipal Waste Combustion Ash	Possibly high metals	2.3 million tons[3]	Landfill at Subtitle C or Subtitle D facilities
5.	Industrial Nonhazardous	93% from 7 industries; wastes vary with industry segment	430 million tons (dry basis)[4]	35 percent of nonhazardous wastes are managed onsite at landfills, surface impoundments or LAUs.[4]
6.	Small Quantity Generator	62% Used lead-acid batteries 18% Spent solvents 5% acids and alkalies	660,000 tons[6]	5,075 landfills[1] 20,909 surface impoundments[1] 1,647 land application units[1]
7.	Construction/Demolition	Lumber, roofing, and sheeting scraps, broken concrete, asphalt, brick, stone, wallboard, glass, other	31 million tons in LFs[20]	2,555 landfills[1] No data on other management practices
8.	Agricultural	Nitrates, pesticides herbicides, fertilizers	unknown	17,159[1] - 19,167[21] surface impoundments. No data on other management practices.
9.	Oil and Gas	Brine and drilling mud which may contain chloride, barium, sodium, and calcium	unknown	125,074[1] surface impoundments. No data on other management practices.
10.	Mining	Bituminous coal and lignite which may contain metals, sulfate, sodium, potassium- and cyanide(82% of impoundments)[21] Anthracite (2% of impoundments)[21] Metals (7% of impoundments)[21] Nonmetals (9% of impoundments)[21]	1.4 billion tons[25]	19,813[1] - 24,376[21] surface impoundments.

Note: Superscripts refer to references at the end of this section.

paperboard and yard wastes; almost 40 percent is metals, food wastes, and plastics; and the remaining 10 percent is wood, rubber and leather, textile, and miscellaneous inorganics. Municipal solid waste composition is highly site dependent, and is significantly influenced by climate, season, and socioeconomic characteristics.

The MSW characterization study concluded that approximately 133 million tons of municipal solid waste were generated in 1984. This volume is expected to grow to 159 million tons by the year 2000.

The management choices for MSW are landfilling, ocean disposal, and incineration with or without energy recovery. According to the MSW characterization study estimates, approximately 6.5 million tons of MSW were used for energy recovery in 1984 and most of the remaining 126.5 million tons of MSW were landfilled.

Household Hazardous Waste

Household hazardous waste is a small subset of MSW. Common household products known to contain concentrations of hazardous materials include drain openers, oven cleaners, wood and metal polishes and cleaners, automotive oil and fuel additives, grease and rust solvents, carburetor and fuel injection cleaners, air conditioning refrigerants, starter fluids, paint thinners, paint removers, adhesives, herbicides, pesticides, fungicides, and wood preservatives.[5]

The available data[15,16] suggest that HHW may constitute between 0.001 and 1 percent of all MSW. No data were available on HHW disposal practices, however, these practices are believed to include codisposal with MSW (primarily in landfills) and direct disposal of liquid HHW into sewers.

Municipal Sludge

Sludge from water and wastewater treatment consists of a variety of organic and inorganic materials. Independent sources[17,18] have estimated that water treatment filter cake generation is between 0.005 and 0.2 pounds per capita per day. This equates to about 207 kilotons to 8,267 kilotons per year. Extensive data on sewage sludge composition and quantities are available from the EPA Office of Water Regulations and Standards (OWRS). The OWRS database of 15,300 POTWs indicates that 8.4 million dry tons of municipal sewage sludge are generated each year.[19]

According to the OWRS database, municipal sewage sludges are managed in a variety of ways, including surface impoundments and landfills (46.4 percent including 1.5 percent in monofills), land application (25.4 percent), incineration (20.3 percent) and ocean disposal (6.6 percent).[19] Data on water treatment sludge management practices are not available.

Municipal Waste Combustion Ash

Combustion of MSW may produce ash of highly variable composition. These ash materials are generated by a variety of facilities ranging from large resource recovery plants to small town or institutional facilities. Analyses of fly ash and bottom ash from municipal waste incinerators have revealed residues with high metal content. Little data on municipal waste combustion ash composition are available.

Assuming an average residue weight of 30 percent of municipal solid waste, about 2.3 million tons are generated each year by waste-to-energy facilities in the United States. Current data indicate that some disposal of ash products is in landfills.[3] However, no data are available on the types of landfills (e.g., monofills, Subtitle D or C) used for disposal or other management practices employed.

Industrial Waste

The industrial nonhazardous waste study[4] yielded estimates of the waste generation rates of the 22 industries believed to generate the majority of the Subtitle D industrial waste. This study revealed that 390 million metric tons of industrial nonhazardous waste are generated annually.

The Subtitle D Census[1] indicates 3,511 landfills, 16,232 surface impoundments, and 5,605 land application units were classified by the State program offices as industrial nonhazardous waste facilities in 1984. The industrial nonhazardous waste study indicated that 12 industries cumulatively generate over 99 percent of the industrial Subtitle D wastes. That study reported that 35 percent of industrial nonhazardous wastes are managed in onsite landfills, surface impoundments, and land application units, and that 75 percent of these wastes are generated by four industries (iron and steel, electric power generation, industrial inorganic chemicals, and plastics and resins).

Small Quantity Generator Hazardous Waste

The National Small Quantity Hazardous Waste Generator Survey[6] indicated that the majority of the total SQG wastes consist of used lead-acid batteries (62 percent) and spent solvents (18 percent) and that 72 percent of SQG wastes are generated from the vehicle maintenance industry. The SQG Survey estimated that SQGs generate 940,000 metric tons of hazardous waste annually. According to Survey estimates, SQG wastes are managed on the site by: recycling (65 percent); discharge to public sewers (8 percent); solid waste facilities (5 percent); Subtitle C facilities (4 percent); and unknown methods (11 percent). The sum of these percentages exceeds 100 because some facilities treat wastes on site, and then dispose of residuals off site. Section 5 presents these data by waste type and industry.

Small quantity generator waste management data were also obtained from the Subtitle D Census,[1] which showed that SQG wastes are managed in 5,075 landfills, 20,909 surface impoundments, and 1,647 land application units. The Census did not identify the quantities managed in these facility categories.

Construction and Demolition Debris

Construction and demolition activities generate large quantities of lumber, roofing and sheeting scraps, broken concrete, asphalt, brick, stone, wallboard, glass, and other materials.[20] The generation rates of these waste materials are highly variable and depend primarily upon geographic location and community age and size. It was estimated in 1970 that urban areas generated an average of 0.72 pounds per capita per day of debris.[20] Other reports[22,23] for independent locations indicate generation rates of between 0.12 and 3.52 pounds per capita per day. Assuming 0.72 pounds per day is accurate, there are 31.5 million tons generated annually.[20] The Subtitle D Census identified 2,591 active demolition debris landfills in 1984.

Agricultural Waste

Agricultural wastes include animal wastes from feedlots and farms, crop production wastes, and collected irrigation field runoff. These wastes are known to have high concentrations of nitrates, pesticides, herbicides, and fertilizers.[24]

The Subtitle D Census[1] and the National Surface Impoundment Assessment[21] provided estimates of numbers of active agricultural waste surface impoundments. The Census reported a total of 17,159 impoundments, and the Assessment reported 19,167 impoundments.

Oil and Gas Waste

Oil and gas wastes consist of brines and drilling muds that are known to have high concentrations of chloride, total dissolved solids, barium, sodium and calcium.[24] The Subtitle D Census report estimated that there are 125,074 oil and gas surface impoundments.

Mining Waste

Mining wastes are the products of crushing, screening, washing, and flotation activities. Such activities can generate high concentrations of heavy metals, sulfate, sodium, potassium, and cyanide.[24] A recent report to Congress on mining wastes[25] estimated that over 1.4 billion tons of nonhazardous mining waste is generated annually.

According to the National Surface Impoundment Assessment,[21] there are 24,376 mining waste surface impoundments. Almost 82 percent of these are associated with bituminous coal and lignite mining. Nonmetal (9 percent), metal (7 percent) and anthracite mining (2 percent) account for the remaining impoundments. The Subtitle D Census[1] identified 19,813 mining waste impoundments.

FACILITIES ASSESSMENT

Subtitle D facilities include landfills, surface impoundments, land application units, and waste piles. Table ES-3 and Figure ES-1 present the numbers of facilities and establishments in each category as determined by the Subtitle D Census. A total of 227,127 facilities were identified, including 191,822 surface impoundments, 18,889 land application units, and 16,416 landfills.

Landfills

A landfill is an area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or compost pile. Landfills are divided into the following waste classes: municipal, industrial, demolition debris, and "other". Municipal waste landfill data are more complete and reliable than data for the other landfill categories.

General Profile--

The Subtitle D Census identified 16,416 active Subtitle D landfills located at 15,719 establishments in the United States. Of these landfills, 9,284 (57 percent) are municipal, 3,511 (21 percent) industrial, 2,591 (16 percent) demolition, and 1,030 (6 percent) other types. Slightly over half of all landfills are owned by local governments. Table ES-4 indicates that more than half of all landfills are less than 10 acres in size and more than 90 percent occupy 100 acres or less. The same table shows that more than 70 percent of all landfills receive less than 30,000 cubic yards of waste annually (approximately 30 short tons per day).

Landfill Leachate and Gas Characteristics--

Few data are available on leachate and gas characteristics for other than municipal landfills. Leachates are generally high in organics and total solids, they have relatively low concentrations of heavy metals, and they tend to be acidic.[10] Gas consists of about 50 to 60 percent methane; 40 to 50 percent carbon dioxide; and 0.5 to 1 percent hydrogen, oxygen, nitrogen, and other trace gases.[10]

Landfill Design and Operation--

Landfill design features include liners, leachate collection and removal systems, methane gas controls and recovery systems, closure and final cover, and location. Landfill operation and maintenance characteristics include the number of employees, daily operations, waste restrictions, and emergency preparedness plans. Landfills may have monitoring systems for ground water, surface water, air, and/or methane monitoring. Table ES-4 presents the percentages of all Subtitle D landfills and municipal waste landfills that use liners, leachate collection, gas collection, runon and runoff controls, waste restrictions, and monitoring systems. These features are also discussed below:

- Liners. The Census reported that 11 percent of all landfills and 15 percent of municipal landfills use either soil or synthetic liners.

TABLE ES-3. UNIVERSE OF SUBTITLE D FACILITIES[a] [1]

Facility Type	Number of units	Number of estiablishments
Landfills	16,416	15,719
Surface Impoundments	191,822	108,383
Land Application Units (LAUs)	18,889	12,312
Waste Piles	No Data	No Data
TOTAL	227,127	128,128[b]

[a] 16% (or approximately 36,000 facilities) are estimates to receive hazardous wastes from households or small quantity generators.

[b] This is the correct total. The numbers for each type of facility do not add to this total since two or more facility types may exist at an establishment.

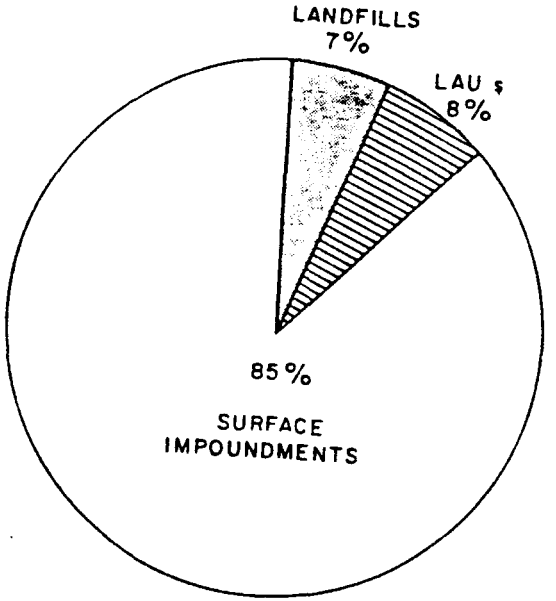

Figure ES-1. Universe of Subtitle D facilities, by percent. [1]

TABLE ES-4. NUMBERS OF LANDFILLS AND MUNICIPAL WASTE LANDFILLS WITH SELECTED DESIGN AND OPERATING CHARACTERISTICS[1]

Characteristic	Percent of all Subtitle D landfills	Percent of all Subtitle D municipal waste landfills
Size		
< 10 acres	55	42
10-100 acres	40	51
> 100 acres	5	6
Waste Received		
< 30,000 cubic yards/yr	72	67
30,000 - 600,000 cubic yards/yr	24	28
> 600,000 cubic yards/yr	4	5
Design Characteristics		
Liners (includes synthetic and soil/clay)	11	15
Leachate Collection	4	5
Gas Collection	11	17
Runon/Runoff Controls	38	46
Operating Characteristics		
Waste Restrictions (includes liquids and/or specific waste types)	40	48
Monitoring Systems		
Ground Water	19	25
Surface Water	9	12
Air	3	4
Methane	3	5

- Leachate collection and removal systems. These systems collect and/or remove leachate, and may collect ground water and/or surface water that flows into or out of the fill. The Census reported that 4 percent of all landfills and 5 percent of municipal landfills have leachate collection systems.

- Methane gas controls and recovery systems. The Census reported methane recovery systems for 11 percent of all landfills and 17 percent of municipal landfills.

- Runon and runoff controls. These controls include dikes, berms, and channels to prevent liquids from flowing into or out of the landfill. Table ES-4 indicates that 38 percent of all landfills and 46 percent of municipal waste landfills use these controls.

- Waste restrictions. Table ES-4 indicates that 40 percent of all municipal landfills employ waste restrictions.

- Ground water monitoring. The Census reported that ground water monitoring is conducted at 19 percent of all landfills and 25 percent of municipal waste landfills (see Table ES-4).

- Surface water monitoring. Table ES-4 shows that surface waters are monitored at 9 percent of all landfills and 12 percent of municipal landfills.

- Air and methane monitoring. According to the Census (Table ES-4), 3 percent of all landfills and 4 percent of municipal landfills have methane or air monitoring systems and 3 and 5 percent, respectively, have methane monitoring systems.

Preliminary Analysis of Environmental and Human Health Impacts at Landfills--

The principal sources of data on the human health and environmental impacts of landfills are the State Subtitle D Census, the National Priorities List (NPL) Subtitle D landfill data base, and available case studies.[9] Of the 16,416 active landfills reported in the Census, 11,540 were inspected at least annually, and there were 2,428 violations due to ground water, surface water, or air contamination. No correlation has been made between these violations and any past, present, or potential health effects.

The NPL data base identified 184 Subtitle D landfills where environmental impacts have been determined by the National Hazard Ranking System to be significant. Of these sites, nearly 75 percent had releases to ground water and for 40 percent, the primary cause of ground water contamination was industrial waste.

Case studies of 127 municipal waste landfills in eight States[9] (Arkansas, Colorado, Connecticut, Delaware, Florida, Oregon, Texas, and Wisconsin) were analyzed in an attempt to correlate location and design

factors with adverse environmental impacts. The analyses indicated that locations with high leachate generation potential, high leachate migration potential, and those lacking certain landfill design features (especially liners and runon and runoff controls) were associated with environmental impacts more often than locations not displaying these characteristics. They also indicated that impacts are more likely for facilities more than 10 years old.

Surface Impoundments

A surface impoundment is a natural topographic depression, man-made excavation, or diked area that is designed to hold liquid wastes or wastes containing free liquids. Wastes stored at Subtitle D surface impoundments include: municipal sewage sludge, municipal runoff, industrial wastes, agricultural wastes, mining wastes, oil and gas wastes, and other types of waste. Table ES-5 lists the percentages of surface impoundments with selected design and operating characteristics. Most respondents to the Subtitle D Census rated the data quality for surface impoundments as fair.

General Profile--

The Subtitle D Census identified 191,822 active surface impoundments located at 108,383 facilities across the States and Territories. The majority of these impoundments (72 percent) are in EPA Regions III and IV (53,770 and 77,752, respectively).

The Census results show that the number of impoundments reported by waste type includes 125,074 (65 percent) oil and gas wastes, 19,813 (10 percent) mining wastes, 17,159 (9 percent) agricultural wastes, 16,232 (8 percent) industrial wastes, 1,938 (1.0 percent) municipal sewage sludge, 488 (0.2 percent) municipal runoff, and 11,118 (6 percent) other types of waste.

The majority (98 percent) of surface impoundments are privately owned. Table ES-5 indicates that most surface impoundments (81 percent) occupy less than 0.4 acres, and more than 80 percent receive less than 50,000 gallons per day.

Surface impoundment wastes are predominantly liquids, sludges, or slurries. Estimates presented in Section 4 of this report indicate that the major sources of surface impoundment wastes are: bituminous and lignite coal mining, oil and gas brining, nonmetallic minerals mining, industrial organic chemical manufacturing, and wastewater processing. The lack of data on particular waste streams and the extent of codisposal of liquid wastes makes generalization on waste characteristics difficult.

Surface Impoundment Design and Operation--

Surface impoundment design features include liners, leachate detection systems, runon and runoff controls, closure, final cover, and location. Census data on these features are presented below:

TABLE ES-5. NUMBERS OF SURFACE IMPOUNDMENTS WITH SELECTED DESIGN AND OPERATING CHARACTERISTICS[1]

Characteristic	Percent of all Subtitle D surface impoundments
Size (Acres)	
< 0.1	35
0.1 - 0.4	46
0.5 - 0.9	9
1 - 5	7
6 - 10	2
11 - 100	0.6
> 100	0.1
Waste Received (gallons/day)	
< 50,000	82
50,000 - 99,000	3
100,000 - 499,000	13
500,000 - 999,000	1
1,000,000 - 9,999,000	1
> 10,000,000	0.3
Design Characteristics	
Liners (includes synthetic and soil/clay)	29
Leak Detection Systems	1
Overtopping Controls	25
Operating Characteristics	
Waste Restrictions	27
Discharge Permit	31
Monitoring Systems	
Ground Water	4
Surface Water	17
Air	0.1

- Liners. Liners at Subtitle D surface impoundments are classified as either soil or synthetic. Approximately 29 percent of surface impoundments use liners, 28 percent use soil and 1 percent use synthetic.

- Leachate detection systems. Slightly over one percent of Subtitle D surface impoundments use leak detection systems.

- Runon and runoff controls. Overtopping controls are used on 25 percent of facilities.

No data were readily available for closure, final cover, or location features at Subtitle D surface impoundments.

Operation and maintenance characteristics for surface impoundments include maintenance of minimum freeboard, restriction of wastes, compliance with a discharge permit, and the maintenance of dike stability. Data were not available on the number of employees and equipment required to operate a surface impoundment. Table ES-5 shows that waste restrictions are applied by 27 percent of the surface impoundments. Thirty-one percent are reported to have discharge permits.

Environmental monitoring systems and parameters for surface impoundments are generally the same as those for landfill environmental monitoring and the media include ground water, surface water, and air. Table ES-5 indicates that, of active surface impoundments, 4 percent monitor ground water, 17 percent monitor surface water and 0.1 percent monitor air emissions.

Preliminary Analysis of Environmental and Human Health Impacts at Surface Impoundments--

The State Subtitle D Census identified the numbers of permit violations due to ground water, surface water, and air contamination, reported in 1984. Of 191,822 active surface impoundments identified by the Census, 76,137 were inspected at least annually, and there were 1,799 violations due to contamination. The Census did not relate these violations to any past, present, or potential health effects.

Land Application Units

Land application units (LAUs) are areas where wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for agricultural purposes or for treatment and disposal. Land application units are categorized according to the following waste classes: municipal sewage sludge, industrial wastes, oil or gas wastes, and other types of waste. Table ES-6 lists the percentages of LAUs with selected design and operating characteristics. Census respondents typically rated the quality of their LAU data as fair, poor, or very poor.

General Profile--

Table ES-3 shows that there are 18,889 Subtitle D LAUs located at 12,312 establishments in the United States. A breakdown by type shows that there are 11,937 LAUs (63 percent) for municipal sewage sludge, 5,605 (30 percent) for

TABLE ES-6. NUMBERS OF LAND APPLICATION UNITS WITH SELECTED DESIGN AND OPERATING CHARACTERISTICS[1]

Characteristic	Percent of all Subtitle D land application units
Size (Acres)	
< 10	22
10 - 49	41
50 - 99	21
> 100	15
Waste Received (ton/year)	
< 50	70
50 - 99	12
100 - 999	15
> 1,000	3
Design Characteristics	
Runon/Runoff Controls	51
Operating Characteristics	
Waste Restrictions	54
Waste Application Rate Limits	75
Restrictions on Growing Food-Chain Crops	60
Monitoring Systems	
Ground Water	6
Surface Water	3
Air	1
Soil	27

industrial wastes, 726 (4 percent) for oil or gas wastes, and 621 (3 percent) for other types of waste. The majority of LAUs are privately owned.

Table ES-6 indicates that about 85 percent of LAUs occupy less than 100 acres. Although three-quarters of the "other" LAUs are greater than 100 acres, more than half of municipal sewage sludge, industrial waste and oil or gas waste LAUs are less than 50 acres in size. Table ES-6 also shows that 70 percent of all LAUs recieve less than 50 tons of waste per year.

The major sources of LAU waste include municipal wastewater treatment plants (liquid and dewatered sludges), households and small businesses (septic tank sludges), industrial establishments (sludges and wastewaters), and oil or gas exploration/extraction sites (drilling muds and sludges). The constituents in some of these wastes may be beneficial to the soil and to plants (nitrogen, phosphorous, carbonates, etc.); however, other wastes may contain constituents that are not appropriate for application to food chain crops (e.g.,cadmium, PCBs, pesticides, etc.).

LAU Design and Operation--

- LAU design considerations include runon and runoff controls and location. The Census reported that 9,645 LAUs (51 percent from Table ES-6) use runon and runoff controls. No location data were available.

LAU operation and maintenance practices include waste application techniques, waste restrictions, food crop restrictions, and application rate limits. Table ES-6 lists the percentage of LAU employing waste restrictions, application rate limits, and restrictions on growing food chain crops.

- Waste restrictions. The Census showed waste restrictions in effect at 10,241 LAUs (54 percent).

- Food crop restrictions. The Census revealed food crop restrictions at 11,395 LAUs (60 percent).

- Application rate restrictions. Application rates are determined by balancing the waste characteristics with soil attenuation capacity and plant uptake (if vegetation is grown). The Census revealed that 14,090 LAUs (75 percent) restrict application rates.

Monitoring of the applied waste, ground water, surface water, air, crops, and soil may be practiced at LAUs. The extent of the monitoring system is usually determined by waste and site characteristics. Ground water, surface water and air monitoring systems are similar to those of landfills; however, parameters to be measured may differ depending on the use of the land. Table ES-6 lists the percentages of LAUs with ground water, surface water, air, and soil monitoring systems.

The State Subtitle D Census indicated that 1,179 LAUs (6 percent) practice ground water monitoring; 632 (3 percent), surface water monitoring; 168 (1 percent), air monitoring; and 5,053 (27 percent), soil monitoring. Industrial units have more ground water monitoring (10 percent of industrial units) than other unit types, and municipal sewage sludge units more soil monitoring (40 percent) than other units.

Preliminary Analysis of Environmental and Human Health Impacts at LAUs--

Of the 18,889 active LAUs reported by the Census, 3,795 were inspected at least annually, and there were 214 violations due to groundwater and surface water contamination. No information was available to associate these violations with health effects.

Waste Piles

Waste piles were not included in the State Subtitle D Program Census and no other sources of information were readily available to determine the number, locations, types, ownership characteristics, or sizes of existing waste piles. (Some data may have been included as "other" landfills in the Census.) Available data[4] identify four industries which annually store 90 million tons of waste in waste piles.

STATE SUBTITLE D PROGRAMS CHARACTERIZATION

The Subtitle D program is implemented and enforced by the States. The EPA has published minimum requirements (40 CFR Part 256) for State solid waste management programs. These include State legal authority and regulatory powers, provisions for classifying facilities, closing or upgrading open dumps, and schedules for compliance with the Federal prohibition of open dumping.

Data collected in the Phase I effort support this State program characterization by addressing the following four areas:

- Program organization and management resources
- Identification and status of solid waste facilities
- Permit and regulation mechanisms
- Enforcement programs

State regulations for each type of Subtitle D facility are summarized as well.

Overview of State Subtitle D Programs

Program Organization and Management Resources--

Few States administer their solid waste management programs in the Federal mold, using one agency or department to handle all Subtitle D activities. Although 15 States and Territories have 1 agency responsible for Subtitle D program implementation, the remaining 39 have from 2 to as many as 8 different agencies that administer parts of the Subtitle D program.

The majority of States and Territories (28) budgeted less than $500,000 for Subtitle D activities (FY84), 13 budgeted between $500,000 and $1 million, and 7 budgeted over $1 million. In fiscal year 1984, 85 percent of the funding for Subtitle D came from State sources, 8 percent was from Federal sources, and 7 percent was from licenses, user fees, and other sources. The last year in which Federal funds were a major portion was 1981 (30 percent).

The States and Territories indicated that surveillance and enforcement accounted for 42 percent of the hours expended on Subtitle D activities and that permitting and licensing accounted for 30 percent during 1984. The data from the Census, however, do not explicitly show whether the States are committing adequate resources for Subtitle D activities.

Identification and Status of Solid Waste Facilities--

The States and Territories have different approaches for identifying and maintaining data on the various Subtitle D facilities and thus have data of varying quality for the different types of facilities. Generally the best information is available for municipal waste landfills.

Permit and Regulation Mechanisms--

Although most States have permit requirements for landfills and waste piles, fewer have requirements for surface impoundments and LAUs. Roughly half of all Subtitle D facilities have been granted permits by the States.

The Federal criteria promulgated in 1979 (40 CFR Part 257) define minimum regulatory standards for Subtitle D facilities. Many States have adopted these criteria in their solid waste management plans. Currently, the EPA has approved 25 such State plans and partially approved 6 others.

Enforcement Programs--

Inspection data indicate that landfills and surface impoundments have been the primary focus of State inspection efforts and that landfills are inspected more often than any other type of facility. The most common violations are operational deficiencies, but a significant number of ground water, surface water, and air contamination violations have also been discovered. No source of information on trends in compliance rates for State programs was identified during Phase I.

Facility-Specific Regulations

Landfills--

Although almost all States require permits or plan approval for landfills, the percentage of landfills with permits is low. Specific permit requirements for landfills vary widely among the States. Design criteria tend to be comprised of general performance standards as opposed to specific engineering design standards. Most States have established requirements for operation and maintenance, location, monitoring, closure and postclosure.

Surface Impoundments--

Only 16 States have regulations for surface impoundments. With a few exceptions, each of the 16 States requires issuance of an application, license, or permit before facilities can become operational. Eleven of the 16 States with surface impoundment regulations have design standards, mostly for leak detection, security, and runon/runoff controls. Twelve States restrict the location of surface impoundments in floodplains and near reservoirs. Thirteen States have monitoring requirements for ground water, surface water, leachates, or air. (Most of these States require ground water monitoring.) Eleven of the 16 States with surface impoundment regulations enforce closure requirements.

Land Application Units--

Twenty-three States have regulations for LAUs. Most of these States require an application or permit before such facilities can become operational. Approximately 65 percent of the facilities in these States have permits; the others have submitted their permit applications. Eighteen States have facility design requirements, typically security and runon and runoff controls; 21 have operation and maintenance regulations; 16 have location standards; and 17 have monitoring requirements. No States have liability requirements for LAUs.

Waste Piles--

About half of the States regulate waste piles and require permits for them. Waste pile permit requirements are limited in scope and vary considerably among the States. Approximately 50 percent of the States have design criteria and operation and maintenance standards. Fifteen States have requirements for location, monitoring and closure at waste piles.

CONCLUSIONS

The Phase I efforts have gathered and summarized much readily available existing data on Subtitle D facilities. However, additional data needs for the report to Congress and for Subtitle D rulemaking efforts were identified. Table ES-7 lists the additional data needs for characterization of Subtitle D wastes, Subtitle D facilities and State Subtitle D programs. These data needs are described more fully in Section 6.

TABLE ES-7. PHASE I REMAINING DATA NEEDS

Data categories	Remaining data needs
Waste Characterization	
Municipal solid waste	• None
Household hazardous waste	• Data on quantities and characteristics of HHW waste
Municipal sludge	• Data on characteristics of municipal water and wastewater treatment sludges
Municipal combustion ash	• More detailed data on characteristics, quantities, and management
Industrial nonhazardous waste	• More precise estimates of quantities generated from specific sources • Quantities and types of wastes managed at Subtitle D facilities • Better waste characterization including concentration ranges and averages
Small quantity generator waste	• None
Construction and demolition waste	• Data on waste characteristics, quantities, and management
Agricultural waste	• Data on waste characteristics, quantities and management
Oil and gas waste	• Data on waste characteristics, quantities and management (focus of separate Agency efforts)
Mining waste	• (Focus of separate Agency efforts)
Facility Characterization	
General profiles	• More accurate profile information for all facility types except municipal landfills

(continued)

TABLE ES-7 (continued)

Data categories	Remaining data needs
Design and operation	
- Landfills	• Facility-specific design and operating data
- Surface impoundments	• Facility-specific design and operating data
- Land application	• Facility-specific design and operating data
- Waste piles	• Information concerning all aspects of waste piles
Leachate and gas characteristics	• Characteristics of organic constituents for leachate and gas at municipal waste landfills
	• Leachate and gas characteristics (if appropriate) for facilities other than municipal waste landfills
	• Data which may help correlate environmental impacts with leachate and gas production
Preliminary environmental and human health impacts	• Additional ground water, surface water, and air monitoring data on all facility types
	• Case studies of contaminant impacts
State Programs Characterization	
Program/organization management	• Further evaluation of existing data
	• Follow-up case studies, if required
Identification/facility status	• Waste pile data (numbers and characteristics)
Permit/regulation	• States/Territories having criteria equivalent to Federal Criteria
Enforcement	• State enforcement authorities
	• Case studies of enforcement programs

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SECTION 1

INTRODUCTION AND BACKGROUND

The 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) require the EPA, by November 8, 1987, to submit a report to Congress addressing whether the Criteria under the Sections 1008(a) and 4004 of the RCRA and 40 CFR Part 257 are adequate to protect human health and the environment from ground water contamination. To meet these Congressional mandates, the EPA is undertaking a Subtitle D study: 1) to assess the impact of nonhazardous waste landfills, surface impoundments, land application units, and waste piles on surface water ground water and air; and 2) to assess implementation of the State nonhazardous waste programs. The Subtitle D study is divided into two major phases:

- Phase I - Compilation and preliminary assessment of information on State programs, facilities, wastes, and contamination impacts from EPA files, the States, published and unpublished literature, and other sources.

- Phase II- Acquisition and analysis of additional information to fill data gaps identified in Phase I; and development of the report to Congress.

This report summarizes the results of all of the Phase I data collection projects, assesses their adequacy for evaluating the current Subtitle D Criteria, and identified some of the key areas to be addressed in Phase II data collection projects. Section 2 presents details on Phase I data collection projects. The next three sections present the Phase I data according to the topics of waste characteristics (Section 3), facility characteristics (Section 4), and State programs (Section 5). The final section, Section 6, presents conclusions and identifies directions for Phase II data collection.

The remainder of this section provides the legislative and regulatory background for understanding the current status of the Subtitle D program. Beginning with discussion of the RCRA legislation establishing Subtitle D, the section briefly reviews Federal and State implementation of Subtitle D from 1978 to 1981, when Federal attention turned to the hazardous waste program under Subtitle C and Federal funding of State Subtitle D implementation programs ended. The section then outlines the new Subtitle D provisions of the HSWA of 1984 and describes EPA plans to implement these provisions. This Subtitle D report constitutes part of that implementation.

1.1 SUBTITLE D OF THE RESOURCE CONSERVATION AND RECOVERY ACT

Subtitle D of RCRA, establishes a framework for coordinating Federal, State and local government management of nonhazardous solid wastes. The Federal role in this arrangement is to establish the regulatory direction and provide technical assistance to States and regions for planning and developing environmentally sound waste management practices. The actual planning and implementation of solid waste programs under Subtitle D, however, remain State and local functions.

The primary planning and technical assistance provisions of Subtitle D are the following:

- Section 4002--Federal Guidelines for State Plans. Requires the EPA to promulgate guidelines to assist in the development and implementation of State solid waste management plans.

- Section 4004--Criteria for Sanitary Landfills. Requires the EPA to establish criteria for determining which facilities shall be classified as sanitary landfills, i.e., those that pose "no reasonable probability of adverse effects on health or the environment from the disposal of solid waste."

- Section 4005--Prohibition of Open Dumps. Imposes a ban on open dumping in facilities that do not meet the criteria for sanitary landfills and requires the EPA to publish an inventory of open dumps in order to assist States in upgrading or closing these facilities.

- Section 4010--Adequacy of certain guidelines and criteria. Requires EPA to conduct a study to determine which guidelines and criteria are adequate to protect human health and the environment. Thirty-six months after the enactment of HSWA, EPA is required to submit a report to congress on the results of this study. Not later than March 31, 1988, the EPA is required to promulgate revisions to the Subtitle D criteria for facilities that may receive hazardous household wastes or hazardous wastes from small quantity generators. The criteria shall be those necessary to protect human health and the environment and at a minimum include ground water monitoring, location, and corrective action requirements.

1.2 IMPLEMENTATION OF SUBTITLE D

In a series of rulemakings beginning in 1978, the EPA began the process of implementing the provisions of Subtitle D. The Agency completed the guidelines for State plans in 1979, and began reviewing plans submitted by States. It also finalized the Criteria for Classifying Solid Waste Management Facilities and Practices in 1979. These Criteria are used by the States to

classify facilities as either sanitary landfills or open dumps. After compiling these State facility classification data, the EPA published the first inventory of open dumps in 1981. To aid them in developing plans and programs to implement the criteria, EPA provided more than $50 million in annual grants to the States. This financial assistance was terminated in 1981.

Guidelines For State Solid Waste Management Plans - 40 CFR Part 256

Pursuant to RCRA Section 4002(b), the EPA promulgated guidelines (40 CFR Part 256) for the development and implementation of State solid waste management plans on July 31, 1979 (44 FR 45066). These guidelines establish the minimum requirements for State plans and describe the procedures for State plan adoption, submission, and approval by the EPA. Furthermore, the guidelines contain requirements and recommendations for solid waste disposal and resource conservation and recovery programs, facility planning and implementation activities, and public participation.

As the centerpiece of the Subtitle D program, the State solid waste management plan serves a critical function. It is through this plan that each State identifies an overall strategy for protecting public health and the environment from potential adverse effects of solid waste disposal, specifies efforts for encouraging resource recovery and resource conservation, and formulates plans for providing adequate disposal capacity within the State. The plan also describes the institutional arrangements that the State will use to implement its solid waste management program.

Under Subtitle D, the EPA reviews and approves State plans that meet the guidelines of 40 CFR Part 256. As of August 1986, the EPA had fully approved 25 State solid waste management plans and partially approved another six.

Criteria For Sanitary Landfills - 40 CFR Part 257

Pursuant to RCRA Sections 4004(a) and 1008(a)(3), the EPA developed the "Criteria, for Classifying Solid Waste Disposal Facilities and Practices" (40 CFR Part 257). These Criteria provide minimum national performance standards for the protection of public health and the environment from solid waste disposal facilities. The Criteria establish the level of protection necessary to ensure that "no reasonable probability of adverse effects on health or the environment" will result from operation of the facility. A facility that meets the Criteria is classified as a "sanitary landfill"; a facility in violation is classified as an "open dump" and must be upgraded or closed. The Criteria, reproduced in Appendix A, were promulgated on September 13, 1979 (44 FR 53438). Minor amendments were issued in September 1981. The Criteria may be summarized as follows:

- A facility or practice shall employ special controls for location in floodplains.
- A facility or practice shall not cause adverse effects on endangered species or their critical habitats.
- A facility or practice shall not cause discharges to surface waters or wetlands that are in violation of Section 402 or 404 of the Clean Water Act.

- A facility or practice shall not cause ground water contamination, particularly underground drinking water sources.

- A facility or practice shall have specific restrictions on waste application to land use for food chain crops.

- A facility or practice shall meet specific requirements for disease vector controls.

- A facility or practice shall not engage in open burning of waste.

- A facility or practice shall have specific requirements for safety provisions to control:

  - Explosive gases

  - Fires

  - Bird hazards to aircraft

  - Public access to the facility.

Implementation and enforcement of these Federal Criteria under Subtitle D are primarily the responsibility of State and local governments. In addition, private citizens may use the RCRA's citizen suit provisions (Section 7002) to bring actions in Federal court to enforce the Criteria.

Inventory Of Open Dumps

Pursuant to RCRA Section 4005(b), the EPA has published the inventory of open dumps in a series of five annual installments. The inventory is a listing of facilities which States have identified as failing to meet the Criteria of 40 CFR Part 257. Based on State efforts in evaluating disposal facilities, the inventory serves two major functions:

- Inform Congress and the public about the extent of the problem presented by disposal facilities that do not adequately protect public health and the environment

- Provide an agenda for action by identifying problem facilities routinely used for disposal that should be addressed by State solid waste management plans.

The first inventory installment was published on May 29, 1981. It reflected the participation of 55 States and territories and listed 1,209 facilities as open dumps. However, many States had not completed their inventory at the time of the publication (i.e., they hadn't evaluated all their sites against the Criteria). The fifth and most recent installment of the inventory appeared in June 1985 and included 1,856 facilities. It represents the efforts of about 20 States to update their lists.

1.3 HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984

On November 8, 1984, the President signed into law the HSWA, which modified virtually every part of RCRA, including Subtitle D. The amended RCRA Section 4010 requires the EPA to "conduct a study of the extent to which the (Criteria) ... applicable to solid waste management and disposal facilities, including, but not limited to landfills and surface impoundments, are adequate to protect human health and the environment from ground water contamination." This study, which must be completed and delivered to Congress in report form by November 8, 1987, "shall also include recommendations with respect to any additional enforcement authorities which the administrator, in consultation with the attorney general, deems necessary" to protect ground water.

The amended Section 4010 also requires the EPA to revise the Subtitle D Criteria by March 31, 1988, for facilities that receive hazardous household waste (HHW) or waste from small quantity generators (SQGs). Such revisions shall be those necessary to protect human health and the environment and may take into account the "practicable capability" of facilities to implement the Criteria. At a minimum, the revisions should require ground water monitoring as necessary to detect contamination, establish location standards for new or existing facilities, and provide for corrective action, as appropriate.

The HSWA amends Section 4005 of the RCRA to require each State to establish by November 8, 1987, a permit program or other system of prior approval for facilities receiving small amounts of hazardous waste. This permit program is meant to ensure that such facilities are in compliance with the current Criteria. Within 18 months of the EPA's promulgation of revised Criteria, each State must modify its permit program or alternative system accordingly. If a State fails to develop and implement an appropriate permit program, or another system of prior approval, by September 31, 1989, the EPA is given the authority to enforce the revised Criteria at facilities accepting HHW or SQG waste.

1.4 IMPLEMENTATION OF THE HSWA

The EPA is currently proceeding with implementation of the HSWA Subtitle D requirements, conducting the Subtitle D study in two phases and considering revisions to the Subtitle D Criteria in a parallel effort. The tight HSWA schedule for completing the study, preparing the report to Congress and promulgating the revisions to the Criteria requires that these efforts take place concurrently.

Subtitle D Study

During Phase I of the Subtitle D study, the EPA gathered existing information from the literature, States, EPA files, voluntary submissions of facility owners or operators, and any other available sources to identify and characterize Subtitle D:

- Wastes
- Facilities
- State programs

This report, which contains a preliminary characterization of the Subtitle D topics identified above, represents the culmination of the EPA's Phase I efforts. Recommendations regarding the Subtitle D study's Phase II data collection activities are also provided in this report.

In Phase II, the EPA will concentrate on filling the information gaps identified during Phase I through the collection of additional existing data. Some data needs may not be met using this procedure, however, so original data collection efforts may also have to be conducted. These may include surveys and field work at a selected number of landfills, land application units, and surface impoundments. In Phase II, the EPA will also recommend regulatory and nonregulatory alternatives that could be used to address any problems identified concerning the Criteria. Phase II will result in the completion of the Subtitle D report and its submission to Congress by November 1987.

Revisions to 40 CFR Part 257 Criteria

In a parallel effort, the EPA is revising the Subtitle D Criteria for those facilities that may receive SQG wastes and/or HHW. These new requirements must address at a minimum ground water monitoring, location criteria, and corrective action. The development of revisions will involve extensive contacts with States, local governments, and trade and environmental groups, and will require the preparation of a complete administrative record, including a regulatory impact analysis. This process is expected to span two years, overlapping the second phase of the Subtitle D study, and to culminate in the promulgation of revisions to the Criteria in March 1988.

Implementation Schedule

The HSWA impose a rigorous schedule on both the EPA and the States for completing their Subtitle D responsibilities. Figure 1-1 provides a time line illustrating the HSWA schedule. As the figure indicates, the EPA must submit the Subtitle D report to Congress by November 1987 and promulgate revisions to the Subtitle D Criteria by March 1988. The States are required by the HSWA to develop a permit or other approval program for implementing the existing Criteria by November 1987 and a revised program within 18 months of promulgation of the revised Criteria (projected as September 1989).

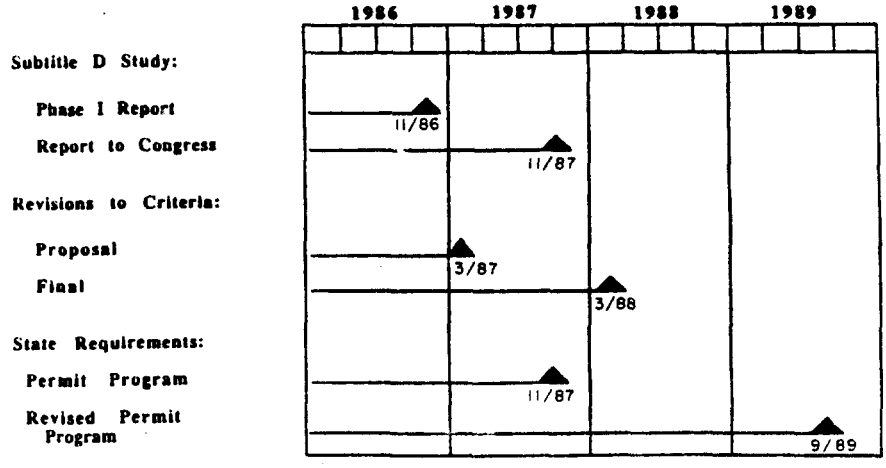

Figure 1-1. Subtitle D Schedule Under HSWA.

SECTION 2

PHASE I PROJECTS

In Phase I of the Subtitle D study, the Agency collected existing data on Subtitle D wastes, facilities, and State programs that were available during the 18 months following the November 1984 passage of the Hazardous and Solid Waste Amendments (HSWA). The data sources for these projects included State and Federal program offices, published and unpublished literature, the regulated community, and technical research. Every effort was made to collect as much existing information as possible in all areas, within the constraints of the broad scope of the study, and time and resource limitations. For the purposes of this section, Phase I projects have been grouped into the following categories:

- Subtitle D waste characterization studies
- Subtitle D facility characterization studies
- State Subtitle D program characterization studies

This section describes Phase I projects, their strengths and limitations, and their relationship to the Subtitle D study. Data from these projects are presented in Sections 3, 4, and 5 of this report. Table 2-1 presents a list of the principal Phase I data collection projects. Table 2-2 correlates the Phase I projects with the major categories of information that were identified at the onset of the Subtitle D study.

2.1 SUBTITLE D WASTE CHARACTERIZATION STUDIES

One objective of the Phase I study was to determine the characteristics, volumes, and management methods of Subtitle D wastes. This objective was addressed by literature reviews and in separate Phase I studies concerning municipal solid wastes, industrial nonhazardous wastes, household hazardous wastes (HHW), two studies addressing SQG wastes and additional literature reviews performed for the purposes of this summary report.

Literature Reviews

Literature reviews were performed to support all of the technical areas covered by this report. They include a study which reviewed and summarized recent documents pertaining to Subtitle D, and supplementary literature reviews performed during the preparation of this report.

TABLE 2-1. PHASE I DATA COLLECTION PROJECTS SUPPORTING SUBTITLE D STUDY AND CRITERIA REVISIONS

1. Subtitle D Waste Characterization Studies

   a. Source, Availability and Review of RCRA Subtitle D Land Disposal Data Published Since 1980

      - Reviews and abstracts of recent literature relevant to the Subtitle D study.

   b. Characterization of Municipal Solid Waste in the United States, 1960 to 2000

      - Inventory and forecast of municipal solid wastes in the U.S.

   c. Summary of Data on Industrial Nonhazardous Waste Disposal Practices

      - Summary of non-state data on solid waste characteristics and solid land disposal practices.

   d. A Survey of Household Hazardous Wastes and Related Collection Programs

      - Review of existing data on the characteristics of HHW and analysis of HHW collection programs.

   e. National Small Quantity Generator Survey

      - Survey to characterize SQG waste volumes and disposal practices.

   f. Hazardous Waste Generator Data and Characteristics of Sanitary Landfills in Selected Counties in Florida.

      - Case history of Florida disposal of small quantity generator hazardous wastes.

2. Subtitle D Facility Characterization Studies (in addition to studies noted above)

   a. Census of State and Territorial Subtitle D Nonhazardous Waste Programs

      - Mail survey of data on State Subtitle D programs and Subtitle D facilities.

   b. Critical Review and Summary of Leachate and Gas Production from Landfills.

      - Summary and evaluation of data on quality of leachate from municipal landfills.

   c. Evaluation of a Landfill with Leachate Recycle.

      - Case study of the Lycoming County, PA landfill with a major emphasis on experiences with leachate recirculation.

   d. Gas Characterization, Microbiological Analysis and Disposal of Refuse in GRI Landfill Simulators.

      - GC/MS analysis of landfill gas samples from the Center Hill lysimeters.

   e. Landfill Gas Update: Summaries of Technical Reports.

      - Summaries of six studies relating to landfill gas production, characteristics and recovery.

   f. Evaluation of NPL/Subtitle D Landfill Data

      - Summary of data on former Subtitle D facilities that are now on the NPL or are candidates for the NPL.

   g. Municipal Landfill Case Studies

      - Preliminary studies of facility characteristics and environmental impacts at 127 municipal waste landfills.

3. State Subtitle D Program Studies (in addition to studies noted above)

   a. State Subtitle D Regulations on Municipal Waste Landfills, Surface Impoundments and Land Application Units.

      - Review of State Subtitle D regulations.

   b. National Solid Waste Survey

      - Mail survey of data on State Subtitle D programs.

TABLE 2-2. PHASE I DATA COLLECTION MATRIX

Data Categories	Principal Phase I Data Collection Projects[a]									
	General Literature Reviews	Municipal Solid Waste Characterization	Industrial Waste Disposal Practices	Household Hazardous Wastes	SQG Survey	State Program Census	Leachate and Gas Characteristics	NPL/ Subtitle D Data Base	Municipal Landfill Case Studies	Subtitle D Regulations Reviews
WASTE CHARACTERIZATION										
Municipal Solid Waste	X	X				X				
HHW	X			X		X				
Municipal Sludge	X	X				X				
Municipal Waste Incineration Ash	X	X								
Industrial Nonhazardous Waste	X		X			X				
SQG-Waste	X				X					
Other Waste	X	X				X				
FACILITY CHARACTERIZATION										
General Profile:										
landfills	X		X			X		X		
surface impoundments	X		X			X				
land application	X		X			X				
Design and Operation										
landfills	X		X			X	X		X	
surface impoundments	X		X			X				
land application	X		X			X				
Leachate/Gas Characteristics	X						X		X	
Health and Environmental Impacts:										
landfills-										
ground water	X					X	X	X	X	
surface water	X					X		X	X	
air	X					X	X	X	X	
surface impoundments-										
ground water	X					X				
surface water	X					X				
air	X					X				
land application-										
ground water	X					X				
surface water	X					X				
air	X					X				
STATE PROGRAM ASSESSMENT										
Regulations	X			X		X				X
Program Administration	X			X						
Program Implementation	X					X				

[a]X's indicate information from a Phase I data collection project and supports a specific data category.

The Phase I study, Source, Availability and Review of RCRA Subtitle D Land Disposal Data Published Since 1980,[1] began with a review of the available information on Subtitle D facilities and regulations. The report produced from this effort contains abstracts and bibliographic information on 110 documents. The abstracts are separated into eight categories: Overview, Design and Construction, Operation and Maintenance, Process Performance, Constituent Characteristics, Sampling and Methodology, Impacts, and Closure.

Characterization of Municipal Solid Waste in the United States, 1960 to 2000

This study[2] examines the historical quantities and composition of municipal solid waste. The quantities and sources of municipal solid wastes are discussed in terms of both the historical quantities and the generation of the raw and manufactured source materials. Future municipal waste volumes and composition are predicted using: 1) available forecasts of activities within various manufacturing industries; and 2) calculations based on estimated waste generation per unit of material produced (these waste generation factors are changed over time to account for technological changes). The results are forecasts of the quantities and composition of municipal solid wastes for the period 1960-2000. These results are summarized in Section 3.

Summary of Data on Industrial Nonhazardous Waste Disposal Practices

This study[3] used published and unpublished literature to characterize and evaluate 22 major manufacturing industries in terms of nonhazardous waste quantities, composition, and management technologies. These industries were selected because they generate significant quantities of nonhazardous wastes or manage nonhazardous wastes in onsite land disposal units (i.e., landfills, surface impoundments, LAUs or waste piles). The data sought for each industry included:

- Characteristics of nonhazardous waste generated
- Amounts of each waste type
- Amounts to different onsite waste management facilities
- Numbers and characteristics of onsite units
- Environmental impacts of onsite units
- Amounts transported to different offsite units

Total nonhazardous waste generation was estimated to be roughly 390,000,000 metric tons per year, with 93 percent of this provided by seven industries: industrial organic chemicals; primary iron and steel; fertilizers and other agricultural chemicals; electric power generation; plastic and resin manufacture; industrial inorganic chemicals; and stone, clay, glass, and concrete products. Detailed results of this study are presented in Section 3 of this report.

This study revealed several limitations in the quality and content of available data on industrial waste generation and management. The transportation equipment industry was cited as having the least data. Data completeness also varied according to data type: most industries had complete data on waste type; waste quantities were available for fewer industries; estimates of waste quantities managed on the site were available for fewer yet; and almost no estimates were available on the numbers of onsite land disposal units within an industry. No nationwide data were available on the typical design characteristics of onsite land disposal units, the location or prevalance of ground water monitoring at these units, or their impacts on the environment.

Household Hazardous Wastes

The HHW study[4] is a literature survey which presents information on the makeup of HHW, their presence in the municipal waste stream, and their impacts on solid waste management. It also presents information on State HHW program and Special HHW collection programs and includes three case studies of HHW programs in the U.S.

Further studies were recommended in the areas of types and quantities of HHW, environmental impacts of HHW by disposal at municipal landfills, and the administration of HHW collection programs. The results of this study are described in more detail in Section 3.

National Small Quantity Hazardous Waste Generator Survey

The national SQG survey[5] was mailed to 50,000 industrial establishments that generate less than 1,000 kilograms of hazardous waste per month. On March 24, 1986, the SQG exemption to regulations under Subtitle C of the RCRA was amended to apply only to "conditionally exempt" SQGs of less than 100 kilograms per month of hazardous waste. The report includes a summary and analysis of the 1900 responses to the survey. The results include the following:

- The estimated number of SQGs and conditionally exempt SQGs and the total quantities of hazardous waste they generate.
- Descriptions of the different SQG and conditionally exempt SQG wastes generated by the 22 major industry groups that contain significant numbers of SQGs.
- Estimates of the management practices currently used by SQGs and conditionally exempt SQGs in the primary industry groups targeted in the survey.

Hazardous Waste Generator Data and Characteristics of Sanitary Landfills in Selected Counties in Florida

This study[6] presents data on small quantity hazardous waste generation and management and sanitary landfill operation in the State of Florida. The

data were collected in 1983 by the Florida Department of Environmental Regulations (FDER). The FDER helped implement Florida's Local Government Hazardous Waste Management Program, which required every county in the State to complete assessments of hazardous waste generation and management. The final report will contain data from all 67 counties in the State. Those data will cover hazardous waste types, amounts, sources, and management and disposal practices. This study is discussed further in Section 3.

2.2 SUBTITLE D FACILITY CHARACTERIZATION STUDIES

Facility characterization studies were conducted to gather existing information in the following areas: numbers and general characteristics of Subtitle D facilities; facility design and operating characteristics; leachate and gas characteristics; and environmental and human health impacts associated with different types of facilities. These data are needed for assessments of: human health and environmental risks due to Subtitle D facilities, and needs for Subtitle D regulatory revisions.

The principal source of information on numbers of facilities and design and operating characteristics is the Subtitle D Census of data available from State program offices. Gas and leachate characteristics were addressed in four Phase I studies and additional data were provided from a preliminary review of municipal landfill case studies.[13] Two Phase I studies were conducted to address environmental and human health impacts: a review of those National Priority List (NPL) sites that were once managed as nonhazardous waste landfills, and the preliminary review of municipal waste landfill case studies. Additionally, the Census provided some environmental contamination data that were available from State program offices. All of these topics were supplemented by literature reviews.

Literature reviews were described previously in Section 2.1. Other Phase I studies conducted to gather information in the areas of facility numbers, design and operating characteristics, leachate and gas characteristics, and environmental and human health impacts are described below.

State Subtitle D Program Census

The State Subtitle D Census[7] was conducted to collect comprehensive data on Subtitle D facilities and regulatory programs across the country. The Census was conducted as a mail survey sent to Subtitle D regulatory program offices in all States and Territories. The questionnaire was developed by the EPA with significant input from the Association of State and Territorial Solid Waste Management Officials (ASTSWMO). The questionnaire was supplemented by telephone follow-up to minimize errors due to inconsistency or nonresponse.

The first part of the questionnaire was designed to produce a directory of agencies in each State that administers Subtitle D programs, and to determine their level of funding and program emphasis. The remaining three parts elicited information on regulations, enforcement activities, numbers of facilities, design and operating characteristics, and data availability.

These three parts are divided into information concerning landfills, land application units (LAUs), and surface impoundments.

The Census topics include the following:

- State organization and resources
  - State agencies
  - Budget
  - Budget sources
  - Person hours
  - Activities
  - Projections
- Landfills, land application units, and surface impoundments
  - Total number
  - Total number, by facility subcategory
  - Total number, by state and region
  - Total number, by ownership, acreage, and amount of waste
  - Total numbers, utilizing key design and operating features
- Program characteristics
  - Regulatory requirements
  - Permitting and licensing
  - Inspections
  - Violations
  - Monitoring and release prevention

The Census data are limited because imperfect and inconsistent record keeping among the State and Territorial regulatory offices has resulted in incomplete or unconsistent responses. Respondents were asked to rate the quality of their information. They rated landfill data quality highest, surface impoundment quality lowest, and land application data quality somewhere in between.

Critical Review and Summary of Leachate and Gas Production from Landfills

This study[8] reviews research studies and field investigations of landfill leachate and gas production and management. The purpose is to provide an inventory of available techniques for containment, control, and treatment of landfill gas and leachate. Methods for management and ultimate disposal are described and evaluated.

Evaluation of a Landfill with Leachate Recycle

This study[9] examines the effectiveness of leachate recirculation as a control technology. The analysis is built upon a case study of a facility in

Lycoming County, Pennsylvania. New techniques were evaluated, and problems were identified for different landfill designs. The feasibility of leachate recircluation is discussed for different locations and various types of landfill cover.

Gas Characterization, Microbiological Analysis, and Disposal of Refuse in Gas Research Institute Landfill Simulators

This study[10], conducted by the Gas Research Institute, used 16 experimental landfills in a 5-year gas enhancement project to describe the microbiology of refuse. The production of trace constituents of gas was monitored using lysimeters. The monitoring results are presented in the report. The results of this study will be used as a reference for the technical, cost, and environmental impact analysis of methane production and gas enhancement at Subtitle D facilities.

Landfill Gas Update: Summaries of Technical Reports

This report[11] summarizes six studies performed on landfill gas production, characteristics, and recovery. The following documents are summarized:

- Pohland, F. G., and S. R. Harper. Critical Review and Summary of Leachate and Gas Production from Landfills. 1984.
- Vogt, W. G., and J. J. Walsh. Volatile Organic Compounds in Gases from Landfill Simulators. 1984.
- Zimmerman, R. E., and M. E. Goodkind. Landfill Methane Recovery: Part I, Environmental Impacts. 1981.
- Zimmerman, R. E., N. W. Flynn, and V. Olivieri. Landfill Methane Recovery: Part II, Gas Characterization. 1982.
- Zimmerman, R. E., G. R. Lytwynshyn, and N. W. Flynn. Landfill Methane Recovery, Part III: Data Analysis and Instrumentation Needs 1983.
- Stamm, J. W., W. G. Vogt, and J. J. Walsh. Demonstration of Landfill Gas Enhancement Techniques in Landfill Simulators.

The purpose of this report is to provide the Subtitle D study with current information related to landfill gas.

Evaluation of NPL/Subtitle D Landfill Data

This study[12] focused on the 184 Subtitle D landfills that are either on, or are proposed for the National Priority List (NPL). Data on these sites were obtained from the CERCLIS data base, NPL site descriptions, the MITRE Hazard Ranking System (HRS) data base, and other EPA data sources. Site

characteristics that were evaluated include: operating dates; NPL rank; HRS score; date listed or proposed for the NPL; site ownership; open-dump status; financial obligations and expenditures for cleanup; site size; hazardous constituents; waste types; and observed releases to ground water, surface water, and air. These characteristics and others, such as wastes received or problems encountered, were entered onto a separate data base for future consideration. The results of this study are discussed further in Section 4.

Municipal Waste Landfill Case Studies

Case study reports[13] were developed for 127 municipal waste landfills located within various hydrogeologic and environmental settings in eight States. The data were collected from State regulatory agency files in Arkansas, Colorado, Connecticut, Delaware, Florida, Oregon, Texas, and Wisconsin. These States were selected in an attempt to sample available data from a broad range of hydrogeologic conditions (geology, climate, and ground water occurrence). It is not assumed that these case studies fully represent the universe of municipal waste landfills throughout the country.

During Phase I, a preliminary analysis of approximately 90 case studies was conducted, considering trends in the following factors: geographic location, hydrogeologic characteristics, engineering design, facility age, potential population exposure, and documented environmental impacts. A complete compilation and evaluation of these case studies will be conducted in Phase II of the Subtitle D study. The results of the preliminary analysis are presented in Section 4.

2.3 STATE SUBTITLE D PROGRAM CHARACTERIZATION STUDIES

The information collected on State Subtitle D programs included data on the current status and funding of Subtitle D programs in the States and Territories. The principal information was collected under three projects: two were conducted by the EPA and one by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO). Some additional information was found in a review of the literature. The EPA projects included the Census of State and Territorial Subtitle D program offices,[7] and a review of Subtitle D regulations in the States and Territories.[14] The ASTSWMO project was a 1983 mail survey of the States and Territories.[15] The information available from the Census was described in Section 2.2 and information from the other projects is discussed below.

Analysis of State Subtitle D Regulations

This project resulted in a draft report[14] in which current State regulations are summarized and analyzed. The most current regulations were obtained from each State as one of their responses to the State Subtitle D Census. Current regulations were received from all States and all but two Territories. The draft report is presented in four volumes, including one each for municipal landfills, surface impoundments, LAUs, and waste piles. The reviewed regulations cover the following categories:

- Permitting and administrative requirements
- Design criteria
- Operation and maintenance criteria
- Location standards and restrictions
- Monitoring requirements
- Closure and postclosure requirements
- Financial responsibility

Appendix D presents a series of tables summarizing the key findings of this report. These findings are discussed in Section 5.

National Solid Waste Survey

In 1983, the ASTSWMO, together with the EPA Office of Solid Waste (OSW) and the National Solid Waste Management Associations (NSWMA), formulated and distributed this survey[15] instrument to solid waste management officials in all States and Territories. A total of 44 States and Territories responded, providing data on the following topics: solid waste agency organization and function; staffing resources; budget resources; solid waste treatment, storage, and disposal facility statistics; facility evaluation, monitoring, and enforcement activities; SQGs; and priorities in solid waste management.

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3. Science Applications International Corporation. Summary of Data on Industrial Nonhazardous Waste Disposal Practices. Contract No. 68-01-7050, U.S. Environmental Protection Agency, Washington, D.C. 1985.

4. SCS Engineers. A Survey of Household Hazardous Wastes and Related Collection Programs. Contract No. 68-01-6621, U.S. Environmental Protection Agency, Washington D.C. 1986.

5. Abt Associates Inc. National Small Quantity Generator Survey. Contract No. 68-01-6892, U.S. Environmental Protection Agency, OSW, Washington, D.C. 1985.

6. Florida State University. Hazardous Waste Generator Data and Characteristics of Sanitary Landfills in Selected Counties in Florida. U.S. Environmental Protection Agency, Washington, D.C. 1986.

7. Westat, Inc. Census of State and Territorial Subtitle D Non-Hazardous Waste Programs. Contract No. 68-01-7047. U.S. Environmental Protection Agency, Washington, D.C. 1986.

8. Pohland, F. G., and S. R. Harper. Critical Review and Summary of Leachate and Gas Production from Landfills. U.S. Environmental Protection Agency, Cincinnati, OH.

9. Pickard and Anderson. Evaluation of a Landfill with Leachate Recycle. U.S. Environmental Protection Agency, OSW, Washington, D.C. 1985.

10. Kinman, R. N., Rickabaugh, J., Nutini, D., and M. Lambert. Gas Characterization, Microbiological Analysis, and Disposal of Refuse in GRI Landfill Simulators. Contract No. 68-03-3210, U.S. Environmental Protection Agency, Cincinnati, OH. 1985.

11. SCS Engineers. Landfill Gas Update, Summaries of Technical Reports. U.S. Environmental Protection Agency, Washington, D.C. 1985.

12. GCA Technology Division, Inc. Evaluation of NPL/Subtitle D Landfill Data: Preliminary Final Report. Contract No. 68-01-7037, U.S. Environmental Protection Agency, Washington, D.C. 1986.

13. The Municipal landfill case studies evaluated in Phase I were obtained from the Office of Solid Waste of the U.S. Environmental Protection Agency. These studies were compiled by PEI, Inc.; SRW, Inc.; and ICF, Inc.

14. PEI Associates, Inc. State Subtitle D Regulations on Solid Waste Landfills, Surface Impoundments, Land Application Units and Waste Piles, Draft Vol. I-IV. Contract No. 68-01-7075/02-3890, U.S. Environmental Protection Agency, Washington, D.C. 1986.

15. Association of State and Territorial Solid Waste Management Officials. National Solid Waste Survey. Washington, D.C. 1984.

SECTION 3

SUBTITLE D WASTE

This section defines the universe of Subtitle D wastes and presents available information on the characteristics of the following waste categories: municipal solid waste (MSW), household hazardous waste (HHW), municipal sludge, municipal waste incinerator ash, industrial waste, small quantity generator (SQG) waste, construction and demolition waste, agricultural waste, oil and gas waste, and mining waste. For each Subtitle D waste category, the Phase I data collection efforts have focused on waste characteristics, generation rates, and management practices.

3.1 DEFINITION OF RCRA SUBTITLE D SOLID WASTES

Subtitle D wastes are solid wastes regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA); they are not subject to the hazardous waste regulations under Subtitle C of RCRA. Solid wastes regulated under RCRA are defined in 40 CFR 257 as:

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

Household hazardous wastes and hazardous SQG wastes are solid wastes that are exempt from Subtitle C regulations and thus are Subtitle D wastes. Household hazardous wastes are hazardous wastes generated by households and must meet the RCRA technical definition of a hazardous waste. "Household" is defined here as any type of living quarters: single and multiple dwellings, hotels, motels, and other residences. Small quantity generator wastes are defined as those wastes that meet the definition of a hazardous waste under 40 CFR 261, and that are generated at a rate of less than 1,000 kg/month. While SQG wastes have been exempt from Subtitle C regulations, a March 24, 1986 rule will apply certain

Subtitle C regulations to SQGs generating between 100 and 1,000 kg/month.[1] This rule took effect on September 22, 1986 for offsite, and September 22, 1987 for onsite treatment, storage, or disposal. After these effective dates, the conditional exemption from Subtitle C will apply only to generators of less than 100 kg/month of hazardous waste.

In accordance with the above-mentioned definitions and exclusions, the following categories of Subtitle D wastes have been identified:

- Municipal solid waste
- Household Hazardous Waste
- Municipal sludge
- Municipal waste combustion ash
- Industrial nonhazardous waste
- Small Quantity Generator waste
- Construction and demolition waste
- Agricultural waste
- Oil and gas waste
- Mining waste

The characteristics, quantities, and management practices of each of these Subtitle D wastes are discussed separately in the following subsections.

3.2 MUNICIPAL SOLID WASTE

Municipal solid waste is a mixture of household, institutional, commercial, municipal, and industrial solid wastes. The composition of MSW is variable, but generally more than half (by weight) is paper products and yard wastes. In 1984, approximately 130 million tons of MSW were discarded, most of them (126 million tons) in landfills. The characteristics, quantities and management of MSW are discussed separately below.

Characteristics of Municipal Solid Waste

Reports on the composition of MSW vary widely.[2,3,4] This variation is attributable in part to regional differences in climatic, seasonal, and socioeconomic factors, as well as differences in waste reporting methods. The reporting methods differ in measurement techniques, definitions of MSW, and the categories of waste constituents. The variation in these reports makes it difficult to construct a national profile of MSW composition.

The best source of information on MSW characteristics is Characterization of Municipal Solid Waste in the United States, 1960 to 2000.[2] This study constructs a national profile of MSW by evaluating a wide range of waste composition data and comparing this information to materials production data in a national materials balance model. It relates historical information on waste generation to information on the production of nondurable and durable materials. The study does not estimate industrial nonhazardous wastes, SQG hazardous wastes, or municipal sludge components of MSW.

As shown in Table 3-1, this study[2] reported that paper products (paper and paperboard) and yard wastes currently make up about 55 percent of all MSW. Table 3-1 also shows the estimated tonnage of materials discarded for the years 1970 and 2000. These estimates indicate that the use of paper and plastics is increasing, whereas the use of glass, metals, and food wastes is decreasing. Other materials retain about the same percentage composition.[2]

Quantities of Municipal Solid Waste

The MSW Characterization study reports that about 133 million tons of MSW were discarded in 1984. This is equivalent to 3.0 pounds per capita per day. The study also presents estimates of annual municipal waste generation (in millions of tons per year) from the period 1960-2000. These estimates are presented in Table 3-2. Waste generation in the year 2000 is projected to be 2.1 times that in 1960.[2]

Management Practices for Municipal Solid Waste

Options available for the management of MSW include land disposal, ocean disposal, incineration with or without energy recovery and recovery of materials. The Characterization study[2] addresses three of the MSW management alternatives: municipal landfills, energy recovery, and materials recovery. The report estimates that 6.5 million tons of MSW per year are used for energy recovery, while the remaining 126.5 million tons are managed through landfills, ocean disposal, or incineration without energy recovery. Since ocean disposal and incineration without energy recovery are considered negligible relative to landfill disposal, 126.5 million tons per year can be accepted as an upper bound estimate of MSW disposal in landfills. In addition to the 133 million tons discarded in 1984, an estimated 15 million tons of MSW were recovered for materials.[2]

Table 3-2 provides estimates of MSW discarded and energy recovery of MSW for the period 1960-2000. In 1984, energy recovery accounted for 5 percent of the MSW discarded. In the year 2000, an estimated 20 percent will be used in energy production facilities.[2]

3.3 HOUSEHOLD HAZARDOUS WASTE

Household hazardous waste is generally discarded into the MSW stream, with a very small fraction diverted by special HHW collection programs. The characteristics, quantities, and management practices for HHW are discussed separately below.

TABLE 3-1. PAST AND PROJECTED TRENDS IN MUNICIPAL WASTE COMPOSITION [2]

Materials	1970		1984		2000	
	Million tons/yr	%	Million tons/yr	%	Million tons/yr	%
Paper and paperboard	36.5	33.1	49.4	37.1	65.1	41.0
Glass	12.5	11.3	12.9	9.7	12.1	7.6
Metals	13.5	12.2	12.8	9.6	14.3	9.0
Plastics	3.0	2.7	9.6	7.2	15.5	9.8
Rubber and leather	3.0	2.7	3.3	2.5	3.8	2.4
Textiles	2.2	2.0	2.8	2.1	3.5	2.2
Wood	4.0	3.6	5.1	3.8	6.1	3.8
Food wastes	12.7	11.5	10.8	8.1	10.8	6.8
Yard wastes	21.0	19.0	23.8	17.9	24.4	15.3
Other non-food product wastes	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous inorganic wastes	1.8	1.6	2.4	1.8	3.1	2.0
TOTAL	110.3	100	133.0	100	158.8	100

Table entries may not add to totals due to rounding.

TABLE 3-2. ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE, 1960 to 2000 [2]

Year	MSW Discarded (millions of tons)	Energy Recovery of MSW (millions of tons)	Energy Recovery of MSW (percent)
1960	76.4	0	0
1965	92.0	0.2	0.22
1970	110.2	0.4	0.36
1975	113.4	0.7	0.62
1980	125.5	2.7	2.15
1981	127.5	2.3	1.84
1982	124.7	3.5	2.89
1983	130.5	5.0	3.83
1984	132.7	6.5	4.90
1990	143.8	13.3	9.25
1995	154.7	22.5	14.54
2000	164.7	32.0	19.43

Characteristics of HHW

Household hazardous wastes are defined as wastes that meet the technical definition of hazardous wastes in RCRA (40 CFR Part 261) and are generated by households. According to Household Hazardous Waste[3], HHW are generated by disposal of products such as those listed in Table 3-3. This table was developed by scanning the ingredients listed on labels of household products for hazardous compounds. Where household products did not have ingredients labels that state the chemical ingredients and their concentrations, professional estimates of the chemical compositions were made. Included in this list are keys to the chemical characteristic responsible for a hazardous classification. Household items that are keyed as being "listed", contain compounds that are toxic or acutely toxic.

Quantities of Household Hazardous Waste

Four local government studies were reviewed to obtain information on quantities of HHW. Two studies[5,6] (both conducted by the Los Angeles County Sanitation District) involved sorting and weighing of MSW. One of these studies estimated that the fraction of HHW was less than 0.2 percent by weight; the other study estimated 0.0015 percent by weight. Although these results are extremely variable, they can be used to estimate a national HHW generation rate of between 1,000 to 100,000 tons per year. A third study,[7] conducted in Albuquerque, New Mexico employed a questionnaire to determine how much hazardous wastes a sample group of household members could recall discarding. Results from this study are limited because respondents may have based their answers on incorrect perceptions of hazardous materials. The fourth study, by the University of Arizona[8], reported numbers of hazardous waste items discarded per ton of MSW. Neither of the latter two studies offered data on the proportion, by weight, of HHW in the MSW stream.

Management Practices of HHW

The volumes of HHW managed by various disposal options are unknown. The major disposal options exercised by the public include management with MSW, and disposal into municipal sewer systems and septic tanks. As mentioned previously, the portion of HHW collected by special programs is very small. In a recent 3 year period, there have been on the order of 100 or more locally sponsored programs. Of these, it is estimated that less than 1 percent of the public participated.

3.4 MUNICIPAL SLUDGE

Municipal sludge includes both water and wastewater (sewage) treatment sludges. The EPA Office of Water Regulations and Standards (OWRS) maintains a database[14] on Publicly Owned Treatment Works (POTWs) which includes data on municipal sewage sludge characteristics, generation and disposal. The Characterization study[2] supplies additional data in these areas for sewage and water treatment sludge.

Biological processes are predominantly used for municipal sewage treatment methods and result in sludges that consist primarily of organic matter. If aerobic or anaerobic sludge digestion are used, the organic

TABLE 3-3. HAZARDOUS HOUSEHOLD WASTES AND THEIR CHARACTERISTICS [3]

Household Cleaners	
Drain openers	(C)[a]
Oven cleaners	(C)
Wood and metal cleaners and polishes	(I)
Toilet bowl cleaners	(C)
General purpose cleaners	(C or I)
Disinfectants	(C or I)
Automotive Products	
Oil and fuel additives	(I or E)
Grease and rust solvents	(I)
Carburetor and fuel injection cleaners	(I)
Air conditioning refrigerants	(Listed)
Starter fluids	(I or Listed)
General lubricating fluids	(I or E)
Radiator fluids and additives	(I)
Waxes, polishes, and cleaners	(I or C)
Body putty	(I)
Transmission additives	(I)
Home Maintenance Products	
Paint thinners	(I)
Paint strippers and removers	(I)
Adhesives	(I)
Paints	(I)
Stains, varnishes, and sealants	(I)
Lawn and Garden Products	
Herbicides	(E or Listed)
Pesticides	(E or Listed)
Fungicides or wood preservatives	(Listed)
Miscellaneous	
Batteries	(C or E)
Fingernail polish remover	(I)
Pool chemicals	(R)
Photo processing chemicals	(E, C, or I)
Electronic items	(E)

[a] I: Ignitable
C: Corrosive
R: Reactive
E: EP toxic

fraction of the sludge solids may be reduced by approximately 50 percent. The EPA OWRS has used the database of 15,300 POTWs to estimate that 7.6 million dry metric tons (8.4 million dry tons) of sludge are generated each year.[14] This data base also shows that sewage sludge is managed through incineration (20.3 percent), land application (25.4 percent), ocean disposal (6.6 percent), and lagooning and landfilling (46.4 percent, including 1.5 percent in monofills). Incineration produces a residue consisting primarily of an inorganic ash. This residue quantity is usually much smaller, by weight, than the original sludge and it is often landfilled.

Water treatment sludges (filter cake wastes, etc.), consist of a variety of organic and inorganic materials, including inorganics from coagulation and softening. Total water treatment sludge quantities are probably much smaller than those of sewage sludges. Filter cake sludge from water treatment is reportedly generated at the rate of 0.005 to 0.2 pounds per capita per day.[9] This equates to about 207 kilotons to 8,267 kilotons per year. Water treatment sludge may be landfilled or subjected to chemical recovery techniques.[2]

3.5 MUNICIPAL WASTE COMBUSTION ASH

Combustion residue is generated from industries, institutions, and other establishments that burn their own solid wastes, or from the burning of collected municipal solid wastes. The latter source of combustion residue is judged to be the largest and reflects incineration of approximately 5 percent of generated municipal solid waste in energy recovery (waste-to-energy) facilities.[2]

The quantity of ash depends on the incoming waste moisture content. Dry ash may represent only 20 percent of the weight of the unburned waste input, whereas wet ash may be as high as 45 percent of the waste input. Assuming an average residue weight of 30 percent of incinerated municipal solid waste, about 2.3 million tons of residue/year are disposed from currently operating waste-to-energy facilities in the United States.[2] Some additional tonnage is generated from municipal solid waste incinerators not practicing energy recovery and from those establishments that burn their own waste. Incinerator residue from this latter category is probably included in estimates of industrial process wastes or other industrial wastes.

Combustion residue has been stored on incinerator sites, and disposed of in monofills and MSW landfills. The fraction of combustion residue in municipal waste landfills is unclear. Tests of fly ash and bottom ash from municipal waste incinerators have shown that these residues often have high concentrations of heavy metals.

3.6 INDUSTRIAL WASTES

The principal source of data on industrial Subtitle D wastes is the report entitled Summary of Data on Industrial Nonhazardous Waste Disposal Practices.[12] This report, referred herein as the Industry Report, includes

a review of compiled available data on industrial nonhazardous wastes characteristics, generation rates. The study presents data on 22 major manufacturing industries, which generate an estimated 390 million metric tons of solid waste annually.

The set of industries selected for this study represents those that generate the largest amounts of nonhazardous waste, manage significant quantities of such wastes onsite, and have high levels of potentially toxic constituents in their waste streams. The characteristics, quantities and management methods for industrial Subtitle D wastes are discussed separately below.

Characteristics of Industrial Nonhazardous Waste

The characteristics of industrial nonhazardous wastes vary from industry to industry and within each industry. Table 3-4 lists the major waste types within each of 22 industries[12] and presents general waste characteristics from each industry with regard to the relative concentration of heavy metals or organics. Twelve of the 22 industries studied are expected to contain relatively high levels of heavy metals and organic constituents; five industries contain relatively moderate levels and the remaining five industries contain low levels.

Quantities of Industrial Waste Generated

Table 3-5 presents estimated waste generation rates for the industries covered in the Industry Report. Approximately 390 million dry metric tons of industrial nonhazardous wastes are generated annually, with almost 90 percent of the waste generated by the six highest ranked industries. About 99 percent of the wastes are generated by 12 industries. Table B-1 (Appendix B). presents the amount of wastes generated for each major waste type in each industry.

Management Practices of Industrial Nonhazardous Wastes

The Subtitle D Census[16] indicates 3,511 landfills, 16,232 surface impoundments, and 5,605 land application units received industrial nonhazardous wastes in 1984. The Industry Report shows that approximately 35 percent of industrial nonhazardous wastes (145 million dry metric tons/year) are managed in onsite landfills, surface impoundments, and land application units. Four industries, iron and steel, electric power generation, industrial organic chemicals, and plastic and resins, generate 75 percent of industrial nonhazardous wastes known to be managed onsite. The wastes generated by each industry are categorized according to disposal practice in Table 3-6. Table B-2 (Appendix B) adds description to these data, and quantities managed are further separated into the major waste types for each industry in Table B-1 (Appendix B).

3.7 SMALL QUANTITY GENERATOR WASTE

The National Small Quantity Hazardous Waste Generator Survey,[13] hereafter referred to as the SQG Survey, is the principal source of data on SQG wastes. The SQG Survey was conducted using a mail questionnaire and was designed to obtain national estimates of the number and type of SQGs and their

TABLE 3-4. INDUSTRIAL NONHAZARDOUS WASTES: MAJOR WASTE TYPES AND CHARACTERISTICS [12]

Industry	Waste type	Relative levels of heavy metals or organics in wastes
Electrical Machinery and Electronic Components (SIC 36)	Wastewater treatment sludges, plastics; oils; paint wastes.	High: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available.
Electric Power Generation (SIC 4911)	Bottom ash (coal); fly ash (coal); flue gas desulfurization (coal) sludge; boiler slag; fly ash (oil).	Moderate: This waste has a potential to reduce pH levels and release metals. Toxicity depends on the source of coal or oil being burned.
Fabricated Metal products (SIC 34)	Wastewater treatment sludge; spent air filters (painting); paint sludge.	High: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available.
Fertilizer and Other Agricultural Chemicals (SIC 2873-2879)	Waste gypsum; wet scrubber liquor; cooling water treatment sludge; WPPA sludge; spent catalyst; sulfur filter cakes; pesticide manufacturing wastes.	High: Waste gypsum piles may cause local pH and metals contamination problems. Pesticide wastes may release organics and heavy metals.
Food and Kindred Products (SIC 20)	Paunch manure; meat sludge; liquid whey; unusable food; soil and trash; non-food waste; grain mill sludge; soil (sugar products); lime mud (sugar products); excess bagasse; spent bleaching earth; fat/oil sludge; non-food fat/oil waste; liquor stillage; unused seafood portions.	Low: Most food industry wastes are biodegradable, but many cause taste and odor problems.
Industrial Inorganic Chemicals Industry (SIC 2812-2819)	Brine muds; salt tailings; red mud; phosphate dust; Na ore residues; lime particulates; gypsum; iron oxide wastes; Li ore residues; bauxite ore wastes; sulfuric ore waste; calcium wastes; insoluble ore residues.	High: Most nonhazardous wastes from this industry do not appear to contain heavy metals, but there are insufficient analytical data on these wastes.
Industrial Organic Chemicals (SIC 2819)	Process wastewater; equipment washdown; steam jet condensate; non-process wastewater; spent scrubber wastes; sludges; precipitates/filtration residues; decantate/filtrate; spent adsorbent; spent catalyst; spent solvent; heavy ends; light ends; off-spec products; containers; liners; rags; treated solids; by-products; other.	High: Many of the waste streams in this industry contain high levels of extremely toxic organic chemicals.

(continued)

TABLE 3-4 (continued)

Industry	Waste type	Relative levels of heavy metals or organics in wastes
Leather and Leather Products (SIC 31)	Trimmings and shavings; unfinished leather trim; buffing dust; finished leather trim; finishing residues; wastewater sludge; miscellaneous solid wastes.	Moderate: These wastes generally contain chromium, but it is generally in the +3-valence state.
Lumber and Wood Products, and Furniture and Fixtures (SIC 24 and 25)	Bark and wood wastes; wood ash; wood preserving sludges; wastewater sludges; paint waste; solvent waste.	Moderate: Most of the wastes (380 million MT/year) from this industry are composed of wood dust, chips, shavings, and other rejects, and most of these wastes are burned or reused.
Machinery Except Electrical (SIC 35)	Plastics and ceramics; fluxes; oils; wastewater treatment sludge; paint sludge.	High: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available.
Pulp and Paper Industry (SIC 26)	Wood wastes; chemical recovery wastes; pulp rejects; wastewater sludges; coal and bark ash; waste paper rejects.	Moderate: Organic pollutants from wood fibers may be significant. Also, coal and bark ash may contain metals. Sulfates and metals are high in some pulping wastes.
Petroleum Refining Industry (SIC 29)	Biological sludge; FCC catalyst; non-leaded tank sludge; primary O/S/W separator sludge; Stretford solution; HF alkylation sludge; spent catalysts; cooling tower sludge; treating clays; secondary O/S/W separator sludge.	High: These wastes generally contain high levels of sulfides, ammonia, phenols, and oils. Some of them also contain mercaptains, benzo-a-pyrene, and other toxic organics.
Pharmaceutical Industry (SIC 2831 to 2834)	Biological sludge; filter aid; carbon sawdust, mycellium, wet plant material; fused plant steroid ingots; extracted animal tissue; fats and oils; filter cake; returned goods. Glass, paper, wood aluminum, and rubber scrap.	Low: The majority of these wastes are fermentation products and are biodegradable.
Plastics and Resins Manufacturing (SIC 2821)	Decantates/filtrates; sludges; off-spec. products; spent solvents; light ends; miscellaneous solids; precipitation/filtration residues; heavy ends; process wastewater; equipment washdown; steam jet condensate; spent scrubber water; non-process wastewater.	High: Many of the waste streams in this industry contain organic solvents and unreacted monomers, which are frequently toxic.

(continued)

TABLE 3-4 (continued)

Industry	Waste type	Relative levels of heavy metals or organics in wastes
Primary Iron and Steel Manufacturing and Ferrous Foundries (SIC 3312-3321)	Coke breeze; blast furnace slag; blast furnace dust; blast furnace sludge; EAF slag; EAF dust and sludge; open hearth slag; continuous casting scale; continuous casting sludge; soaking pit scale; primary mill scale; primary mill sludge; rolling scale (hot and cold); rolling sludge (hot and cold); pickle liquor sludge; galvanizing sludge; tin plating sludge; bricks and rubble; fly ash and bottom ash; foundry sand and other wastes.	High: Many of the wastes from this industry are low in pH and may release significant quantities of heavy metals.
Primary Non-Ferrous Metals Manufacturing and Non-Ferrous Foundries (SIC 3330-3399)	Primary aluminum wastes; primary copper wastes; primary zinc wastes; primary lead wastes; foundry sand and other wastes.	High: Several of the waste streams contain high levels of heavy metals.
Rubber and Miscellaneous Plastic Products (SIC 30)	Tire/inner tube waste streams; rubber and plastics footwear waste streams; reclaimed rubber waste streams; rubber and plastics hose, and belting waste streams; fabricated rubber products NEC waste streams; miscellaneous plastic products waste streams.	High: Data are sketchy, but indicate possibly significant levels of elastomers, carbon black, plastic resins, plasticizers, and pigments.
Soaps; Other Detergents; Polishing, Cleaning, and Sanitation Goods (SIC 2841-2842)	Lost product; tower cleanouts; sludges; dust and fines.	Low: Most of these wastes are composed of packaging, lost products, salts, inerts. Some organics are generated from floor polishes (plasticizers) and pine oils (solvents).
Stone, Clay, Glass, and Concrete Products (SIC 32)	Silica particulates; spent diatomaceous earth; soda ash; lime; brine residues; air pollution control sludge (clay); lubricants; pottery sludge; air pollution control sludge (concrete, gypsum and plaster); waste cullet; fiber resin masses.	Low: Most of the wastes produced are inert, earth-type materials. However, significant quantities of pollution control sludges are generated, some of which may contain heavy metals.
Textile Manufacturing (SIC 22)	Wastewater treatment sludge; wool scouring wastes; clippings; dye containers; dry flick; waste fiber.	Low: Waste descriptions indicate low organics and heavy metals, but there are virtually no analytical data to confirm this assumption.
Transportation Equipment (SIC 37)	Solvents; paint wastes; metal treating wastes.	High: Wastes are expected to be similar in quantity and composition to those generated within SIC 34 and 35.
Water Treatment (SIC 4941)	Coagulation sludges; softening sludges.	Low: These wastes are composed mainly of alum and lime, but may contain some heavy metals.

TABLE 3-5. LISTING OF INDUSTRIES BY ESTIMATED ANNUAL AMOUNTS OF NONHAZARDOUS WASTE GENERATED[a] [12]

Industry	Waste quantity (dry metric tons)	Percent of total
Industrial organic chemicals (SIC 2819)	97,354,100[b,c]	24.8
Primary iron and steel manufacturing and ferrous foundries (SIC 3312-3325)	60,679,000[b]	15.5
Fertilizer and other agricultural chemicals (SIC 2873-2879)	59,037,400[b]	15.0
Electric power generation (SIC 4911)	55,878,000[b]	14.2
Plastics and resins manufacturing (SIC 2821)	44,991,700[b,d]	11.5
Industrial inorganic chemicals industry (SIC 2812-2819)	26,191,800[b]	6.7
Stone, clay, glass, and concrete products (SIC 32)	>18,600,000	4.7
Pulp and paper industry (SIC 26)	8,627,000[e]	2.2
Primary non-ferrous metals manufacturing and non-ferrous foundries (SIC 3330-3399)	6,575,000[b]	1.7
Food and kindred products (SIC 20)	6,361,500[f]	1.6
Water treatment (SIC 4941)	4,960,000	1.3
Petroleum refining industry (SIC 29)	1,276,400	0.3
Rubber and miscellaneous plastic products (SIC 30)	542,600[b]	0.1
Transportation equipment (SIC 37)	520,000	0.13
Fabricated metal products (SIC 34)	300,000	0.08
Pharmaceutical preparations (SIC 2834)	256,900	0.07
Machinery, except electrical (SIC 35)	>193,500[g]	0.05

(continued)

TABLE 3-5 (continued)

Industry	Waste quantity (dry metric tons)	Percent of total
Lumber and wood, and furniture and fixtures (SIC 24 and 25)	>122,700[b,h]	0.03
Textile manufacturing (SIC 22)	>45,000	0.01
Soaps; other detergents; polishing, cleaning, and sanitation goods (SIC 2841-2842)	31,300[b]	0.01
Leather and leather products	24,600	0.01
Electrical machinery and electronic components (SIC 36)	10,400[i]	0.01
Total:	392,579,900	

[a]Estimates do not include wastes that are discharged to publicly-owned treatment works (POTW) or recycled unless they are sometimes stored or treated in waste piles, or surface impoundments prior to recycling.

[b]Dry or wet weight not specified; assume wet weight.

[c]36,164,800 when aqueous wastes are not counted.

[d]8,643,400 when aqueous wastes are not counted.

[e]6,081,000 when aqueous wastes are not counted.

[f]Wet weight.

[g]Includes only wastes from SIC 355 and 357 (representing 12 percent of total sales).

[h]The total amount of wastes in this industry is large, however, most of the wastes are recycled; no quantities on total waste generation are available. The quantity shown above may include significant quantities of hazardous waste.

[i]Data on waste types and amounts were available only for SIC 367 (represents only 2 percent of total value of 1976 product shipments from the industry).

TABLE 3-6. EXISTING QUANTITATIVE DATA ON INDUSTRIAL MANAGEMENT OF NONHAZARDOUS WASTES [12]

Quantities of Nonhazardous Wastes Managed (Dry Metric Tons)[a]

Industry[b]	Onsite				Offsite	
	Landfill	Surface impoundment	Land applications	Other	Land disposal	Other
Electric power generation (SIC 4911)	NA[c]	28,497,800[d]	NA	NA	NA	NA
Fertilizer and other agricultural chemicals (SIC 2873-2879)	187,800	8,640,800[d]	NA	39,487,900[e]	1,502,700	12,961,200[d,h]
Food and kindred chemicals (SIC 20)	NA	NA	NA	NA	NA	NA
Industrial organic chemicals (SIC 2819)	1,668,000	38,058,700[d]	255,700	22,418,500[d]	1,369,500	59,662,700[d]
Leather and leather products (SIC 31)	1,200	1,200	NA	NA	12,300	9,800
Machinery, except electrical (SIC 35)	NA	NA	NA	19,300[g]	135,500	38,700[g]
Pulp and paper industry (SIC 26)	5,962,300	579,700	NA	862,700	NA	NA
Petroleum refining industry (SIC 29)	NA	NA	753,300	NA	523,500[f]	NA
Pharmaceutical preparations (SIC 2834)	NA	NA	NA	NA	219,400	NA
Plastics and resins manufacturing (SIC 2821)	378,500	30,513,700[d]	43,200	26,146,400	392,400	34,914,600[h]
Primary iron and steel manufacturing and ferrous foundries (SIC 3312-3321)	14,563,000	14,563,000	NA	39,441,400[e]	NA	NA
Primary non-ferrous metals manufacturing and non-ferrous foundries (SIC 3330-3399)	233,900	147,300	NA	NA	78,000	NA
Totals:	22,994,700	121,002,200	1,052,200	128,376,200	4,233,300	107,587,000

[a]Wastes managed in surface impoundments and land application units are reported in wet metric tons.

[b]Includes only industries for which there are estimated quantities of wastes being managed by the above listed methods. The quantities listed above may represent the entire industry or only one waste stream within an industry.

[c]NA = Data not available.

[d]Dry or wet weight not specified; assume wet weight.

[e]Mostly waste piles.

[f]Mostly land application.

[g]Management method unknown.

[h]Mostly discharges to POTWs and surface waters.

waste generation and management practices. The detailed results of the survey (presented in Tables 3-7 and 3-8) address 22 primary industries and 27 targetted wastes, accounting for 378,000 of the estimated 630,000 generators and 598,000 of the estimated 940,500 metric tons of hazardous waste generated annually. Results distinguish between SQGs of between 100 and 1,000 kg/month of hazardous waste and SQGs of less than 100 kg/month (which are conditionally exempt from Subtitle C regulations). The "conditionally exempt" SQGs are referred to hereafter as very small quantity generators, or VSQGs.

Additional information on the types and amounts of SQG hazardous wastes is available from an extensive survey of small quantity generators and municipal landfills in Florida. [15] These data also include some waste quantities from large quantity generators.

Characteristics of SQG Waste

The SQG waste streams in the industries addressed in the SQG survey are presented in Table 3-7. This table indicates that used lead acid batteries represent the largest waste quantity and the largest number of generators, in both VSQG and other SQG categories. Other significant wastes are spent solvents, dry cleaning filtration residues and photographic wastes.

There are an estimated 600,000 to 660,000 SQGs of hazardous waste in the United States representing 98 percent of the total number of hazardous waste generators.[13] Nearly 85 percent of these generators are in nonmanufacturing industries, including fifty percent in vehicle maintenance and 10 percent in construction. Other nonmanufacturing establishments include laundries, photographic processors, equipment repair shops, laboratories, and schools. The remaining 15 percent of SQGs are manufacturing establishments, with two-thirds of these in metal manufacturing and the remaining generators in manufacturing industries such as printing, chemical manufacturing, and textile manufacturing.[13] Table 3-8 presents SQG waste generation by industry.

Very small quantity generators constitute 72 percent of the SQGs. The industry distribution of VSQGs differs from that of other SQGs. Vehicle maintenance and nonmanufacturing establishments are more heavily concentrated among VSQGs. Table 3-8 shows that generators from service related industry groups such as pesticide end users and application services, laundries, equipment repair shops, construction, furniture, printing, education establishments, and wholesale and retail establishments are also more heavily concentrated in the VSQG category. In contrast, a relatively large number of generators engaged in chemical manufacturing, wood preserving, textile manufacturing, cleaning agent manufacturing, and paper products are non-exempt SQGs.[13]

Quantities of SQG Waste Generated

Small quantity generators are estimated to generate about 940,000 metric tons of hazardous waste annually, which is 0.05 percent of the total quantity of hazardous waste.[13] Approximately 598,000 metric tons of wastes are generated by the industry group studied in more detail in the SQG survey.

TABLE 3-7. NUMBER OF SMALL QUANTITY GENERATORS AND WASTE QUANTITY GENERATED BY WASTE STREAM [13]

Waste Stream	VSQGs: Generators of <100 kg of waste/month		Other SQGs: Generators of 100 kg to 1,000 kg of waste/month		Total SQGs	
	Number of generators	Waste quantity (MT/yr)	Number of generators	Waste quantity (MT/yr)	Number of generators	Waste quantity (MT/yr)
Arsenic wastes	21	7	19	104	40	111
Cyanide wastes	587	17	1,384	2,129	1,972	2,146
Dry cleaning filtration residues	13,168	5,151	2,540	8,509	15,708	13,660
Empty pesticide containers	9,809	1,293	1,963	2,366	11,772	3,659
Heavy metal dust	48	10	40	163	88	173
Heavy metal solutions	15	6	30	52	45	58
Heavy metal waste materials	121	31	117	537	238	568
Ignitible paint wastes	12,788	1,841	3,122	4,872	15,910	6,713
Ignitible wastes	8,951	909	2,873	7,576	11,824	8,485
Ink sludges containing chromium or lead	1,093	90	83	127	1,176	217
Mercury wastes	19	1	0	0	19	1
Other reactive wastes	1,133	88	497	1,090	1,630	1,178
Paint wastes containing heavy metals	381	12	156	7	537	19
Pesticide solutions	3,027	1,047	1,747	5,022	4,774	6,069
Photographic wastes	21,287	4,408	4,949	14,023	26,236	18,431
Solvent still bottoms	2,114	114	738	1,863	2,852	1,977
Spent plating wastes	3,960	493	1,422	5,275	5,382	5,768
Spent solvents	77,629	19,445	33,475	85,923	111,104	105,368
Solutions of sludges containing silver	4,482	938	2,648	7,981	7,130	8,919
Strong acids or alkalies	13,739	1,970	10,480	27,821	24,219	29,791
Used lead-acid bateries	119,747	64,903	77,880	304,194	197,627	369,097
Waste formaldehyde	11,930	3,454	2,014	5,396	13,944	8,850
Waste inks containing flammable solvents of heavy metals	3,642	263	718	1,359	4,360	1,622
Waste pesticides	2,852	400	990	857	3,842	1,257
Wastewater containing wood preservatives	88	26	108	693	196	719
Wastewater sludges containing heavy metals	894	188	79[illegible]	2,216	1,684	2,404
Wastes containing ammonia	1,154	96	100	271	1,254	367
Total:	264,895	107,198	113,086	490,427	377,981	597,625

TABLE 3-8. NUMBER OF SMALL QUANTITY GENERATORS BY INDUSTRY GROUP AND QUANTITY OF WASTE GENERATED [13]

Industry	VSQGs: Generators of <100 kg of waste/month		Other SQC Generators of<100 kg to 1,000 kg of waste/month		Total SQGs	
	Number of generators	Percent of generators	Number of generators	Percent of generators	Number of generators	Waste quantity (MT/yr)
Pesticide end users	1,392	86	231	14	1,623	1,122
Pesticide-application services	7,786	82	1,660	18	9,444	8,444
Chemical manufacturing	362	48	391	52	753	2,373
Wood preserving	86	45	107	55	193	715
Formulators	507	57	395	43	902	2,333
Laundries	13,131	84	2,515	16	15,646	13,418
Other services	13,913	85	2,409	15	16,322	10,706
Photography	6,538	70	2,817	30	9,355	18,052
Textile manufacturing	149	54	124	46	272	650
Vehicle maintenance	142,105	63	82,528	37	224,632	427,287
Equipment repair	1,526	85	269	15	1,795	943
Metal manufacturing	26,245	70	11,076	30	37,320	64,652
Construction	11,561	91	1,117	9	12,677	5,033
Motor freight terminals	103	70	45	30	148	161
Furniture/wood manufacture and refinishing	2,776	83	579	17	3,355	3,703
Printing/ceramics	21,190	86	3,450	14	24,640	18,307
Cleaning agents and cosmetic manufacturing	277	51	265	49	543	1,569
Other manufacturing	1,618	63	946	37	2,564	5,361
Paper industry	98	54	83	46	181	544
Analytical and clinical laboratories	5,123	80	1,286	20	6,409	7,171
Educational and vocational establishments	3,239	93	241	7	1,179	
Wholesale and retail establishments	5,156	90	575	10	5,731	3,876
Total:	264,895	70	113,086	30	377,981	597,625

Sixty-two percent (3700,000 metric tons/year) of the waste generated by SQGs are used lead-acid batteries; 18 percent (105,000 metric tons/year) are solvents; and 5 percent (30,000 metric tons/year) are acids and alkalies. Table 3-7 presents the generation rates of various types of VSQG and other SQG wastes.[13]

Very small quantity generators generate about one-fifth of all SQG hazardous waste. Small quantity generator waste quantities generated by the 22 primary industries are presented in Table 3-8. Vehicle maintenance and metal manufacturing are the most numerous and generate the most waste in both SQG categories.

Management Practices of SQGs

Most SQG waste is managed offsite (85 percent) and much of it (65 percent) is recycled offsite (Table 3-9). Much of the offsite recycling involves lead acid batteries. Eighteen percent of SQG waste is managed onsite, with 8 percent going to RCRA-exempt disposal into public sewers. Some SQG waste is treated onsite and then managed offsite.

Waste management practices by VSQGs differ somewhat from those of other SQGs. A lower percentage of VSQGs recycle their waste, both onsite and offsite. Of those VSQGs that manage waste onsite, only 23 percent recycle waste, compared to 39 percent of the other SQGs. Among those that ship waste offsite, only 61 percent of the VSQGs send it to recycling facilities, while 78 percent of the SQGs send it to recycling facilities.

The Florida hazardous waste generators and sanitary landfill study[15] presents an extensive database on characteristics of SQGs and municipal landfills in Florida. Summary statistics include quantities and percentages of hazardous wastes (virtually all SQG wastes) disposed by various means.[5] Although the SQG Survey presents data in a similar fashion, the numbers cannot be directly compared due to the fact that disposal categories are set up differently.

The State Subtitle D Census[16] solicited estimates of the numbers of Subtitle D landfills that receive SQG wastes. As shown in Table 3-10, the respondants estimated that 5,075 of the reported 16,416 Subtitle D landfills receive SQG waste and over half (53 percent) of municipal waste landfills receive SQG wastes. Much lower percentages of the other types of landfills are believed to receive these wastes. The Census estimated that 9.6 percent of land application units and 14.5 percent of surface impoundments receive SQG wastes.

3.8 CONSTRUCTION AND DEMOLITION WASTES

Solid wastes from construction and demolition of structures include mixed lumber, roofing and sheeting scraps, broken concrete, asphalt, brick, stone, plaster, wallboard, glass, piping, and other building materials. The exact nature of construction and demolition wastes depends upon the type of structures involved, and varies with geographical location, and the age and size of a community.

TABLE 3-9. DISTRIBUTION OF OFFSITE AND ONSITE MANAGEMENT PRACTICES FOR SQG WASTES [13]

	Approximate amount of waste (MT/year)	Percent of waste	Percent of generators
Off-Site			
Recycling	377,000	65	52
Solid waste facility	29,000	5	14
Subtitle C facility	23,000	4	4
Unknown	64,000	11	13
		85	
On-Site			
Public sewer	46,000	8	14
Recycling	35,000	6	8
Treatment	23,000	4	6
	598,000	18	

Note: Percentages do not add to 100 due to multiple management practices.

Source: Estimates based on Small Quantity Generator Survey data: 378,000 small quantity generators provides detailed information for targeted wastes - 598,000 MT/year of waste.

TABLE 3-10. ESTIMATED LAND DISPOSAL FACILITIES RECEIVING SQG WASTE [16]

	Reported number of facilities	Response Rate (percent)	Estimated percentage of facilities receiving SQG waste	Reported number of facilities receiving SQG waste
Landfills				
Municipal	9,284	88	52.9	4,327
Industrial	3,511	83	12.3	360
Demolition debris	2,591	89	13.5	312
Other	1,030	28	26.7	76
Subtotal	16,416	84	37.1	5,075
Land Application Units				
Municipal sewage sludge high rate	(242)	--	(16.4)	(33)
Municipal sewage sludge low rate	(9,779)	--	(11.2)	(1,050)
Total Municipal sewage total[a]	11,937	92	12.6	1,382
Industrial waste	5,605	95	3.1	164
Oil or gas waste	726	57	5738.1	101
Other	621	100	0	0
Subtotal	18,889	90	9.6	1,647
Surface Impoundments				
Municipal sewage sludge	1,938	75	37.6	548
Municipal runoff	488	77	41.5	157
Industrial waste	16,232	65	14.7	1,541
Agricultural waste	17,159	79	0.7	88
Mining waste	19,813	59	7.0	824
Oil or gas waste	125,074	77	18.5	17,746
Other	11,118	99	0.1	5
Subtotal	191,822	75	14.5	20,909

[a]High rate application and low rate application may not equal the total municipal sewage sludge figures because some states do not distinguish between high and low rate land application units.

The quantities of demolition and construction wastes reported in various locations across the nation range from 0.12 to 3.52 lbs per capita per day (pcd).[17] An urban average of 0.72 pcd was reported from 1970 data.[18] A California study reported 0.27 pcd for communities under 10,000 people, 0.68 pcd for communities between 10,000 and 100,000 people, and 1.37 pcd in communities of over 100,000 people.[19] A study of waste generation in the Kansas City area estimated quantities of demolition and construction wastes at about 0.6 pcd.[19]

At an average of 0.72 pcd[2], the total quantity of construction and demolition wastes generated in the United States is estimated at about 31.5 million tons/year. This is about 24 percent as much as the municipal solid waste disposed of in 1984.[2]

Management options for construction and demolition wastes include municipal, industrial, and demolition debris landfills and waste piles. The fraction of construction and demolition wastes received at any of these facilities is unknown. Since most of these wastes are generally viewed as requiring less stringent disposal than MSW, special demolition debris landfills are often used.[2]

3.9 AGRICULTURAL WASTES

Agricultural wastes include animal wastes from feedlots and farms, crop production wastes, irrigation wastes, and collected field runoff. Not all agricultural wastes are regulated by RCRA. Irrigation return flows and agricultural wastes (manures and crop residues) which are returned to the soil as fertilizers or soil conditioners are exempt from regulations under RCRA. High concentrations of nitrates, pesticides, herbicides, and fertilizers are common in agricultural wastes.

The best available information on Subtitle D agricultural waste types and volumes is that which has been collected on agricultural surface impoundments.[16,20] The Surface Impoundment Assessment National Report[20] counted agricultural SIs and categorized them by the type of agricultural production facility but did not report the waste input rates. The number of SIs are listed below to give a measure of the characteristics of agricultural waste:

Agricultural Production Facility	Number of SIs
Crop production	190
Cattle feedlot	2,974
Hogs	3,492
Livestock, general	5,333
Dairy farms	4,732
Poultry farms	717
Other fur bearing animals	336
General farms	1,208
Fish hatcheries	95

The Subtitle D Census[16] reported that 93 percent of agricultural SIs receive 50,000 or fewer gallons per day. According to the National SI report, there were 19,167 active agricultural SIs. (Note, the National SI report specifically inventoried SIs. The Subtitle D Census[16] mail survey reports a somewhat smaller number of agricultural SIs.) Assuming that the average agricultural SI receives less than 50,000 gallons per day, one billion gallons per day is an upper limit to the amount of agricultural waste disposed into SIs.

3.10 OIL AND GAS WASTES

Oil and gas wastes consist of brines and drilling muds which are characterized by high concentrations of chloride, total dissolved solids, barium, sodium , and calcium. These wastes are the subject of an ongoing EPA study scheduled for completion in the near future. That study is noted in the discussion of Phase II studies in Section 6.

The information on Subtitle D oil and gas waste volumes is limited to that which has been collected on oil and gas surface impoundments.[16,20] The Subtitle D Census[16] reported that 85 percent of oil and gas SIs receive 50,000 or fewer gallons per day. According to the Census, there were 125,074 active oil and gas SIs. (This number is far greater than the 64,951 SIs reported in the National SI Assessment.)[20] Assuming that the average oil and gas SI receives less than 50,000 gallons per day, 6.25 billion gallons per day is an upper limit to the amount of oil and gas waste stored in SIs.

3.11 MINING WASTES

Mining wastes included as RCRA solid wastes are the products of activities such as crushing, screening, washing, and flotation. High concentrations of heavy metals, sulfate, sodium, potassium, and cyanide can be present. A significant portion of mining wastes are not regulated by RCRA, specifically, any mining overburden that is returned to the mine site. EPA has recently completed a report to Congress[21] on mining wastes (other than coal mining wastes) and is continuing to gather data to support rulemaking efforts. Those efforts are noted in the discussion of Phase II studies in Section 6.

The EPA report to Congress on mining wastes,[21] issued in December 1985, indicated that 1.4 billion short tons of mining wastes (other than coal mining wastes) are produced each year. Of these, only 1 percent (12 million tons) are hazardous under current RCRA criteria. The National SI Assessment[20] counted mining SIs and categorized them by the material mined but did not report the rates of waste input. The numbers of SIs are listed below to give a qualitative measure of the characteristics of mining waste.

Material Mined	Number of SIs
Metals	1,754
Anthracite	459
Bituminous coal & lignite	19,891
Non-metals	2,272
Total	24,376

The Subtitle D Census[16] categorized mining SIs by waste flow amounts. Because the Assessment reports only a fourth (6,053) of the number of SIs that the National SI reports, and because those counted by the Census may not be representative of mining SIs, a rough estimate of the amount of mining wastes flowing into SIs was not generated. The report to Congress[21] found that most mining waste disposal sites are not hazardous due, in part, to the tendency toward locating in remote areas with dry climates and deep water tables.

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SECTION 4

FACILITIES CHARACTERIZATION

This section presents Phase I study data on Subtitle D landfills, surface impoundments, land application units, and waste piles. The presentation is oriented toward statistics on Subtitle D facility numbers and characteristics. The principal source of this information is the Subtitle D Census.[1]

According to the Subtitle D Census[1], there are 227,000 Subtitle D facilities in the United States, 85 percent of which are surface impoundments. Land application units and landfills make up the remaining 8 percent and 7 percent of the universe respectively. There are also 120,000 establishments which contain one or more Subtitle D facilities. Table 4-1 and Figure 4-1 describe this universe of Subtitle D facilities.

4.1 NEED FOR FACILITIES ASSESSMENT

The major objective of the Subtitle D study is to collect data to assess the adequacy of current Subtitle D Criteria to protect human health and the environment from ground water contamination. The adequacy of the current Criteria can be judged, in part, by evaluating their effectiveness in ensuring that Subtitle D facilities are designed and operated in a manner that protects human health and the environment. As part of this effort, the facilities assessment detailed in this section summarizes the Phase I data on the general profiles, design and operating characteristics, and environmental impacts of nonhazardous waste disposal facilities in the United States.

This section uses the State Subtitle D Census[1] as its primary source of information. Data from other Subtitle D program efforts and other non-program data are used when Census data are not available. Nonresponse to survey questions was a significant problem with the Subtitle D Census data. This factor contributed to underestimates for many of the numbers listed in the Census. In an effort to verify the data quality obtained, Census respondents were asked to indicate whether they felt the quality of their data was good, fair, poor, or very poor. The data quality for Subtitle D facilities was found to vary markedly by facility type. Municipal landfill data were found to be the highest quality while industrial surface impoundment data were found to be the lowest.

TABLE 4-1. UNIVERSE OF SUBTITLE D FACILITIES[a] [1]

Facility Type	Number of units	Number of estiablishments
Landfills	16,416	15,719
Surface Impoundments	191,822	108,383
Land Application Units (LAUs)	18,889	12,312
Waste Piles	No Data	No Data
TOTAL	227,127	128,128[b]

[a]16% (or approximately 36,000 facilities) are estimates to receive hazardous wastes from households or small quantity generators.

[b]This is the correct total. The numbers for each type of facility do not add to this total since two or more facility types may exist at an establishment.

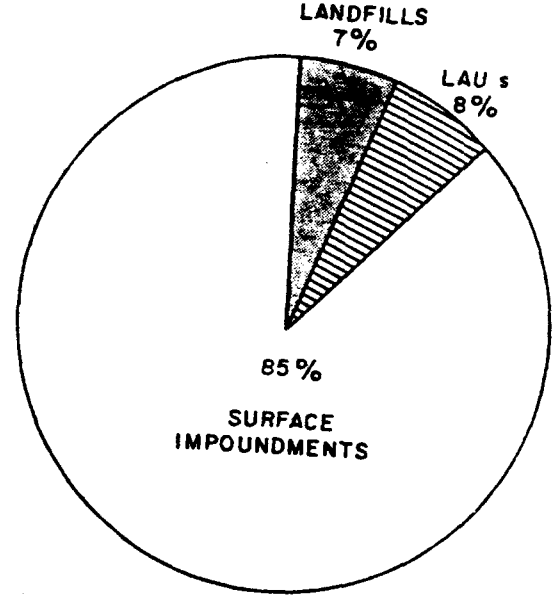


Figure 4-1. Universe of Subtitle D facilities, by percent. [1]

4.2 LANDFILLS

This part presents data on Subtitle D landfills. The topics covered include general profile, leachate and gas characteristics, landfill design and operation, and environmental and human health impacts of landfills.

4.2.1 GENERAL PROFILE

For purposes of the Subtitle D Census[1] data collection, landfills were defined as:

> A part of an establishment at which waste is placed in or on land and which is not a land application unit, a surface impoundment, an injection well, or a compost pile.

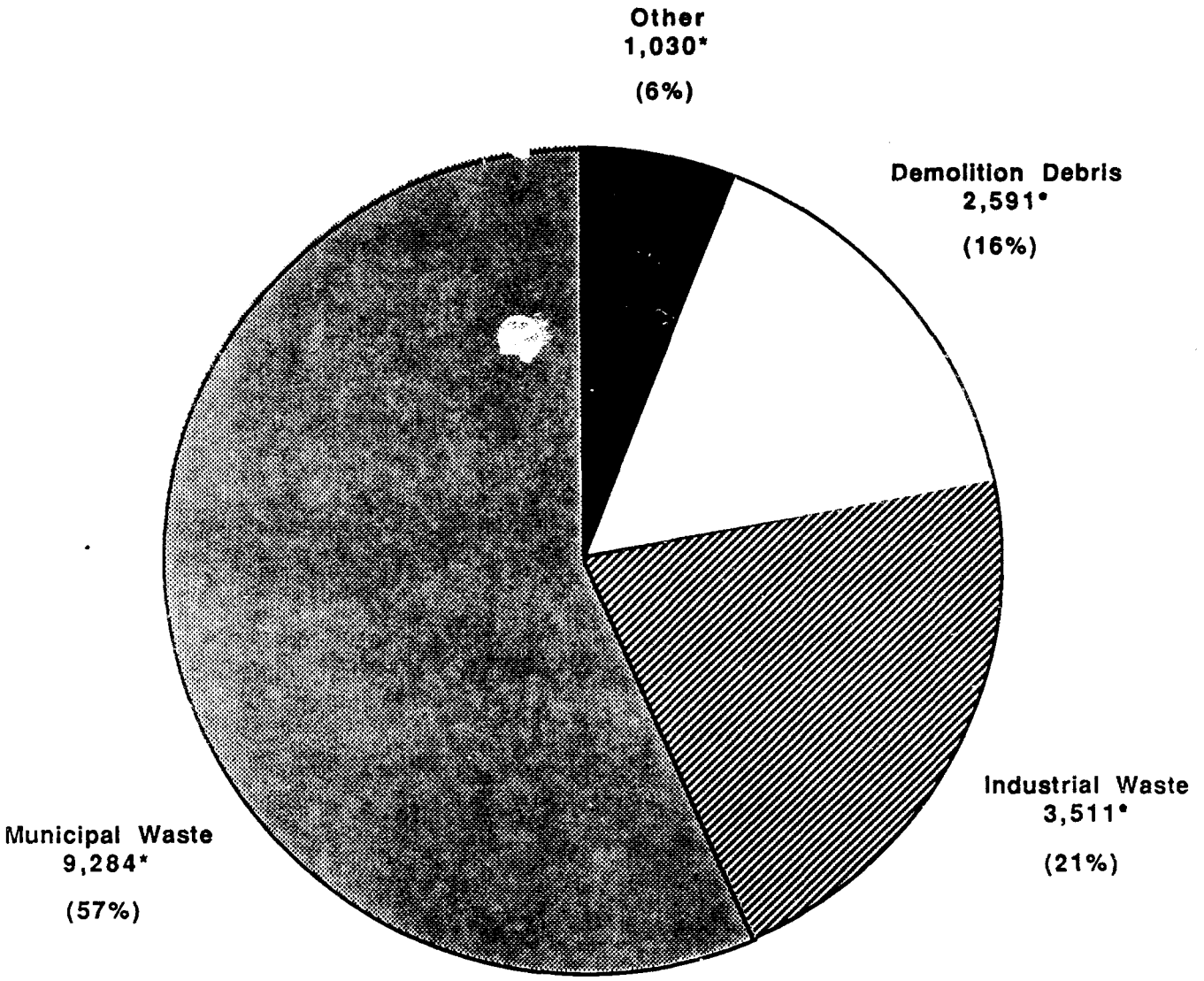
The Census subdivided landfills into the following classes:

- Municipal waste landfills primarily receive household refuse and nonhazardous commercial waste. These may also receive a limited amount of other types of Subtitle D waste, such as municipal sewage sludge and industrial wastes.
- Industrial waste landfills receive nonhazardous waste from factories, processing plants, and other manufacturing activities.
- Demolition debris landfills receive only construction or demolition debris.
- Other landfills receive Subtitle D waste and do not fall into any of the above categories (for example, receive only municipal sewage sludge).

In general, the data quality for municipal waste landfills was rated as good by the respondents of the Census. Industrial waste estimates are thought to be underestimated to an unknown degree because some States do not have permitting requirements for onsite industrial waste landfills. Estimates for demolition debris landfills are believed to fall between the high quality of the municipal waste landfills data and the lower quality of the industrial waste estimates.

Landfill Numbers, Ownership, Acreage, Waste Volumes, and Capacity Status

Census results indicate that in 1984 there were 16,416 active Subtitle D landfills located at 15,719 establishments across the United States. More than half of the landfills identified were municipal landfills. Figure 4-2 portrays the number and relative share of the total for each of the four types of landfills. The distribution among States and Territories is shown in Figure 4-3. West Virginia reported the largest number of Subtitle D landfills (1,209), followed by Pennsylvania (1,204), Texas (1,201), Wisconsin (1,033), Alabama (800), Alaska (740), and California (720).



*No estimates of industrial waste landfills were obtained for MA or MT; and no estimates of demolition debris landfills were obtained for OH.

Figure 4-2. Number of Subtitle D landfills, by type. [1]

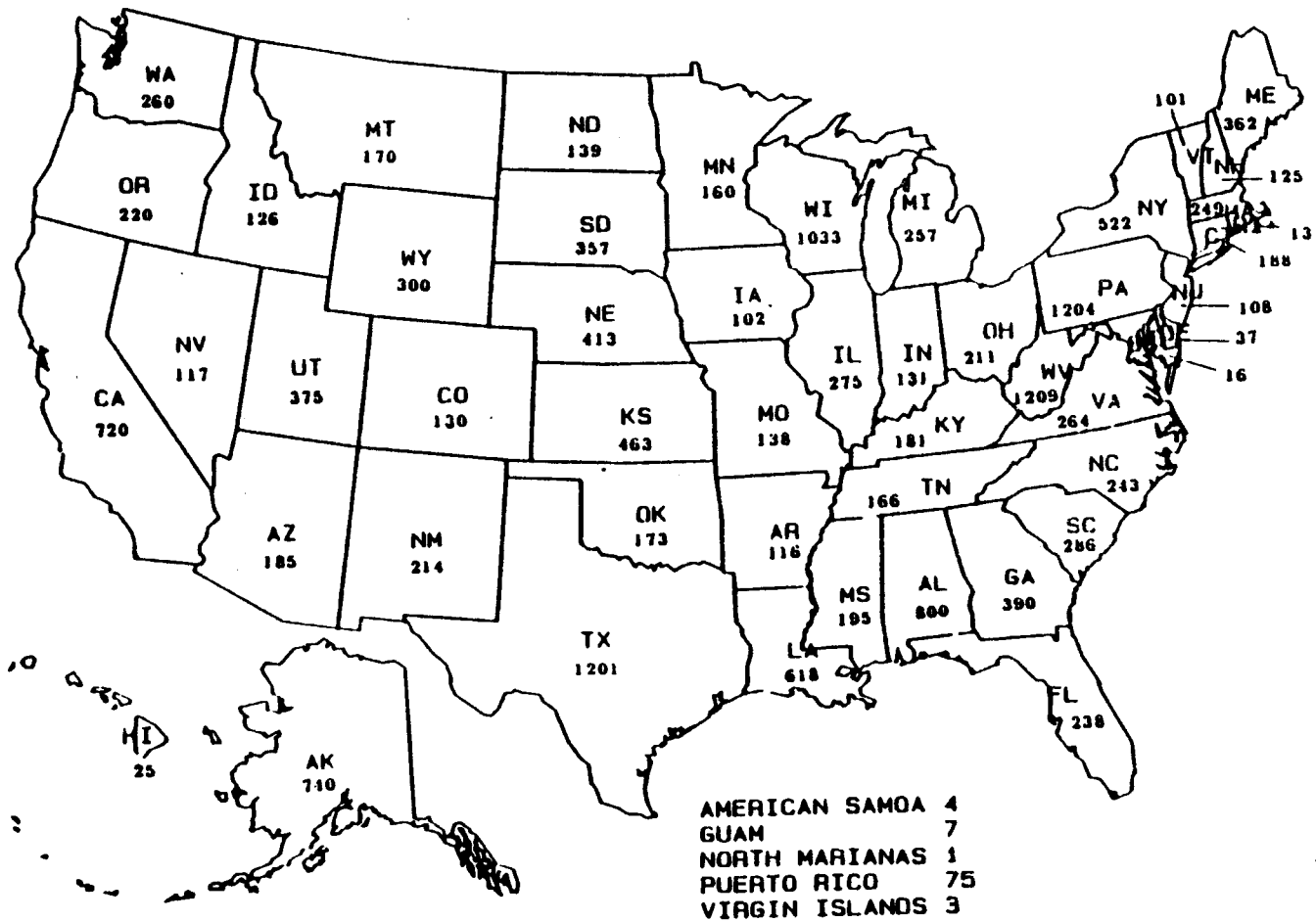


Figure 4-3. Number of Subtitle D landfills by State. [1]

Ownership data were reported for 15,578 (94.9 percent) of the Subtitle D landfills. Just over half of these landfills are owned by local governments. Table 4-2 depicts ownership counts and percentages for each type of landfill, plus totals for all landfills.

Information on landfill acreage was supplied for 13,143 (80.1 percent) of the total Subtitle D landfills. As shown in Table 4-3, more than half of all landfills were less than 10 acres, and about 95 percent were 100 acres or less.

Waste quantities were reported for 13,818 (84.2 percent) of the landfills. Some quantities were reported in terms of volume (cubic yards per year) and others were reported in terms of weight (tons per day). As indicated in Table 4-4, about three-quarters of all Subtitle D landfills were reported to receive less than 30,000 cubic yards of waste (or less than 30 tons/day) during 1984.

Information related to capacity status is available only for municipal waste landfills. The Census[1] reported many States have municipal landfills that were either reaching capacity, at capacity, or beyond capacity at the present time. A few States and Territories reported that they had no landfill capacity problems. New sites for landfills were said to be difficult to obtain, highly opposed by the public, and costly. Some States reported that incinerators and resource recovery plants represent promising future alternatives to landfills, but were not viable alternatives for solving immediate capacity problems. Specific capacity data (i.e., volumes) are not available. Appendix C contains specific State and Territory responses to the census question on capacity status.

The following approximate numbers of new landfill and landfill expansion approvals by the States were reported from another study[2]: 559 landfills and 139 expansions in 1981, 524 landfills and 151 expansions in 1982, and 416 landfills and 141 expansions in 1983. The number of expansion approvals have remained relatively constant over this period, but approvals for new landfills have dropped almost 25 percent over the same 3-year time period.

Waste Characteristics

The major types of wastes that can be found in Subtitle D landfills are municipal and industrial. Other types include agricultural, municipal sludge, demolition debris, incinerator ash, household hazardous wastes, and small quantity generator hazardous wastes. Most of these wastes are solid, although municipal and industrial sludges are not uncommon. Section 3 presents available data on the physical and chemical characteristics of wastes in each of these categories.

Table 4-4 presents data on the amount of waste disposed in the different types of landfills and indicates that most landfills (72.3 percent) receive less than 30 ton/day (30,000 cy/yr) of waste. Table 4-5 presents data from a Phase I report on industrial nonhazardous wastes. The table presents estimates of industrial nonhazardous waste disposal in onsite landfills for selected industries. Limitations of the industrial nonhazardous waste disposal study are discussed in Sections 2 and 3.

TABLE 4-2. NUMBER OF SUBTITLE D LANDFILLS BY OWNERSHIP CATEGORY [1]

Landfill Type	Response Rate	Owned by State govern-ment	Owned by local govern-ment	Owned by Federal govern-ment	Pri-vately owned	Other	Total
Municipal waste	96%	126 (1.4%)	6,908 (77.9%)	348 (3.9%)	1,482 (16.7%)	8 (0.1%)	8,872 (100.0%)
Industrial waste	97%	17 (0.5%)	74 (2.2%)	126 (3.7%)	3,177 (93.6%)	2 (0.1%)	3,396 (100.1%)
Demolition debris only	91%	33 (1.4%)	1,190 (50.5%)	82 (3.5%)	1,050 (44.6%)	0	2,355 (100.0%)
Other	93%	89 (9.3%)	203 (21.3%)	60 (6.3%)	603 (63.1%)	0	955 (100.0%)
Total	95%	265 (1.7%)	8,375 (53.8%)	616 (4.0%)	6,312 (40.5%)	10 (0.1%)	15,578 (100.1%)

TABLE 4-3. SUBTITLE D LANDFILLS BY ACREAGE CATEGORY [1]

Landfill type	Response Rate	Less than 10 acres	10 - 100 acres	More than 100 acres	Total
Municipal waste	75%	2,944 (42.3%)	3,572 (51.3%)	449 (6.4%)	6,965 (100.0%)
Industrial waste	88%	2,182 (70.7%)	834 (27.0%)	72 (2.3%)	3,088 (100.0%)
Demolition debris only	84%	1,327 (60.6%)	797 (36.4%)	64 (2.9%)	2,188 (99.9%)
Other	88%	831 (92.1%)	70 (7.8%)	1 (1.1%)	902 (100.0%)
Total	80%	7,284 (55.4%)	5,273 (40.1%)	586 (4.5%)	13,143 (100.0%)

TABLE 4-4. SUBTITLE D LANDFILLS BY AMOUNT OF WASTE [1]

Landfill type	Response Rate	Received less than 30,000 cubic yards in 1984 (30 tons per day)	Received 30,000 - 600,000 cubic yards in 1984 (30-500 tons per day)	Received more than 600,000 cubic yards in 1984 (500 tons per day)	Total
Municipal waste	85%	5,309 (67.0%)	2,211 (27.9%)	408 (5.1%)	7,928 (100.0%)
Industrial waste	82%	2,289 (79.4%)	523 (18.1%)	72 (2.5%)	2,884 (100.0%)
Demolition debris only	83%	1,608 (74.7%)	468 (21.7%)	78 (3.6%)	2,154 (100.0%)
Other	83%	790 (92.7%)	51 (6.0%)	11 (1.3%)	852 (100.0%)
Total	84%	9,996 (72.3%)	3,253 (23.5%)	569 (4.1%)	13,818 (99.9%)

TABLE 4-5. INDUSTRIAL DISPOSAL OF NONHAZARDOUS WASTES AT ONSITE LANDFILLS [3] (Quantities of Nonhazardous Wastes Managed in Dry Tons Per Year)[a]

Industry[b]	Onsite landfill
Fertilizer and other agricultural chemicals (SIC 2873-2879)	207,050
Industrial organic chemicals (SIC 2819)	1,838,970
Leather and leather-products (SIC 31)	1,323
Pulp and paper industry (SIC 26)	6,573,436
Plastics and resins manufacturing (SIC 2821)	417,296
Primary iron and steel manufacturing and ferrous foundries (SIC 3312-3321)	16,055,708
Primary nonferrous metals manufacturing and nonferrous foundries (SIC 3330-3399)	257,875
Total	25,351,658

NA = Data not available.

[a]From Table 3-6.

[b]Include only industries for which there are estimated quantities of wastes being managed in onsite landfills.

4.2.2 LANDFILL LEACHATE AND GAS CHARACTERISTICS

This subsection addresses the byproducts of landfills, namely leachate and gas. The data presented are for municipal landfills only; information for other landfill types was unavailable.

Leachate--

Leachate composition is a function of numerous factors including those inherent in the refuse mass and landfill location, and those created by engineers and site operators.

Table 4-6 illustrates concentration ranges of municipal leachate chemical composition. From this table (and the references indicated), the following observations can be made: leachate is highly variable with respect to constituent concentration; leachate is generally high in total organic carbon and total solids (from the high TOC results); and leachate tends to be acidic. Table 4-7 shows the preliminary types and concentration ranges of organic constituents. In general, this table highlights the wide variability both in the constituents identified and their concentration ranges. No information was available on leachate generation and migration volumes from any other landfill type.

Gas--

Municipal landfill gas production occurs through bacterial decomposition of organic matter. This process proceeds through stages controlled by local site conditions which affect the bacterial population such as: pH, temperature, moisture, and oxygen content (both gaseous and chemically available). Within a landfill, methane is produced after the gas in the voids changes from aerobic to anaerobic and the chemically available oxygen in the refuse is consumed. The type of organisms, rate of reaction, and completeness of the reaction are controlled by the availability of oxygen and the process temperature range.

Municipal landfill gas usually consists of about 50 percent methane and 40 to 50 percent carbon dioxide, plus 0.5 to 1 percent of hydrogen, oxygen, nitrogen, and other trace gases.[8] Table 4-8 presents data which support this statement. Trace gases are described in Table 4-9. Only one compound (vinyl chloride) has a median concentration which exceeds OSHA limits. Other compounds whose concentration range has exceeded these levels in some samples are benzene, tetrachloroethylene, toluene, vinyl chloride, and xylene. No information was found for other landfill types.

Total gas production ratios have ranged from 0.003 to 0.43 m^3/kg of refuse.[14] Other studies[7,14] report values from 0.022 to 2.5 m^3/kg of refuse, and 0.005 to 0.10 m^3/kg of refuse, respectively. No information was available on the gas volumes released.

4.2.3 LANDFILL DESIGN AND OPERATION

The following discussion of design and operating characteristics of Subtitle D landfills presents statistics under the topics of landfill design, landfill operation and maintenance, and environmental monitoring.

TABLE 4-6. RANGE OF CONSTITUENT CONCENTRATIONS IN LEACHATE FROM MUNICIPAL WASTE LANDFILLS (From Ref 6 unless noted) (in mg/L unless noted)

Constituent	Concentration range	Constituent	Concentration range
COD	50-90,000	Hardness (as C_aCO_3)	0.1-36,000
BOD	5-75,000	Total P	0.1-150
Total Organic Carbon (TOC)	50-45,000	Organic P	0.4-100
Total solids (TS)	1-75,000	Nitrate nitrogen	0.1-45
TDS	725-55,000	Phosphate (inorganic)	0.4-150
Total Suspended Solids (TSS)	10-45,000	Ammonia nitrogen (NH_3-N)	0.1-2,000
Volatile Suspended Solids (VSS)	20-750	Organic N	0.1-1,000
Total Volatile Solids (TVS)	90-50,000	Total Kjeldahl Nitrogen (TKN)[b]	7-1,970
Fixed Solids (FS)	800-50,000	Acidity	2,700-6,000
Alkalinity[c] (as C_aCO_3)	0.1-20,350	Turbidity (Jackson units)	30-450
Total coliform[b] (CFU/100 mL)	0-10^5	Cl[b]	30-5,000
$Fe^{a,c}$	200-5,500	pH (dimensionless)	3.5-8.5
Zn[b]	0.6-220	Na[b]	20-7,600
Sulfate[a]	25-500	Cu[a]	0.1-9
Ni[b]	0.2-79	Pb[b]	0.001-1.44
Total volatile acids (TVA)[b]	70-27,700	$Mg^{b,c}$	3-15,600
Mn[b]	0.6-41	K[b]	35-2,300
Fecal coliform[b] (CFU/1,000 mL)	0-10^5	$Cd^{b,c}$	0-0.375
Specific conductance[c] (mhg/cm)	960-16,300	Hg[c]	0-0.16
Ammonium nitrogen[c] (NH_4-N)	0-1,106	Se[c]	0-2.7
		Cr[b]	0.02-18

[a]Reference 14.

[b]Reference 7.

[c]Reference 10.

TABLE 4-7. PRELIMINARY DATA ON CONCENTRATIONS OF ORGANIC CONSTITUENTS IN LEACHATE FROM MUNICIPAL WASTE LANDFILLS (units in ppb)[a]

CONSTITUENT	MINIMUM	MAXIMUM	MEDIAN
Acetone	140	11,000	7,500
Benzene	2	410	17
Bromomethane	10	170	55
1-Butanol	50	360	220
Carbon tetrachloride	2	398	10
Chlorobenzene	2	237	10
Chloroethane	5	170	7.5
bis (2-Chloroethoxy) methane	2	14	10
Chloroform	2	1,300	10
Chloromethane	10	170	55
Delta BHC	0	5	0
Dibromomethane	5	25	10
1,4-Dichlorobenzene	2	20	7.7
Dichlorodifluoromethane	10	369	95
1,1-Dichloroethane	2	6,300	65.5
1,2-Dichloroethane	0	11,000	7.5
cis 1,2-Dichloroethene	4	190	97
trans 1,2-Dichloroethene	4	1,300	10
Dichloromethane	2	3,300	230
1,2-Dichloropropane	2	100	10
Diethyl phthalate	2	45	31.5
Dimethyl phthalate	4	55	15
Di-n-butyl phthalate	4	12	10
Endrin	0	1	0.1
Ethyl acetate	5	50	42
Ethyl Benzene	5	580	38
bis (2-Ethylhexyl) phthalate	6	110	22
Isophorene	10	85	10
Methyl ethyl ketone	110	28,000	8,300
Methyl isobutyl ketone	10	660	270
Naphthalene	4	19	8
Nitrobenzene	2	40	15
4-Nitrophenol	17	40	25
Pentachlorophenol	3	25	3
Phenol	10	28,800	257
2-Propanol	94	10,000	6,900
1,1,2,2-Tetrachloroethane	7	210	20
Tetrachloroethene	2	100	40
Tetrahydrofuran	5	260	18
Toluene	2	1,600	166
Toxaphene	0	5	1
1,1,1-Trichloroethane	0	2,400	10
1,1,2-Trichloroethane	2	500	10
Trichloroethene	1	43	3.5
Trichlorofluoromethane	4	100	12.5
Vinyl chloride	0	100	10
m-Xylene	21	79	26
p-Xylene + o-Xylene	12	50	18

[a]The table was provided by U.S. EPA, Office of Waste, Economic Analysis, Branch. It includes data from 15 municipal landfill case studies performed by OSW[12]; data from landfill leachate sampling studies performed by Wisconsin and Minnesota; and data from NPDES discharge permits for leachates from landfills in New Jersey. These studies provided reliable data, albeit on a relatively small number of facilities.

TABLE 4-8. TYPICAL COMPOSITION OF GAS FROM MUNICIPAL WASTE LANDFILLS [8]

	Component percentage (dry volume basis)			
	Study 1	Study 2	Study 3	Study 4
Methane	44.0	47.5	50.0	53.4
Carbon dioxide	34.2	47.0	35.0	34.3
Nitrogen	20.8	3.7	13.0	6.2
Oxygen	1.0	0.8	1.7	0.05
Paraffin hydrocarbons	-	0.1	-	0.17
Aromatic and cyclic hydrocarbons	-	0.2	-	-
Hydrogen	-	0.1	0.3	0.005
Hydrogen sulfide	0.4-0.9	0.01	-	0.005
Carbon monoxide	-	0.1	-	0.005
Trace compounds[a]	-	0.5	-	-

[a]Includes sulfur dioxide, benzene, toluene, methylene chloride, perchlorethylene, and carbonyl sulfide in concentrations $\leq$50 ppm.

TABLE 4-9. TYPICAL TRACE CONSTITUENTS IN LANDFILL GAS [9]

COMPOUND	NUMBER OF SITES SAMPLED	NUMBER OF SAMPLES	RANGE OF CONCENTRATION (Vppm)	MEDIAN CONCENTRATION (Vppm)	STANDARD DEVIATION (Vppm)	PEL (Vppm)
Benzene	13	21	0 - 12	0.3	3.0	10
Ethylbenzene	11	14	0 - 91	1.5	24	100
Heptane	4	6	0 - 11	0.45	5.2	500
Hexane	8	9	0 - 31	0.8	11	500
Isopentane	5	7	0.05 - 4.5	2.0	1.5	---
Methylcyclohexane	6	7	0.017 - 19	3.6	8.8	500
Methylcyclopentane	6	7	0 - 12	2.8	4.4	---
Methylene Chloride	10	17	0 - 118	0.83	30	500
Nonane	6	8	0 - 24	0.54	8.2	400
Tetrachloroethylene	13	19	0 - 186	0.03	44	100
Toluene	16	26	0 - 357	6.8	82	100
1,1,1-Trichloroethane	11	18	0 - 2.4	0.03	0.6	350
Trichloroethylene	12	19	0 - 44	0.12	10	100
Vinyl Chloride	10	16	0 - 10	2.2	3.7	1
Xylene	5	6	0 - 111	0.1	48	100
m-Xylene	4	9	1.7 - 76	4.1	28	100
o-Xylene	7	9	0 - 19	1.8	7.7	100

Notes: PEL = Permissible Exposure Level prescribed by OSHA for workplace exposure
OSHA has proposed revising the PEL for benzene to 1 Vppm
--- = No PEL set
____ = Exceeds OSHA limit (PEL)

Landfill Design

This subsection outlines the major environmental protection elements in landfill design and presents available statistics on the frequency of their use. These elements are liners, leachate collection/removal systems, runon/runoff controls, methane gas controls/recovery systems, cover and closure characteristics and location factors.

Liners--

The purpose of a liner is to prevent migration of pollutants from the landfill into the ground water. Liner types include soil and synthetic. Soil liners are typically compacted clays. Synthetic liners include a variety of low permeability materials.

Table 4-10 presents Subtitle D Census data on landfill liner status. This table shows that few of the active landfills in any category employ liners. About 1 percent of all landfills use synthetic liners and about 11 percent use natural liners. Municipal landfills tend to be the predominant landfill type to employ both types of liners.

Soil liners--In-place soils are used to the maximum extent possible as liner material to save the costs of purchasing and hauling soils to the site. If appropriate clayey soil does not exist, or exists only on a part of the site or at certain depths, imported clays or chemical additions are used. Many types of clays or mixes of clays (montmorillonite, kaolinite, illite, bentonite) are used, as well as artificial soil amendments. With proper quality control and construction techniques, clay liners can achieve permeabilities of approximately 10^{-7} cm/sec.[4]

Synthetic liners--These types of liners are used when soil permeability is not adequate or economically attainable to prevent pollutant migration, or when required by regulations. These liners include asphalt and portland cement compositions, soil sealants, sprayed liquid rubbers, and synthetic polymeric (or flexible) membranes. Synthetic polymeric and asphaltic materials are the most common membrane liners used for landfills.[5] Using the best present construction and placement technologies, permeabilities on the order of 10^{-10} cm/sec can be achieved.[4] Certain landfill waste and leachate can damage membrane liners. Damaging characteristics include high or low pH, oily waste, exchangeable ions, and organic compounds.

Leachate Controls/Recovery Systems--

These systems refer to the control and collection, composition control, and treatment of leachate.

Control and collection--Control and collection techniques have been well established and include drains, wells, liners, slurry trenches, cut-off walls, grading (runon), and surface sealing. No data were available on numbers of techniques being used. Table 4-10 indicates that about 4 percent of all landfills have leachate collection systems of some type. Municipal landfills employ these systems more frequently than other landfills.

TABLE 4-10. NUMBERS OF SUBTITLE D LANDFILLS USING VARIOUS TYPES OF RELEASE PREVENTION METHODS [1]

Management method	Municipal waste	Industrial waste	Demolition debris only	Other	Total
Synthetic liners	71 (0.8%)	45 (1.3%)	1 (<0.1%)	2 (0.2%)	119 (0.7%)
Natural liners (e.g., clay), including slurry walls	1,353 (14.6%)	392 (11.2%)	117 (4.5%)	5 (0.5%)	1,867 (11.4%)
Leachate collection systems	481 (5.2%)	112 (3.2%)	3 (0.1%)	6 (0.6%)	602 (3.7%)
Runon/runoff controls	4,240 (45.7%)	1,150 (32.8%)	685 (26.4%)	78 (7.6%)	6,153 (37.5%)
Methane controls (vents, recovery)	1,539 (16.6%)	98 (2.8%)	107 (4.1%)	3 (0.3%)	1,747 (10.6%)
Leachate treatment (except leachate recirculation)	245 (2.6%)	69 (2.0%)	1 (<0.1%)	2 (0.2%)	317 (1.9%)
Leachate recirculation	205 (2.2%)	27 (0.8%)	0	0	232 (1.4%)
Restrictions on receipt of liquid wastes (e.g., bulk liquid restrictions)	4,436 (47.8%)	1,200 (34.2%)	818 (31.6%)	128 (12.4%)	6,582 (40.1%)
Total Landfills	9,284	3,511	2,591	1,030	16,416

Composition control--This control can be accomplished through design and operating features, and addition of selected sorbents into the fill. Landfill design and operating features which are significant to leachate composition are chemical and physical characteristics of waste input, including particle size (shredding) and density (compaction and baling); rate of water application; landfill depth or lift height; and landfill temperature (which can be regulated to some extent through cover material, refuse density, and lift height.[6]

Treatment processes--Leachate treatment can be performed by existing wastewater plants, or by processes specifically designed for landfill leachate. Available technologies include aerobic/anaerobic biological processes, and physical/chemical processes. Table 4-10 indicates that 317 landfills (2 percent) utilize leachate treatment. Municipal landfills are the major users of these processes. No data were found on leachate treatment for any other landfill types, or on the treatment technologies used nationwide. Leachate recirculation was reported to be used at 205 municipal waste landfills (2.2 percent).

Runon/Runoff Controls--

Runon/runoff controls are important to landfill pollution control since runon contributes to leachate generation and runoff could cause harmful compounds to be swept out of the landfills. From Table 4-10, about 37 percent of all landfills employ these controls, and municipal landfills comprise the largest user category.

Methane Gas Controls/Recovery Systems--

Many factors determine the feasibility of a methane gas recovery system at a landfill. Since the gas generation process depends on several environmental variables, it is difficult to predict the exact production rate, volume, and composition of the gas. Nevertheless, different kinds of collection systems have been designed, depending on whether the purpose of collection is migration control and/or recovery. This section presents an overview of the methods of gas collection, processing, and enhancement.

Table 4-10 presents data on landfills using methane controls. About 11 percent of all landfills employ these controls, and most of these facilities are municipal landfills. This reflects the fact that municipal landfills generally produce significant quantities of methane (see discussion of leachate and gas characteristics), while other landfills generally do not. The remaining discussion on landfill gas mainly applies to municipal waste landfills.

Collection--A landfill gas recovery system is designed to maximize gas recovery without disturbing the anaerobic conditions within the landfill. Recovery systems typically include extraction wells at the interior of the fill, a pump, and a collection pipe network. Gas migration control systems were originally designed to prevent buildup and migration beyond the landfill boundary using wells or trenches at the landfills exterior to vent the gas. Current trends are to tie together the migration and recovery systems to increase gas collection.[8]

The layout of the wells depends on many factors, including results of a field testing program, end use of the landfill surface, and the purpose of the collection system. Testing at a landfill will indicate which areas of the landfill might provide the most gas of good quality for a recovery system.

Processing--Before the gas can be sold or used, it may be purified. A processing unit is used to treat the gas to certain specifications, depending on the grade desired (medium or high Btu gas). For medium Btu gas, processing requires removal of particulates and water. For high Btu gas, processing requires removal of particulates, water, carbon dioxide, and most trace components. According to the literature, typical gas processing rates are from 0.001 to 0.008 m^3/kg dry refuse/year.[7]

Enhancement--Landfill gas production enhancement involves accelerating gas production and increasing the total amount of gas produced. In general, enhancement of landfill gas production is possible through several techniques: (1) moisture can be added and circulated through the landfill; (2) nutrients and bacteria can be introduced with anaerobically digested sewage sludge; (3) the pH can be adjusted with a buffer such as calcium carbonate or certain waste products; and (4) particle size can be reduced by shredding the incoming refuse. The technical and economic feasibility of increasing gas yield with these techniques remain to be determined by large-scale field tests.[8]

Cover and Closure Characteristics--

The final cover is installed when a landfill has reached the end of its useful life and is a key element in site closure. The purpose of the final cover is to seal the fill material for environmental protection, and so the land can provide some benefit (farming, recreation, development, etc.). Control of water infiltration, which contributes to leachate generation, is the major focus of landfill cover design. No data were available on the numbers of landfill cover systems being used.

Cover systems are generally composite systems with several layers of soil and synthetic membranes. The major elements of cover design and analysis include determination of allowable percolation, water balance analysis, soil and membrane selection, compaction and placement, surface slope, and drainage. The usual intention of a landfill cover is to impede the flow of water, but covers can be designed to permit water flow for gas enhancement and chemical stabilization.

Location Factors--

Topography, hydrogeology, ecology, and demography of a of a landfill site may influence the potential for leachate generation (through precipitation and waste generation), the dilution potential of the area surrounding the waste site, and the potential for human or environmental exposure. The Census[1] provided geographical data on municipal waste landfills, and the EPA is in the process of evaluating these data. No data were available for industrial or demolition debris landfills concerning location characteristics of different facilities or numbers of landfills employing location factors in their designs. A discussion of State and Territorial location requirements is presented in Section 5.

Landfill Operation and Maintenance

The operation and maintenance of a landfill can be viewed as an ongoing construction project. As with any construction effort, it proceeds according to detailed plans and is accompanied by appropriate equipment, materials, and personnel. Characteristics addressed in this subsection include: landfill employees, equipment, daily operations, waste restrictions, emergency preparedness and contingency plans. Most of this discussion pertains to municipal waste landfills; little information is available on any other landfill type.

Employees--

The variety of positions at municipal landfills depends on the size of the operation. For small sites (50 to 70 tons per day), a single full-time operator may be able to satisfactorily operate equipment, record waste quantities, and perform administrative and maintenance functions. Larger municipal sites may require more positions, including one or more of the following: supervisor, equipment operator, check station attendant, mechanic, and laborer. As a general rule, one employee is needed per 70 tons per day of waste received.[5] However, requirements are site-specific and the number of employees may be affected by: size of landfill (waste received); operating method (trench, area, shredding, balefill); site characteristics; and operating hours. No data were available on the number of employees used per landfill.

Equipment--

Equipment at Subtitle D landfills serves three basic functions: waste handling; excavating soil and handling cover soil; and performing support functions. Handling of solid waste at a landfill site resembles earth-moving, but differences exist that require consideration. Solid waste is less dense, more compressible, and more heterogeneous than earth. Spreading a given volume of solid waste requires less energy than an equal volume of soil. Support equipment may be required to perform such tasks as road construction and maintenance, dust control, fire protection, and possibly assistance in waste unloading operations.

Equipment functions and performance specifications vary with the size of the landfill. Excepting large landfills, the same piece of equipment normally performs all functions. Additional equipment may be on hand for busy times and when other equipment is out of service.[5] No data were available on the number and types of equipment used per landfill.

Daily Operations--

Daily municipal landfill operations include fill operations, fill-related tasks, and other general procedures. The two basic fill methods are trench and area. Trench operations employ a prepared excavation which confines the working face between two side walls. The area method does not use extensive surface preparation, therefore, the width of the working face is limited only by the site boundaries. Some landfills use a combination of both methods at different locations or times. Other methods involve the preparation of wastes by shredding or bailing, but are essentially variations to trench and area.

Procedures dependent on the landfilling method include: site preparation, traffic flow and unloading, and compaction and covering. General operational procedures are as follows: environmental control practices (siltation and erosion, mud, dust, vectors, odors, noise, aesthetics, birds, litter, fires); inclement weather practices; hours of operation; and ongoing engineering (site preparation, road maintenance, as-built drawings). No data were available on any of these daily operating characteristics of landfills.

Waste Restrictions--

Waste restrictions vary widely with the design and operation criteria of the individual landfill. Table 4-10 indicates that about 41 percent of all landfills employ some type of restrictions on input wastes. Municipal landfills have these restrictions more often than any other landfill types.

Emergency Preparedness and Contingency Plans--

Anticipating the operational problems and addressing contingencies in the operation plan may reduce risks to human health and the environment. Some of the major potential problems at municipal landfills include fires, inclement weather, and equipment and personnel shortages.

There are many potential sources of fires at landfills including: receipt of hot wastes such as incinerator ash, sparks from vehicles igniting flammable wastes, and vandalism. Many facilities employ tight security to spot hot or highly flammable wastes and direct them to specific areas to be wet down or smothered with soil or water. When fires do occur they are usually dug out and smothered with soil and/or water,or smothered by placing damp soil on the surface of the fill. Several particularly large facilities have a fire department onsite.

Out of service equipment is common at landfills due to high usage. Contingency plans may include well documented procedures for repairs, either with onsite mechanics or by outside means, having redundant equipment at the fill, or borrowing or leasing from allied agencies (i.e., public works, contractors, etc.).

Additional personnel may be required for seasonal or other peak waste receiving times, or to temporarily replace sick or injured workers. Employees may be trained to perform multiple tasks, and procedures for labor overhires can be outlined in advance and initiated quickly when needs arise.

No data were available concerning the use and elements of emergency preparedness and contingency plans.

Environmental Monitoring at Landfills

Landfill monitoring is used to measure changes in the environment that occur as a result of disposal. Environmental monitoring design may vary depending on landfill design, operation and maintenance characteristics, wastes received, and location. Monitoring for any given landfill may measure ground and surface water, and air and methane. Monitoring of these media and specific test parameters is discussed below.

Table 4-11 presents data on the number of active landfills with monitoring systems. Ground water is the most frequently monitored medium, and air is the least. No data are available beyond numbers of facilities monitoring different media.

Ground Water Systems/Parameters--

Census data[1] reported in Table 4-11 show 3,314 landfills (19 percent) monitor ground water. Municipal landfills are the major facilities which perform this monitoring. Ground water monitoring will be discussed with respect to devices and locations.

Devices--Monitoring equipment may be classified as: wells with the capacity to sample at a single depth (single screened wells), multi-sampling wells for sampling at different depths (multi-probe wells or well clusters), and piezometers which are designed to obtain samples utilizing airlift methods (airlift samplers). No data are available on the number of facilities using different devices.

Locations--Ground water monitoring systems are very site-specific. Landfill size and site hydrogeology are factors which dictate the actual number of installed wells. The spacing and depths of monitoring wells depend on the particular pattern of ground water flow, making it extremely difficult to specify aggregate statistics for this area. During Phase II of the Subtitle D study, EPA will be examining landfill case studies to evaluate the adequacy of ground water monitoring systems now in place at Subtitle D facilities.

Surface Water Systems/Parameters--

Surface water monitoring is often implemented as a component of a total monitoring network. The proximity of a solid waste landfill to surface water and local drainage patterns may determine whether surface water monitoring is necessary. Indicator parameters and analytical methods used for surface water samples are usually consistent with those for ground water testing.

Data concerning the extent of surface water monitoring for landfills are presented in Table 4-11. Fewer than 9 percent of all landfills have surface water monitoring systems. Municipal and industrial landfills have the highest percentage of surface water monitoring system use (12 and 7 percent, respectively).

Air and Gas Systems/Parameters--

The characteristics of gases produced at landfills were discussed earlier in the Landfill Leachate and Gas Characteristics subsection. The current Federal Criteria (see Appendix A) state that any explosive gas shall not exceed 25 percent of the lower explosive limit (LEL) in facility structures, or exceed the LEL at the solid waste disposal property boundary. Gas monitoring is not specifically required by the Criteria.

Gas sampling devices usually consist of simple, inexpensive gas probes. The probe is usually polyethylene, copper, or stainless steel tubing. Due to

TABLE 4-11. NUMBERS OF ACTIVE LANDFILLS WITH MONITORING SYSTEMS [1]

Landfill type	Ground Water monitoring	Surface water monitoring	Air emissions monitoring	Methane monitoring
Municipal waste	2,331 (25.1%)	1,100 (11.8%)	358 (3.7%)	427 (4.6%)
Industrial waste	626 (17.8%)	230 (6.6%)	80 (2.3%)	63 (1.8%)
Demolition debris only	135 (5.2%)	69 (2.7%)	7 (0.3%)	8 (0.3%)
Other	42 (4.1%)	16 (1.6%)	0 (1.6%)	0
Total	3,134 (19.1%)	1 ,415 (8.6%)	445 (2.7%)	498 (3.0%)

the small diameter of probes, a series of these devices can be situated at various depths within a single hole. The sample collection technique depends upon the type of sampling probe installed. Most frequently, a portable meter is used to monitor methane gas. The sampling frequency often depends upon the frequency of monitoring in other media. The estimated rate of movement of gas in a particular soil may be useful for developing sampling frequencies.

Data concerning the extent of ambient air or methane monitoring for Subtitle D waste landfills are presented in Table 4-11. Few landfills have air or methane monitoring systems (about 3 percent for both).

4.2.4 PRELIMINARY ANALYSIS OF ENVIRONMENTAL AND HUMAN HEALTH IMPACTS AT LANDFILLS

This subsection presents Phase I data relating to environmental and human health impacts of Subtitle D landfills. Phase I efforts to meet these objectives include aggregate data collected in the Subtitle D Census and detailed case studies available from various sources. The aggregate Census data can be used to correlate different types of contaminant problems with different landfill categories, and to indicate the extent of these problems across the universe of landfills. EPA is also conducting a risk analysis on municipal waste landfills to support both the Subtitle D study effort and the development of Subtitle D Criteria revisions. The results of this analysis will be included in the report to Congress on the Subtitle D study.

Table 4-12 presents the relevant Subtitle D Census data for ground water, surface water and air impacts at Subtitle D landfills. This table also presents statistics on the number of State landfill inspections and on the number of landfills with monitoring systems in place (by medium).

The following discussion presents the available aggregate and case study information for ground water, surface water and air contaminant impacts.

Ground Water

Census Data--

The Census data in Table 4-12 indicate 720 ground water contamination violations at Subtitle D landfills, 586 of which were at municipal waste landfills. The number of reported contamination violations is an imperfect measure of environmental impacts because: a) "violations" may be defined differently among States and Territories, b) many violations may go unreported due to inspection or monitoring inadequacies; and c) multiple violations can occur at a facility. Fewer violations were reported for other facility types, both in terms of numbers of violations and percentages of these other, possibly related, statistics.

Case Studies--

During Phase I, EPA performed preliminary case study evaluations of 127 municipal waste landfills located within various hydrogeologic and environmental settings in eight States.[12] These case studies are currently

TABLE 4-12. AGGREGATE DATA RELATING TO ENVIRONMENTAL CONTAMINATION AT LANDFILLS [1]

	Number of Subtitle D Landfills, by type				
	Municipal waste	Industrial waste	Demolition waste	Other	Total
Total active facilities	9,284	3,511	2,591	1,030	16,416
Violations detected by State inspection programs					
- Ground water contamination	586	111	16	7	720
- Surface water contamination	660	50	42	6	758
- Air contamination	845	18	33	54	950
- Methane control deficiencies	180	8	0	1	189
State inspection at least once each year[a]	6,708	2,653	1,548	631	11,540
Facilities with monitoring					
- Ground water	2,331	626	135	42	3,134
- Surface water	1,100	230	69	16	1,415
- Air	358	80	7	0	445
- Methane	427	63	8	0	498

[a]These data include numbers cited by States or Territories for frequencies ranging from once a year to more than four times a year. It excludes less frequent inspections and entries under the questionnaire category of "other".

being compiled in the Phase II data collection efforts. Beyond these, many of the sites listed on the NPL/Subtitle D data base have detailed case study information.

The preliminary evaluation of 127 municipal waste landfill case studies provided evidence of ground water contamination or an adverse trend in ground water quality at 33 facilities. These impact cases ranged from relatively minor to major environmental impacts. As an example, one landfill located in the northeastern U.S. showed an upward trend of some key indicators of municipal waste landfill leachate (i.e., total dissolved solids, chloride, specific conductance and ammonia) in ground water samples from downgradient monitoring wells. Much more severe impacts were identified at a facility in the southern U.S., where a well defined leachate plume is traveling nearly 300 feet per year toward two active public well fields. Regardless of the degree of ground water impact, certain factors were common to these cases. Most were located within 8 feet of ground water, underlain by relatively high permeability soils, or engineered without an effectively impermeable liner. In addition to these generic factors, the degree of ground water impact appeared to be more severe in areas characterized by higher net infiltration rates and ground water flow rates.

The preliminary analysis of case study information identified several factors which in various combinations determine failure at a particular facility. However, it is difficult to separate out the specific factors responsible for such failure. These factors include:

- Age of landfill;
- Location (e.g., climate, depth to ground water, soil permeability, and leachate migration potential); and
- Engineering design (e.g., liner use, runoff control) and design/operation practices.

The case studies indicated that the facilities impacting the environment were generally more than 10 years older than facilities reporting no impacts. The location factors which most contribute to ground water pollution are high precipitation and infiltration. Of the facilities located in relatively poor hydrogeological settings, success in preventing ground water contamination appeared to be directly related to the sophistication of the liner and leachate collection system design.

NPL/Subtitle D Data--

The Phase I report on NPL/Subtitle D landfills[11] identified some pertinent characteristics for the Subtitle D landfills on the National Priorities List (NPL). Of the approximately 19,000 sites inventoried by EPA as hazardous waste substance sites and listed on the CERCLA data base (CERCLIS), approximately 2,000 have been identified as Subtitle D landfills by EPA. Of the sites ranked by EPA as part of the process of identifying sites for inclusion on the NPL, 325 sites were identified as subtitle D landfills that have recieved municipal wastes. Finally, of the 850 sites listed or

proposed for listing on the NPL, 184 sites were identified as NPL/Subtitle D landfills that had received municipal wastes. This relationship is illustrated in Figure 4-4.

The most common chemicals found at these landfills are halogenated organics, aromatics, and metals. No specific constituents were sited as being most common. The most significant chemical origin was found to be industrial waste, followed by sludge and household hazardous waste. The NPL sites have been scored using the Hazardous Ranking System which considers toxicity of substances, observed or potential releases to the surrounding media, potential routes of exposure, as well as the population exposed. Releases of hazardous material to ground water is documented in nearly 75 percent of those sites listed. Figure 4-5 presents these data. Industrial waste was listed as the primary cause of ground water contamination in 130 sites.

Surface Water

Census Data--

· The Census indicates that 660 surface water contamination violations were reported at municipal landfills, compared to 50 at industrial landfills, 42 at demolition debris landfills and 6 at other landfills (see Table 4-12). For reasons cited previously, the number of reported violations is an imperfect measure of environmental impacts.

Case Studies--

At 16 facilities where case study reports were developed,[12] there was documentation or evidence of surface water degradation as a result of leachate seeps and runoff control deficiencies. While the extent of surface water degradation was limited in most cases, some impacts had either an unmeasureable effect on local wetland environments or subsequently caused ground water degradation. As in the cases of ground water impacts, these case studies were characterized by locations with high net infiltration rates, limited runoff control features, and highly permeable native soils.

NPL/Subtitle D Data--

Of the 184 Subtitle D landfills either listed in the NPL or being considered for listing, surface water was found to be affected at 43 percent of these sites (see Figure 4-5). Liquid waste was present at approximately 70 of the facilities showing surface water contamination; solid waste was present at approximately 65 facilities. Industrial waste was present at approximately 75 of those sites showing surface water contamination; while sludge was present at approximately 45 sites. Pesticides were only found to be present at approximately 10 of those sites affected.

Air

Census Data--

As shown in Table 4-12, the Subtitle D Census provides information on Statewide requirements for air monitoring at landfills, percentages of facilities which have air monitoring, and information on air quality violations which have been reported to occur in 1984. These data indicate that 815 air contamination violations were reported at municipal landfills, compared to 16 at industrial landfills, 33 at demolition debris landfills and

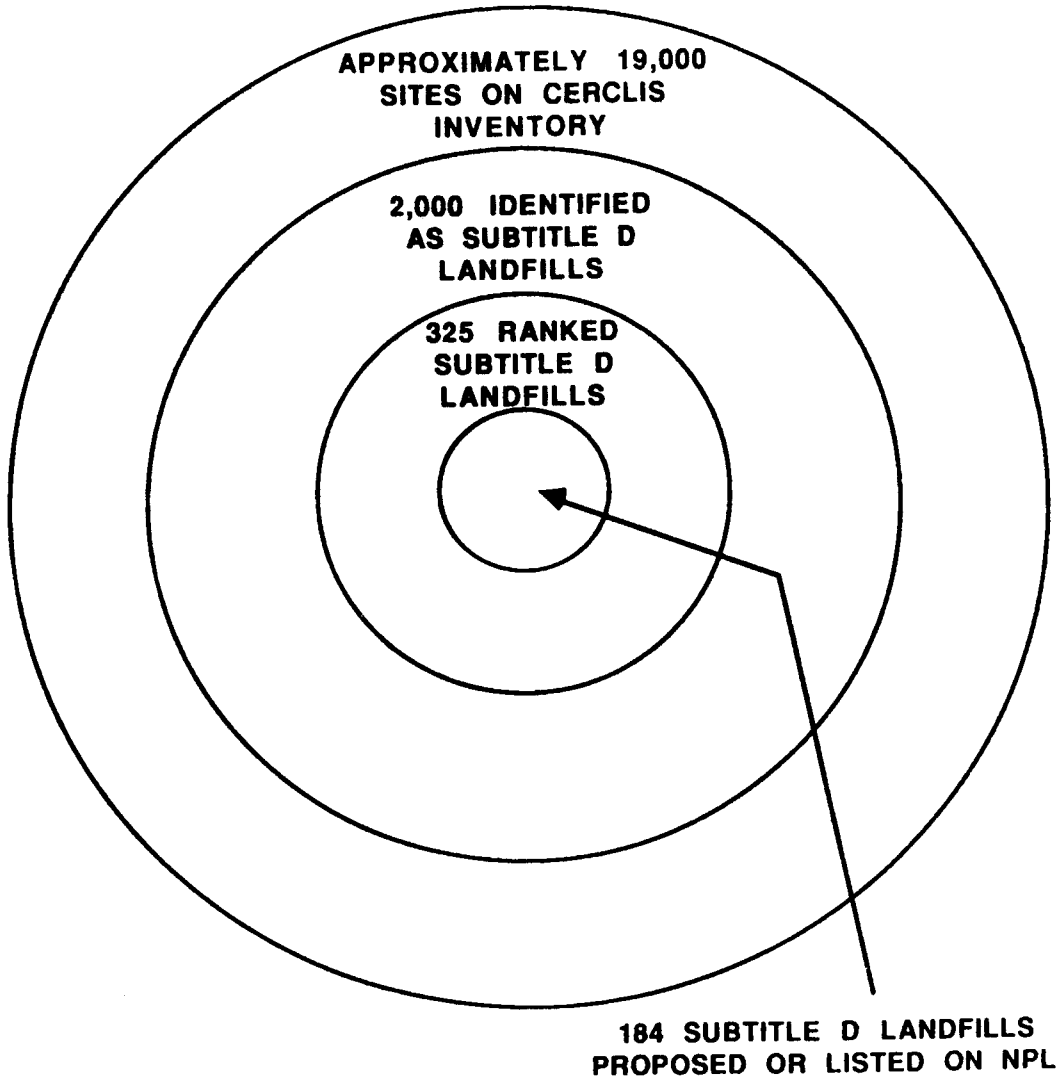


Figure 4-4. Subset of Subtitle D landfills within CERCLIS data base. [11]

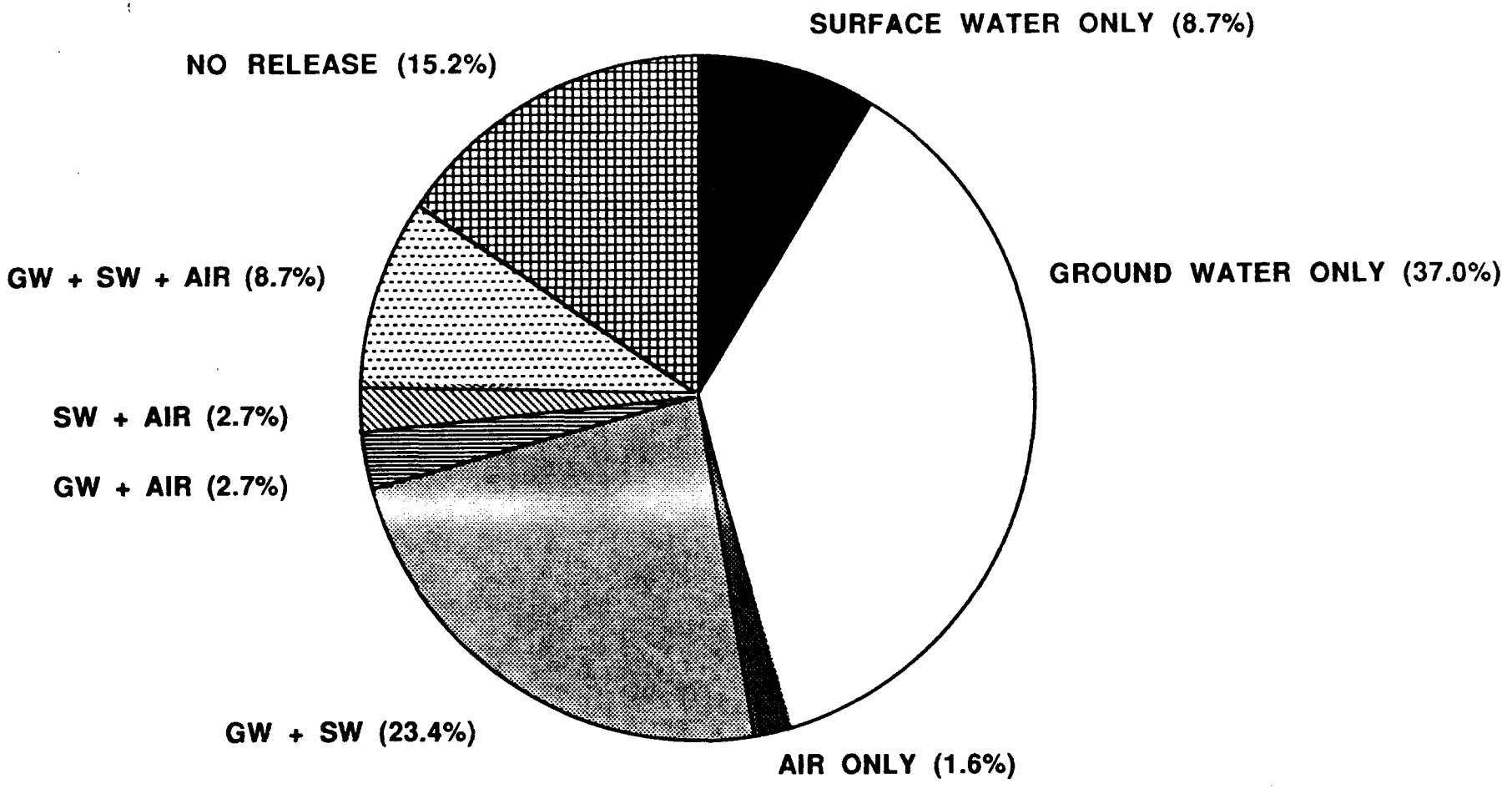


Figure 4-5. Observed releases at Subtitle D landfills on the NPL. [11]

54 at other landfills. These groups reported 180, 8, 0, and 1 incidences of methane control deficiency violations, respectively. For reasons cited previously, the number of reported violations is an imperfect measure of environmental impacts.

Case Studies--

Air and methane impacts were documented at four of the case study[12] facilities. The impacts include odor problems, landfill fires, vegetation destruction, and explosions caused by methane accumulation. In all cases, gas venting systems were absent, and in the cases of air emission impacts, the use of daily and final cover was inadequate.

Significant air impacts have been found to occur during methane gas recovery operations at municipal landfills. Methane gas is produced in landfills during anaerobic bacterial digestion of organic matter. Gas that is produced in the landfill migrates through the refuse and soil by both convection and diffusion. Trace quantities of many other types of hazardous wastes have also been observed at Subtitle D landfills. A recent study by the Gas Research Institute and the U.S. Department of Energy,[13] found that since methane gas is produced at most landfills, it may serve as a vehicle for other hazardous contaminants to be released to the atmosphere.

Public health hazards associated with contaminants existing in methane gas have not been well quantified. The greatest threat would be to the onsite workers themselves, but if the gas is processed and distributed to consumers, the possibility then exists of exposing consumers to contamination.

NPL/Subtitle D Data--

The NPL/Subtitle D landfill study showed that only 16 percent of the 184 NPL/Subtitle D landfills had significant emissions problems (see Figure 4-5). Most of these sites were used primarily for industrial waste disposal.

Summary

The prelimanry Phase I analysis of environmental and human impacts of landfills indicates that improperly located and/or designed landfills may be causing significant impacts. Additional analysis during Phase II of the study is necessary to determine the overall impact of these facilities on human health and the environment.

4.3 SURFACE IMPOUNDMENTS

This part presents data on Subtitle D surface impoundments. The topics covered include general profile, surface impoundment design and operation, and environmental and human health impacts at surface impoundments.

4.3.1 GENERAL PROFILE

The Subtitle D Census[1] provided general information on surface impoundments including numbers, ownership, acreage, and waste volumes. Information on waste characteristics was available through other sources. The general definition of surface impoundment used in the Subtitle D Census[1] is:

A part of an establishment which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials) that is designed to hold an accumulation of liquid wastes or wastes containing free liquids. Treatment, storage, and disposal surface impoundments are included. Surface impoundments are often referred to as pits, ponds, or lagoons. This definition does not include any type of tank, including concrete, fiberglass or steel tanks.

This definition is broken down further into the following categories:

- Municipal sewage sludge surface impoundments receive sewage sludge from publicly owned or privately owned domestic sewage treatment establishments, including septic tanks.

- Municipal runoff surface impoundments are used for the collection of runoff or leachate from municipal waste landfills or municipal waste LAUs.

- Industrial waste surface impoundments primarily receive wastes from factories, processing plants (including food processing), and other manufacturing or commercial activities. Also included in this category are surface impoundments used for the collection of runoff or leachate from industrial or demolition landfills and industrial land application units.

- Agricultural waste surface impoundments only receive waste from agricultural operations, including farming, crop production, and animal husbandry (including feedlots). Specifically excluded from this category are surface impoundments that are used for wastes from slaughterhouses and other animal and food processing operations, which are included in the industrial surface impoundment category.

- Mining waste surface impoundments are associated with mineral extraction and beneficiation activities such as crushing, screening, wasting, floatation. These minerals include metallic and non-metallic ores, coal, sand and gravel, but exclude oil and gas processing wastes from manufacturing establishments which are included in the industrial surface impoundment category.

- Oil or gas surface impoundments receive waste from oil and gas exploration and extraction, commonly known as brine pits. Both disposal and emergency brine pits are included. Specifically excluded are surface impoundment used for petroleum refinery wastes which are included in the industrial surface impoundment category.

- Other surface impoundments receive Subtitle D wastes, but do not fall into any of the above categories.

The estimated total number of Subtitle D surface impoundments is believed to underestimate the actual number of surface impoundments nationwide, owing to data gaps. Nine States and Territories were unable to provide any

estimates of numbers of surface impoundments. One State provided an estimate of the total, but was unable to break down that estimate into the different categories. Five more States could not provide estimates for one or more of the categories.

Surface Impoundment Numbers, Ownership, Acreage, and Waste Volumes

The Subtitle D Census indicates that there were 191,822 active surface impoundments in 1984 located at 108,383 establishments. There were more than five times as many oil or gas waste impoundments (125,074) as the next largest category, mining waste impoundments (19,813). Figure 4-6 depicts the numbers and relative shares of the seven different types of surface impoundments. These impoundments are distributed throughout the country, as shown on the map presented in Figure 4-7. Pennsylvania (32,653) reported the largest number of surface impoundments, followed by Arkansas (25,705), Louisiana (20,010), West Virginia (18,705), and New Mexico (17,044).

Ownership data were reported for 149,711 (78.2 percent) of the Subtitle D surface impoundments. More than 98 percent were privately owned, as shown in Table 4-13, although local governments owned most of the municipal sewage sludge and municipal runoff surface impoundments.

Acreage was reported for 123,412 (64.5 percent) of the surface impoundments. As Table 4-14 shows, the majority of these impoundments were less than one acre, although about a third of mining impoundments were 6 acres or more.

Census respondents supplied waste quantity data for 124,038 (64.8 percent) of the surface impoundments. As shown in Table 4-15, more than four-fifths of these impoundments received less than 50,000 gallons each day. Fewer than 1 percent of all impoundments were reported to receive 10 million gallons or more per day.

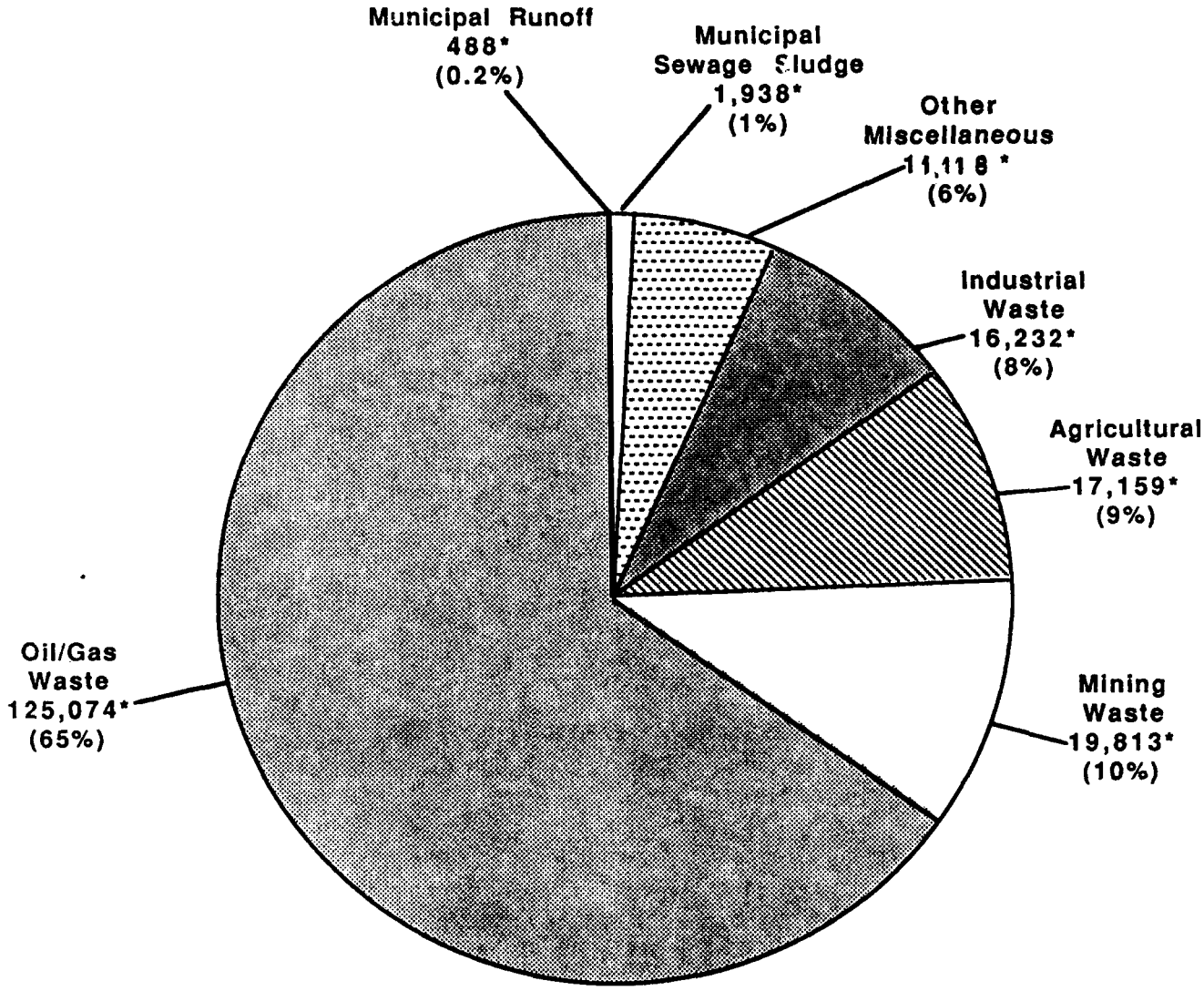
Waste Characteristics

Wastes disposed in Subtitle D surface impoundments are generally in liquid, sludge or slurry form. The available information on physical and chemical characteristics of these wastes is presented in Section 3 of this report under the headings of: municipal sludge, agricultural waste, mining waste, industrial waste, and oil and gas waste.

The Census results[1] indicate that most surface impoundments receive 50,000 gpd or less of waste (Table 4-15). The Phase I report on industrial nonhazardous wastes[3] provides a further break down of numbers of facilities for specific industries (Table 4-16). Limitations to the waste quantities in the industrial nonhazardous waste disposal study are discussed in Sections 2 and 3.

4.3.2 SURFACE IMPOUNDMENT DESIGN AND OPERATION

The following discussion of design and operating characteristics of Subtitle D surface impoundments summarizes the pertinent Phase I data collection efforts. The information is organized under the topics of design, operation and maintenance, and environmental monitoring characteristics.



TOTAL SURFACE IMPOUNDMENTS = 191,822

*No estimate of surface impoundments was obtained form CA, KY, MO, MN, UT, VT, WY, PR, and VI; estimate from SD was not broken down by category. In addition, no estimates of municipal sewage sludge were obtained from IL, LA, or RI; no estimates of industrial waste from LA; no estimates of agricultural waste from LA, or NY; no estimates of mining waste from NY; no estimates of oil/gas waste from IN, MT, NY, or RI; and no estimates of municipal runoff from IL, LA, or RI.

Figure 4-6. Number of Subtitle D surface impoundments, by type. [1]

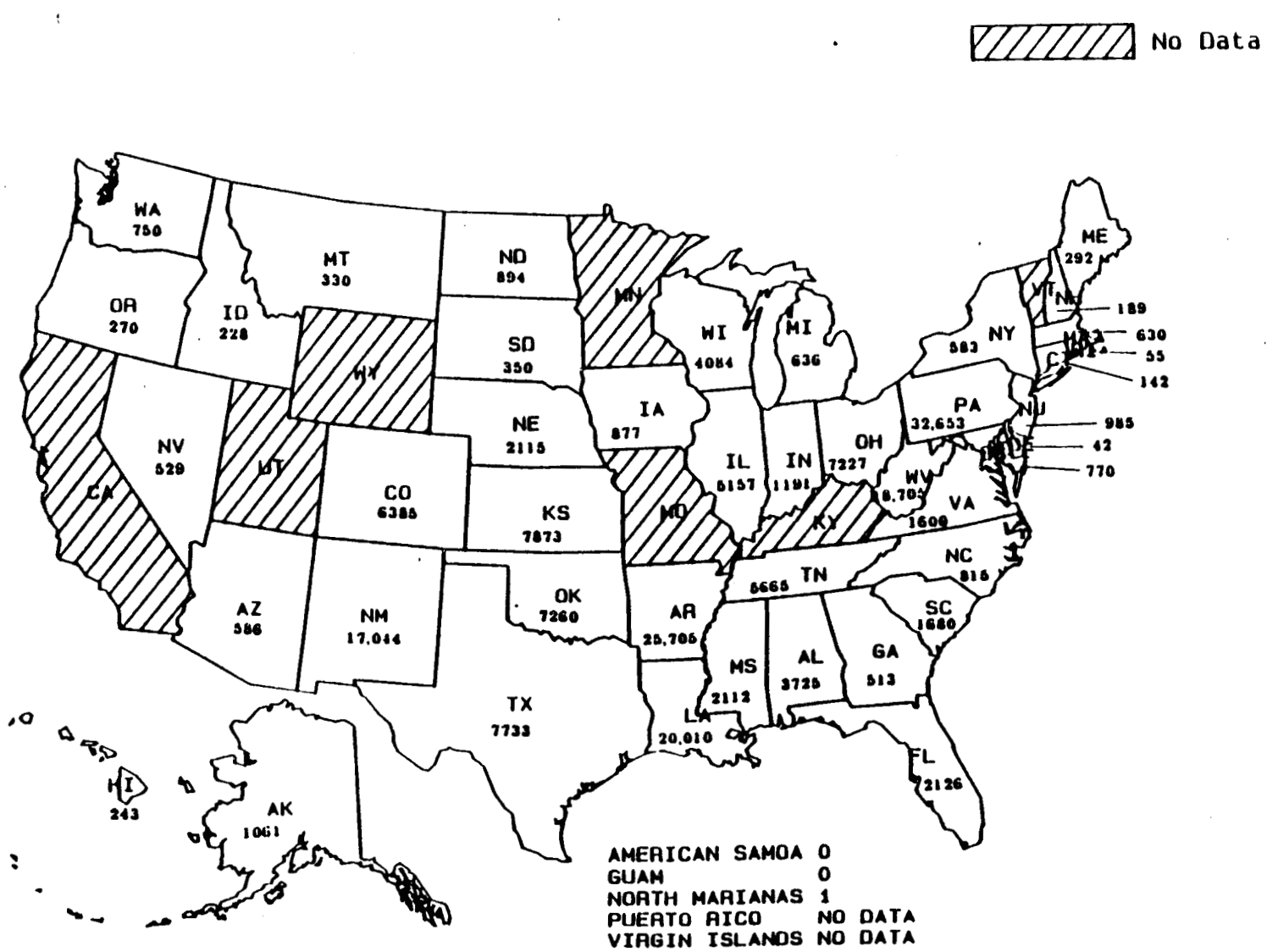


Figure 4-7. Number of Subtitle D surface impoundments by State. [1]

TABLE 4-13. NUMBER OF SUBTITLE D SURFACE IMPOUNDMENTS BY OWNERSHIP CATEGORY [1]

Surface impoundment type	Response rate (percent)	Owned by State government	Owned by local government	Owned by Federal government	Privately owned	Total number of surface impoundments by type
Municipal sewage sludge	95%	19 (1.0%)	1327 (72.4%)	42 (2.3%)	446 (24.3%)	1,834 (100.0%)
Municipal runoff	100%	0	368 (75.4%)	5 (1.0%)	115 (24.6%)	488 (100.0%)
Industrial waste	66%	94 (0.9%)	71 (0.7%)	74 (0.7%)	10,519 (97.8%)	10,758 (100.0%)
Agricultural waste	92%	25 (0.2%)	0	3 (0.02%)	15,733 (99.8%)	15,761 (100.0%)
Mining waste	69%	0	5 (0.04%)	0	13,625 (99.96%)	13,630 (100.0%)
Oil or gas waste	69%	0	0	0	101,884 (100.0%)	101,884 (100.0%)
Other	48%	20 (0.4%)	663 (12.4%)	11 (0.2%)	4,662 (87.0%)	5,356 (100.0%)
Total	78%	158 (0.1%)	2,434 (1.6%)	135 (0.1%)	146,984 (98.2%)	149,711 (100.0%)

TABLE 4-14. NUMBER OF SUBTITLE D SURFACE IMPOUNDMENTS BY ACREAGE CATEGORY [1]

Acreage category	Municipal sewage sludge	Municipal runoff	Industrial waste	Agricultural waste	Mining waste	Oil or gas waste	Other	Total
Response Rate	68%	71%	40%	69%	33%	73%	47%	64%
<0.1 acre	138 (11.1%)	43 (12.4%)	705 (10.8%)	560 (4.7%)	320 (5.0%)	36,575 (39.9%)	4,833 (91.7%)	43,174 (35.0%)
0.1 - 0.4 acres	524 (42.0%)	123 (35.5%)	1,627 (24.8%)	5,843 (49.5%)	439 (6.9%)	241 (52.7%)	241 (4.6%)	57,115 (46.3%)
0.5 - 0.9 acres	405 (32.5%)	92 (26.6%)	2,205 (33.6%)	2,445 (20.7%)	927 (14.4%)	5,316 (5.8%)	137 (2.6%)	11,527 (9.3%)
1 - 5 acres	155 (12.4%)	67 (19.4%)	1,113 (17.0%)	2,791 (23.6%)	2,679 (41.6%)	1,244 (1.4%)	42 (0.8%)	8,091 (6.5%)
6 - 10 acres	16 (1.3%)	16 (4.6%)	458 (7.0%)	68 (0.6%)	1,801 (28.0%)	237 (0.3%)	15 (0.3%)	2,611 (2.1%)
11-100 acres	4 (0.3%)	5 (1.4%)	380 (5.8%)	102 (0.9%)	257 (4.0%)	27 (0.03%)	2 (0.04%)	777 (0.6%)
>100 acres	5 (0.4%)	0	70 (1.1%)	0	17 (0.3%)	25 (0.03%)	0	117 (0.1%)
Total	1,247 (100.0%)	346 (99.9%)	6,558 (100.1%)	11,809 (100.0%)	6,440 (100.2%)	91,742 (100.2%)	5,270 (100.0%)	123,412 (99.9%)

TABLE 4-15. NUMBER OF SUBTITLE D SURFACE IMPOUNDMENTS BY AMOUNT OF WASTE [1]

Amount of waste received (in 1,000's)	Municipal sewage sludge	Municipal runoff	Industrial waste	Agricultural waste	Mining waste	Oil or gas waste	Other	Total
Response Rate	79%	58%	40%	70%	31%	74%	46%	65%
50 or fewer gallons/day	1,392 (95.7%)	215 (75.7%)	2,998 (46.1%)	11,074 (92.9%)	2,372 (39.2%)	79,096 (85.3%)	5,013 (97.8%)	102,160 (82.3%)
50 - 99 gallons/day	50 (3.4%)	58 (20.4%)	1,202 (18.5%)	831 (7.0%)	619 (10.2%)	266 (0.3%)	71 (1.4%)	3,097 (2.5%)
100 - 499 gallons/day	14 (1.0%)	0	935 (14.4%)	21 (0.2%)	1,136 (18.8%)	13,316 (14.4%)	36 (0.7%)	15,458 (12.5%)
500 - 999 gallons/day	2 (0.2%)	3 (1.1%)	817 (12.6%)	0	630 (10.4%)	0	5 (0.1%)	1,457 (1.2%)
1,000 - 9,999 gallons/day	0	8 (2.8%)	470 (7.2%)	0	946 (15.6%)	0	7 (0.1%)	1,431 (1.2%)
10,000 or more gallons/day	0	0	85 (1.3%)	0	350 (5.8%)	0	0	435 (.3%)
Total	1,458 (100.2%)	284 (100.0%)	6,507 (100.1%)	11,926 (100.1%)	6,053 (100.0%)	92,678 (100.0%)	5,132 (100.1%)	124,038 (100.0%)

TABLE 4-16. ESTIMATES OF SPECIFIC SUBTITLE D SURFACE IMPOUNDMENT NUMBERS, QUANTITIES MANAGED AND WASTES RECEIVED WITHIN EACH IMPOUNDMENT CATEGORY [1,4,19]

Waste description	Quantity managed[a] per year (10^3 wet metric ton)	Number of impoundments[c]
Municipal Sewage Sludge		1,938[b]
Municipal Runoff		488[b]
Industrial Waste:	121,002	16,232[b]
Industrial Organic Chemicals	38,059	4,377
Plastics and Resins Manufacturing	30,514	235[a]
Electric Power Generation	28,498	1,671
Primary Iron and Steel Manufacturing and Ferrous Foundaries	14,563	1,380
Fertilizer and Other Agricultural Chemicals	8,641	
Pulp and Paper Industry	580	1,249
Primary Non-Ferrous Metals Manufacturing and Non-Ferrous Foundaries	147	1,380
Leather and Leather Products	1	104
Agricultural Waste		17,159[b]
Livestock, General		5,333
Daily Farm		4,732
Hogs		3,492
Cattle Feedlot		2,974
General Farm		1,208
Poultry Farm		717
Other Fur-Bearing Animals		336
Crop Production		190
Fish Hatcheries		95
Mining Waste		19,813[b]
Bituminous Coal and Lignite		19,891
Non-Metallic Minerals		2,272
Metals		1,754
Anthracite		459
Oil and Gas Waste[d]		125,074[b]
Other Wastes		11,118[b]

[a]Based on data from [3].
[b]Based on data from [1]. Note that numbers from various sources do not generally concur.
[c]Based on data from [15] unless indicated otherwise. Note that numbers from various sources do not generally concur.
[d]Mostly brine waste.

Surface Impoundment Design

Design of a surface impoundment may be a complex engineering activity in which waste characteristics, facility usage characteristics and site characteristics are considered in the specification of design features. This subsection will outline the major environmental protection features of a surface impoundment design. These features include liners, runon/runoff controls, leachate detection systems, cover and closure characteristics, and location factors.

Liners--

Liners constructed of low permeability materials are used to prevent waste migration through impoundment floors and sidewalls. Since liner use for landfills and surface impoundments is similar, descriptions of soil, membrane, and composite liners are analagous to those provided in the landfill subsection (Subsection 4.2.3). Table 4-17 presents Census data on liner use status that indicate that less than one-third of active surface impoundments are lined.

Soil liners for surface impoundments are similar to those for landfills, although surface impoundment designs usually consider the additional effects of hydraulic head on the integrity of the liner. The Subtitle D Census (see Table 4-17) indicates that 28 percent of active Subtitle D surface impoundments use soil liners. Soil liner use is most frequent among agricultural waste impoundments (54 percent), followed by other waste (43 percent), municipal runoff (29 percent), oil and gas waste (27 percent), municipal sewage sludge (26 percent), industrial waste (17 percent), and mining waste impoundments (4 percent). No data were available to describe the quality of the soil liners used in these impoundments.

Membrane liners are ideally impermeable to liquid wastes, so the effect of hydraulic head is reduced. Shultz, et al.,[16] have demonstrated the feasibility of retrofitting surface impoundments with membrane liners using a "pull-through" technique with a flexible chlorosulfonated polyethylene membrane.

The Subtitle D Census (see Table 4-17), indicates that just over 2 percent of the active Subtitle D surface impoundments use membrane liners. Industrial waste, municipal runoff, municipal sewage sludge, and oil and gas waste impoundments are found with membrane liners more than the average 2.2 percent of the time. Mining waste, agricultural waste, and other waste impoundments are all below this average in terms of membrane liner use. No data were available that described the membrane liners used in the lined impoundments.

Runon/Runoff Controls--

Dikes, channels and berms control runon and runoff by damping, diverting and/or slowing storm water flow into and out of surface impoundments. Design requirements are dictated by site topography, normal climate, and expected extreme weather conditions.

TABLE 4-17. NUMBERS OF SUBTITLE D SURFACE IMPOUNDMENTS USING VARIOUS TYPES OF RELEASE PREVENTION METHODS [1]

Method management	Municipal sewage sludge	Municipal runoff	Industrial waste	Agricultural waste	Mining waste	Oil or gas waste	Other (e.g., drinking water treatment sludges)	Total
Synthetic liners	76 (3.9%)	23 (4.7%)	756 (4.7%)	60 (0.3%)	200 (1.0%)	2,950 (2.4%)	6 (0.1%)	4,071 (2.1%)
Natural liners (e.g., clay)	508 (26.2%)	140 (28.7%)	2,818 (17.4%)	9,299 (54.2%)	868 (4.4%)	33,768 (27.0%)	4,835 (43.5%)	52,236 (27.2%)
Leak detection systems	32 (1.7%)	37 (7.6%)	896 (5.5%)	26 (0.2%)	335 (1.7%)	1,406 (1.1%)	0	2,732 (1.4%)
Overtopping controls	589 (30.4%)	269 (55.1%)	3,672 (22.6%)	6,713 (39.1%)	4,144 (20.9%)	28,541 (22.8%)	4,733 (42.6%)	48,661 (25.4%)
Waste restrictions (ban on certain Subtitle D waste types)	634 (32.7%)	71 (14.5%)	2,685 (16.5%)	8,371 (48.8%)	4,358 (22.0%)	30,509 (24.4%)	4,736 (42.6%)	51,364 (26.8%)
Discharge permits	522 (26.6%)	16 (3.3%)	4,738 (29.2%)	2,018 (11.8%)	4,970 (25.1%)	46,491 (37.2%)	171 (1.5%)	58,926 (30.7%)
Total Surface Impoundments	1,938	488	16,232	17,159	19,813	125,074	11,118	191,822

Dikes are used for impoundment sidewall construction and runoff control. Lined sidewall dikes on fill and filled/excavated impoundments serve to ensure slope stability and prevent lateral seepage. Both kinds of dikes are designed to provide surface drainage control, resist wind driven wave erosion, rain erosion, burrowing animals and tree roots, and meet stability criteria.

Channels and berms are used in conjunction with dikes to minimize runoff, erosion, and infiltration. Channels may be constructed of concrete, sod, corrugated metal, or admix materials. They divert runon away from impoundments, and their design is determined by site topography and expected climatic conditions. Berms are flattened embankments surrounding impoundments designed to lessen runon velocity and allow sufficient room for the equipment used in liner installation and maintenance.

The Subtitle D Census reported that over-topping controls are used at 30 percent of surface impoundments (see Table 4-17). The Census did not distinguish between types of over-topping controls and no other data concerning runon/runoff control technology uses were available. Over-topping controls are used most frequently among municipal runoff impoundments (55 percent), followed by other waste (43 percent), agricultural (39 percent), municipal sewage sludge (30 percent), industrial (23 percent), oil and gas (23 percent), and mining waste impoundments (21 percent).

Leak Detection System--

Leachate detection systems indicate liner failure and subsequent waste migration from lined surface impoundments. The Census reports that leak detection systems are found on only 1.5 percent of active impoundments. As shown in Table 4-17, the highest rate of leak detection system use is with municipal runoff (7.6 percent) and industrial waste impoundments (5.5 percent).

Impoundment wastes exhibit phenomena which distinguish them from normal ground water conditions. Leachate detection requires the discovery of the wastes' distinctive phenomena outside of the impoundment boundaries. Distinctive phenomena which yield to modern detection systems include: changes in specific conductivity, the presence of subgrade and impoundment materials, ground water flow fields, and liner and soil distress.

Cover and Closure Characteristics--

When a surface impoundment has reached the end of its useful life and after the liquid wastes have been dewatered and otherwise treated, a permeable or impermeable cap may be installed. The specific features of surface impoundment cover design are dependent upon the intended final use of the waste site as dictated in the closure plan. Cover designs for dewatered and treated surface impoundment wastes are the same as cover designs for landfilled waste. Characteristics of landfill covers were discussed previously.

In most cases, impoundment closure follows a procedure of dewatering, sludge removal and disposal, liner repair or removal, dike repair and contaminated soil removal, monitoring system installation, backfill, cover, and surface reclamation.[17] No data were available on the numbers of cover systems being used.

Location Factors--

Physical location factors (site and surrounding topography, climate, and hydrogeologic setting) present the final line of defense for contaminant control. No data were available concerning location characteristics of different facilities or numbers of surface impoundments employing location factors in their designs. A discussion of State and Territorial location requirements is presented in Section 5.

Surface Impoundment Operation and Maintenance

As with landfills, operation and maintenance of a surface impoundment is an ongoing project. It includes elements of equipment, materials and personnel. Due to the nature of liquid wastes, operation and maintenance of a surface impoundment is less labor and equipment intensive than operation and maintenance of a landfill, and operating costs are generally lower.

Census statistics for release prevention/management methods that may be employed during surface impoundment operations are presented in Table 4-18. The numbers of surface impoundments that have waste restrictions, and discharge permit requirements are shown for the different facility types. Almost 27 percent of surface impoundments have waste restrictions and over 32 percent have discharge permits.

Limited information is available to indicate the incidence of other operating and maintenance features. An operation and maintenance plan for surface impoundments may include: staff structure and requirements, facility description and design parameters, emergency procedures, operation variables and procedures, trouble-shooting procedures, preventive maintenance procedures personnel safety requirements and procedures, equipment maintenance records, permissible waste list, unacceptable waste lists, and an additional record of all additions, deletions, or revisions of procedures.[4] Maintenance of the physical plant will include control of: design, construction, construction materials, wastes received, impoundment performance, liner condition, earth work condition, vegetation, rodents, inspections, and unacceptable practices.[4]

Environmental Monitoring at Surface Impoundments

This section presents pertinent environmental monitoring characteristics of Subtitle D surface impoundments. Environmental monitoring may be performed in three media: ground water, surface water, and air.

The Subtitle D Census provides an indication of active Subtitle D surface impoundment monitoring activity. As shown in Table 4-18, 4 percent use ground water monitoring, 17 percent monitor surface waters, and 0.1 percent monitor air emissions. The following subsections describe the design and extent of ground water, surface water, and air emissions monitoring for Subtitle D surface impoundments.

Ground Water Systems/Parameters--

The purpose of ground water monitoring is to determine the presence or extent of contaminant migration from the impoundment. Consideration for ground water monitoring systems and parameters for surface impoundments are

TABLE 4-18. NUMBERS OF ACTIVE SURFACE IMPOUNDMENTS WITH MONITORING SYSTEMS [1]

Surface impoundment type	Ground water monitoring	Surface water monitoring	Air emissions monitoring
Municipal sewage sludge	131 (6.8%)	50 (2.6%)	10 (0.5%)
Municipal runoff	192 (39.3%)	57 (11.7%)	0
Industrial waste	1,396 (8.6%)	3,151 (19.4%)	73 (0.4%)
Agricultural waste	44 (0.3%)	135 (0.8%)	1 (<0.1%)
Mining waste	5,399 (27.2%)	8,679 (43.8%)	15 (0.1%)
Oil and gas waste	165 (0.1%)	20,030 (16.0%)	25 (<0.1%)
Other	7 (0.1%)	133 (1.2%)	0
TOTAL	7,334 (3.8%)	32,235 (16.8%)	124 (0.1%)

identical to design consideration for landfill ground water monitoring and can be found in Section 4.2.3. Table 4-18 indicates that about 4 percent of all impoundments have ground water monitoring systems. Mining waste impoundments are more likely to have these systems than other impoundments.

Surface Water Systems/Parameters--

The Subtitle D Census (see Table 4-18) indicates that approximately 17 percent of Subtitle D impoundments presently have surface water monitoring systems. Mining waste (44 percent) and industrial waste (19 percent) have higher percentages of surface water monitoring than do the other impoundment types.

Proximity of waste surface impoundments to surface water and drainage patterns determine the necessity of surface water monitoring. Sampling programs generally include upstream stations to collect adequate background water quality data, and downstream stations in areas of most likely contamination.

Air Monitoring Systems/Parameters--

Nonhazardous waste surface impoundments do not generally contain explosive or highly volatile gases. Accordingly, Table 4-18, indicates that only 0.1 percent of active Subtitle D surface impoundments have air monitoring systems. Excluding methane monitoring (which is not relevant to surface impoundments), the air monitoring systems and parameters at surface impoundments are identical to those used for landfill air monitoring and are described in the landfill section.

4.3.3 PRELIMINARY ANALYSIS OF ENVIRONMENTAL AND HUMAN HEALTH IMPACTS AT SURFACE IMPOUNDMENTS

This subsection presents Phase I data relating to environmental and human health impacts of Subtitle D surface impoundments, and has the same objectives as Subsection 4.2.4.

Table 4-19 presents Subtitle D Census data relating to ground water, surface water and air impacts at Subtitle D surface impoundments. The table also presents statistics on State inspections, and on the numbers of surface impoundments with monitoring systems. The following discussion reviews the available aggregate and case study information for ground water, surface water and air contamination.

Ground Water

Ground water impacts of Subtitle D surface impoundments were not described in detail in any of the Phase I data collection efforts nor were they described in any of the literature reviewed for this study. However, the Census presented data on ground water related permit violations at Subtitle D surface impoundments.

Census Data--

Table 4-19 presents data showing that few surface impoundments monitor ground water. This table also presents numbers of violations due to ground water contamination, numbers of facilities with ground water monitoring and

TABLE 4-19. AGGREGATE DATA RELATING TO ENVIRONMENTAL CONTAMINATION AT SURFACE IMPOUNDMENTS [1]

	Number of Subtitle D Surface Impoundments, by type							
	Municipal sewage sludge	Municipal runoff	Industrial waste	Agricultural waste	Mining waste	Oil and gas waste	Other	Total
Total active facilities	1,938	488	16,232	17,159	19,813	125,074	11,118	191,822
Violations detected by State inspection programs								
- ground water contamination	35	32	416	29	48	111	6	677
- surface water contamination	24	18	279	189	249	128	22	909
- air contamination	20	12	145	21	5	10	0	213
State inspection at least once each year[a]	1,148	350	5,541	3,334	2,366	62,724	674	76,137
Facilities with monitoring								
- ground water	131	192	1,396	44	5,399	165	7	7,334
- surface water	50	57	3,151	135	8,679	20,030	133	32,235
- air	10	0	73	1	15	25	0	124

[a]These data include numbers cited by states for frequencies ranging from once a year to more than four times a year. It excludes less frequent inspections and entries under the questionaire category of "other".

numbers of facilities with inspections at least once each year. The Census reported 416 ground water violations at industrial surface impoundments, and lesser numbers at other types of surface impoundments. A reported 32 ground water contamination violations were at municipal runoff surface impoundments. These values and those for other types of surface impoundments may understate the total number of violations substantially, since of the active industrial and municipal runoff surface impoundments, only 9 percent and 39 percent, respectively, had ground water monitoring programs. For these and other reasons cited previously (in the discussion of impacts at landfills), the number of reported violations is an imperfect measure of environmental impacts.

Case Studies--

Four case studies of Subtitle D surface impoundments were prepared under the Phase I effort.[12] These case studies were selected by the EPA Office of Solid Waste, as examples of nonhazardous industrial waste lagoons in operation throughout the country. In spite of this, the cases cannot be considered as representative of the surface impoundments operated across the nation. The case study data were not sufficient to develop any general conclusions regarding causes or effects of ground water contamination at surface impoundments. However, the data provided in four surface impoundment case studies indicate that common ground water impacts are: elevated COD, TDS, and BOD levels; and increased levels of metals. No health impacts were associated with ground water contamination occurring at the case study facilities.

Surface Water

Surface water impacts of Subtitle D surface impoundments were not described in detail in any of the Phase I data collection efforts or literature reviews. However, the Census presents data on surface water related violations at Subtitle D surface impoundments. In the absence of case studies or data regarding surface water impacts associated with surface impoundments, actual public health or environmental impacts associated with contamination from this type of facility cannot be made.

Census Data--

Table 4-19 shows that about 17 percent of all impoundments monitor surface water. The table also indicates that 24 surface water contamination violations were reported at municipal sewage sludge surface impoundments, compared to 279 at industrial facilities, 189 at agricultural units, and 249 at mining waste units, contributing to a total of 909 violations in 1984.

Case Studies--

No case studies were available for evaluation of surface water impacts associated with surface impoundments.

Air

Air impacts at Subtitle D surface impoundments were not described in detail in any of the Phase I data collection efforts or literature reviews. However, the Census presents data on air-related violations at Subtitle D surface impoundments. In the absence of information regarding actual

occurrences of air contamination due to surface impoundments or air monitoring data from case studies, the nature and significance of impacts associated with these occurrences cannot be evaluated. However, the fact that air contamination violations have been reported indicates that these problems do exist.

Census Data--

Table 4-19 indicates that little air monitoring is performed at surface impoundments. This table indicates that 20 air contamination violations were reported at municipal sewage sludge surface impoundments, compared to 140 at industrial facilities, 21 at agricultural units, and 5 at mining waste units, contributing to a total of 208 violations in 1984.

Case Studies--

No case studies which examine actual impact upon air quality due to the presence of a surface impoundment were available for this study.

Summary

Surface impoundments have not yet been characterized sufficiently to determine human health and environmental impacts.

4.4 LAND APPLICATION UNITS

This part presents data on Subtitle D land application units (LAUs), The topics covered include general profile, design and operation, and environmental and human health impacts at LAUs.

4.4.1 GENERAL PROFILE

The Subtitle D Census[1] provided general information on LAUs, including numbers, ownership, acreage, and waste volumes. Information on waste characteristics was available from other sources. The definition of land application unit (LAU) used in the Subtitle D Census[1] was:

> A part of an establishment at which waste is applied onto or incorporated into the soil surface for the purpose of beneficial use or waste treatment and disposal. Land application is often referred to as landfarming or landspreading. Specifically excluded from this definition are manure spreading operations.

This definition is broken down further into:

- Municipal sewage sludge LAUs, which primarily receive sewage sludge from publicly owned or privately owned domestic sewage treatment facilities, including sludge from domestic septic tanks (wastewater LAUs are not included in the Census). These LAUs are divided into two types: High application units where the application rate exceeds the nutrient needs of crops and low application units where the application rate is based on crop nutrient needs.

- Industrial waste LAUs, which receive waste (including sludge or wastewater) primarily from factories, processing plants, and other manufacturing or commercial activities.

- Oil and gas LAUs, which receive waste generated by oil and gas exploration and extraction operations, e.g., drilling muds.

- Other LAUs, which receive Subtitle D wastes but do not fall into any of the above categories, e.g., a drinking water treatment waste LAU.

LAU Numbers, Ownership, Acreage, and Waste Volumes

For each type of LAU, Census data were collected on total numbers, ownership, acreage and amount of wastes received. Respondents typically rated the data quality of land application unit total numbers in the fair, poor or very poor range.

According to Census results, there were 18,889 Subtitle D land application units located at 12,312 establishments in the United States in 1984. Municipal sewage sludge units accounted for about two-thirds of this total. Figure 4-8 presents the number and relative share of the total for each of the four types of LAU. The total estimated number of active Subtitle D land application units in 1984 for each State and Territory is shown on the map presented in Figure 4-9. Wisconsin has the highest number of reported Subtitle D LAUs (4,181), followed by Michigan (2,501), Pennsylvania (2,400), Indiana (1,300), and Minnesota (850).

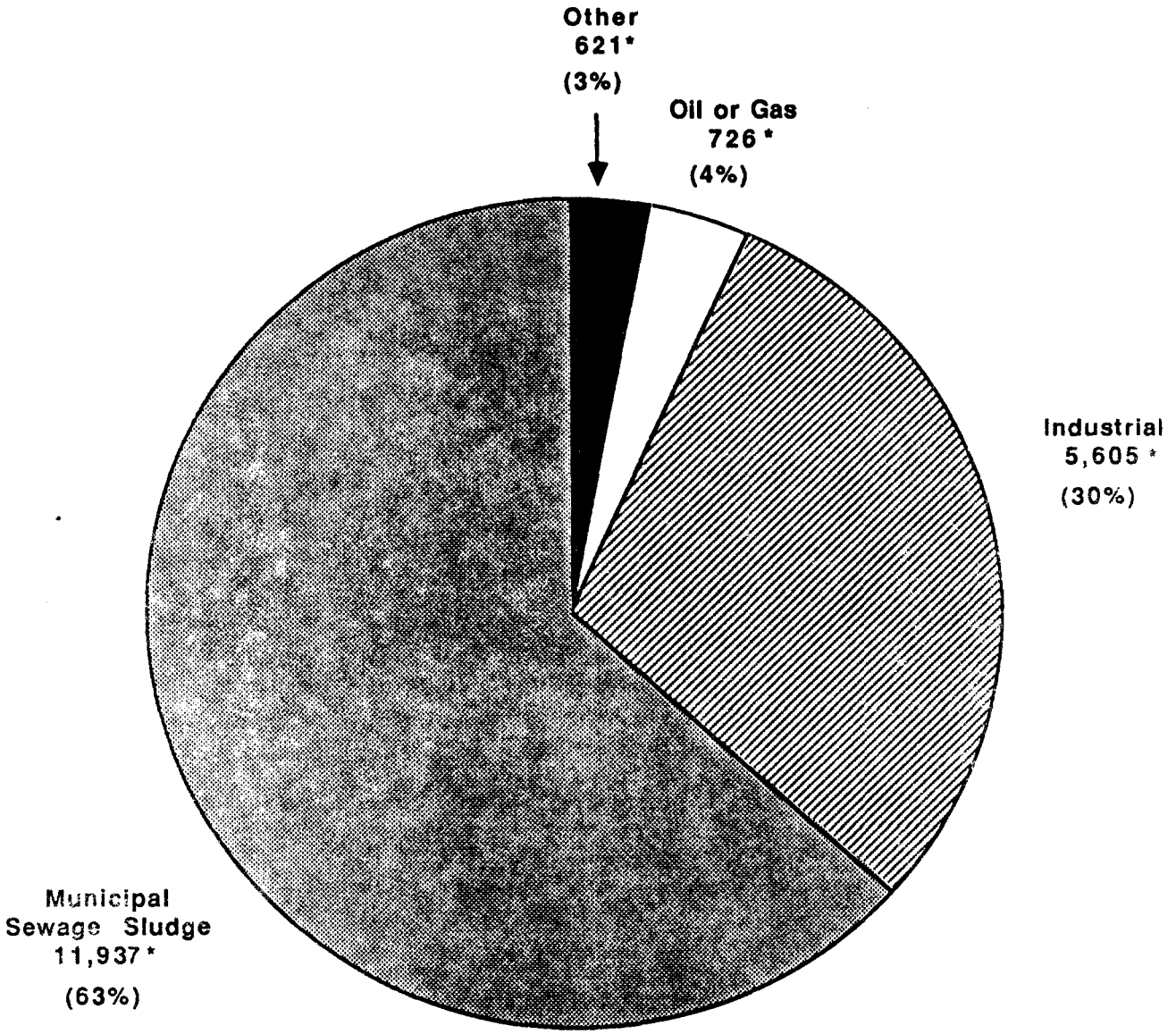
Ownership data were reported for 18,782 (99.4 percent) of the total Subtitle D LAUs. As Table 4-20 makes clear, the great majority of all kinds of LAUs are privately owned.

For 15,576 (82.4 percent) of all LAUs, acreage information was supplied. Although three-quarters of "other" LAUs were greater than 100 acres, more than half of municipal sewage sludge, industrial waste and oil and gas waste LAUs were less than 50 acres. Acreage for each type of LAU and for total LAUs is presented in Table 4-21.

Information on the amounts of waste received was reported for 12,020 (63.6 percent) of the Subtitle D land application units. Most LAUs received less than 50 tons of waste (dry weight) in 1984, as shown in Table 4-22, although the majority of oil or gas waste LAUs received 100 to 999 tons during the year.

Waste Characteristics

The principal waste types that are disposed in Subtitle D LAUs include: municipal sewage sludge, industrial wastewater and sludge, and oil and gas wastes. The characteristics of these wastes are presented in Section 3. The following subsections describe the physical and chemical waste characteristics and quantities received in Subtitle D land application units.



*No estimates of municipal sewage sludge LAUs obtained for IL, LA, MO, or WV; no estimates of industrial waste LAUs obtained for IL, LA, MO, or MT; and no estimates of oil or gas waste LAUs obtained for IL, MO, or MT.

Figure 4-8. Number of Subtitle D land application units, by type. [1]

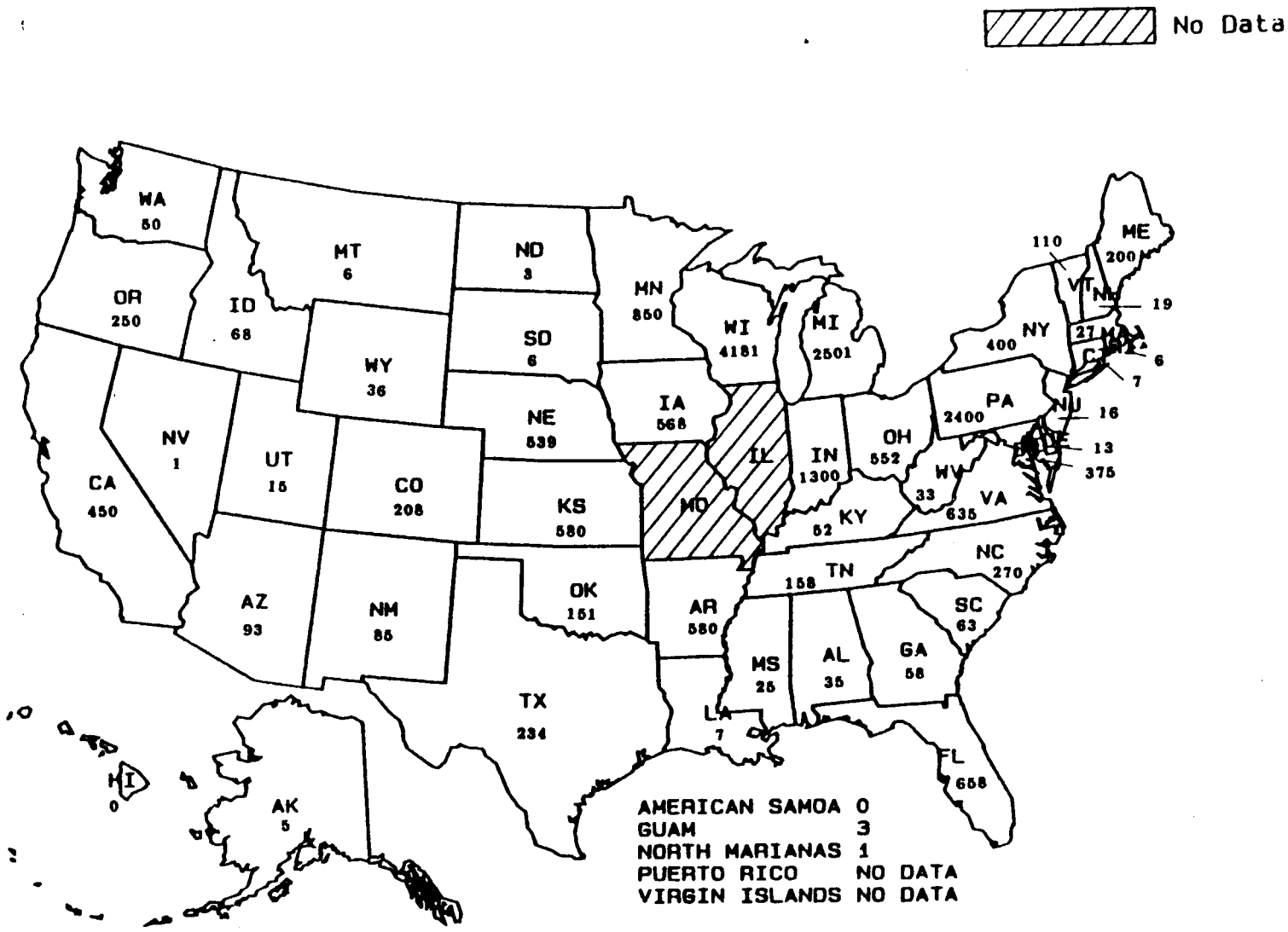


Figure 4-9. Number of Subtitle D land application units by State. [1]

TABLE 4-20. NUMBER OF SUBTITLE D LAND APPLICATION UNITS BY OWNERSHIP CATEGORY [1]

Land application unit type	Response rate (percent)	Owned by State governments	Owned by local governments	Owned by Federal government	Privately owned	Total
Municipal sewage sludge at high application rates[a]	98	2 (0.8%)	48 (20.3%)	0	187 (78.9%	237 (100.0%)
Municipal sewage sludge at low application rates[a]	99	72 (0.7%)	1,028 (10.6%)	17 (0.2%)	8,570 (88.5%	9,687 (100.0%)
Total municipal sewage sludge[a]	99	104 (0.9%)	1,524 (12.9%)	72 (0.6%)	10,145 (85.6%	11,845 (100.0%)
Industrial waste	99	1 (0.1%)	18 (0.3%)	13 (0.2%)	5,558 (99.4%	5,590 (100.0%)
Oil or Gas waste	100	1 (0.1%)	6 (0.8%)	16 (2.2%)	703 (96.8%	726 (99.9%)
Other	100	10 (1.6%)	26 (4.2%)	9 (1.4%)	576 (92.8%	621 (100.0%)
TOTAL	99	116 (0.3%)	1,574 (8.4%)	110 (0.6.%)	16,982 (90.4%)	18,782 (100.0%)

[a]High rate application and low rate application do not equal the total municipal sewage sludge figures because some states do not distinguish high and low application rates.

TABLE 4-21. NUMBER OF SUBTITLE D LAND APPLICATION UNITS BY ACREAGE CATEGORY [1]

Land application unit type	Response rate (percent)	Less than 10 acres	10 - 49 acres	50 - 99 acres	100 acres or more	Total
Municipal sewage sludge at high application rates[a]	98	96 (40.7%)	57 (24.2%)	64 (27.1%)	19 (8.0%)	236 (100.0%)
Municipal sewage sludge at low application rates[a]	78	1,503 (19.6%)	3,339 (43.6%)	1,476 (19.3%)	1,336 (17.5%)	7,654 (100.0%)
Total municipal sewage sludge[a]	82	2,077 (21.2%)	4,567 (46.5%)	1,789 (18.2%)	1,378 (14.0%)	9,811 (99.9%)
Industrial waste	96	681 (15.4%)	1,805 (40.9%)	1,462 (33.1%)	470 (10.6%)	4,418 (100.0%)
Oil or gas waste	100	568 (78.2%)	69 (9.5%)	44 (6.1%)	45 (6.2%)	726 (100.0%)
Other	100	154 (24.8%)	7 (1.1%)	6 (1.0%)	454 (73.1%)	621 (100.0%)
TOTAL	82	3,480 (22.3%)	6,448 (41.4%)	3,301 (21.2%)	2,347 (15.1%)	15,576 (100.0%)

[a]High rate application and low rate application do not equal the total municipal sewage sludge figures because some states do not distinguish between high and low application rates.

TABLE 4-22. NUMBER OF SUBTITLE D LAND APPLICATION UNITS BY AMOUNT OF WASTE [1]

Land application unit type	Response rate (percent)	Received less than 50 tons per year (dry weight)	Received 50 - 99 tons per year (dry weight)	Received 100 - 999 tons per year (dry weight)	Received 1,000 or more tons per year (dry weight)	Total
Municipal sewage sludge at high application rates[a]	32	20 (26.0%)	24 (31.2%)	5 (6.5%)	28 (36.4%)	77 (100.1%)
Municipal sewage sludge at low application rates[a]	52	2,727 (53.9%)	958 (18.9%)	1,050 (20.8%)	321 (6.3%)	5,056 (99.9%)
Total municipal sewage sludge[a]	57	4,276 (63.3%)	1,043 (15.4%)	1,080 (16.0%)	355 (5.3%)	6,754 (100.0%)
Industrial waste	81	3,740 (91.3%)	174 (4.2%)	151 (3.7%)	30 (0.7%)	4,095 (99.9%)
Oil or gas waste	76	81 (14.7%)	22 (4.0%)	439 (79.8%)	8 (1.5%)	550 (100.0%)
Other	100	319 (51.4%)	151 (24.3%)	151 (24.3%)	0	621 (100.0%)
TOTAL	64	8,416 (70.0%)	1,390 (11.6%)	1,821 (15.1%)	393 (3.3%)	12,020 (100.0%)

[a]High rate application and low rate application do not equal the total municipal sewage sludge figures because some states do not distinguish between high and low application rates.

Chemical and Physical Characteristics--

Waste restrictions are widely practiced at LAUs, therefore the chemical and physical characteristics of land applied wastes are determined as much by facility operating or design parameters as by waste generator characteristics.

Table 4-23 lists waste constituent ranges for industrial wastes that are well suited for disposal through land application. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are commonly used to determine a waste's degradability.

The municipal sewage sludge characteristics of of interest to land application include solids content, total fixed dissolved solids, and suspended solids, BOD and COD. As with industrial wastes, municipal sludge characteristics define a waste's degradability and are used to establish application rate limits.

Quantities Received--

Table 4-22 presents Subtitle D Census data on waste amounts received at land application units in 1984. The table shows that most reported LAUs (70 percent) receive less than 50 tons/year of waste and approximately 81 percent of the reported industrial LAUs receive less than 99 tons/year. A study of industrial nonhazardous wastes[3] presents data from 12 major industries concerning industrial nonhazardous wastes managed at land application sites. These data are summarized in Table 4-24. Limitations of the industrial nonhazardous waste disposal study are discussed in Sections 2 and 3.

4.4.2 LAU DESIGN AND OPERATION

The following discussion summarizes the pertinent Phase I data collection efforts regarding design and operating characteristics of Subtitle D land application units. Topics discussed in this section include design, operation and maintenance, and environmental monitoring.

LAU Design

Many variables may affect the design of land application units. The existing soil characteristics determine the waste types that can be used. The waste characteristics determine the application method. This section presents design information concerning slope, runon/runoff control and soil requirements.

Slope--

Slope can affect the amount of soil erosion and potential runoff of applied sludge. Steep slopes are acceptable if the soil is well-drained and well-aerated. With very permeable soils, however, steep slopes increase the possibility of surface runoff of sludge. Rapid surface runoff and soil erosion can transport sludge-soil mixtures to surface waters. The particular wastes must also be considered. No data were available concerning various slopes at active LAUs.

TABLE 4-23. CHARACTERISTICS OF VARIOUS INDUSTRIAL WASTEWATERS APPLIED TO LAND [20] (units in mg/l unless noted)

Constituent	Food processing	Pulp and paper	Dairy
BOD	200 - 4,000	60 - 30,000	4,000
COD	300 - 10,000	-	-
Suspended solids	200 - 3,000	200 - 100,000	-
Total fixed dissolved solids	1,800	2,000	1,500
Total nitrogen	10 - 50	-	90 - 400
pH, dimensionless	4.0 - 12	6 - 11	5 - 7
Temperature, °F	145	195	-

TABLE 4-24. INDUSTRIAL DISPOSAL OF NONHAZARDOUS WASTES IN LAND APPLICATION UNITS [3][a]

Industry	Quantity managed by onsite land application (ton/year)
Industrial Organic Chemicals (SIC 2819)	255,700
Petroleum Refining Industry (SIC 29)	753,300
Plastics and Resins Manufacturing (SIC 2821)	43,200
Total	1,052,200

[a]Approximately 0.3 percent of the industrial waste produced (12 of 22 industries) is being managed on land application sites.

Runon/Runoff Controls--

Runon/runoff control requirements are used to protect water quality and prevent unauthorized discharge into the ground water or surface water. Selection of runon/runoff control usually depends upon sludge application technique. The following is a list of common techniques and practices used to control runoff:[18]

- Fill depressions from cut ridges and mounds to control ponding;
- Terraces to protect lower lands;
- Diversion terraces graded and grass covered to deliver water at nonerosive flows to a control discharge point;
- Vegetation to control erosion and reduce surface runoff;
- Collection and storage of surface runoff;
- Leachate collection and control.

Table 4-25 shows that 51 percent of LAUs employ runon/runoff controls. Municipal sewage sludge LAUs are the most likely to have these controls.

Soil Type Requirements--

Soil characteristics effect land application unit siting because the conditions and properties of soil and sludge determine sludge application rates. Soil characteristics commonly considered include soil test information, permeability requirements, and special considerations for crop growth. No data were available concerning various soil types at LAUs.

LAU Operation and Maintenance

The operating and maintenance characteristics of a land application unit consist of a wide spectrum of activities and precautions. This section is concerned with the following characteristics: safety precautions and controls, employees and equipment, waste application techniques, waste application rate limits, emergency preparedness and contingency plans. Limited data are available on current LAU practices in these areas.

Safety Precautions and Controls--

Data are presented in Table 4-25 for waste restrictions, application rate limits and crop restrictions. Fifty-four percent of all LAUs employ waste restrictions, 75 percent have application rate limits, and 60 percent have restrictions on growing food chain crops. The majority of facilities using these methods are municipal sewage sludge units.

Employees and Equipment--

Equipment at LAUs is used for transportation, storage and application of waste. No useful information was found pertaining to LAU employees.

The equipment used for waste transport and application varies according to the consistency of the waste applied (i.e., dewatered, liquid sludge or wastewater). For dewatered sludge, open dump trucks are used for

TABLE 4-25. NUMBERS OF SUBTITLE D APPLICATION UNITS USING VARIOUS TYPES OF RELEASE PREVENTION METHODS [1]

Management method	Municipal sewage sludge[a]			Industrial waste	Oil or gas waste	Other	Total
	High application rate	Low application rate	Subtotal[a]				
Runon/Runoff controls	(59) (24.4%)	(4,090) (41.8%)	5,075 (42.5%)	3,837 (68.5%)	569 (78.4%)	164 (26.4%)	9,645 (51.1%)
Waste restrictions (ban on certain Subtitle D waste types)	(185) (76.4%)	(5,698) (58.3%)	5,932 (49.7%)	3,633 (64.8%)	122 (16.8%)	544 (89.2%)	10,241 (54.2%)
Waste application rate limits	(195) (80.6%)	(8,164) (83.5%)	9,437 (79.1%)	4,085 (72.9%)	93 (12.8%)	475 (76.5%)	14,090 (74.6%)
Restrictions on the growing of food chain crops	(198) (81.8%)	(7,672) (78.5%)	8,401 (70.4%)	2,395 (42.7%)	23 (3.2%)	576 (92.8%)	11,395 (60.3%)
Total LAUs			11,937	5,605	726	621	18,889

[a]High and low rate application may not equal the subtotal because some States do not distinguish between these two types.

transporting, while bulldozers, loaders, graders, or box spreaders are used for spreading. Regular farm equipment is used for spreading or filling dewatered sludge and heavy-duty discs or disk harrows are commonly used to bury the sludge.

Liquid sludge and wastewater are usually transported in tank trucks or pipelines (also used are closed railroad tanks and barges). Tank truck sprayers and spreaders with splash guards are used to apply the waste. Subsurface application is achieved by using subsurface injection dischargers mounted to plows or discs.

Storage facilities are used in case of equipment breakdowns, adverse weather conditions, or to accommodate fluctuations in sludge production rate and agricultural cropping patterns. These storage facilities include lagoons, Imhoff and community septic tanks, holding tanks, unconfined hoppers and bins.[18]

Waste Application Techniques--

Waste application techniques also vary with waste consistency. The application techniques for dewatered or liquid sludge differ from those for wastewater. These techniques are described below.

Municipal wastewater sludge can be applied to land in either liquid or dewatered form. Dewatered sludge application is similar to that of fertilizers, lime, or animal manure. Liquid sludge can be applied by tank truck, farm tank wagon-spreading or by using subsurface injection.

Industrial wastewater land application is used for waste treatment and disposal. Surface application methods include: sprinkler systems, ridge and furrow, border strip, and basin flooding. Land treatment methods include slow and rapid-rate infiltration.

Waste Application Rate Limits--

The municipal sludge application rate may be determined by sludge composition, soil test information, fertilizer need of the crop grown, and annual waste addition limits.

Emergency Preparedness--

Emergency preparedness procedures used at LAUs to avoid possible hazardous situations include: training personnel for emergency situations, keeping emergency equipment on standby, using fire precaution procedures such as prohibition of unauthorized open burning, constructing stormwater channels to prevent flooding of potentially harmful wastewater, and using proper monitoring procedures (see section on Environmental Monitoring at LAUs).

Contingency Plans--

No information is available regarding the role of contingency plans in the operation of land application sites.

Environmental Monitoring at LAUs

Monitoring LAU sites after sludge application indicates the extent of environment changes that have occurred as a result of waste application. Environmental monitoring needs vary according to land utilization (i.e., dedicated land disposal, agricultural purposes, etc.) and existing site characteristics. In general, monitoring at a land application unit may possibly include sampling and analysis of:

- Sludge quantities and characteristics,
- Soil characteristics, (physical and chemical),
- Ground water quality beneath and adjacent to the site in the direction of ground water flow,
- Surface water runoff from the site,
- Surface waters potentially affected by the site,
- Odor, dust, and/or aerosol emissions from the site, and/or
- Crops grown on the site.

Data from the Subtitle D Census are presented in Table 4-26, showing the number of active Subtitle D LAUs with ground water, surface water, or air monitoring systems in place.

Sludge System/Parameters--

A sludge monitoring system is often used as a quality control tool and a warning of the presence of high concentrations of undesirable constituents. In addition, data on plant nutrients (N, P, and K) are sometimes monitored to assist sludge users (e.g., farmers, commercial tree growers, etc.) in efficient use of nutrients.

The frequency of sludge sampling and analysis is commonly a function of:[21] system size, historical variations in sludge characteristics, the land application option being utilized, and the sampling frequency required by the appropriate regulatory agency.

Sludge may be analyzed for pH, and a variety of chemical constituents. In addition, if the system used is potentially sensitive to pathogens and/or priority organics, these parameters may also be measured. No data were available on the numbers of facilities which monitor sludge or input wastes.

Soil System/Parameters--

Periodic soil monitoring of a land application unit may be done when the sludge contains significant quantities of heavy metals or priority persistent organics, when heavy sludge application rates are used (i.e., as with a dedicated disposal site) and there is concern that the soil will become

phytotoxic to vegetation on the site, or when the LAU's State or local permit requires certain periodic soil monitoring. Table 4-26 shows that about 27 percent of all LAUs monitor the soil. Most of these are municipal sewage sludge LAUs.

Ground Water System/Parameters--

A detailed discussion of ground water monitoring systems can be found in Section 4.2 (Landfills). The constituents analyzed from ground water samples depend on monitoring goals, waste composition, uses of ground water, and regulatory requirements. About 6 percent of all LAUs monitor ground water (from Table 4-26). Most of these are industrial waste LAUs.

Surface Water System/Parameters--

Surface water monitoring is generally performed when it is required by an NPDES permit, or when the site is near a sensitive surface water body.[18] Surface water monitoring parameters may include those which either may effect public health, or those which may contribute to eutrophication; (e.g., nitrogen and phosphorus). According to Table 4-26, about 3 percent of all LAUs monitor surface water. Municipal sewage sludge and oil and gas units monitor surface waters most frequently.

Air System/Parameters--

As shown in Table 4-26, few LAUs (less than 1 percent) monitor the air. No data were available on the monitoring systems or parameters used at the sites reporting air monitoring.

Crop Monitoring/Parameters--

Vegetation monitoring is usually done when heavy sludge application rates are used (i.e., as with a dedicated disposal site) and there is concern that food-chain vegetation grown on the site may accumulate potentially harmful quantities of heavy metals (particularly Cd) from the amended soil. It may also be performed to assure private farm owners that their crops are not being adversely affected by the use of sludge. The actual parameters monitored may vary from this list, depending on the sludge constituents of concern. No data on numbers of facilities that monitor crops were available.

4.4.3 PRELIMINARY ANALYSIS OF ENVIRONMENTAL AND HUMAN HEALTH IMPACTS AT LAUs

This subsection presents Phase I data relating to environmental and human health impacts of Subtitle D land application units, and has the same objectives as Subsection 4.2.4. It presents the available aggregate and case study information for ground water, surface water and air contaminant impacts. No data on actual public health impacts of LAUs were available for this study.

Table 4-27 presents Subtitle D Census data relating to ground water, surface water and air impacts at Subtitle D LAUs. The table also presents statistics on State inspections, and on the numbers of LAUs with monitoring systems.

TABLE 4-26. NUMBERS OF ACTIVE LAND APPLICATION UNITS WITH MONITORING SYSTEMS [1]

Land application unit type	Ground water monitoring	Surface water monitoring	Air monitoring	Soil monitoring
(Municipal sewage sludge at high application rate)	(43) (17.8%)	(16) (6.6%)	(0)	(206) (85.1%)
(Municipal sewage sludge at low application rate)	(170) (1.7%)	(74) (0.8%)	(0)	(4157) (46.2%)
Subtotal of municipal sewage sludge*	337 (2.8%)	265 (2.2%)	100 (0.8%)	4804 (40.2%)
Industrial waste	592 (10.6%)	137 (2.4%)	31 (0.6%)	204 (3.6%)
Oil or gas waste	247 (34.0%)	230 (31.7%)	37 (5.1%)	42 (5.8%)
Other	3 (0.5%)	0	0	3 (0.5%)
Total	1,179 (6.2%)	632 (3.3%)	168 (0.9%)	5,053 (26.8%)

*High and low rate application may not equal the subtotal because some States do not distinguish between these two types.

TABLE 4-27. AGGREGATE DATA RELATING TO ENVIRONMENTAL CONTAMINATION AT LAND APPLICATION UNITS [1]

	Number of Subtitle D Land Application Units, by Type						
	Municipal sewage sludge						
	High application rate	Low application rate	Subtotal of municipal sewage sludge[a]	Industrial waste	Oil or gas waste	Other	Total
Total active facilities	(242)	(9,779)	11,937	5,605	726	621	18,889
Violations detected by State inspection programs							
- ground water contamination	(4)	(13)	17	45	2	2	66
- surface water contamination	(1)	(15)	17	60	25	24	126
- air contamination	(0)	(12)	12	10	0	0	22
State inspection at least once each year[b]	(18)	(1,267)	2,321	796	652	26	3,795
Facilities with monitoring							
- ground water	(43)	(170)	337	592	247	3	1,179
- surface water	(16)	(74)	265	137	230	0	632
- air	(0)	(0)	100	31	37	0	168
- soil	(206)	(4,517)	4,804	204	42	3	5,053

[a]High rate application and low rate application do not equal the total municipal sewage sludge figures because some States do not distinguish between high and low application rates.

[b]These data include numbers cited by States or Territories for inspection frequencies ranging from once a year to more than four times a year. It excludes less frequent inspections and entries under the questionaire category of "other".

Ground Water

Census Data--

As shown in Table 4-27, few land application units monitor ground water. This table indicates 17 ground water contamination violations at municipal sewage sludge LAUs, 45 at industrial LAUs, and 2 at oil or gas and other LAUs. These data suggest that industrial LAUs cause more ground water contamination than municipal, oil and gas, or other units. The number of reported violations is an imperfect measure of environmental impacts for reasons cited previously (in the discussion of impacts at landfills).

Case Studies--

Land treatment field studies were conducted for field application unit facilities in an effort to determine the environmental acceptability of LAU operations.[21] The conclusions of the case studies are site-specific, with each site possessing a unique balance of decomposition and waste migration depending upon the various properties of the waste, site, and land cultivation techniques. These case studies are not reviewed here because their data were insufficient to draw general conclusions about health and environmental impacts at LAUs.

Surface Water

Census Data--

As shown in Table 4-27, few LAUs monitor surface water. The data in this table indicate 17 surface water contamination violations at municipal sewage sludge facilities, 60 at industrial facilities, 25 at oil or gas LAUs, and 24 at other facilities.

Case Studies--

No case studies providing significant information on surface water impacts from land application units were available for this report.

Air

Census Data--

As shown in Table 4-27, few LAUs monitor air. This table indicates 12 air contamination violations at municipal sewage sludge facilities, and 10 at industrial LAUs.

Case Studies--

No case studies were available which provided information on air impacts associated with LAUs.

Summary

Land application unts have not yet been characterized sufficiently to determine human health or environmental impacts.

4.5 WASTE PILES

Waste piles were not included in the Subtitle D Census and no other sources of information are available that provide the numbers, locations, types, ownership characteristics, or sizes of existing waste piles. A general profile of scrap tire piles was reviewed for this report and found to have useful statistics for this particular type of piled waste.[22]

Available data[3] indicate that the following approximate amounts of industrial nonhazardous waste are contained in waste piles:

Industry type	SIC code	Waste amounts (kkg)
Plastics and resins manufacturing	2821	69,740
Industrial organic chemicals	2819	658,734
Fertilizer and other agricultural chemicals	2873-2879	39,487,900
Primary iron and steel manufacture turning, and ferrous foundaries	3312-3321	39,441,400
Total:		79,657,774

No data are presently available on design, operation and maintenance, or environmental monitoring, or ground water, surface water, or air impacts from Subtitle D waste piles.

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SECTION 5

STATE SUBTITLE D PROGRAM CHARACTERIZATION

This section characterizes the current status of State Subtitle D programs. The discussion is organized as follows:

- 5.1 discusses the quality of the data used for characterizing the State programs
- 5.2 provides an overview of State Subtitle D programs, focusing on:
  - Program Organization/Management - organization and resources in managing State programs
  - Identification/Status - identification of all solid waste management facilities
  - Permit/Regulation - permit or other approval mechanism for imposing minimum regulatory requirements on facilities and practices
  - Enforcement - enforcement program for Subtitle D compliance.
- 5.3 reviews State regulations specific to four types of Subtitle D facilities.

The section concludes with a brief summary.

5.1 QUALITY OF DATA FOR CHARACTERIZATION

The primary sources of State programs used in this Phase I assessment are the Subtitle D Census[1] and the Regulations Reviews[2], both completed in mid-1986. Not only are these two reports the most recent State Subtitle D data collection efforts, they are also the most comprehensive. Data from other Subtitle D program information sources are used in this assessment only when data are not available from either the Subtitle D Census or the Regulations Reviews.

One significant problem with respect to most of the estimates presented in the Subtitle D Census is nonresponse to survey questions. This factor results in underestimates for many of the totals presented in this assessment (especially significant with respect to estimates of dollars and hours spent on Subtitle D activities, and numbers of surface impoundments and industrial facilities). In an effort to verify the quality of the data obtained, respondents to the Subtitle D Census were asked to indicate whether they felt

that the quality of their responses was good, fair, poor, or very poor. As a result, it was determined that the quality of the data on Subtitle D facilities, for example, varies markedly by type of facility. The quality of the data on municipal waste landfills is considered highest by the respondents, the quality of the data on industrial surface impoundments lowest. Data quality concerns are noted in this discussion where pertinent.

5.2 OVERVIEW OF STATE SUBTITLE D PROGRAMS

This part presents an overview of State Subtitle D programs. The discussion is organized according to the four topics identified at the beginning of this section.

5.2.1 PROGRAM ORGANIZATION AND MANAGEMENT

The specific program elements that make up organization/management are: State organization in terms of administrative authority to handle Subtitle D activities, budgetary and personnel resources allocated to Subtitle D functions, the qualifications and training of these personnel, and the overall program strategy as demonstrated in a solid waste management plan. The available program data are analyzed according to these elements.

State Organization

The Subtitle D Census asked each State and Territory to list all agencies responsible for developing, regulating, enforcing, overseeing, and otherwise administering any part of the Subtitle D program. Fifteen States and Territories indicated that they have one agency with administrative authority for Subtitle D activities. The remaining 39 respondents indicated that from two to as many as eight different agencies administer parts of the Subtitle D program. The most frequently listed were solid waste and water-related agencies. Some of the other agencies reported to be involved in administering programs for specific Subtitle D facility types include oil and gas commissions, mining and reclamation bureaus, and air compliance offices.

Subtitle D programs for landfills were most frequently reported to be administered by solid waste agencies; programs for surface impoundments, on the other hand, were most frequently reported to be administered by water agencies. Subtitle D land application programs are usually administered by either a solid waste or a water agency.

Although the response rate on State administrative organization was high in the Subtitle D Census, it is likely that not all agencies involved in Subtitle D activities are represented. With the exception of solid waste agencies, other State agency activities are not generally perceived to be related to Subtitle D programs. Many water agencies, for example, do not view their activities as being related to the implementation of Subtitle D, despite the fact that some of their work involves direct enforcement efforts at Subtitle D facilities (e.g., surface impoundments).

Further complicating the organization data is the fact that few agencies are perceived as having a unique budget for Subtitle D activities, even though they may spend money on Subtitle D work (e.g., inspecting municipal landfills). In some cases it appears that money is redirected from other agency programs to offset the lack of money for Subtitle D programs. Furthermore, the list of agencies may not account for State regional or district offices, even where State organizational structures are such that these offices may be heavily involved in Subtitle D inspection and enforcement activities.

Overall, few States and Territories administer their solid waste management programs in the Federal mold, using one agency or department to handle all Subtitle D activities. Most, in fact, have at least two separate agencies, generally a solid waste and a water agency, that carry out Subtitle D functions.

Resources, Staff Qualifications and Training, Program Strategy

The Subtitle D Census provides the following types of data: estimates of total dollars spent, sources of funding, total person hours expended, types of program activities undertaken, and importance rankings for different Subtitle D program activities. Although these data do not present a complete picture of State programs they do indicate the level of effort that States and Territories currently commit to Subtitle D activities.

Of the 141 agencies that responded, 104 included the portion of their overall budget that was spent on Subtitle D activities. The total dollar amount reported for these agencies nationwide was $39,282,455 in FY84. The average number of dollars reported per State or Territory was $785,649. Water agency expenditures were larger on average ($631,389 per State or Territory) than solid waste agency expenditures ($427,184 per State or Territory). The majority of the States and Territories (28) budgeted less than $500,000 on Subtitle D actitivities, a sizable number (13) allocated between $500,000 and $1,000,000. A few States and Territories (7) spent more than $1,000,000 for Subtitle D programs.

The total dollar amount reported above is probably an underestimate of the amount spent on Subtitle D activities nationwide. As noted above, some agencies with Subtitle D responsibilities failed to provide an estimate of the amount spent on Subtitle D activities, and even among those providing estimates, the figures are admittedly very rough.

The Subtitle D Census also asked each State to provide an estimate of the percentage of its total Subtitle D budget for FY84 and FY85 that came from State, Federal, license or user fees, and other funding sources. These estimates are presented in Table 5-1. The Subtitle D Census found that in FY84, 84.6 percent of all Subtitle D funding was attributed to State sources and that only 7.5 percent of such funding came from Federal sources (the Federal funding for Subtitle D activities came almost exclusively through water agencies). The National Solid Waste Survey[3] results for FY84 roughly parallel those of the Subtitle D Census, with an average of 89 percent of all Subtitle D funding coming from State sources and 3.5 percent coming from Federal sources.

TABLE 5-1. SOURCES OF SUBTITLE D FUNDING [1]

Funding source	Fiscal year ending in 1984 (percent)	Fiscal year ending in 1985 (percent)
a. State sources	84.6	85.1
b. Federal sources	7.5	7.1
c. License or user fees	3.5	6.0
d. Other	4.4	1.9
TOTAL	100.0	100.1

In contrast, data for FY81 reported by the National Solid Waste Survey show that 58 percent of the funding for Subtitle D activities came from State sources and 30 percent was provided by Federal sources. The Census data reveal the marked change in the balance of State and Federal funding for Subtitle D programs since 1981. In addition to State and Federal sources, the Subtitle D Census reports that in FY84 and FY85, 9 and 10 States, respectively, used license or user fees and other funding sources to account for 7.9 percent of the aggregate funding in those years.

Estimates of the total number of person hours expended on Subtitle D activities in FY84 were reported for 103 of the 141 agencies identified by the States and Territories as being involved in Subtitle D activities. A total of 1,715,539 hours was reported by the respondents (although this number is probably an underestimate for the reasons cited earlier). Using 2,000 hours as a rough measure of person hours per year, this number represents a total of 858 person years committed to Subtitle D functions by the States and Territories. As with the Subtitle D budget estimates discussed above, these work year estimates vary widely among the States and Territories. Twenty-two States and Territories allocate 10 or fewer person years to Subtitle D, fifteen devote between 10 and 25, and ten commit 25 or more person years.

The Subtitle D Census also reports estimates of the percentage of total hours expended in performing seven different Subtitle D program activities. The results are displayed in Table 5-2. The two types of activities most frequently pursued were surveillance/enforcement and permitting/licensing. Together these accounted for almost 70 percent of all hours expended on Subtitle D activities. Training and research had the smallest percentages of hours devoted to them, with less than 5 percent between them.

TABLE 5-2. STATE SUBTITLE D ACTIVITIES [1]

Subtitle D activity		Percent of hours
1.	Surveillance and enforcement	41.1
2.	Permitting and licensing	27.8
3.	Technical assistance	9.1
4.	Planning	5.8
5.	Regulation development	4.5
6.	Training	2.8
7.	Research	1.5

As an indication of additional needs, the Subtitle D Census asked each State and Territory to rank the seven activities listed in Table 5-2 with respect to their potential for improving Subtitle D program effectiveness, assuming additional resources were available. The overall and facility-specific activity rankings are shown in Table 5-3. Surveillance and enforcement activities ranked highest overall, and for each of the three facility types. This indicates that the States and Territories perceive that Subtitle D program effectiveness would be improved most by further expanding the activity that is now most frequently pursued (see Table 5-2).

TABLE 5-3. IMPORTANCE OF SUBTITLE D PROGRAM ACTIVITIES AS RANKED BY THE STATES [1]

Overall ranking	Subtitle D activity	Landfill ranking	Surface impoundment ranking	Land application ranking
1	Surveillance and enforcement	1	1	1
2	Technical assistance	2	2	3
3	Permitting or licensing	3	4	2
4	Regulation development	5	3	4
5	Training given	6	5	5
6	Planning	4	6	6
7	Research	7	7	7

It is apparent that States and Territories do not place great emphasis on training in their Subtitle D programs. The small percentage of hours devoted to training and the low ranking in importance are indications of this. The data are less conclusive regarding overall program strategy, but strongly suggest that States and Territories have recognized priorities should additional funding become available.

5.2.2 IDENTIFICATION/STATUS

This discussion describes State activities regarding the identification and determination of the Status of Subtitle D facilities. The specific program elements that make up identification/status are: an active solid waste facility/practice identification effort, an accurate data base on facilities, and an up-to-date status determination for all facilities. The available program data are analyzed according to these program elements.

Identification Effort

The Subtitle D Census contains no data on the efforts State and Territorial programs make in identifying the universe of Subtitle D facilities and in ensuring that they are in the regulatory system. The best indications of State efforts in this respect are the data bases they have developed on facilities and the confidence States indicate that they have in the data.

Data on Facilities

The Subtitle D Census collected State and Territorial data on three of the four basic types of facilities regulated under Subtitle D: landfills, surface impoundments, and land application units. Section 4 of this report presented the data States have available on the numbers of such facilities and a discussion of State indications of the quality of such data.

In brief, the available State and Territorial data on Subtitle D facilities suggest that the total universe is approximately 227,000 facilities, although this number is likely to be an underestimate. The Subtitle D Census indicates that the States and Territories do not have consistent approaches for identifying and maintaining data on Subtitle D facilities and thus have data of varying degrees of accuracy for the different facilities regulated by Subtitle D.

Status Determination

The bases for determining the status of a facility or practice are the Federal Criteria promulgated by EPA at 40 CFR Part 257 for distinguishing a sanitary landfill from an open dump. The Subtitle D Census does not include data (other than inspection data discussed below in enforcement) on State and Territorial efforts at determining the regulatory status of facilities based on the Part 257 Criteria. The Inventory of Open Dumps[4], however, provides a limited record of State evaluations of Subtitle D facilities. Published annually since 1981, the inventory lists facilities that the States have found

to be in violation of the Part 257 criteria and thus to pose a reasonable probability of adverse effects on human health or the environment. The inventory also includes brief State descriptions of actions and approaches taken in evaluating the universe of facilities.

The inventory represents an incomplete record of status determinations for Subtitle D facilities, however, because State participation in the inventory has been extremely limited in recent years due to the termination of dedicated Federal Subtitle D funding. For example, the most recent installment of the inventory, published in June 1985, received new information from only 16 States. Table 5-4 presents data from this inventory on the number of open dumps reported by the States and Territories.

5.2.3 PERMIT/REGULATION

The specific program elements under this topic are: specific permit, license, or approval mechanism requirements; minimum regulatory standards or criteria applicable to facilities; and an active permitting program. The available State and Territorial data are analyzed according to these program elements.

Permit or Approval Mechanisms

The Subtitle D Census[1] and Regulations Reviews[2] contain data on the number of States and Territories that have permit or plan approval requirements for Subtitle D facilities. Figure 5-1 presents a map of the United States depicting the number of States and Territories that have such requirements. A total of ten States and Territories report having permit, license or plan approval mechanisms for all four types of Subtitle D facilities. Although most States and Territories have permit requirements for landfills (50) and waste piles (29), fewer have requirements for surface impoundments (16) and land application units (27). The breakdown by facility type is discussed in subsection 5.3 of this section. (These data on State permit requirements run contrary to information EPA has on State and Territorial solid waste management plans. EPA has approved 25 State plans, as discussed below, which must include permit requirements to be in accordance with 40 CFR Part 256. This discrepancy has not yet been reconciled).

The Census also solicited information about permit fee requirements. Fifty-one percent of the States and Territories responding had permit fees for landfills, 40 percent had fees for surface impoundments, and 46 percent had permit fees for land application units.

Minimum Regulatory Standards or Criteria

The Federal Criteria promulgated in 1979 (40 CFR Part 257) represent the minimum regulatory standards that a State program must apply to Subtitle D facilities. Many States and Territories have incorporated these Criteria into regulations as part of their solid waste management plans. At this time, EPA

TABLE 5-4. NUMBERS OF OPEN DUMPS IN THE 1985 INVENTORY [4]

State	Number of dumps	State	Number of dumps
Alabama	12	New Mexico	5
Alaska	50	New York	55
Arizona	39	North Carolina	0
Arkansas	26	North Dakota	8
California	35	Ohio	50
Colorado	11	Oklahoma	61
Connecticut	30	Oregon	20
Delaware	1	Pennsylvania	48
Florida	37	Rhode Island	6
Georgia	11	South Carolina	3
Hawaii	1	South Dakota	64
Idaho	39	Tennessee	6
Illinois	12	Texas	11
Indiana	12	Utah	31
Iowa	3	Vermont	9
Kansas	3	Virginia	1
Kentucky	9	Washington	32
Louisiana	338	West Virginia	45
Maine	16	Wisconsin	51
Maryland	6	Wyoming	17
Massachusetts	61	Am. Samoa	5
Michigan	151	Guam	1
Minnesota	66	N. Mar. Is.	3
Mississippi	88	Puerto Rico	64
Missouri	3	Virgin Is.	5
Montana	42		
Nebraska	1		
Nevada	52		
New Hampshire	28		
New Jersey	5		

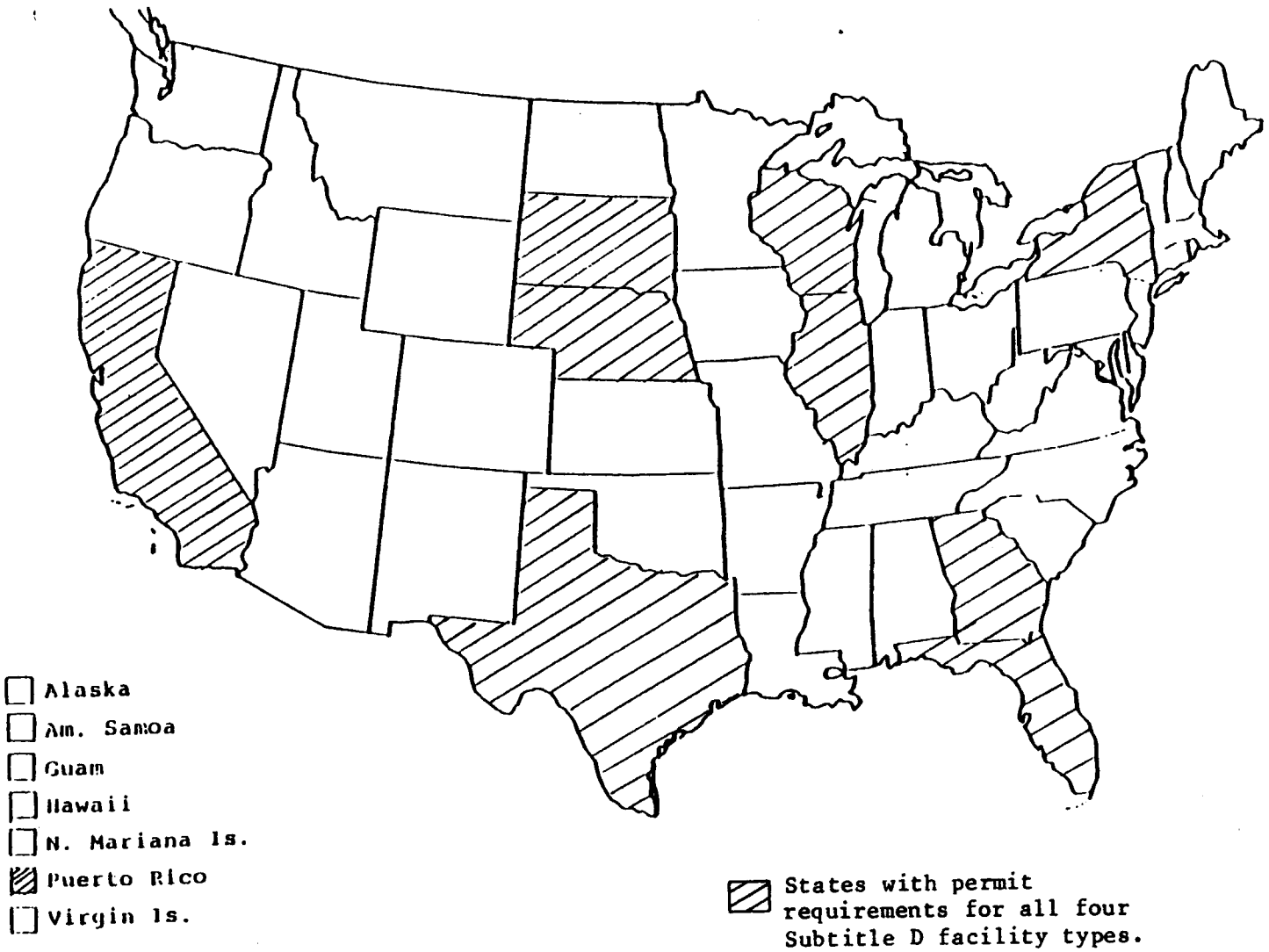

Figure 5-1. States and Territories that have permit requirements for all Subtitle D facilities.[2]

has approved 25 such plans and partially approved six others. However, the EPA has not actively reviewed State solid waste management plans since 1981 when the Federal emphasis shifted to the hazardous waste program. During Phase II of the Subtitle D Study, the EPA plans to evaluate how many additional States have regulations equivalent to or more stringent than the Federal Criteria.

A number of States and Territories have established regulatory requirements for their Subtitle D facilities that are, in many instances more stringent than the Subtitle D Criteria. The Subtitle D Census and Regulations Reviews contain extensive information on the number and types of other regulatory requirements imposed by the States. A breakdown of these additional requirements by facility type is contained in the discussion of specific facility requirements in subsection 5.3 of this section.

Permit Program Implementation

The Subtitle D Census contains data on the number of Subtitle D facilities (excluding waste piles) that have permits or approved facility plans. Table 5-5 presents these data on the numbers of Subtitle D facilities with a permit or approved plan and the percentage of the total universe of facilities (note that those that have "licenses" are not included here). A further breakdown by facility type of the number of permits and percentage permitted is contained in subsection 5.3. The data indicate that while the number of permits granted to Subtitle D facilities is high, almost half of the facilities remain unpermitted.

TABLE 5-5. NUMBERS OF SUBTITLE D FACILITIES WITH PERMITS [1]

Facility type	Number	Percent of total
Landfills	8,422	51.3
Surface Impoundments	95,478	49.8
Land Application Units	12,502	66.2
Waste Piles	n/a	n/a
TOTAL	116,402	51.2

5.2.4 ENFORCEMENT

The specific program elements covered under this topic are: an inspection program for discovering non-compliance, data on the violations discovered, and follow-up enforcement actions for remedying violations.

Inspection Program

The Subtitle D Census contains data on numbers and frequency of State inspections at Subtitle D facilities in 1984 (data do not include waste piles). Table 5-6 presents these data in the aggregate; a breakdown of inspection data by facility type is presented in subsection 5.3. The data indicate that landfills and surface impoundments have been the primary focus of State inspection efforts and that landfills are inspected more often than any other type of facility.

The Census also reports whether or not States and Territories used checklists for their inspections. The summary results indicate that 71.5 percent had checklists for landfill inspections and 30.4 percent did so for land application units, but no summary results were available for surface impoundments.

TABLE 5-6. NUMBERS OF INSPECTIONS AT SUBTITLE D FACILITIES IN 1984 [1]

Facility Type	Number of inspections	Percentage of units inspected yearly or more often
Landfills	32,852	77
Surface Impoundments	48,103	56
Land Application Units	8,085	19
Waste Piles	n/a	n/a

Discovery of Violations

The Subtitle D Census contains data on the number and type of violations found by States and Territories at Subtitle D facilities in 1984 (except for waste piles). Table 5-7 presents these data in aggregate form. A breakdown of the data by facility type is presented in subsection 5.3. The data indicate that the most common violations discovered at Subtitle D facilities are violations of facility operating requirements, but a significant number of ground water, surface water, and air contamination violations have also been uncovered.

TABLE 5-7. NUMBERS OF VIOLATIONS AT SUBTITLE D FACILITIES IN 1984 [1]

Type of facility	Ground water contamination	Surface water contamination	Air contamination	Methane control	Operational deficiencies
Landfills	720	758	950	189	5,973
Surface Impoundments	677	909	213	n/a	4,907
Land Application Units	66	126	22	n/a	293
Waste Piles	n/a	n/a	n/a	n/a	n/a

Enforcement Actions

The Subtitle D Census does not contain any such enforcement data from State Subtitle D programs. The National Solid Waste Survey[3], however, does include limited enforcement data on the number of actions brought against Subtitle D facility owners/operators in 1983. In that year, 897 State actions were brought against municipalities and counties and 1,158 against private firms and individuals. Another 931 unclassified actions were filed in 1983.

5.3 FACILITY-SPECIFIC STATE REGULATIONS

The Regulations Reviews[2] contain detailed information on the State and Territorial regulations that apply to the various types of Subtitle D facilities. This regulatory information is discussed under the following headings: permitting and administrative requirements; design criteria; operation and maintenance standards; location standards and restrictions; monitoring requirements; closure and post-closure requirements; and financial responsibility requirements. The discussion that follows presents a summary of State and Territorial regulations for each facility type. More detailed information on what requirements are imposed by which States appears in tabular form in Appendix D.

5.3.1 LANDFILLS

Permitting and Administrative Requirements

According to the Subtitle D Census, most States and Territories require some permit/plan approval or license/registration for the various types of landfills (all but one have such requirements for municipal landfills). Out of a total of 16,416 landfills, 8,422 (51 percent) have permits and 2686 (16 percent) have licenses. Table 5-8 peresents these data by landfill type.

TABLE 5-8. NUMBERS OF SUBTITLE D LANDFILLS WITH PERMITS AND LICENSES [1]

Landfill type	Number of landfills with permits or approved plans	Number of landfills with licenses or registrations
Municipal waste	5,444	2,206
Industrial waste	1,392	319
Demolition debris only	1,377	150
Other	209	11
TOTAL	8,422	2,686

Most available data on specific permit information requirements, contained in the Regulations Reviews, are limited to municipal landfills. These data are presented in Table 1 of Appendix D. As the table indicates, the States and Territories vary widely in permit information requirements for municipal landfills. Most require some information on soil conditions, the location of surface water, and a determination of surface water background quality. Fewer have requirements with respect to total acreage, life of the facility and future use of the property. About half require certification of the permit application by a Registered Professional Engineer.

Design Criteria and Standards

Fifty States and Territories have a general performance standard that requires the owner/operator of a municipal landfill to control the generation, storage, collection, transportation, processing and reuse, and disposal of solid waste in a safe, sanitary, aesthetically acceptable, and environmentally sound manner. Few specific design requirements have been promulgated. The data on requirements for municipal landfills are presented in Table 2 of Appendix D. Those States and Territories imposing design requirements typically include runon/runoff controls and, to a lesser extent, leachate management and gas controls. Eighteen States have liner design specifications, ranging from thickness to permeability, for both natural and synthetic liners.

Operation and Maintenance Standards

Fifty-two States and Territories have established minimum standards for the operation and maintenance of municipal landfills. Requirements regarding

the operation and maintenance of municipal landfills are presented in Table 3 of Appendix D. Most States and Territories employ a fairly consistent set of controls, including waste management, leachate controls, daily cover, safety requirements, and other controls.

Location Standards and Restrictions

Forty-four States and Territories have some sort of location standards or restrictions applicable to municipal landfills. The different requirements, ranging from flood protection and minimum distances to restrictions with respect to critical habitat, geologically sensitive areas, and soil conditions, are presented in Table 4 of Appendix D. As shown, most States specify minimum distances to man-made or natural structures and have some form of flood control restrictions.

Monitoring Requirements

Forty-one States and Territories require ground water monitoring, 23 require leachate monitoring, and 10 require surface water monitoring to be installed and operated around municipal landfills. Four of the States or Territories which require leachate monitoring do not require ground water monitoring. No States or Territories require air monitoring. The data on types of monitoring are presented in Table 5 of Appendix D.

Closure, Post-Closure, and Financial Responsibility Requirements

Fifty-one States and Territories have some sort of closure and postclosure regulatory requirements and 21 require some form of financial assurance. The differing requirements are presented in Table 6 of Appendix D.

Enforcement Efforts

The Subtitle D Census contains limited data on State enforcement activities at Subtitle D landfills. These include number and frequency of inspections and number and type of violations discovered at landfills, but no data on enforcement actions and compliance rates. The Census data on inspections, presented in Table 5-9, demonstrate the special attention given municipal landfills compared to the other types. This is also confirmed by the data on frequency of inspections shown in Table 5-10. Census data on violations discovered at landfills are presented in Table 5-11. These data indicate that while most of the violations reported in 1984 were for operational deficiencies, a significant number also were reported for ground water, surface water, and air contamination violations. It should be noted that States used their own definitions of "contamination in reporting these data, and thus both minor and serious contamination incidents are likely to be included.

TABLE 5-9. NUMBERS OF INSPECTIONS OF SUBTITLE D LANDFILLS IN 1984 [1]

Landfill type	Number of inspections during 1984	Number of landfills
Municipal waste	24,865	9,284
Industrial waste	4,354	3,511
Demolition debris only	2,834	2,591
Other	799	1,030
TOTAL	32,852	16,416

TABLE 5-10. FREQUENCY OF INSPECTION OF SUBTITLE D LANDFILLS IN 1984[1]

	Municipal waste	Industrial waste	Demolition debris	Other	TOTAL
Response Rate	90%	94%	92%	98%	91%
Never inspected	431 (5.1%)	157 (4.8%)	212 (9.2%)	64 (6.4%)	864 (5.8%)
Less than once every two years	347 (4.1%)	347 (11.4%)	202 (8.8%)	10 (1.0%)	935 (6.2%)
Once every two years	776 (9.3%)	87 (2.6%)	308 (13.4%)	301 (30.0%)	1,472 (9.8%)
Once a year	2,609 (31.1%)	512 (15.3%)	580 (25.2%)	513 (51.0%)	4,214 (28.1%)
Twice a year	1,272 (15.2%)	482 (14.6%)	733 (31.9%)	100 (9.9%)	2,587 (17.3%)
Four times a year	1,548 (18.5%)	416 (12.6%)	142 (6.2%)	15 (1.5%)	2,121 (14.2%)
More than four times a year	1,279 (15.3%)	1,243 (37.7%)	93 (4.0%)	3 (0.2%)	2,618 (17.5%)
Other	122 (1.5%)	24 (0.7%)	30 (1.3%)	0	176 (1.2%)
TOTAL	8,384 (100%)	3,297 (100%)	2,300 (100%)	1,006 (100%)	14,987 (100%)

TABLE 5-11. NUMBER OF LANDFILLS BY TYPE OF VIOLATION IN 1984 [1]

Violation Type	Municipal waste	Industrial waste	Demolition debris only	Other	TOTAL
Ground water contamination	586	111	16	7	720
Ground water monitoring program deficiencies	834	117	82	108	1,141
Surface water contamination	660	50	42	6	758
Air contamination	845	18	33	54	950
Methane control deficiencies	180	8	0	1	189
Operational deficiencies (e.g., daily cover violation or blowing litter and other minor violations)	4,784	433	531	225	5,973
Other violations in 1984	222	13	7	0	242

5.3.2 SURFACE IMPOUNDMENTS

Sixteen of the States and Territories studied for the Regulations Reviews[2] have regulations that address surface impoundments. These regulations are discussed briefly below.

Permitting and Administrative Requirements

With a few exceptions, each of the 16 States and Territories requires issuance of an application, license, or permit before facilities can become operational. A significant number of surface impoundments actually have permits or approved plans. A smaller number have licenses or registrations, as shown in Table 5-12. Specific permit information requirements that apply to surface impoundments--ranging from soil conditions, ground and surface water information to future use of the property--are shown in Table 7 of Appendix D. In most cases, the requirements include certification by a Professional Engineer and, to a lesser extent, surface and ground water information.

TABLE 5-12. NUMBERS OF SUBTITLE D SURFACE IMPOUNDMENTS WITH PERMITS AND LICENSES [1]

Surface impoundment type	Number of surface impoundments with permits or plan approvals	Number of surface impoundments with licenses or registrations
Municipal sewage sludge	1,121	0
Municipal runoff	365	0
Industrial waste	7,747	354
Agricultural waste	10,505	210
Mining waste	11,218	77
Oil or gas waste	59,295	0
Other	5,227	0
TOTAL	95,478	641

Design Criteria and Standards

Of the 16 States and Territories that have surface impoundment requirements, 11 have criteria with respect to facility design. As can be seen in Table 8 of Appendix D, not all of these specific criteria are implemented in each of the 11 States. Nine specify security requirements and runon/runoff controls, eight require leachate management, seven include some form of natural or synthetic liner design specifications.

Operations and Maintenance Standards

Thirteen of the 16 States and Territories with surface impoundment requirements have established minimum operation and maintenance standards. The reasons typically cited for promulgating such standards are to minimize nuisances, to protect public health and safety, and to prevent pollution of the environment. Despite this uniformity of purpose, the breadth and specificity of these minimum standards vary widely among the States and Territories, as shown in Table 9 of Appendix D, and the actual levels or methods of performance are frequently left to the discretion of the enforcement agency.

Location Standards and Restrictions

Twelve States and Territories have location standards for surface impoundments. The distribution of the specific location standards and

restrictions, ranging from flood protection to critical habitat controls shown in Table 10 of Appendix D. As with landfills, States are more likely to restrict sites in floodplains and within specified distances to man-made structures and natural resources.

Monitoring Requirements

Monitoring requirements pertaining to ground water, surface water, leachate, or air are imposed in 14 States, as can be seen in Table 11 of Appendix D. Ground water monitoring is required in 11 of these States, leachate and air in about half, and surface water in only four States.

Closure, Post-Closure, and Financial Responsibility Requirements

Eleven of the 16 States and Territories have included closure requirements in their g surface impoundment regulations. These are shown in Table 12 of Appendix D. Ten States have requirements covering post-closure and seven of these States impose financial responsibility requirements as well.

Enforcement Efforts

The Subtitle D Census contains limited data on State enforcement activities at Subtitle D surface impoundments. These include number and frequency of inspections and number and type of violations discovered, but no data on enforcement actions and compliance rates. The inspection data, presented in Table 5-13, indicate that inspections have occurred at oil or gas waste surface impoundments more often than at all other types combined. The frequency of inspection data shown in Table 5-14, on the other hand, reveal that the municipal runoff impoundments are the most frequently inspected. Census data on violations at landfills are presented in Table 5-15. As with landfills, these data indicate that while most of the violations reported in 1984 were for operational deficiencies, a significant number also were reported for ground water, surface water, and air contamination violations. As mentioned previously, the States' definitions of "contamination" vary.

TABLE 5-13. NUMBERS OF INSPECTIONS OF SUBTITLE D SURFACE IMPOUNDMENTS IN 1984 [1]

Surface impoundment type	Number of inspections during 1984	Number of surface impoundments
Municipal sewage sludge	1,079	1,938
Municipal runoff	1,768	488
Industrial waste	6,164	16,232
Agricultural waste	3,765	17,150
Mining waste	7,674	19,813
Oil or gas waste	26,340	125,074
Other	1,313	11,118
TOTAL	48,103	191,822

TABLE 5-14. FREQUENCY OF INSPECTION OF SUBTITLE D SURFACE IMPOUNDMENTS IN 1984 [2]

	Municipal sewage sludge	Municipal run-off	Industrial waste	Agricultural waste	Mining waste	Oil or gas waste	Other	TOTAL
Response Rate	93%	98%	73%	88%	38%	77%	47%	72%
Never inspected	37 (2.1%)	34 (7.1%)	191 (1.6%)	3,634 (24.2%)	658 (8.8%)	11,478 (11.9%)	3 (0.06%)	16,035 (11.6%)
Less than once every two years	401 (22.4%)	59 (12.3%)	2,981 (25.2%)	5,568 (37.1%)	927 (12.4%)	15,239 (15.7%)	104 (2.0%)	25,279 (18.2%)
Once every two years	208 (11.6%)	30 (6.3%)	2,835 (24.0%)	1,013 (6.7%)	3,294 (44.0%)	7,344 (7.6%)	108 (2.1%)	14,832 (10.7%)
Once a year	851 (47.4%)	106 (22.1%)	4,645 (39.3%)	2,918 (19.4%)	2,009 (26.8%)	60,152 (62.2%)	425 (8.2%)	71,106 (51.3%)
Twice a year	234 (13.0%)	24 (5.0%)	498 (4.2%)	413 (2.8%)	100 (1.3%)	1,426 (1.5%)	27 (0.5%)	2,722 (2.0%)
Four times a year	61 (3.4%)	82 (17.1%)	234 (2.0%)	3 (0.1%)	51 (0.7%)	406 (0.4%)	222 (4.3%)	1,059 (0.8%)
More than four times a year	2 (0.1%)	138 (28.8%)	164 (1.4%)	0	206 (2.7%)	740 (0.8%)	0	1,250 (0.9%)
Other	0	6 (1.3%)	275 (2.3%)	1,465 (9.8%)	249 (3.3%)	0	4,324 (82.9%)	6,319 (4.6%)
TOTAL	1,794 (100%)	479 (100%)	11,823 (100%)	15,014 (100%)	7,494 (100%)	96,785 (100%)	5,213 (100%)	138,602 (100%)

TABLE 5-15. NUMBER OF SURFACE IMPOUNDMENTS BY TYPE OF VIOLATION IN 1984 [1]

Violation type	Municipal sewage	Municipal runoff	Industrial waste	Agricultural waste	Mining waste	Oil or gas waste	Other	TOTAL
Ground water contamination	35	32	416	29	48	111	6	677
Ground water monitoring program deficiencies	28	12	317	34	137	110	5	643
Surface water contamination	24	18	279	189	249	128	22	909
Air contamination	20	12	145	21	5	10	0	213
Operational deficiencies and other minor violations	137	37	616	672	534	2,893	18	4,907
Other violations in 1984	0	0	0	0	7	0	0	7

5.3.3 LAND APPLICATION UNITS

Twenty-three of the States and Territories reviewed in the Regulations Reviews[2] have regulations that address land application units (LAUs). These regulations are discussed briefly below.

Permitting and Administrative Requirements

Out of a total of 18,889 LAUs, 12,502 (66 percent) have permits or approved plans annd 410 (2 percent) have licenses or registrations. These numbers are presented, by LAU type, in Table 5-16. Twenty-two of the 23 States and Territories require an application, license, or permit before facilities can become operational. The range of specific permit information requirements is shown in Table 13 of Appendix D. In most State and Territory regulations, the governing agency reserves the right to require any additional information deemed necessary. Along the same lines, nearly all States have specific administrative procedures that allow exemptions, variances, and restrictions based on a case-by-case evaluation of site-specific circumstances.

TABLE 5-16. NUMBERS OF SUBTITLE D LAND APPLICATION UNITS WITH PERMITS AND LICENSES [1]

Land application unit type	Number with permits or approved plans	Number with licenses or registrations
Municipal sewage sludge	7,955	297
Industrial waste	3,331	113
Oil or gas waste	697	0
Other	519	0
TOTAL	12,502	410

Design Criteria and Standards

Eighteen States and Territories have requirements pertaining to facility design. The variability with respect to the enforcement of such requirements across States is shown in Table 14 of Appendix D. Typically these requirements include security and runon/runoff controls, and to a lesser extent, leachate management and air protection design specifications.

Operations and Maintenance Standards

Twenty-one of the 23 States and Territories with restrictions on LAUs have operation and maintenance regulations. Table 15 of Appendix D shows which of these regulatory areas are covered by the different States and Territories. Eighteen States and Territories require safety controls, 15 have waste management and waste application controls, seven have crop management restrictions, and six have leachate management restrictions.

Location Standards and Restrictions

Sixteen States and Territories have location standards and restrictions that pertain to land application units as can be seen in Table 16 of Appendix D. Consistent with other types of Subtitle D facilities, LAU location controls usually include floodplain and minimum distance restrictions.

Monitoring Requirements

Sixteen States and Territories have monitoring requirements. The distribution of these requirements across States and Territories is shown in Table 17 of Appendix D. Fifteen call for ground water monitoring, but fewer than half that number require surface water, soil, or air monitoring.

Closure, Post-Closure, and Financial Responsibility Requirements

Wide variations exist among State and Territory regulatory requirements for LAU closure and post-closure. The 12 that have such regulations are shown in Table 18 of Appendix D. The six States having regulations regarding financial responsibility also are shown in that table. No States or territories are reported to have liability requirements for land application units.

Enforcement Efforts

The Subtitle D Census contains limited data on State enforcement activities at Subtitle D land application units. These include number and frequency of inspections and number and type of violations discovered. The inspection data, presented in Table 5-17, indicate that almost twice as many inspections occurred at municipal sewage sludge units compared to the other types. The data on frequency of inspection shown in Table 5-18, on the other hand, reveals that most municipal sludge units were inspected once every two years or less, whereas most oil and gas units were inspected once a year or more. Census data on violations at land application units are presented in Table 5-19. As with landfills and suface impoundments, these data indicate that most of the violations reported in 1984 were for operational deficiencies, but ground water, surface water, and air contamination violations were reported as well.

TABLE 5-17. NUMBERS OF INSPECTIONS OF SUBTITLE D LAND APPLICATION UNITS IN 1984 [1]

Land application unit type	Number of inspections during 1984	Number of land application units
Municipal sewage sludge	5,326	11,937
Industrial waste	1,601	5,605
Oil or gas waste	1,124	726
Other	34	621
TOTAL	8,085	18,889

5.3.4 WASTE PILES

Thirty States and Territories have regulations that address waste piles. These regulations are discussed briefly below.

Permitting and Administrative Requirements

Twenty-nine States and Territories require a permit, license, or application for waste piles. Table 19 of Appendix D presents a matrix of these permit requirements. Specific permit information requirements for waste piles are limited in scope and vary considerably among the States and Territories, but typically require information on soil conditions, surface water location, and ground water elevation and flow. As with the other types of facilities, most States require certification of permit applications by a Professinal Engineer.

Design Criteria and Standards

Twenty-two States and Territories have design criteria applicable to waste piles. Specific requirements for waste piles range from liner specifications to leachate management and decomposition gas controls. The distribution of these requirements is presented in Table 20 of Appendix D.

Operation and Maintenance Standards

Twenty-seven States and Territories impose some sort of operation and maintenance standards on waste piles. Specific standards range from waste composition requirements to vector, dust, and noise controls. The distribution of these requirements among the States is presented in Table 21 of Appendix D.

TABLE 5-18. FREQUENCY OF INSPECTION OF SUBTITLE D LAND APPLICATION UNITS IN 1984 [1]

	Total municipal sewage sludge	Industrial waste	Oil and gas waste	Other	TOTAL
Response Rate	95%	99%	100%	100%	97%
Never inspected	388 (3.4%)	1,308 (23.7%)	15 (2.1%)	71 (11.4%)	1,782 (9.8%)
Less than once every two years	6,489 (57.2%)	2,487 (45.0%)	6 (0.8%)	46 (7.4%)	9,028 (49.5%)
Once every two years	1,403 (12.4%)	845 (15.3%)	33 (4.5%)	28 (4.5%)	2,309 (12.7%)
Once a year	1,787 (15.8%)	639 (11.6%)	175 (24.1%)	26 (4.2%)	2,627 (14.4%)
Twice a year	254 (2.2%)	126 (2.3%)	465 (64.0%)	0	845 (4.6%)
Four times a year	98 (0.9%)	21 (0.4%)	4 (0.6%)	0	123 (0.7%)
More than four times a year	182 (1.6%)	10 (0.2%)	8 (1.1%)	0	200 (1.1%)
Other	743 (6.5%)	94 (1.7%)	20 (2.8%)	450 (72.5%)	1,307 (7.2%)
TOTAL	11,344 (100%)	5,530 (100%)	726 (100%)	621 (100%)	18,221 (100%)

TABLE 5-19. NUMBER OF LAND APPLICATION UNITS BY TYPE OF VIOLATION IN 1984 [1]

Violation Type	Total municipal sewage sludge	Industrial waste	Oil or gas waste	Other	TOTAL
Ground water contamination	17	45	2	2	66
Ground water monitoring program deficiencies	14	41	8	1	64
Surface water contamination	17	60	25	24	126
Air contamination	12	10	0	0	22
Operational deficiencies and other minor violations	115	88	82	8	293
Other violations in 1984	10	0	0	0	10

Location Standards and Restrictions

Fifteen States and Territories have some sort of location standards or restrictions applicable to waste piles. As with other facility types, the most common location requirements apply to floodplains and minimum distances. These location standards or restrictions are presented in Table 22 of Appendix D.

Monitoring Requirements

Sixteen States and Territories impose monitoring requirements on waste piles. The specific types of monitoring required, i.e., ground water, surface water, leachate or air, vary considerably. These requirements are presented in Table 23 of Appendix D. More States require ground water monitoring systems (14) and leachate monitoring and control (10) than require surface water (5) or air monitoring (2).

Closure, Post-Closure, and Financial Responsibility Requirements

Fifteen States and Territories have closure and post-closure maintenance requirements for waste piles. These are presented in Table 24 of Appendix D. This table also shows the six States that impose financial responsibility requirements for waste piles.

Enforcement Efforts

The Subtitle D Census does not contain data on waste piles, so there are no nationwide data on the number and frequency of State inspections of waste piles or the number and types of violations uncovered currently available.

5.4 SUMMARY

This section has presented data on State and Territorial Subtitle D programs. It has also identified the limitations in the available data that make a complete State program characterization difficult. The data on State and Territorial Subtitle D programs collected during Phase I will continue to be examined, and will be supplemented as necessary during Phase II of the Subtitle D study.

REFERENCES

1. Westat, Inc. Census of State and Territorial Subtitle D Non-Hazardous Waste Programs. Contract No. 68-01-7047. U.S. Environmental Protection Agency, OSW, Washington. D.C., 1986.

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3. Association of State and Territorial Solid Waste Management Officials. National Solid Waste Survey, Unpublished. 1984.

4. U.S. Environmental Protection Agency. Inventory of Open Dumps. U.S. Environmental Protection Agency, Washington, D.C. 1985.

SECTION 6

CONCLUSIONS

At the beginning of the Subtitle D study, the Agency identified waste characterization, facility assessment, and State program assessment as the key topic areas to be addressed during the study. This section identifies the major data needs within each of these topic areas that are outstanding at the end of Phase I of the study. The EPA will consider these data needs in developing the workplan for Phase II of the study. Some key Phase II projects that are already underway are briefly reviewed at the end of this section.

6.1 DATA NEEDS

The Phase I data collection efforts described in Sections 3 through 5 have provided adequate information to satisfy many of the Subtitle D study needs, but some needs remain unfulfilled. The following discussion identifies these key outstanding data needs.

Waste Characterization

The major data sources used to address the Subtitle D waste characterization portion of Phase I varied by waste and included: the MSW Characterization Study[1], the Household Hazardous Waste Study[2], the Subtitle D Census[3], the Industry Report[4], the National Surface Impoundment Assessment[5], and the National Small Quantity Generator Survey[6]. This subsection presents the remaining data needs associated with each of the nine major Subtitle D waste categories identified in Section 3.

Municipal Solid Waste (MSW)--

Phase I efforts revealed significantly more data on MSW than on any of the other Subtitle D waste types. The data include national generation rates for key MSW components and projections of future MSW generation. Preliminary analyses indicate these data provide adequate detail and accuracy for the EPA report to Congress.

Household Hazardous Waste (HHW)--

Available information on HHW is limited to descriptions of current HHW management practices, local studies of HHW quantities, and lists of items believed to qualify as HHWs. The most significant data needs remaining are:

- Additional estimates on the quantities and characteristics of the HHW received at Subtitle D facilities.

Municipal Water and Wastewater Treatment Sludge--

The characterization of water and wastewater treatment sludges included readily available data on the composition, quantities and disposal methods used for municipal sludge including numbers of surface impoundments and LAUs which primarily receive municipal sludges. Additional data are needed on the composition and quantities of these sludges. Much of these data are available in the literature or are currently being gathered by EPA's Office of Water. These data will be incorporated in the EPA report to Congress.

Municipal Waste Combustion Ash--

Limited data are available which characterize municipal waste combustion ash and its management. The remaining data needs include characterization of the composition and quantities of combustion ash.

Industrial Nonhazardous Waste--

The Phase I efforts provide estimates of industrial nonhazardous waste quantities and management practices for those industries that are believed to generate the largest quantities of these wastes. The greatest remaining data needs are:

- More precise estimates of the waste quantities generated from specific industrial waste sources.
- Better characterization of each waste type including concentration ranges and averages for the major waste constituents.
- The quantities and types of wastes managed in industrial surface impoundments, landfills, LAUs, and waste piles.

Small Quantity Generator (SQG) Waste--

Information sources for SQG wastes provided detailed information on the composition, quantities, and management practices associated with SQG disposal, including numbers of Subtitle D facilities receiving SQG wastes (by facility type). These data appear to provide adequate detail and accuracy for the EPA report to Congress.

Construction and Demolition, and Agricultural Wastes--

The available data on these waste categories provide only very rough estimates of nationwide waste quantities, typical compositions, and quantities received at facilities dedicated to these wastes. The outstanding data needs include better characterization, nationwide waste quantities, and associated management practices.

Mining, and Oil and Gas Wastes--

Data on Subtitle D mining wastes have been provided by a recent EPA Report to Congress and these are being supplemented by current efforts in support of rulemaking. Oil and gas waste is the subject of another Report to Congress that is now being prepared by the EPA. Remaining data gaps will be addressed by these separate, more comprehensive efforts on mining, and oil and gas wastes.

Facility Characterization

The principal facility characterization data provided in Phase I of the Subtitle D study is from the Subtitle D Census,[3] the Industry Report,[4] the NPL/Subtitle D study,[7] and the preliminary review of case studies from municipal landfills.[8] Data needs presented below are organized according to general facility profiles, design and operation, preliminary environmental and human health impact analysis, and leachate and gas characteristics of Subtitle D facilities.

General Profiles--

Facility profile information that supports the Subtitle D study includes statistical profiles of the different facility classes, including such characteristics as: numbers of active facilities, locations, types, ownership characteristics, sizes, and wastes received. Remaining data needs include:

- General profile information on waste piles, including facility numbers, locations, types, ownership characteristics, sizes, and wastes received.

- For all facility types except municipal waste landfills, more facility-specific data are needed on facility numbers, locations, sizes, and wastes recieved.

Design and Operation--

Subtitle D facility design and operating data will support EPA evaluation of the effect of the Federal Criteria and the State Subtitle D regulatory programs on the level of environmental controls at Subtitle D facilities. Remaining data needs are presented below for landfills, surface impoundments, land application units, and waste piles.

Landfills--The Phase I studies provided aggregate statistics of the numbers of landfills using soil and synthetic liners, leachate control systems, methane control systems, runon/runoff controls, and employing waste restrictions and environmental monitoring. In addition, Phase I research provided descriptions of design and operating practices that may be employed at municipal waste landfills. There is a general lack of data on other landfill types. Data needs are as follows:

- Identification of major differences between the design and operation methods for industrial, demolition debris, and other landfills, and those for municipal landfills.

- Facility-specific data on design and operating characteristics. This information could be compiled for correlation among design and operating characteristics or correlation with contamination impacts. (Aggregate data collected in the State Census cannot be used to make these correlations.)

Surface impoundments--Phase I studies provided general statistics on the numbers of surface impoundments using soil and membrane liners, overtopping controls, leak detection systems, waste restrictions, and environmental monitoring. This data was of low quality, however. The major remaining data needs include facility-specific design and operating data for all impoundments. This information could be compiled for correlation among design and operating characteristics or correlation with contamination impacts.

Land application units--The Phase I studies identified the numbers of LAUs using runon/runoff controls, waste restrictions, application rate limits, food chain crop restrictions, and environmental monitoring. Current literature provides complete information concerning recommended slopes for various treatment/disposal procedures, available runon/runoff controls, and environmental monitoring. The most critical information needs remaining are facility-specific design and operating statistics for all LAUs. This information could be compiled for correlation among design and operating characteristics or correlation with contamination impacts.

Waste piles--No data were collected during Phase I on waste piles. Data needs include:

- Information concerning typical design, operation, and management practices.

- Types of nonhazardous waste managed in piles, and amounts managed by each industry.

Leachate and Gas Characteristics--

Municipal landfill leachate information is complete for inorganic constituents and very limited for organic constituents. No information was obtained on leachate from industrial or demolition debris landfills, or from any type of surface impoundments or waste piles. Landfill gas information is also incomplete in the area of trace organic constituents. Remaining data needs are:

- Organic constituents for leachate and gas from municipal landfills.

- Leachate characteristics from nonmunicipal waste landfills (i.e., industrial and demolition debris waste landfills), surface impoundments, and waste piles.

- Gas characteristics for non-municipal waste landfills.

- Leachate and gas production rates and the effects of organics in gas and leachate. Research should attempt to reveal the constituents sources and their environmental impacts since organic data are limited.

Preliminary Environmental and Human Health Impact Analysis--

Available data on environmental and health impacts at Subtitle D facilities include numbers of reported violations for ground water, surface water, and air contamination, and preliminary case study information on contamination at various Subtitle D facilities (mostly municipal landfills). In order to fully evaluate the environmental and human health impacts of these facilities, these data must be used in conjunction with the results from a risk analysis. The data needs for documenting the extent of contamination problems include more extensive ground water, surface water and air monitoring data for all facility types. Additional field data may be required. These data could be complemented with case studies which assess risk and evaluate probable causes of contaminent releases.

State Program Characterization

The principal resources used in the State program characterization were the State Subtitle D Census,[3] and the State Regulations Reviews.[9] The additional data and analysis needs identified here are organized according to the topics addressed in this report: program organization/management; facility identification/status; permit/regulation; and enforcement.

Program Organization/Management--

In order to assess the implementation impacts on States of any Subtitle D criteria revisions, EPA needs to further examine the information in hand, then follow up if necessary with case studies.

Identification/Status--

To fully understand the size and composition of the universe of Subtitle D facilities, and to anticipate the likely impacts of the Criteria revisions on these facilities, the EPA will need to obtain State program data on waste piles to complete the picture on numbers and characteristics of facilities.

Permit/Regulation--

All States and Territories that have an approved Subtitle D program must, by definition, have criteria that are at least as stringent as those in 40 CFR Part 257. It remains uncertain how many more States and Territories have criteria that are equivalent to or more stringent than those required by the

Federal government. The EPA will need further analysis to determine whether or not existing criteria are adequate to protect human health and the environment from ground water contamination, as required under the 1984 Amendments to RCRA. This will include determining which States and Territories, in addition to the 25 with approved State plans, employ criteria equivalent to the current Federal Criteria.

Enforcement--

To determine if State enforcement authorities are adequate, as specified under Section 4010 of RCRA, the following data should be obtained:

- State enforcement authority information.
- Enforcement program case studies

6.2 DIRECTIONS FOR PHASE II

The EPA is now developing a workplan for Phase II of the Subtitle D study. The data needs identified in the previous discussion will be considered in this workplan. These data needs will be more fully examined to determine whether additional or somewhat different data are needed to address the objective of the Subtitle D study, i.e., to evaluate the adequacy of the Subtitle D Criteria protection of human health and the environment. The specific Phase II data collection projects will be determined based on a number of factors, including contributions toward the Subtitle D study objective, and timing and resource constraints.

Although the workplan is not yet complete, the EPA has already initiated several Phase II data collection projects to address some of the more critical data needs. These projects are listed in Table 6-1 and described in further detail below:

- Municipal Landfill Survey- A survey of a representative sample of municipal landfills to gather facility-specific data on design and operating characteristics and environmental contamination.
- Industrial Facilities Survey- A telephone and mail survey of a representative sample of industrial nonhazardous waste land disposal facilities to gather facility-specific data on design and operating characteristics and environmental contamination.
- Case Studies at Municipal Landfills- Evaluation of detailed data on facility design and operating characteristics and environmental impacts for a set of about 110 case studies prepared during Phase I. This includes case studies collected for State regulatory agencies.

TABLE 6-1. CURRENT PHASE II PROJECTS

Municipal Landfill Survey. Survey to gather site specific information.

Initial survey - November 1986
Draft Report - May 1987

Industrial Facilities Survey. Telephone and mail survey of land disposal facilities owned by industry.

Telephone survey:
Survey initiation - November 1986
Draft Report - May 1987
Mail Survey:
Survey initiation - January 1987
Draft Report - August 1987

Case Studies at Municipal Landfills. Case studies on facility D&O and environmental impacts. (ongoing)

Municipal Waste Landfill Leachate Characterization. Field sampling of leachate from selected municipal solid waste landfills. (ongoing)

Characterization of Municipal Waste Incinerator Residues. Sampling and analysis of residues at municipal incinerators and ash monofill units. (ongoing)

Hazardous Household Waste Sorting and Evaluation. Assessment of hazardous household wastes in selected municipal waste streams. (ongoing).

- Municipal Solid Waste Leachate Characterization- Field sampling of leachate from a selected set of municipal waste landfills to collect more comprehensive data on the hazardous organic constituents in leachate.

- Characterization of Municipal Waste Incinerator Residues- Sampling and analysis of combustion residues at selected municipal incinerators and ash monofill units.

- Hazardous Household Waste Sorting and Evaluation- Quantitative and qualitative assessment of hazardous household wastes in selected municipal waste streams.

Other Phase II projects may be initiated following completion of the workplan and further consideration of additional data submissions from the Agency or from waste management trade associations. Additional Agency efforts which will contribute to the Subtitle D Report to Congress include separate and comprehensive efforts on mining wastes, oil and gas wastes and municipal wastewater sludges.

REFERENCES

1. Franklin Associates, Ltd. Characterization of Municipal Solid Waste in the Unites States, 1960 to 2000. Draft Report. U.S. Environmental Protection Agency, Washington, D.C. May 1986.

2. SCS Engineers. A Survey of Household Hazardous Wastes and Related Collection Programs. Contract No. 68-01-6621, U.S. Environmental Protection Agency, Washington, D.C. 1986.

3. Westat, Inc. Census of State and Territorial Subtitle D Nonhazardous Waste Programs. Contract No. 68-01-7047, U.S. Environmental Protection Agency, Washington, D.C. 1986.

4. Science Applications International Corporation. Summary of Data on Industrial Nonhazardous Waste Disposal Practices. Contract No. 68-01-7050, U.S. Environmental Protection Agency, Washington, D.C. 1985.

5. U.S. Environmental Protection Agency. Surface Impoundment Assessment National Report. EPA 57/9-84-002, U.S. Environmental Protection Agency/ODW, Washington, D.C. 1983.

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8. Municipal landfill case studies used in this analyses were from the U.S. Environmental Protection Agency, Office of Solid Waste. These studies were prepared by PEI, SRW, and ICF. 1986.

9. PEI Associates, Inc. State Subtitle D Regulations on Landfills, Surface Impoundment, Land Treatment and Waste Piles, Draft Vol. I-IV. Contract No. 68-01-7075/02-3890, U.S. Environmental Protection Agency, OSW, Washington, D.C. 1986.

APPENDIX A

40 CFR Part 257
CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

PART 257—CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

Sec.
257.1 Scope and purpose.
257.2 Definitions.
257.3 Criteria for classification of solid waste disposal facilities and practices.
257.3-1 Floodplains.
257.3-2 Endangered species.
257.3-3 Surface water.
257.3-4 Ground water.
257.3-5 Application to land used for the production of food-chain crops (interim final).
257.3-6 Disease.
257.3-7 Air.
257.3-8 Safety.
257.4 Effective date.

APPENDIX I
APPPENDIX II

AUTHORITY: Sec. 1008(a)(3) and sec. 4004(a), Pub. L. 94-580, 90 Stat. 2803 and 2815 (42 U.S.C. 6907(a)(3) and 6944(a)); sec. 405(d), Pub. L. 95-217, 91 Stat. 1606 (33 U.S.C. 1345(d)).

SOURCE: 44 FR 53460, Sept. 13, 1979, unless otherwise noted.

§ 257.1 Scope and purpose.

(a) These criteria are for use under the Resource Conservation and Recovery Act (the Act) in determining which solid waste disposal facilities and practices pose a reasonable proba-

bility of adverse effects on health or the environment. Unless otherwise provided, these criteria are adopted for purposes of both Section 1008(a)(3) and Section 4004(a) of the Act.

(1) Facilities failing to satisfy criteria adopted for purposes of Section 4004(a) will be considered open dumps for purposes of State solid waste management planning under the Act.

(2) Practices failing to satisfy criteria adopted for purposes of Section 1008(a)(3) constitute open dumping, which is prohibited under Section 4005 of the Act.

(b) These criteria also provide guidelines for sludge utilization and disposal under Section 405(d) of the Clean Water Act, as amended. To comply with Section 405(e) the owner or operator of any publicly owned treatment works must not violate these criteria in the disposal of sludge on the land.

(c) These criteria apply to all solid waste disposal facilities and practices with the following exceptions:

(1) The criteria do not apply to agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners.

(2) The criteria do not apply to overburden resulting from mining operations intended for return to the mine site.

(3) The criteria do not apply to the land application of domestic sewage or treated domestic sewage. The criteria do apply to disposal of sludges generated by treatment of domestic sewage.

(4) The criteria do not apply to the location and operation of septic tanks. The criteria do, however, apply to the disposal of septic tank pumpings.

(5) The criteria do not apply to solid or dissolved materials in irrigation return flows.

(6) The criteria do not apply to industrial discharges which are point sources subject to permits under Section 402 of the Clean Water Act, as amended.

(7) The criteria do not apply to source, special nuclear or byproduct material as defined by the Atomic Energy Act, as amended (68 Stat. 923).

(8) The criteria do not apply to hazardous waste disposal facilities which are subject to regulation under Subtitle C of the Act.

(9) The criteria do not apply to disposal of solid waste by underground well injection subject to the regulations (40 CFR Part 146) for the Underground Injection Control Program (UICP) under the Safe Drinking Water Act, as amended, 42 U.S.C. 3007 et seq.

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.2 Definitions.

The definitions set forth in Section 1004 of the Act apply to this part. Special definitions of general concern to this part are provided below, and definitions especially pertinent to particular sections of this part are provided in those sections.

"Disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

"Facility" means any land and appurtenances thereto used for the disposal of solid wastes.

"Leachate" means liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such wastes.

"Open dump" means a facility for the disposal of solid waste which does not comply with this part.

"Practice" means the act of disposal of solid waste.

"Sanitary landfill" means a facility for the disposal of solid waste which complies with this part.

"Sludge" means any solid, semisolid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility or any other such waste having similar characteristics and effect.

"Solid waste" means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant,

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

"State" means any of the several States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

[44 FR 53460, Sept. 13, 1979; 44 FR 58910, Oct. 12, 1979]

§ 257.3 Criteria for classification of solid waste disposal facilities and practices.

Solid waste disposal facilities or practices which violate any of the following criteria pose a reasonable probability of adverse effects on health or the environment:

§ 257.3-1 Floodplains.

(a) Facilities or practices in floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources.

(b) As used in this section:

(1) "Based flood" means a flood that has a 1 percent or greater chance of recurring in any year or a flood of a magnitude equalled or exceeded once in 100 years on the average over a significantly long period.

(2) "Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, which are inundated by the base flood.

(3) "Washout" means the carrying away of solid waste by waters of the base flood.

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979]

§ 257.3-2 Endangered species.

(a) Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.

(b) The facility or practice shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.

(c) As used in this section:

(1) "Endangered or threatened species" means any species listed as such pursuant to Section 4 of the Endangered Species Act.

(2) "Destruction or adverse modification" means a direct or indirect alteration of critical habitat which appreciably diminishes the likelihood of the survival and recovery of threatened or endangered species using that habitat.

(3) "Taking" means harassing, harming, pursuing, hunting, wounding, killing, trapping, capturing, or collecting or attempting to engage in such conduct.

§ 257.3-3 Surface water.

(a) For purposes of Section 4004(a) of the Act, a facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act, as amended.

(b) For purposes of Section 4004(a) of the Act, a facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under Section 404 of the Clean Water Act, as amended.

(c) A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

(d) Definitions of the terms "Discharge of dredged material", "Point source", "Pollutant", "Waters of the United States", and "Wetlands" can be

found in the Clean Water Act, as amended, 33 U.S.C. 1251 et seq., and implementing regulations, specifically 33 CFR Part 323 (42 FR 37122, July 19, 1977).

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.3–4 Ground water.

(a) A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary or beyond an alternative boundary specified in accordance with paragraph (b) of this section.

(b)(1) For purposes of Section 1008(a)(3) of the Act or Section 405(d) of the CWA, a party charged with open dumping or a violation of Section 405(e) may demonstrate that compliance should be determined at an alternative boundary in lieu of the solid waste boundary. The court shall establish such an alternative boundary only if it finds that such a change would not result in contamination of ground water which may be needed or used for human consumption. This finding shall be based on analysis and consideration of all of the following factors that are relevant:

(i) The hydrogeological characteristics of the facility and surrounding land, including any natural attenuation and dilution characteristics of the aquifer;

(ii) The volume and physical and chemical characteristics of the leachate;

(iii) The quantity, quality, and direction of flow of ground water underlying the facility;

(iv) The proximity and withdrawal rates of ground-water users;

(v) The availability of alternative drinking water supplies;

(vi) The existing quality of the ground water, including other sources of contamination and their cumulative impacts on the ground water;

(vii) Public health, safety, and welfare effects.

(2) For purposes of Sections 4004(a) and 1008(a)(3), the State may establish an alternative boundary for a facility to be used in lieu of the solid waste boundary only if it finds that such a change would not result in the contamination of ground water which may be needed or used for human consumption. Such a finding shall be based on an analysis and consideration of all of the factors identified in paragraph (b)(1) of this section that are relevant.

(c) As used in this section:

(1) "Aquifer" means a geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of ground water to wells or springs.

(2) "Contaminate" means introduce a substance that would cause:

(i) The concentration of that substance in the ground water to exceed the maximum contaminant level specified in Appendix I, or

(ii) An increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the maximum contaminant level specified in Appendix I.

(3) "Ground water" means water below the land surface in the zone of saturation.

(4) "Underground drinking water source" means:

(i) An aquifer supplying drinking water for human consumption, or

(ii) An aquifer in which the ground water contains less than 10,000 mg/l total dissolved solids.

(5) "Solid waste boundary" means the outermost perimeter of the solid waste (projected in the horizontal plane) as it would exist at completion of the disposal activity.

[44 FR 53460, Sept. 13, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.3–5 Application to land used for the production of food-chain crops (interim final).

(a) *Cadmium.* A facility or practice concerning application of solid waste to within one meter (three feet) of the surface of land used for the production of food-chain crops shall not exist or occur, unless in compliance with all requirements of paragraph (a)(1) (i) through (iii) of this section or all requirements of paragraph (a)(2) (i) through (iv) of this section.

(1)(i) The pH of the solid waste and soil mixture is 6.5 or greater at the time of each solid waste application,

except for solid waste containing cadmium at concentrations of 2 mg/kg (dry weight) or less.

(ii) The annual application of cadmium from solid waste does not exceed 0.5 kilograms per hectare (kg/ha) on land used for production of tobacco, leafy vegetables or root crops grown for human consumption. For other food-chain crops, the annual cadmium application rate does not exceed:

Time period	Annual Cd application rate (kg/ha)
Present to June 30, 1984	2.0
July 1, 1984 to Dec. 31, 1986	1.25
Beginning Jan. 1, 1987	0.5

(iii) The cumulative application of cadmium from solid waste does not exceed the levels in either paragraph (a)(1)(iii)(A) of this section or paragraph (a)(1)(iii)(B) of this section.

(A)

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)	
	Background soil pH less than 6.5	Background soil pH more than 6.5
Less than 5	5	5
5 to 15	5	10
More than 15	5	20

(B) For soils with a background pH of less than 6.5, the cumulative cadmium application rate does not exceed the levels below: *Provided,* That the pH of the solid waste and soil mixture is adjusted to and maintained at 6.5 or greater whenever food-chain crops are grown.

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)
Less than 5	5
5 to 15	10
More than 15	20

(2)(i) The only food-chain crop produced is animal feed.

(ii) The pH of the solid waste and soil mixture is 6.5 or greater at the time of solid waste application or at the time the crop is planted, whichever occurs later, and this pH level is maintained whenever food-chain crops are grown.

(iii) There is a facility operating plan which demonstrates how the animal feed will be distributed to preclude ingestion by humans. The facility operating plan describes the measures to be taken to safeguard against possible health hazards from cadmium entering the food chain, which may result from alternative land uses.

(iv) Future property owners are notified by a stipulation in the land record or property deed which states that the property has received solid waste at high cadmium application rates and that food-chain crops should not be grown, due to a possible health hazard.

(b) *Polychlorinated Biphenyls (PCBs).* Solid waste containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight) is incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation of the solid waste into the soil is not required if it is assured that the PCB content is less than 0.2 mg/kg (actual weight) in animal feed or less than 1.5 mg/kg (fat basis) in milk.

(c) As used in this section:

(1) "Animal feed" means any crop grown for consumption by animals, such as pasture crops, forage, and grain.

(2) "Background soil pH" means the pH of the soil prior to the addition of substances that alter the hydrogen ion concentration.

(3) "Cation exchange capacity" means the sum of exchangeable cations a soil can absorb expressed in milli-equivalents per 100 grams of soil as determined by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the summation method for distinctly acid soils or the sodium acetate method for neutral, calcareous or saline soils ("Methods of Soil Analysis, Agronomy Monograph No. 9." C. A. Black, ed., American Society of Agronomy, Madison, Wisconsin. pp 891-901, 1965).

(4) "Food-chain crops" means tobacco, crops grown for human consumption, and animal feed for animals whose products are consumed by humans.

(5) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(6) "Pasture crops" means crops such as legumes, grasses, grain stubble and stover which are consumed by animals while grazing.

(7) "pH" means the logarithm of the reciprocal of hydrogen ion concentration.

(8) "Root crops" means plants whose edible parts are grown below the surface of the soil.

(9) "Soil pH" is the value obtained by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the electrometric method. ("Methods of Soil Analysis, Agronomy Monograph No. 9," C.A. Black, ed., American Society of Agronomy, Madison, Wisconsin, pp. 914-926, 1965.)

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979]

§ 257.3-6 Disease.

(a) *Disease Vectors.* The facility or practice shall not exist or occur unless the on-site population of disease vectors is minimized through the periodic application of cover material or other techniques as appropriate so as to protect public health.

(b) *Sewage sludge and septic tank pumpings (Interim Final).* A facility or practice involving disposal of sewage sludge or septic tank pumpings shall not exist or occur unless in compliance with paragraphs (b) (1), (2) or (3) of this section.

(1) Sewage sludge that is applied to the land surface or is incorporated into the soil is treated by a Process to Significantly Reduce Pathogens prior to application or incorporation. Public access to the facility is controlled for at least 12 months, and grazing by animals whose products are consumed by humans is prevented for at least one month. Processes to Significantly Reduce Pathogens are listed in Appendix II, Section A. (These provisions do not apply to sewage sludge disposed of by a trenching or burial operation.)

(2) Septic tank pumpings that are applied to the land surface or incorporated into the soil are treated by a Process to Significantly Reduce Pathogens (as listed in Appendix II, Section A), prior to application or incorporation, unless public access to the facility is controlled for at least 12 months and unless grazing by animals whose products are consumed by humans is prevented for at least one month. (These provisions do not apply to septic tank pumpings disposed of by a trenching or burial operation.)

(3) Sewage sludge or septic tank pumpings that are applied to the land surface or are incorporated into the soil are treated by a Process to Further Reduce Pathogens, prior to application or incorporation, if crops for direct human consumption are grown within 18 months subsequent to application or incorporation. Such treatment is not required if there is no contact between the solid waste and the edible portion of the crop; however, in this case the solid waste is treated by a Process to Significantly Reduce Pathogens, prior to application; public access to the facility is controlled for at least 12 months; and grazing by animals whose products are consumed by humans is prevented for at least one month. If crops for direct human consumption are not grown within 18 months of application or incorporation, the requirements of paragraphs (b) (1) and (2) of this section apply. Processes to Further Reduce Pathogens are listed in Appendix II, Section B.

(c) As used in this section:

(1) "Crops for direct human consumption" means crops that are consumed by humans without processing to minimize pathogens prior to distribution to the consumer.

(2) "Disease vector" means rodents, flies, and mosquitoes capable of transmitting disease to humans.

(3) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(4) "Periodic application of cover material" means the application and

compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede vectors access to the waste.

(5) "Trenching or burial operation" means the placement of sewage sludge or septic tank pumpings in a trench or other natural or man-made depression and the covering with soil or other suitable material at the end of each operating day such that the wastes do not migrate to the surface.

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979]

§ 257.3-7 Air.

(a) The facility or practice shall not engage in open burning of residential, commercial, institutional or industrial solid waste. This requirement does not apply to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land-clearing debris, diseased trees, debris from emergency clean-up operations, and ordnance.

(b) For purposes of Section 4004(a) of the Act, the facility shall not violate applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the Administrator pursuant to Section 110 of the Clean Air Act, as amended.

(c) As used in this section "open burning" means the combustion of solid waste without (1) control of combustion air to maintain adequate temperature for efficient combustion, (2) containment of the combustion reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion, and (3) control of the emission of the combustion products.

[44 FR 53460, Sept. 13, 1979; 44 FR 54708, Sept. 21, 1979, as amended at 46 FR 47052, Sept. 23, 1981]

§ 257.3-8 Safety.

(a) *Explosive gases.* The concentration of explosive gases generated by the facility or practice shall not exceed:

(1) Twenty-five percent (25%) of the lower explosive limit for the gases in facility structures (excluding gas control or recovery system components); and

(2) The lower explosive limit for the gases at the property boundary.

(b) *Fires.* A facility or practice shall not pose a hazard to the safety of persons or property from fires. This may be accomplished through compliance with § 257.3-7 and through the periodic application of cover material or other techniques as appropriate.

(c) *Bird hazards to aircraft.* A facility or practice disposing of putrescible wastes that may attract birds and which occurs within 10,000 feet (3,048 meters) of any airport runway used by turbojet aircraft or within 5,000 feet (1,524 meters) of any airport runway used by only piston-type aircraft shall not pose a bird hazard to aircraft.

(d) *Access.* A facility or practice shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site.

(e) As used in this section:

(1) "Airport" means public-use airport open to the public without prior permission and without restrictions within the physical capacities of available facilities.

(2) "Bird hazard" means an increase in the likelihood of bird/aircraft collisions that may cause damage to the aircraft or injury to its occupants.

(3) "Explosive gas" means methane (CH_4).

(4) "Facility structures" means any buildings and sheds or utility or drainage lines on the facility.

(5) "Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases which will propagate a flame in air at 25°C and atmospheric pressure.

(6) "Periodic application of cover material" means the application and compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede disease vectors' access to the waste.

(7) "Putrescible wastes" means solid waste which contains organic matter capable of being decomposed by microorganisms and of such a character and

proportion as to be capable of attracting or providing food for birds.

§ 257.4 Effective date.

These criteria become effective October 15, 1979.

APPENDIX I

The maximum contaminant levels promulgated herein are for use in determining whether solid waste disposal activities comply with the ground-water criteria (§ 257.3–4). Analytical methods for these contaminants may be found in 40 CFR Part 141 which should be consulted in its entirety.

1. *Maximum contaminant levels for inorganic chemicals.* The following are the maximum levels of inorganic chemicals other than fluoride:

Contaminant	Level (milligrams per liter)
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10
Selenium	0.01
Silver	0.05

The maximum contaminant levels for fluoride are:

Temperature [1] degrees Fahrenheit	Degrees Celsius	Level (milligrams per liter)
53.7 and below	12 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

[1] Annual average of the maximum daily air temperature.

2. *Maximum contaminant levels for organic chemicals.* The following are the maximum contaminant levels for organic chemicals:

	Level (milligrams per liter)
(a) Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-Hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenyl) ethane)	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67 to 69 percent chlorine)	0.005
(b) Chlorophenoxys:	
2,4-D (2,4-Dichlorophenoxy-acetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophen- oxy-propionic acid)	0.01

3. *Maximum microbiological contaminant levels.* The maximum contaminant level for coliform bacteria from any one well is as follows:

(a) using the membrane filter technique:

(1) Four coliform bacteria per 100 milliliters if one sample is taken, or

(2) Four coliform bacteria per 100 milliliters in more than one sample of all the samples analyzed in one month.

(b) Using the five tube most probable number procedure, (the fermentation tube method) in accordance with the analytical recommendations set forth in "Standard Methods for Examination of Water and Waste Water", American Public Health Association, 13th Ed. pp. 662-688, and using a Standard sample, each portion being one fifth of the sample:

(1) If the standard portion is 10 milliliters, coliform in any five consecutive samples from a well shall not be present in three or more of the 25 portions, or

(2) If the standard portion is 100 milliliters, coliform in any five consecutive samples from a well shall not be present in five portions in any of five samples or in more than fifteen of the 25 portions.

4. *Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity.* The following are the maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity:

(a) Combined radium-226 and radium-228—5 pCi/l;

(b) Gross alpha particle activity (including radium-226 but excluding radon and uranium)—15 pCi/l.

APPENDIX II

A. Processes to Significantly Reduce Pathogens

Aerobic digestion. The process is conducted by agitating sludge with air or oxygen to maintain aerobic conditions at residence times ranging from 60 days at 15° C to 40

days at 20° C, with a volatile solids reduction of at least 38 percent.

Air Drying: Liquid sludge is allowed to drain and/or dry on under-drained sand beds, or paved or unpaved basins in which the sludge is at a depth of nine inches. A minimum of three months is needed, two months of which temperatures average on a daily basis above 0° C.

Anaerobic digestion: The process is conducted in the absence of air at residence times ranging from 60 days at 20° C to 15 days at 35° to 55° C, with a volatile solids reduction of at least 38 percent.

Composting: Using the within-vessel, static aerated pile or windrow composting methods, the solid waste is maintained at minimum operating conditions of 40° C for 5 days. For four hours during this period the temperature exceeds 55° C.

Lime Stabilization: Sufficient lime is added to produce a pH of 12 after 2 hours of contact.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

B. Processes to Further Reduce Pathogens

Composting: Using the within-vessel composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the static aerated pile composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the windrow composting method, the solid waste attains a temperature of 55° C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow.

Heat drying: Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80° C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80° C.

Heat treatment: Liquid sludge is heated to temperatures of 180° C for 30 minutes.

Thermophilic Aerobic Digestion: Liquid sludge is agitated with air or oxygen to maintain aerobic conditions at residence times of 10 days at 55–60° C, with a volatile solids reduction of at least 38 percent.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Any of the processes listed below, if added to the processes described in Section A above, further reduce pathogens. Because the processes listed below, on their own, do not reduce the attraction of disease vectors, they are only add-on in nature.

Beta ray irradiation: Sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Gamma ray irradiation: Sludge is irradiated with gamma rays from certain isotopes, such as ^{60}Cobalt and ^{137}Cesium, at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Pasteurization: Sludge is maintained for at least 30 minutes at a minimum temperature of 70° C.

Other methods: Other methods or operating conditions may be acceptable if pathogens are reduced to an extent equivalent to the reduction achieved by any of the above add-on methods.

APPENDIX B

INDUSTRIAL NONHAZARDOUS WASTE TABLES

1. Tables B-1 and B-2 are presented as Tables 1-1 and 1-4 in: Summary of Data on Industrial Nonhazardous Waste Disposal Practices, by Science Application International Corporation for U.S. EPA, 1985.

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]							
			LF	SI	LT	Other	Total	On-Site LF	SI	LT	Other	Total	Off-Site Disposal	Other
Electrical Machinery and Electronic Components (SIC 36)		10,400[1,2]	--[3]	391[4]	--	--	--	--	--	--	--	--	M[5]	M	--
	Wastewater treatment sludges	5,400[1,2]					--	M	M	--	--	--	--	--	--
	Plastics	4,600[1,2]					--	--	--	--	--	--	M	M	--
	Oils	200[1,2]					--	--	--	--	--	--	M	M	--
	Paint wastes	200[1,2]					--	--	--	--	--	--	M	M	--
Electric Power Generation (SIC 4911)		55,878,000[6,7]	--	1,671[4]		--	M	--	51	--	--	--	--	--	--
	Bottom ash (coal)	10,220,000[6,7]					M	--	81	--	--	--	--	--	--
	Fly ash (coal)	40,760,000[6,7]					M	--	43	--	--	--	--	--	--
	Flue gas desulfurization (coal) sludge	3,600,000[6,7]					M	--	--	--	--	--	--	--	--
	Boiler slag	1,280,000[6,7]					M	--	81	--	--	--	--	--	--
	Fly ash (oil)	18,000[6,7]					M	--	--	--	--	--	--	--	--
Fabricated[8] Metal Products (SIC 34)		300,000[7,9]	--	1,316[4]	--	--	20[9,10]	--	--	--	--	--	80[9,10]	--	--
	Wastewater treatment sludge	--					--	--	--	--	--	--	--	--	--
	Spent air filters (painting)	--					--	--	--	--	--	--	--	--	--
	Paint sludge	--					--	--	--	--	--	--	--	--	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	On-Site SI	On-Site LT	On-Site Other	On-Site Total	Off-Site Disposal	Off-Site Other
Fertilizer and Other Agricultural Chemicals (SIC 2873-2879)		59,037,400	--	--	--	--	--	--	--	--	--	--	--	--
	Waste gypsum	39,075,000[7]					90	--	--	--	90	--	--	--
	Wet scrubber liquor	678,100[11]					--	--	--	--	--	--	--	--
	Cooling water treatment sludge	>500,000[11]					--	--	--	--	--	--	--	--
	WPPA sludge	--					--	--	--	--	--	--	--	--
	Spent catalyst	--					--	--	--	--	--	--	--	--
	Sulfur filter cakes	--					--	--	--	--	--	--	--	--
	Pesticide manufacturing wastes	18,784,300[6,12,13]					--	<.1	46	0	23	70	8	69
Food and Kindred Products (SIC 20)		6,361,500[14,15]	--	4,960[4]	--	--	--	--	--	--	--	--	--	--
	Paunch manure	772,600[14,15]					20	2.2	2.2	15.6	--	80	80	--
	Meat sludge	347,000[14]					--	--	--	M	--	--	--	--
	Liquid whey	373,200[14]					20-25	0	10-15	10-15	0	75-80	75-80	0
	Unusable food	1,493,000[14,15]					10-15	--	--	10-15	--	--	M	--
	Soil and trash	229,500[14]					--	--	--	--	--	--	M	--
	Non-food waste	386,000[14]					10-15	--	--	--	--	--	M	--
	Grain mill sludge	55,900[14,15]						--	--	--	--	--	--	M
	Soil (sugar prod.)	1,100,000[14]					100	0	100	0	0	0	0	0
	Lime mud (sugar products)	1,100,000[14]					100	0	100	0	0	0	0	0
	Excess bagasse	242,600[14,15]					100	100	0	0	0	0	0	0
	Spent bleaching earth	55,300[16]					--	--	--	--	--	--	--	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]							
			LF	SI	LT	Other	Total	LF	On-Site SI	LT	Other	Total	Off-Site Disposal	Other
Food and Kindred Products (SIC 20) (continued)	Fat/oil sludge	8,600[16]					--	--	--	--	--	--	--	--
	Non-food fat/oil waste	11,200[16]					--	--	--	--	--	--	--	--
	Liquor stillage	74,600[14]					--	--	--	--	--	--	--	--
	Unused seafood portions	112,000[14]					--	--	--	--	--	--	--	--
Industrial Inorganic Chemicals Industry (SIC 2812-2819)		26,191,800[6,17]	--	--	--	--	--	--	--	--	--	--	--	--	--
	Brine muds	378,300[6,17]					--	M,LUN[18]	M,LUN	--	--	--	--	--
	Salt tailings	12,600,000[6,17]					--	--	M,LUN	--	--	--	--	--
	Red mud	7,600,000[6,17]					--	--	M,LUN	--	--	--	--	--
	Phosphate dust	148,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Na ore residues	1,200,000[6,17]					--	--	M,LUN	--	--	--	--	--
	Lime particulates	2,350,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Gypsum	1,335,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Iron oxide wastes	44,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Li ore residues	260,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Bauxite ore wastes	120,000[6,17]					--	M,LUN	--	--	--	--	--	--
	Sulfuric ore waste	32,500[6,17]					--	M,LUN	--	--	--	--	--	--
	Calcium wastes	122,500[6,17]					--	M,LUN	--	--	--	--	--	--
	Insoluble ore residues	1,500[6,17]					--	M,LUN	--	--	--	--	--	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b] LF	SI	LT	Other	Total	Percent of Non-Hazardous Wastes Managed[c] On-Site LF	SI	LT	Other	Total	Off-Site Disposal	Other
Industrial Organic Chemicals (SIC 2819)		97,354,100[6,12]		4,377[4,19]			--	1.7	34.1	0.3	23.7	--	1.4	61.3
	Process wastewater	51,734,000[6,12]					--	0.15	60	0	7.7	--	<.1	89
	Equipment washdown	240,800[6,12]					--	NR[20]	93.8	NR	0.1	--	NR	99
	Steam jet condensate	129,200[6,12]					--	NR	67	NR	6.1	--	NR	69
	Non-process wastewater	328,700[6,12]					--	NR	20.7	NR	77.7	--	NR	22.3
	Spent scrubber wastes	8,735,900[6,12]					--	NR	35.3	NR	40.3	--	0.4	59.5
	Sludges	682,500[6,12]					--	2.8	46.1	30.3	17.5	--	38.8	3.5
	Precipitates/ filtration residues	3,067,900[6,12]					--	47.3	22.2	NR	46.6	--	15.3	6.4
	Decantate/filtrate	3,630,700[6,12]					--	<0.1	54.8	NR	1.8	--	0.1	76.6
	Spent adsorbent	53,500[6,12]					--	6.5	14.6	0.3	0.3	--	165	76.2
	Spent catalyst	10,900[6,12]					--	10.6	2.1	1.4	17.9	--	40.5	27.5
	Spent solvent	130,900[6,12]					--	NR	<0.1	NR	70.6	--	0.3	36.2
	Heavy ends	4,782,400[6,12]					--	1.0	8.0	0.8	25.3	--	5.4	74.1
	Light ends	20,446,000[6,12]					--	0.2	1.0	NR	41.5	--	1.1	3.4
	Off-spec products	472,600[6,12]					--	<0.1	8.2	1.9	66.2	--	2.2	23.1
	Containers, liners, rags	1,100[6,12]					--	0.9	NR	NR	47.9	--	50.9	0.2
	Treated solids	81,800[6,12]					--	33.8	NR	NR	3.9	--	61.9	0.3
	By-products	2,788,300[6,12]					--	NR	<0.1	NR	82	--	0.6	23.8
	Other	36,900[6,12]					--	NR	NR	NR	74.3	--	3.4	11.2

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	On-Site SI	On-Site LT	On-Site Other	On-Site Total	Off-Site Disposal	Off-Site Other
Leather and Leather Products (SIC 31)		24,600[2,9]	--	104[4]	--	--	10	5	5			90	50	40
	Trimmings and shavings	7,600[2,9]					--	--	--	--	--	--	--	--
	Unfinished leather trim	1,400[2,9]					--	--	--	--	--	--	--	--
	Buffing dust	400[2,9]					--	--	--	--	--	--	--	--
	Finished leather trim	2,800[2,9]					--	--	--	--	--	--	--	--
	Finishing residues	700[2,9]					--	--	--	--	--	--	--	--
	Wastewater screenings	1,300[2,9]					--	--	--	--	--	--	--	--
	Wastewater sludge	4,200[2,9]					--	--	--	--	--	--	--	--
	Miscellaneous solid wastes	6,300[2,9]					--	--	--	--	--	--	--	--
Lumber and Wood Products and Furniture and Fixtures (SIC 24 and 25)[21]		>122,900	--	816[4]	--	--	--	--	--	--	--	--	--	--
	Bark and wood wastes						--	--	--	--	--	--	--	--
	Wood ash						--	80	--	--	--	--	--	--
	Wood preserving sludges	86,700[6,9,11]					--	80	--	--	--	--	--	20
	Wastewater sludges						--	--	--	--	--	--	--	--
	Paint waste	31,400[6,9,11]					--	20	--	--	--	--	--	--
	Solvent waste	4,600[6,9,11]					--	20	--	--	--	--	80	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	On-Site SI	On-Site LT	On-Site Other	On-Site Total	Off-Site Disposal	Off-Site Other
Machinery Except Electrical (SIC 35)		193,500[22]	--	294[4]	--	--	10[22]	--	--	--	--	90[22]	70	20
	Plastics and ceramics	--					--	--	--	--	--	--	--	--
	Fluxes	--					--	--	--	--	--	--	--	--
	Oils	--					--	--	--	--	--	--	--	--
	Wastewater treatment sludge	--					--	--	--	--	--	--	--	--
	Paint sludge	--					--	--	--	--	--	--	--	--
Pulp and Paper Industry (SIC 26)		8,627,000[23]	650-900	1,154[11]	0	0	--	72,LUN	7,LUN	--	10	--	--	--
	Wood Wastes	2,000,000[23]					--	M	--	--	--	--	--	--
	Chemical recovery wastes	610,000[23]					--	M,LUN	--	--	--	--	--	--
	Pulp rejects	460,000[6,23]					--	M,LUN	--	--	--	--	--	--
	Wastewater sludges	2,217,000[23]					78	78	--	--	22	22	--	--
	Coal and bark ash	1,140,000[23]					--	M,LUN	--	--	--	--	--	--
	Waste paper rejects	2,200,000[23]					--	--	--	--	--	--	--	--
Petroleum Refining Industry (SIC 29)		1,276,400[13]	--	1,884[4]	100[13]	--	59	0	0	59	0	41	41[24]	0
	Biological sludge	786,300[13]					46	0	0	46	0	54	54	0
	FCC catalyst	147,400[13]					24	0	0	24	0	76	76	0

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	LF	On-Site SI	LT	Other	Total	Off-Site Disposal	Other
Petroleum Refining Industry (continued)	Non-leaded tank bottoms	131,600[13]					52	0	0	52	0	48	48	0
	Primary O/S/W separator sludge	77,600[13]					37	0	0	37	0	63	63	0
	Stretford solution	42,800[13]					0	0	0	0	0	100	100	0
	HF alkylation sludge	34,400[13]					26	13	0	37	0	74	37	0
	Spent catalysts	19,100[13]					15	0	0	15	0	85	85	0
	Cooling tower sludge	15,800[13]					60	0	0	60	0	40	40	0
	Treating clays	13,500[13]					21	0	0	21	0	79	79	0
	Secondary O/S/W separator sludge	7,900[13]					44	0	0	44	0	56	56	0
Pharmaceutical Industry (SIC 2831 -2834)		256,900[25]	--	--	--	--	--	--	0	0	--	--	90	--
	Biological sludge	82,600[25]						--	0	0	--	--	85-90	--
	Filter aid, carbon sawdust, mycellium	78,400[25]					--	--	0	0	--	--	85-90	--
	Wet plant material	2,000[25]					--	--	0	0	--	--	M	--
	Fused plant steroid ingots	800[25]					--	--	0	0	--	--	M	--
	Extracted animal tissue	7,500[25]					--	--	0	0	--	--	M	--
	Fats and oils	400[25]					--	--	0	0	--	--	M	--
	Filter cake	200[25]					--	--	0	0	--	--	M	--
	Returned goods	10,000[25]					--	--	0	0	--	--	M	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	SI	LT	Other	Total	Off-Site Disposal	Other
Pharmaceutical Preparations (continued)	Glass, paper, wood aluminum, and rubber scrap	75,000[6,25]					--	--	0	0	--	--	100	--
Plastics and Resins Manufacturing (SIC 2821)		44,991,700[6,12,26]	63	235	11	--	69	0.8	68	0.1	58	79	1.3	78
	Decantates/ filtrates	7,265,100[6,12,26]					--	NR	34.8	NR	97.5	--	1.7	52.3
	Sludges	434,900[6,12,26]					--	81.6	5.7	6.4	2	--	4.4	1.5
	Off-spec. products	293,800[6,12,26]					--	1.7	9.1	NR	76.6	--	8.3	0.57
	Spent solvents	286,600[6,12,26]					--	NR	<0.1	NR	99.5	--	<0.1	4.2
	Light ends	195,700[6,12,26]					--	NR	<0.1	NR	74.4	--	NR	32.8
	Miscellaneous solids	121,600[6,12,26]					--	2.3	NR	NR	79.0	--	84.7	2.4
	Precipitation/ filtration residues	31,000[6,12,26]					--	21.5	28.4	NR	33.3	--	39.8	27.6
	Heavy ends	16,300[6,12,26]					--	NR	3.4	NR	89.9	--	4.3	17.6
	Process waste water	30,936,200[6,12,26]					--	NR	80.9	<0.1	41.5	--	0.4	83.6
	Equipment washdown	258,900[6,12,26]					--	NR	92.2	NR	7.6	--	NR	100
	Steamjet condensate	117,600[6,12,26]					--	NR	NR	NR	100	--	NR	100
	Spent scrubber water	2,354,500[6,12,26]					--	NR	0.2	NR	65.8	--	7.7	100
	Nonprocess wastewater	2,679,500[6,12,26]					--	NR	89	NR	89.1	--	NR	90.2

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	On-Site SI	On-Site LT	On-Site Other	On-Site Total	Off-Site Disposal	Off-Site Other
Primary Iron and Steel Manufacturing and Ferrous Foundries (SIC 3312-3321)		60,679,000[6,7]	--	1,380[4,27]	--	--	--	24,LUN	24,LUN	--	65,R[28]	--	--	--
	Coke breeze	1,752,000[6,7,9]					100	0	0	0	100,R	0	0	0
	Blast Furnace slag	23,132,000[6,7]					0	0	0	0	0	100	0	100,R
	Blast furnace dust	1,467,000[6,7]					100	--	--	--	100,R	--	--	--
	Blast furnace sludge	1,536,000[6,7]					--	12,LUN	12,LUN	--	88,R	--	--	--
	EAF slag	3,764,000[6,7]					100	90	0	0	10,R,50S[29]	--	--	--
	EAF dust and sludge	408,000[6,7,9]					--	100	0	0	0	0	0	0
	Open hearth slag	2,026,000[6,7]					--	25,LUN	25,LUN	--	75,R	--	--	--
	Continuous casting scale	319,000[6,7]					--	--	--	--	100,S	--	--	--
	Continuous casting sludge	4,000[6,7]					--	--	--	--	--	--	--	--
	Soaking pit scale	837,000[6,7]					--	--	--	--	--	--	--	--
	Primary mill scale	2,505,000[6,7]					--	--	--	--	100,S	--	--	--
	Primary mill sludge	104,000[6,7]					--	--	--	--	--	--	--	--
	Rolling scale (hot and cold)	973,000[6,7]					100	--	--	--	100,S	--	--	--
	Rolling sludge (hot and cold)	5,000[6,7]					--	--	--	--	--	--	--	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	LF	On-Site SI	LT	Other	Total	Off-Site Disposal	Other
Primary Iron and Steel Manufacturing and Ferrous Foundries (continued)	Pickle liquor sludge	--					--	--	--	--	--	--	--	--
	Galvanizing sludge	40,000[6,7]					100	--	--	--	100,R	--	--	--
	Tin plating sludge	16,000[6,7]					--	--	--	--	--	--	--	--
	Bricks and rubble	7,374,000[6,7]					--	100,LUN	--	--	--	--	--	--
	Fly ash and bottom ash	--					--	--	--	--	--	--	--	--
	Foundry sand and other wastes	14,417,000[6,7]					100	100	--	--	--	--	--	--
Primary[30] Non-Ferrous Metals Manufacturing and Non-Ferrous Foundries (SIC 3330-3399)		6,575,000	--	1,380[4,31]		--	--	--	--	--	--	--	--	--
	Primary aluminum wastes	311,900[6,16]					75	75	--	--	--	25	25	--
	Primary copper wastes	3,305,300[6,16]					--	--	--	--	--	--	--	--
	Primary zinc wastes	513,800[26]					--	--	--	--	--	--	--	--
	Primary lead wastes	340,000[6,26]					--	--	--	--	--	--	--	--
	Foundry sand and other wastes	2,104,000[7]					100	88-98	2-12	--	--	--	--	--

TABLE 1-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	On-Site LF	SI	LT	Other	Total	Off-Site Disposal	Othe
Rubber and Miscellaneous Plastic Products (SIC 30)		542,600[2,6]	--	252[4]	--	--	--	--	--	--	--	--	--	--
	Tire/inner tube waste streams	223,400[2,6,9,30]					--	--	--	--	--	--	--	--
	Rubber and plastics footwear waste streams	32,000[2,6,9,30]					--	--	--	--	--	--	--	--
	Reclaimed rubber waste streams	38,900[2,6,9,30]					--	--	--	--	--	--	--	--
	Rubber and plastics hose and belting waste-streams	53,200[2,6,9,30]					--	--	--	--	--	--	--	--
	Fabricated rubber products NEC waste streams	195,100[2,6,9,30]					--	--	--	--	--	--	--	--
	Miscellaneous plastic products waste streams	--					--	--	--	--	--	--	--	--
Soaps; Other Detergents; Polishing, Cleaning and Sanitation Goods (SIC 2841-2842)		31,300[6,13]	--	--	--	--	--	--	--	--	--	--	--	--
	Lost product	--					--	--	--	--	--	--	--	--
	Tower cleanouts	--					--	--	--	--	--	--	--	--
	Sludges	--					--	--	--	--	--	--	--	--
	Dust and fines	--					--	--	--	--	--	--	--	--
Stone, Clay Glass, and Concrete Products (SIC 32)		>18,600,000[32]	--	1,243[4]	--	--	--	--	--	--	--	--	--	--
	Silica particulates	--					--	--	--	--	--	--	--	--
	Spent diatomaceous earth	--					--	--	--	--	--	--	--	--
	Soda ash	--					--	--	--	--	--	--	--	--
	Lime	--					--	--	--	--	--	--	--	--

TABLE 1-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]						
			LF	SI	LT	Other	Total	LF	On-Site SI	LT	Other	Total	Off-Site Disposal	Other
Stone, Clay Glass and Concrete Products (SIC 30) (continued)	Brine residues	--					--	--	M	--	--	--	--	--
	Air pollution control sludge (cement)	12,100,400					--	--	--	--	--	--	--	--
	Air pollution control sludge (clay)	4,370,000					--	--	--	--	M	--	--	--
	Lubricants	--					--	--	--	--	--	--	--	--
	Pottery sludge	SIC 33					--	M	--	--	--	--	--	--
	Air pollution control sludge (concrete, gypsum and plaster)	2,151,000					--	--	--	--	--	--	--	--
	Waste cullet	--					--	--	--	--	--	--	--	--
	Fiber resin masses	--					--	--	--	--	--	--	--	--
Textile Manufacturing (SIC 22)		>45,000	--	536[4]	--	--	--	10	--	--	--	--	55	--
	Wool scouring wastes						--	--	--	--	--	--	M	--
	Clippings						--	--	--	--	--	--	M	--
	Dye containers						--	--	--	--	--	--	M	--
	Dry flick						--	--	--	--	--	--	M	--
	Waste fiber						--	--	--	--	--	--	M	--

TABLE B-1. SUMMARY OF INDUSTRIAL NON-HAZARDOUS WASTE GENERATION AND MANAGEMENT (Continued)

Industry	Waste Type[a]	Amount of Waste Generated (Dry Metric Tons/Yr)	Number of On-Site Non-Hazardous Disposal Facilities[b]					Percent of Non-Hazardous Wastes Managed[c]							
			LF	SI	LT	Other	Total	LF	On-Site SI	LT	Other	Total	Off-Site Disposal	Other
Textile Manufacturing (SIC 22) (continued)	Wastewater treatment sludge	--					--	--	--	--	--	--	M	--
Transportation Equipment (SIC 37)		520,000[11]	--	--	--	--	--	--	--	--	--	--	--	--
	Solvents	148,000					--	37	--	--	--	--	63	--
	Paint wastes	248,000					--	20	--	--	--	--	80	--
	Metal treating wastes	124,000					--	100	--	--	--	--	--	--
Water Treatment (SIC 4941)		4,960,000[34]	--	--	--	--	--	--	--	--	--	--	--	--
	Coagulation sludges	--					--	--	--	--	--	--	--	--
	Softening sludges	--					--	--	--	--	--	--	--	--

a. Waste types from more than one product or process within an industry often are combined under one listing in this table. Such combining often prevented the listing of waste management information for a given waste. This information is available in Section 4 of this report.
b. LF = landfill; SI = surface impoundment; LT = land treatment
c. Numbers in all columns represent the percentage of total wastes; note the sum of numbers in one row may exceed 100 percent if one management method is used prior to another method for the same waste stream. Also note: The management data represent the same year as the quantity data, unless otherwise indicated.
1. Data on waste types and amounts were available only for SIC 367 (represents only 2 percent of total value of 1976 product shipments for the industry)
2. 1975 data
3. "--" = data not available
4. Data from the "Surface Impoundment Assessment National Report" were collected in 1978-1980. EPA 570/9-84-002. Office of Drinking Water, December, 1983.
5. M = most of the referenced wastes are managed by this technology; however, no percentage values are available in the literature.
6. Dry or wet weight not specified; assume wet weight.
7. 1983 data
8. Data on non-hazardous waste streams in this industry are almost completely non-existent. The list of waste types is incomplete.
9. Includes hazardous and non-hazardous wastes, depending on the source.
10. Electroplating and metal finishing only; other SIC 34 groups unknown; 1979 data.
11. 1980 data
12. Estimated from the Industry Studies Data Base, compiled for the USEPA by SAIC.
13. 1981 data
14. 1976 data
15. Wet weight
16. 1984 data
17. 1979 data
18. LUN = location of the management site (i.e., on-site or off-site) is unknown.
19. Includes the entire chemical manufacturing industry (SIC 28).
20. NR = Not reported by any industries surveyed to compile the Industry Studies Data Base. See footnote number 12 above.
21. The total amount of wastes within this industry is large; however, most of the wastes are recycled; no quantities on total waste generation are available.
22. Includes only wastes from SIC 355 and 357 (representing 12 percent of total sales in SIC 35); 1977 data.
23. 1977 data
24. Landfilling is the prominent off-site disposal method for petroleum wastes
25. 1973 data
26. 1982 data
27. Includes the primary non-ferrous metals industry.
28. R = This waste is stockpiled prior to recycling
29. S = Stockpiled
30. The number of waste streams in this category were too numerous to include in the table. See Section 4.16 for more detail.
31. Includes the primary iron and steel industry.
32. This estimate is known to exclude significant quantities of non-hazardous wastes.
33. SIG = significant quantities are believed to be generated.
34. Disposal methods are the subject of an ongoing survey.

TABLE B-2. QUALITATIVE ANALYSES OF INDUSTRIAL NON-HAZARDOUS WASTE DATA

Industry	Data Availability[a]	Relative Levels of Heavy Metals or Organics in Wastes	Prevalent Waste Management Methods
Electrical Machinery and Electronic Components (SIC 36)	POOR: The descriptions of waste types are incomplete and waste quantity data are available only for SIC 367, which represents only 2 percent of total SIC 36 sales. (Year = 1977)	HIGH: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available. Since this industry generates considerable quantities of hazardous waste, some small quantity generators may dispose hazardous wastes in on-site, land-based facilities.	General trend indicates off-site landfill disposal, based on 1977 data. Large quantities of non-hazardous wastewaters may be managed in on-site surface impoundments.
Electric Power Generation (SIC 4911)	GOOD: Detailed descriptions of waste types and quantities are available. Waste management data are fairly good. (Year = 1983)	MODERATE: This waste has a potential to reduce pH levels and release metals. Organics, such as naphthalenes and benzofluorenes, also may be released. Toxicity depends on the source of coal or oil being burned.	General trend is on-site disposal in clay-lined surface impoundments and landfills. Some of these facilities are synthetic-lined and have ground-water monitoring.
Fabricated Metal Products (SIC 34)	POOR: Waste type and quantity data are almost completely non-existent. Some management data are available. (Years = 1976, 1979, and 1983)	HIGH: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available. Since this industry generates considerable quantities of hazardous wastes, some small quantity generators may dispose hazardous wastes in on-site, land-based facilities.	Data from 1976 indicate that 20-30 percent of wastes are managed on-site in landfills and lagoons.
Fertilizer and Other Agricultural Chemicals (SIC 2873-2879)	MODERATE: Waste quantity and management data are very good for pesticide formulation and manufacturing, but are poor for some segments of fertilizer manufacturing. Waste types are fairly well-defined for fertilizer and detailed analyses are available for pesticides. (Years = 1980 and 1983)	HIGH: Waste gypsum piles may cause local pH and metals contamination problems. Pesticide wastes may release organics and heavy metals.	Waste gypsum is stored in unlined piles. Large quantities of wastewaters are stored or treated in surface impoundments.
Food and Kindred Products (SIC 20)	GOOD: Waste types and quantities are well-defined and waste management methods are fairly well-described. (Year = 1980)	LOW: Most food industry wastes are biodegradable, but may cause taste and odor problems.	Off-site landfills and land application are used extensively, with some on-site land disposal.

TABLE B-2. QUALITATIVE ANALYSES OF INDUSTRIAL NON-HAZARDOUS WASTE DATA (Continued)

Industry	Data Availability[a]	Relative Levels of Heavy Metals or Organics in Wastes	Prevalent Waste Management Methods
Industrial Inorganic Chemicals Industry (SIC 2812 - 2819)	MODERATE: Data on waste quantities and amounts are good, but there are very little analytical data. (Year = 1979)	HIGH: Most non-hazardous wastes from this industry do not appear to contain heavy metals, but there are insufficient analytical data on these wastes. Since this industry generates considerable quantities of hazardous wastes, some small-quantity generators may dispose hazardous wastes in on-site, land-based facilities.	On-site landfills and surface impoundments are used for most wastes. Design data on these facilities are not available.
Industrial Organic Chemicals (SIC 2819)	VERY GOOD: Detailed information is available on all data areas except the design features of the waste management facilities. (Years = 1981 and 1982)	HIGH: Many of the waste streams in this industry contain high levels of extremely toxic organic chemicals. Since this industry generates considerable quantities of hazardous wastes, some small-quantity generators may dispose of hazardous wastes in on-site, land-based facilities.	Most land-based disposal is performed at off-site facilities; however, approximately 34 percent of wastewater and sludges are treated in on-site impoundments prior to discharge.
Leather and Leather Tanning (SIC 31)	GOOD: Waste types and quantities are well-described and general management methods are known. (Year = 1975)	MODERATE: These wastes generally contain chromium, but it is generally in the +3-valence state.	Off-site landfills are used most commonly and approximately 90 percent of all wastes are sent to off-site facilities. Ten percent of the wastes are managed in on-site surface impoundments and landfills.
Lumber and Wood Products and Furniture and Fixtures (SIC 24 AND 25)	MODERATE: The waste types in this industry are described, but there are no dependable data on quantities or analytical results. (Year = 1980)	MODERATE: Most of the wastes (380 million MT/year) from this industry are composed of wood dust, chips, shavings, and other rejects, and most of these wastes are burned or reused. However, the ash from burning these wastes are generated in very high quantities and is high in pH.	There are no data on land disposal of wastes from this industry.

TABLE B-2. QUALITATIVE ANALYSES OF INDUSTRIAL NON-HAZARDOUS WASTE DATA (Continued)

Industry	Data Availability[a]	Relative Levels of Heavy Metals or Organics in Wastes	Prevalent Waste Management Methods
Machinery Except Electrical (SIC 35)	POOR: The descriptions of waste types are incomplete and waste quantity data were available only for SIC 355 and and SIC 357, which represent only 12 percent of total SIC 35 sales. (Year = 1977)	HIGH: Wastewater treatment sludges, oils, and paint wastes have potential to release heavy metals and organics. No specific analytical data are available. Since this industry generates considerable quantities of hazardous waste, some small quantity generators may dispose hazardous wastes in on-site, land-based facilties.	Data from 1977 indicate that 90 percent of these wastes are managed off-site and that 70 percent of the total waste stream from this industry are land disposed. Ten percent of these wastes are managed on-site, however, the management methods are not known.
Pulp and Paper Industry (SIC 26)	GOOD: The quantities and types of wastes from this industry are well-described, and management methods are known for each waste type. Some data are available on waste management facility designs. (Year = 1977)	MODERATE: Organic pollutants from wood fibers may be significant. Also, coal and bark ash may contain metals. Sulfates and metals are high in some pulping wastes.	Approximately 72 percent of all wastes are managed in on-site landfill facilities. On-site surface impoundments account for 7 percent of industry wastes, about 10 percent of pulp and paper wastes are managed in on-site incinerators.
Petroleum Refining Industry (SIC 29)	VERY GOOD: All data needs were available except typical designs of waste management facilities. (Year = 1981)	HIGH: These wastes generally contain high levels of sulfides, ammonia, phenols, and oils. Some of them also contain mercaptains, benzo-a-pyrene, and other toxic organics. Since this industry generates considerable quantities of hazardous wastes, some small-quantity generators may dispose hazardous wastes in on-site, land-based facilities.	Approximately 59 percent of the wastes are managed in on-site land application facilities. The remaining 41 percent are managed at off-site, land-based disposal sites.
Pharmaceutical Preparations (SIC 2834)	GOOD: The quantities and types of wastes from this industry are fairly well-described and the general waste management methods are known. (Year = 1976)	LOW: The majority of these wastes are fermentation products and are biodegradable.	Approximately 85 to 90 percent of the wastes from this industry are managed in off-site, land-based disposal facilities.
Plastics and Resins Manufacturing (SIC 2821)	VERY GOOD: Detailed information is available on all data areas except the design features of the waste management facilities. (Year = 1982)	HIGH: Many of the waste streams in this industry contain organic solvents and unreacted monomers, which are frequently toxic.	Approximately 68 percent of these wastes are treated in surface impoundments, 1 percent are landfilled, and 1.5 percent are managed in off-site, land-based disposal facilities.

TABLE B-2. QUALITATIVE ANALYSES OF INDUSTRIAL NON-HAZARDOUS WASTE DATA (Continued)

Industry	Data Availability[a]	Relative Levels of Heavy Metals or Organics in Wastes	Prevalent Waste Management Methods
Primary Iron and Steel Manufacturing and Ferrous Foundries (SIC 3312-3321)	GOOD: The waste types and quantities generally are available and the compositions of each waste are known. Management methods generally are known for each waste type. (Year = 1983)	HIGH: Many of the wastes from this industry are low in pH and may release significant quantities of heavy metals.	Approximately 25 percent of these wastes are managed in on-site impoundments and landfills. Also, 65 percent of the wastes (mainly slag) are stored in waste piles prior to recycling.
Primary Non-Ferrous Metals Manufacturing and Non-Ferrous Foundries (SIC 3330-3399)	POOR: Good descriptions of the types of wastes produced by each sector, but not much analytical data. Good estimates on the quantities of each waste type, but almost no waste management data. (Year = 1984)	HIGH: Several of the waste streams contain high levels of heavy metals.	No data.
Rubber and Miscellaneous Plastic Products (SIC 30)	POOR: Good data on quantities of wastes, but poor descriptions of waste characteristics and management methods. (Year = 1975)	HIGH: Data are sketchy, but indicate possibly significant levels of elastomers, carbon black, plastic resins, plasticizers, and pigments.	At least some on-site landfilling and incineration, but data are almost non-existent.
Soaps; Other Detergents; Polishing, Cleaning, and Sanitation Goods (SIC 2841-2842)	POOR: Waste types poorly defined and quantity data is almost non-existent. (Year = 1974)	LOW: Most of these wastes are composed of packaging, lost products, salts, inerts. Some organics are generated from floor polishes (plasticizers) and pine oils (solvents).	Most of these wastes are expected to be sent off-site because the industry is composed of a large number of small establishments.
Stone, Clay, Glass, and Concrete Products (SIC 32)	POOR: Waste quantity data are available only for some waste types. Waste types are fairly well-described, but lack analytical data. Management methods are poorly documented.	LOW: Most of the wastes produced are inert, earth-type materials. However, Significant quantities of air pollution control sludges are generated, some of which may contain heavy metals.	No data, however, most wastes are expected to be managed on-site due to generally low toxicity and high volumes.
Textile Manufacturing (SIC 22)	POOR: Waste types are fairly well-described, but there are virtually no analytical data and no data on waste quantities and management methods.	LOW: Waste descriptions indicate low organics and heavy metals, but there are virtually no analytical data to confirm this assumption.	No data.

TABLE B-2. QUALITATIVE ANALYSES OF INDUSTRIAL NON-HAZARDOUS WASTE DATA (Continued)

Industry	Data Availability[a]	Relative Levels of Heavy Metals or Organics in Wastes	Prevalent Waste Management Methods
Transportation Equipment (SIC 37)	POOR: There are no data in the literature pertaining to non-hazardous waste generation and management within this industry.	HIGH: Wastes are expected to be similar in quantity and composition to those generated within SIC 34 and 35. Since this industry generates considerable quantities of hazardous wastes, some small-quantity generators may dispose hazardous wastes in on-site, land-based facilities.	No data.
Water Treatment (SIC 4941)	POOR: Waste types are fairly well-described and an overall estimate on waste quantities was available; however, there were no data on waste management methods.	LOW: These wastes are composed mainly of alum and lime, but may contain some heavy metals.	No data.

[a]Data areas pursued in this study included: Detailed analyses on each type of waste generated by each industry, the amount of each type of waste, the types and numbers of on-site, land-based disposal methods used by each industry, the general design of these facilities, and the amounts of each waste type managed in each different type of facility. The year for which most data were found is given in parentheses.

APPENDIX C

MUNICIPAL WASTE LANDFILL CAPACITY PROBLEMS

1. Presented as Appendix A in: Census of State and Territorial Subtitle D Nonhazardous Waste Programs. Westat, Inc., for U.S. EPA, 1986.

APPENDIX A

LANDFILL CAPACITY PROBLEMS

As part of the Landfill Section of the State Subtitle D Program Questionnaire, the States were asked to respond to the following:

> "Please describe any local, regional, or statewide landfill capacity problems in your State."

The responses are listed below, alphabetically, by State.

Alabama. Many of the landfills are reaching capacity. Very difficult to site new landfills due to technical requirements and public opposition.

Alaska. There is no capacity problem in Alaska as far as space, but in most areas the soil and topography are not suitable for landfills (wetlands and permafrost) due to the climate.

American Samoa. The existing landfill on the island of Tutuila is rapidly approaching capacity. With limited useable land, alternate methods of municipal waste disposal may have to be used, e.g., incineration, waste transfer to other islands.

Arizona. It is getting more difficult to site new landfills and this is causing a problem especially in the Phoenix Area, Maricopa, & Mojave Counties. Also, much of the land is federally owned and is leased on a highest bidder basis. Many of the area's lands are going back to private companies and this is causing problems siting landfills.

Arkansas. A few individual landfills are reaching capacity but no problems are foreseen in finding new locations. This is primarily due to a 1974 Arkansas ruling which said that landfills can only be turned down because of physical criteria siting problems but not public opposition. Additionally, zoning regulations are not restrictive in siting new landfills.

California. Most urban areas have capacity for only approximately 20 years--need to expedite planning for future capacity.

Colorado. There are 6 landfills which service the greater Denver metropolitan area. Within the next three years, two with a possible four landfills may close. At the present time, there are no new landfills proposed to replace these facilities. If no new landfills are permitted, the Denver area may face a critical shortage of landfill space.

Connecticut. The State of Connecticut is approaching a statewide capacity shortage, estimated to become critical in late 1988. Currently, 50% of the state's solid waste is going to 9 major regional landfills. These sites will all reach their permitted capacity at about the same time because the waste flow is easily diverted to the few remaining landfills. No new municipal waste fills have been permitted in Connecticut since 1978. The permitted landfills will be used up before the planned resource recovery projects are in operation.

Delaware. No capacity problems. Increased volume at landfills in Kent and Sussex County would allow economic resource recovery

facilities to be built (similar to the one presently operating in New Castle County).

Florida. An evaluation of current and projected population growth in Florida indicates a need for an estimated equivalent 2,700 acres of additional landfill area, annually, through year 1995.

Georgia. Gwinnet County, Fulton County, Douglas County, Cobb County. The above counties are located in the Atlanta area and have problems locating and zoning new sites due to public opposition. All have limited remaining landfill capacity at existing sites.

Guam. Single municipal landfill owned and operated by Government of Guam will reach capacity in 1-2 years.

Hawaii. Statewide: shortage of suitable and available sites (no community opposition) for landfills is the major concern of all the counties. Except for the City and County of Honolulu, the amount of refuse generated per day on each of the counties is too small to consider refuse-to-energy as an aletrnate method of refuse disposal. City and County of Honolulu: the three municipal landfills are rapidly approaching their capacities; the two smallest landfills will be closed within 18 months and the largest within 3 years. The city is finalizing a contract with a private firm to design, construct, and operate a refuse-to-energy (RFD) plant.

Idaho. Approximately 12 landfills are in need of replacement due to capacity problems, 8 of which are the major or only landfill for the counties in which they are located.

Indiana. Please see attached map. (Map shows estimated lifetimes of all landfills in indiana.)

Iowa. No significant landfill capacity problems at this time statewide. Local capacity problems usually result in landfill expansion at nearby sites.

Louisiana. Lack of permitted disposal facilities for oil field waste encourages illegal dumping.

Kansas. None.

Kentucky. No response.

Maine. Some small communities, particularly those in the more remote areas not serviced by regional or commercial landfills or resource recovery projects, are in need of regional solutions. Many small municipal sites have little remaining capacity.

Maryland. Calculating the total disposal capacity for the state would be misleading. Each of the 23 Maryland Counties and Baltimore City is responsible for providing landfill capacity for its residents. This capacity at present ranges from less than one to more than 25 years. There is no programmatic mechanism for moving waste from an area with a capacity shortage to an area with a capacity surplus. The Draft State Solid Waste Plan found, in early 1985, that eight of the 24 jurisdictions had less than five years disposal capacity under permit.

Massachusetts. The capacity of Massachusetts' active landfills is actively running out. [Plus an additional page of text.]

Michigan. The capacities for solid waste disposal areas are addressed as part of the solid waste management plans which are required to be developed pursuant to act 641.PA1978. The plan requires each county to identify disposal sites which will accept solid waste generated within their political boundaries for a 5 year period. The plans are to be updated every 5 years with new sites identified as necessary.

Minnesota. Many landfills have 5 years or less for capacity and some disposal option will be needed. However, we are stressing reuse of the waste and will need less capacity. Other landfills have as much as 20-40 years left.

Mississippi. Within 5 years only about 5% of our landfills in Mississippi will need new sites. We expect more recycling and incineration. In general there are no landfill capacity problems.

Missouri. No response.

Montana. Statewide many of the existing landfills are nearing capacity. In general it is very difficult to obtain new sites for landfills.

Nebraska. One municipality (pop 18,000) has been unable to site a landfill and is transferring refuse 50 miles to another site. One major landfill has less than two years remaining life with no known effort to find a replacement at this time. Another major landfill with about the same remaining life serves 180,000 people. The city involved is seeking a new site.

Nevada. None at this time.

New Hampshire. Many landfills are reaching capacity. Also a large number have shown leachate breakouts and are under closing orders. As a result, many towns are opting for refuse-to-energy facilities.

New Jersey. Capacity problems are very severe across the state. Siting due to public opposition is the largest contributing factor to the capacity problem.

New Mexico. There are currently 61 landfills on federal land and 12 on state land. Both entities have told the landfills that as leases expire to find new land or purchase the existing land at current market rates. Communities either do not have the funds for purchase or no other land is available or suitable. Also the "not in my backyard" syndrome is beginning to come forth in New Mexico.

New York. No response.

North Carolina. The biggest issue facing landfill operators is economic considerations needed to construct and maintain landfill facilities. With stringent rules in place for protection of the environment, new techniques and technologies are mandated for protecting the environment.

North Dakota. There are no capacity problems at this time in North Dakota.

Northern Marianas. The only solid waste facility at the present time is an open dump and although there are no capacity problems

we are looking for a new site for a landfill. We hope to find a suitable site in the not too distant future.

Ohio. There are 41 counties (out of 88) that will reach landfill capacity within four years. These are major municipal landfills that accept general solid waste (in the 41 counties).

Oklahoma. Almost every area of the state experiences some landfill capacity problems. The primary problem facing the state, however, is the lack of new landfills. Rising costs of operation, more stringent permitting requirements, and increasing public opposition has caused many landfills to close at capacity and not permit new sites.

Oregon. Unable to estimate. Most areas of state have at least 5 years remaining life. The Portland Metropolitan Area with over one half of the state population has less than 4 years life with no new site identified. The Portland Metropolitan Area landfill that serves 4 counties is scheduled for closure in 1989. We are looking for a new site but have not found one yet. By July 1987 they hope to find a site. Rest of state has no real capacity problems.

Pennsylvania. Problems in landfills are especially acute in Southeast Pennsylvania. This is primarily because of three factors: 1) closure of "full" landfills; 2) closure of substandard landfills; and 3) public resistance. The Delaware and Lehigh Valleys have only a 2-3 year capacity and include 40% of the state population. Overall, the state has an estimated landfill capacity of about 6 years.

Puerto Rico. The landfill capacity problem is enormous in all Puerto Rico. Almost all of the landfills operating in the Commonwealth are at the last portion of their useful life. Since Puerto Rico is a small island characterized mainly by high population densities and surface water bodies throughout all the country, it is very difficult to obtain additional land for landfill expansion or relocation. Therefore, this critical problem will only be solved by looking toward other solid waste alternatives (such as incineration).

Rhode Island. Many landfills nearing capacity. Three landfills active in 1984 have closed.

South Carolina. Eight to 10 sites need additional acreage within the next year and two of these sites are at capacity right now.

South Dakota. There are no existing capacity problems in South Dakota.

Tennessee. The urban areas, due to population densities, property of adequate acreage, and approvable geology, are difficult to acquire. The public pressure to reject siting is also a factor. This situation is acute in the Middle Tennessee Area as geologically approvable sites are so difficult to locate.

Texas. Replacement landfills in most urban areas are coming under increasing public opposition. This has significantly increased the time required to process a permit which diverts resources from other applications and causes an ever increasing backlog in permit evaluation.

Utah. Capacity is not a big problem but there are some localized problems with siting, especially in the industrial landfills which are in heavily populated areas and don't want to haul waste long distances.

Vermont. The Vermont Agency of Environmental Conservation recognizes two regional solid waste (i.e., landfill) capacity problems. Both regions lack landfill volume to dispose of solid waste generated within the region. Solid waste must be transported excessive distances to approved landfills. New landfills are not being developed due to lack of acceptable land, lack of resources to develop landfills and/or regulations. One region has committed to an alternative disposal method, which has not been implemented due to regulatory and environmental issues. A state wide capacity problem has also been identified. "Approved" solid waste disposal capacity project for the year 1990 is estimated to be 573,000 cubic yards to dispose of a projected 983,000 cubic yards of solid waste.

Virginia. Public resistance to siting of new facilities has caused delays in providing new facilities. Therefore, many landfills are near full and some are in heavily populated areas. Some municipal governments have moved to resource recovery facilities or contracted disposal as an alternative.

Virgin Islands. No response

Washington. There are no capacity problems now but rather siting problems for the future for new locations especially in the metropolitan areas of Spokane and Seattle. Lack of sites and appropriate land to build landfills is primarily due to public resistance and lack of necessary geographic locations. Planning

is being done for other methods of disposal such as resource recovery and burning.

West Virginia. 1) Approximately 50% of municipal solid waste generated in west virginia is disposed at unpermitted facilities; 2) approximately 50% of permitted sites within 3 to 5 years of exhaustion of space/capacity; 3) northeast area of West Virginia has had severe flood damage to solid waste disposal facilities; 4) older permitted sites were designed without adequate consideration of capacity; 5) we believe we will have a 70% shortfall of capacity in 3 to 5 years if something is not done to improve conditions.

Wisconsin. Capacity problems are mostly short-term and localized. Long-distance hauling sometimes needed on an interim basis. Replacement (new or expanded) landfills are being sited in state at rate of about 10-20/year. State siting process is the same for both new and expanded landfills. It is a long process (2-5 years), but does allow siting to take place.

Wyoming. A few areas of tHe state now have capacity problems, mainly Teton County, near Yellowstone, which is having a problem siting a landfill. The Federal Bureau of Land Management is no longer leasing land cheaply and in the next ten years siting will be a statewide problem.

APPENDIX D

STATE SUBTITLE D PROGRAM REGULATIONS FOR MUNICIPAL WASTE LANDFILLS[1], SURFACE IMPOUNDMENTS[2], LAND APPLICATION UNITS,[3] AND WASTE PILES[4]

1 PEI Associates. State Subtitle D Regulations on Municipal Solid Waste Landfills, Final Draft Report. Contract No. 68-01-7075, U.S. EPA, OSWER, Washington, D.C., 1986.

2 PEI Associates. State Subtitle D Regulations on Surface Impoundments, Draft Volume II. Contract No. 68-02-3890, U.S. EPA, OSWER, Washington, D.C., 1986.

3 PEI Associates. State Subtitle D Regulations on Land Treatment, Draft Volume III. Contract No. 68-02-3890, U.S. EPA, OSWER, Washington, D.C., 1986.

4 PEI Associates. State Subtitle D Regulations on Waste Piles, Draft Volume IV. Contract No. 68-02-3890, U.S. EPA, OSWER, Washington, D.C., 1986.

TABLE 1. SPECIFIC PERMIT REQUIREMENTS FOR MUNICIPAL LANDFILLS

State	Soil conditions	Ground water information	Surface water information	Total acreage	Life of facility	Future use	P.E. certification
Alabama	X	X			X		X
Alaska	X	X	X				
Arizona		X	X				
Arkansas	X	X	X		X	X	X
California	X	X	X	X	X	X	X
Colorado	X	X	X	X	X		
Connecticut	X	X			X	X	X
Delaware		X	X				X
Florida	X	X	X	X	X		X
Georgia							
Hawaii							
Idaho		X	X	X			
Illinois	X	X	X	X			X
Indiana	X		X			X	
Iowa	X	X		X			
Kansas				X			X
Kentucky	X	X	X	X	X		X
Louisiana	X	X					X
Maine	X	X	X				
Maryland	X	X	X	X	X		X
Massachusetts	X	X	X		X		
Michigan	X	X	X			X	X
Minnesota	X	X	X				
Mississippi							
Missouri	X	X	X				X
Montana	X	X	X	X			
Nebraska	X	X	X				
Nevada	X	X					
New Hampshire	X	X			X		
New Jersey		X		X	X	X	X
New Mexico			X	X	X		
New York	X	X	X		X		X
North Carolina	X	X	X				
North Dakota	X	X	X				
Ohio	X	X					

TABLE 1 (continued).

State	Soil conditions	Ground water information	Surface water information	Total acreage	Life of facility	Future use	P.E. certification
Oklahoma	X	X	X		X		
Oregon	X	X	X		X	X	X
Pennsylvania	X	X	X		X	X	
Rhode Island	X	X	X		X	X	
South Carolina	X	X	X				X
South Dakota		X	X				
Tennessee			X				
Texas	X	X	X	X	X	X	X
Utah	X	X	X	X			
Vermont	X	X	X	X			X
Virginia							X
Washington							
West Virginia	X	X	X				
Wisconsin	X	X	X				X
Wyoming	X	X			X	X	
Am. Samoa							
Guam	X	X	X		X	X	
N. Mar. Is.	X		X				X
Puerto Rico		X	X				X
Virgin Is.							

Source: Reference 1

TABLE 2. DESIGN CRITERIA FOR MUNICIPAL LANDFILLS

State	Liner design	Leachate management	Run-on/run-off controls	Gas controls
Alabama	X		X	X
Alaska	X	X	X	X
Arizona			X	
Arkansas		X	X	
California	X	X	X	X
Colorado		X		X
Connecticut			X	X
Delaware	X	X	X	X
Florida	X	X	X	X
Georgia			X	X
Hawaii				
Idaho				X
Illinois		X	X	
Indiana			X	X
Iowa			X	X
Kansas			X	X
Kentucky	X	X	X	X
Louisiana	X		X	
Maine			X	
Maryland	X	X	X	
Massachusetts	X	X	X	
Michigan	X	X	X	X
Minnesota		X	X	X
Mississippi	X	X	X	X
Missouri	X	X	X	
Montana	X	X	X	X
Nebraska	X	X		X
Nevada			X	
New Hampshire				X
New Jersey		X	X	X
New Mexico			X	
New York	X	X	X	X
North Carolina			X	X
North Dakota		X	X	X
Ohio		X	X	

TABLE 2 (continued).

State	Liner design	Leachate management	Run-on/run-off controls	Gas controls
Oklahoma	X	X	X	
Oregon		X	X	X
Pennsylvania		X	X	
Rhode Island			X	
South Carolina			X	X
South Dakota			X	
Tennessee			X	
Texas	X		X	X
Utah				
Vermont	X		X	
Virginia				
Washington		X		
West Virginia				X
Wisconsin				
Wyoming				
Am. Samoa				
Guam				
N. Mar. Is.		X	X	X
Puerto Rico		X	X	X
Virgin Is.				X

Source: Reference 1

TABLE 3. MUNICIPAL LANDFILL OPERATION AND MAINTENANCE STANDARDS

State	Waste management	Leachate controls	Gas controls	Cover	Safety	Other O&M controls
Alabama	X	X	X	X	X	X
Alaska	X	X	X	X	X	X
Arizona	X			X	X	X
Arkansas	X	X		X	X	X
California	X	X	X	X	X	X
Colorado	X	X	X	X	X	X
Connecticut	X			X	X	X
Delaware	X	X		X	X	X
Florida	X	X	X	X	X	X
Georgia	X			X	X	X
Hawaii	X	X		X	X	X
Idaho	X	X		X	X	X
Illinois	X	X		X	X	X
Indiana	X			X	X	X
Iowa	X	X		X	X	X
Kansas	X		X		X	
Kentucky	X	X	X	X	X	X
Louisiana	X	X		X	X	X
Maine	X	X	X	X	X	X
Maryland	X	X		X	X	X
Massachusetts	X	X	X	X	X	X
Michigan	X	X		X	X	X
Minnesota	X	X		X	X	X
Mississippi	X	X	X	X	X	X
Missouri	X	X	X	X	X	X
Montana	X	X		X	X	X
Nebraska	X	X			X	X
Nevada	X	X		X	X	X
New Hampshire	X		X	X	X	X
New Jersey	X	X	X	X		X
New Mexico	X			X	X	X
New York	X	X	X	X	X	X
North Carolina	X	X	X	X	X	X
North Dakota	X	X		X	X	X
Ohio	X	X		X	X	X

TABLE 3 (continued).

State	Waste management	Leachate controls	Gas controls	Cover	Safety	Other O&M controls
Oklahoma	X	X	X	X	X	X
Oregon	X	X	X		X	X
Pennsylvania	X	X			X	X
Rhode Island	X			X	X	X
South Carolina	X			X	X	X
South Dakota	X	X		X	X	X
Tennessee	X			X	X	X
Texas	X	X	X	X	X	X
Utah	X			X	X	X
Vermont	X			X	X	X
Virginia	X			X	X	X
Washington	X	X		X	X	X
West Virginia	X		X	X	X	X
Wisconsin	X		X	X	X	X
Wyoming	X		X	X	X	X
Am. Samoa	X					
Guam	X	X	X	X	X	X
N. Mar. Is.				X	X	X
Puerto Rico					X	X
Virgin Is.						

Source: Reference 1

TABLE 4. MUNICIPAL LANDFILL LOCATION STANDARDS AND RESTRICTIONS

State	Flood protection	Minimum distances	Critical habitat	Geologically sensitive areas	Soil conditions
Alabama	X	X	X	X	
Alaska	X	X			
Arizona					X
Arkansas	X	X			
California	X	X		X	
Colorado	X	X			
Connecticut	X	X	X		
Delaware		X			
Florida	X	X		X	
Georgia					
Hawaii	X				
Idaho					
Illinois					
Indiana	X	X			
Iowa	X	X			
Kansas	X	X	X		
Kentucky	X	X	X		
Louisiana	X	X	X		
Maine	X	X	X		
Maryland					
Massachusetts	X	X	X		
Michigan	X	X			
Minnesota	X	X			
Mississippi	X	X			
Missouri	X	X			
Montana	X	X			
Nebraska	X	X			
Nevada		X			
New Hampshire	X		X		
New Jersey		X			
New Mexico		X			
New York		X	X		X
North Carolina	X	X	X		
North Dakota					
Ohio	X	X			

TABLE 4 (continued).

State	Flood protection	Minimum distances	Critical habitat	Geologically sensitive areas	Soil conditions
Oklahoma	X	X			
Oregon	X				
Pennsylvania	X				
Rhode Island	X	X	X		
South Carolina					
South Dakota	X	X	X		
Tennessee	X	X			
Texas	X	X	X		
Utah		X			
Vermont	X	X	X		
Virginia					
Washington		X			
West Virginia	X		X		
Wisconsin	X	X			
Wyoming		X			
Am. Samoa					
Guam	X	X	X		
N. Mar. Is.					
Puerto Rico	X	X	X		
Virgin Is.					

Source: Reference 1

TABLE 5. MUNICIPAL LANDFILL MONITORING REQUIREMENTS

State	Ground water	Surface water	Leachate	Air
Alabama	X			
Alaska	X	X	X	
Arizona	X			
Arkansas			X	
California	X		X	
Colorado	X			
Connecticut	X			
Delaware	X		X	
Florida	X		X	
Georgia				
Hawaii	X			
Idaho	X			
Illinois	X	X	X	
Indiana	X		X	
Iowa	X			
Kansas	X	X	X	
Kentucky	X			
Louisiana	X	X		
Maine	X			
Maryland	X		X	
Massachusetts	X		X	
Michigan	X	X	X	
Minnesota	X	X		
Mississippi				
Missouri	X		X	
Montana	X			
Nebraska			X	
Nevada				
New Hampshire	X			
New Jersey	X		X	
New Mexico				
New York	X			
North Carolina	X	X	X	
North Dakota	X		X	
Ohio	X		X	
Oklahoma	X		X	
Oregon	X			
Pennsylvania	X		X	
Rhode Island	X			
South Carolina	X			

TABLE 5 (continued).

State	Ground water	Surface water	Leachate	Air
South Dakota	X	X		
Tennessee				
Texas	X		X	
Utah				
Vermont	X			
Virginia				
Washington			X	
West Virginia	X	X		
Wisconsin			X	
Wyoming	X			
Am. Samoa				
Guam	X	X	X	
N. Mar. Is.	X			
Puerto Rico				
Virgin Is.				

Source: Reference 1

TABLE 6. MUNICIPAL LANDFILL CLOSURE, POST-CLOSURE, AND FINANCIAL RESPONSIBILITY REQUIREMENTS

State	Closure requirements	Post-closure requirements	Financial responsibility requirements
Alabama	X	X	
Alaska	X	X	
Arizona	X	X	
Arkansas	X	X	X
California	X	X	X
Colorado	X	X	
Connecticut	X	X	X
Delaware	X	X	
Florida	X	X	X
Georgia	X	X	
Hawaii	X	X	
Idaho	X	X	X
Illinois	X	X	
Indiana	X	X	
Iowa	X	X	
Kansas	X	X	X
Kentucky	X	X	X
Louisiana	X	X	X
Maine	X	X	
Maryland	X	X	
Massachusetts	X	X	X
Michigan	X	X	X
Minnesota	X	X	
Mississippi	X	X	
Missouri	X	X	
Montana	X		
Nebraska	X	X	X
Nevada	X		
New Hampshire	X	X	
New Jersey		X	X
New Mexico	X		
New York	X	X	X
North Carolina	X	X	
North Dakota	X		
Ohio	X	X	

TABLE 6 (continued).

State	Closure requirements	Post-closure requirements	Financial responsibility requirements
Oklahoma	X	X	X
Oregon	X	X	X
Pennsylvania	X		
Rhode Island	X	X	X
South Carolina	X	X	
South Dakota	X	X	
Tennessee	X	X	
Texas	X	X	X
Utah	X	X	
Vermont	X	X	X
Virginia	X		
Washington	X	X	
West Virginia			
Wisconsin	X	X	X
Wyoming	X	X	
Am. Samoa			
Guam	X	X	X
N. Mar. Is.	X	X	X
Puerto Rico			
Virgin Is.			

Source: Reference 1

TABLE 7. PERMIT REQUIREMENTS FOR SURFACE IMPOUNDMENTS

State	Gen. permit req.	Soil cond.	Ground water infor-mation	Surface water infor-mation	Total acre-age	Life of facil-ity	Future use	P.E. certif.
California	x	x	x	x	x	x	x	x
Colorado	x	x	x	x	x	x		
Florida	x							
Georgia	x							x
Illinois	x							x
Louisiana	x	x	x					x
Montana	x	x	x	x	x			
Nebraska	x							x
New Hampshire	x	x	x	x				x
New Jersey	x				x			x
New York	x							x
Oregon	x	x	x	x		x	x	x
South Dakota	x							
Texas	x	x	x		x	x	x	x
Wisconsin	x	x	x	x	x	x	x	x
Puerto Rico	x			x				x

Source: Reference 2

TABLE 8. DESIGN CRITERIA FOR SURFACE IMPOUNDMENTS

State	Liner design	Leachate management	Run-on/ run-off control	Dike stability and air protection	Security requirements
California	x	x	x	x	x
Colorado	x	x	x	x	x
Florida		x			
Georgia					
Illinois					
Louisiana	x	x	x	x	x
Montana			x		x
Nebraska	x		x	x	x
New Hampshire			x	x	x
New Jersey					
New York	x	x		x	x
Oregón		x	x		
South Dakota					
Texas	x	x	x	x	x
Wisconsin	x	x	x	x	x
Puerto Rico					

Source: Reference 2

TABLE 9. OPERATIONS AND MAINTENANCE STANDARDS FOR SURFACE IMPOUNDMENTS

State	Waste management	Leachate management	Cover	Safety	Operations and maintenance
California	x	x		x	x
Colorado	x	x	x	x	x
Florida		x			
Georgia					
Illinois					
Louisiana	x	x	x	x	x
Montana		x		x	x
Nebraska		x		x	
New Hampshire	x			x	x
New Jersey		x			
New York		x		x	x
Oregon		x		x	
South Dakota		x			x
Texas	x	x		x	x
Wisconsin	x	x		x	x
Puerto Rico		x		x	x

Source: Reference 2

TABLE 10. LOCATION STANDARDS AND RESTRICTIONS FOR SURFACE IMPOUNDMENTS

State	Floodplain protection	Minimum distances	Critical habitat	Geologically sensitive areas	Soil conditions
California	x	x		x	
Colorado	x				
Florida		x			
Georgia					
Illinois					
Louisiana	x	x	x	x	
Montana	x	x		x	x
Nebraska	x	x			
New Hampshire	x				
New Jersey					
New York	x				x
Oregón					
South Dakota	x	x			
Texas	x	x	x	x	
Wisconsin	x	x	x	x	
Puerto Rico	x	x	x		

Source: Reference 2

TABLE 11. MONITORING REQUIREMENTS FOR SURFACE IMPOUNDMENTS

State	Ground water	Surface water	Leachate	Air
California	x		x	
Colorado	x		x	
Florida				x
Georgia	x			
Illinois				
Louisiana	x		x	x
Montana	x			
Nebraska			x	
New Hampshire	x			x
New Jersey			x	
New York	x	x		x
Oregon				
South Dakota	x	x	x	x
Texas	x			x
Wisconsin	x	x	x	x
Puerto Rico	x	x		x

Source: Reference 2

TABLE 12. CLOSURE POST-CLOSURE AND FINANCIAL REQUIREMENTS FOR SURFACE IMPOUNDMENTS

State	Closure requirements	Post-closure maintenance	Financial assurance/responsibility requirements
California	x	x	x
Colorado	x	x	
Florida			
Georgia			
Illinois	x	x	
Louisiana	x	x	x
Montana			
Nebraska	x		
New Hampshire	x	x	
New Jersey			
New York	x	x	x
Oregon	x	x	x
South Dakota	x	x	
Texas	x	x	x
Wisconsin	x	x	x
Puerto Rico			

Source: Reference 2

TABLE 13. PERMIT REQUIREMENTS FOR LAND APPLICATION UNITS

State	Gen. permit req.	Soil cond.	Ground water information	Surface water information	Total acreage	Life of facility	Future use	P.E. certif.
Alaska	x			x				
Arkansas	x			x		x	x	
California	x	x	x	x	x	x	x	x
Colorado	x	x	x	x	x	x		
Florida	x							
Georgia	x							x
Illinois	x							x
Iowa	x							x
Kentucky	x	x	x	x				
Louisiana	x	x	x			x		
Michigan	x		x					x
Mississippi	x							
Montana	x	x	x	x	x			
Nebraska	x		x	x				x
New Hampshire	x							
New York	x							x
Oklahoma	x			x		x		x
South Carolina	x	x				x		x
South Dakota	x							
Texas	x	x	x		x	x	x	x
Vermont	x							
Wisconsin	x	x	x	x	x	x	x	x
Puerto Rico	x			x				x

Source: Reference 3

TABLE 14. DESIGN CRITERIA FOR LAND APPLICATION UNITS

State	Environmental criteria	Leachate management	Air protection	Run-on/run-off control system	Temp. storage system design	Security req.
Alaska				x		x
Arkansas						
California		x		x	x	x
Colorado			x	x		x
Florida		x			x	x
Georgia						
Illinois						
Iowa					x	x
Kentucky	x			x		x
Louisiana		x		x		x
Michigan					x	x
Mississippi						
Montana				x		x
Nebraska				x	x	
New Hampshire			x	x		x
New York		x		x		x
Oklahoma		x		x		
South Carolina				x		x
South Dakota						
Texas		x	x	x	x	x
Vermont						
Wisconsin		x		x	x	x
Puerto Rico						

Source: Reference 3

TABLE 15. OPERATIONS AND MAINTENANCE STANDARDS FOR LAND APPLICATION UNITS

State	Waste management	Waste application	Crop management	Leachate management	Safety req.	Operations & maintenance requirements
Alaska		x			x	x
Arkansas	x				x	
California				x	x	x
Colorado	x				x	
Florida	x	x	x	x	x	x
Georgia	x	x				
Illinois						
Iowa	x				x	x
Kentucky	x	x	x		x	x
Louisiana	x	x	x		x	x
Michigan	x	x			x	x
Mississippi	x	x	x		x	x
Montana					x	x
Nebraska	x	x	x		x	x
New Hampshire		x			x	x
New York	x	x		x	x	x
Oklahoma				x		x
South Carolina					x	x
South Dakota						x
Texas	x	x	x	x	x	x
Vermont						
Wisconsin	x	x	x	x	x	x
Puerto Rico		x			x	x

Source: Reference 3

TABLE 7-16. LOCATION STANDARDS AND RESTRICTIONS FOR LAND APPLICATION UNITS

State	Floodplain protection	Minimum distances	Critical habitat	Geologically sensitive areas	Soil conditions
Alaska	x	x			
Arkansas					
California	x	x		x	
Colorado	x				
Florida		x		x	
Georgia					
Illinois					
Iowa					
Kentucky	x	x	x	x	
Louisiana	x	x	x		x
Michigan	x	x			
Mississippi		x			
Montana	x	x		x	x
Nebraska		x			
New Hampshire	x				
New York	x				
Oklahoma		x			
South Carolina					
South Dakota	x	x			
Texas	x	x	x	x	
Vermont					
Wisconsin	x	x	x	x	
Puerto Rico	x	x		x	

Source: Reference 3

TABLE 17. MONITORING REQUIREMENTS FOR LAND APPLICATION UNITS

State	Ground water	Surface water	Leachate monitoring	Soil monitoring	Air monitoring
Alaska	x	x			
Arkansas					
California	x	x	x		
Colorado	x				x
Florida	x		x	x	
Georgia	x				
Illinois					
Iowa					
Kentucky	x			x	x
Louisiana	x			x	x
Michigan					
Mississippi					
Montana	x		x		
Nebraska				x	
New Hampshire	x				x
New York	x			x	
Oklahoma	x				
South Carolina					
South Dakota	x	x		x	x
Texas	x		x	x	
Vermont					
Wisconsin	x	x	x	x	x
Puerto Rico	x	x	x		x

Source: Reference 3

TABLE 18. CLOSURE, POST-CLOSURE, AND FINANCIAL REQUIREMENTS FOR LAND APPLICATION UNITS

State	Closure	Post-closure	Financial assurance/responsibility
Alaska	x	x	
Arkansas			
California	x	x	x
Colorado	x	x	
Florida			
Georgia			
Illinois	x	x	x
Iowa			
Kentucky		x	
Louisiana	x	x	x
Michigan			
Mississippi	x	x	
Montana			
Nebraska			
New Hampshire			
New York	x	x	
Oklahoma			x
South Carolina	x		
South Dakota	x	x	
Texas	x	x	
Vermont			
Wisconsin	x	x	x
Puerto Rico			

Source: Reference 3

TABLE 19. SPECIFIC PERMIT REQUIREMENTS FOR WASTE PILES

State	Soil conditions	Ground water information	Surface water information	Total acreage	Life of facility	Future use	P.E. cert.
Alabama	x	x			x		x
Arkansas	x	x	x		x	x	x
California	x	x	x	x	x	x	x
Delaware							
Florida							
Georgia							
Idaho							
Illinois							x
Iowa							x
Maine							x
Maryland							x
Minnesota	x		x				x
Mississippi							
Missouri							x
Nebraska	x	x	x				
Nevada							
New Jersey				x			x
New York							x
Ohio	x	x	x			x	
Oklahoma				x	x		x
Oregon	x	x	x		x	x	x
Pennsylvania					x	x	x
South Dakota							
Tennessee			x				
Texas					x		x
Washington							
West Virginia							
Wisconsin	x	x	x				x
Wyoming	X	x	x		x	x	
Puerto Rico			x				x

Source: Reference 4

TABLE 20. DESIGN CRITERIA FOR WASTE PILES

State	Liner design	Leachate collection	Gas controls	Run-on/ run-off controls	Security controls
Alabama	x		x	x	x
Arkansas					
California	x			x	x
Delaware					
Florida				x	
Georgia					x
Idaho					
Illinois					
Iowa					x
Maine					x
Maryland			x		x
Minnesota					
Mississippi				x	
Missouri			x		x
Nebraska	x		x	x	x
Nevada					
New Jersey					
New York					x
Ohio	x		x	x	x
Oklahoma	x			x	x
Oregon				x	x
Pennsylvania				x	x
South Dakota					
Tennessee					x
Texas	x		x	x	x
Washington				x	x
West Virginia					x
Wisconsin				x	x
Wyoming	x				x
Puerto Rico				x	

Source: Reference 1

TABLE 21. OPERATIONS AND MAINTENANCE STANDARDS FOR WASTE PILES

State	Waste management	Leachate controls	Gas controls	Cover	Safety	Operations and maintenance
Alabama		x	x		x	x
Arkansas						
California	x	x		x	x	x
Delaware						
Florida		x			x	x
Georgia					x	x
Idaho					x	x
Illinois						
Iowa	x				x	x
Maine	x				x	x
Maryland	x				x	x
Minnesota					x	x
Mississippi					x	
Missouri	x				x	x
Nebraska		x	x	x	x	x
Nevada					x	
New Jersey	x				x	x
New York		x			x	x
Ohio	x				x	x
Oklahoma		x			x	x
Oregon		x			x	x
Pennsylvania		x			x	x
South Dakota						x
Tennessee					x	x
Texas	x		x		x	x
Washington					x	x
West Virginia	x				x	x
Wisconsin		x	x	x	x	x
Wyoming	x				x	x
Puerto Rico					x	x

Source: Reference 4

TABLE 22. LOCATION STANDARDS AND RESTRICTIONS FOR WASTE PILES

State	Floodplain protection	Minimum distances	Critical habitat	Geologically sensitive areas	Soil conditions
Alabama	x	x			
Arkansas					
California	x	x			x
Delaware					
Florida		x			
Georgia					
Idaho					
Illinois					
Iowa					
Maine	x	x			
Maryland					
Minnesota			x		
Mississippi					
Missouri					
Nebraska	x	x	x		
Nevada		x			
New Jersey					
New York	x				
Ohio					
Oklahoma	x	x			
Oregon			x	x	
Pennsylvania	x	x			
South Dakota	x			x	
Tennessee					
Texas	x	x			
Washington					
West Virginia	x				
Wisconsin					
Wyoming					
Puerto Rico	x				x

Source: Reference 4

TABLE 24. CLOSURE, POST-CLOSURE, AND FINANCIAL REQUIREMENTS FOR WASTE PILES

State	Closure	Post-closure	Financial assurance/responsibility requirements
Alabama	x	x	
Arkansas			
California	x	x	x
Delaware			
Florida			
Georgia	x		
Idaho			
Illinois	x	x	
Iowa			
Maine	x		
Maryland			
Minnesota	x		
Mississippi			
Missouri			
Nebraska	x		
Nevada			
New Jersey			
New York	x	x	x
Ohio	x	x	
Oklahoma	x		x
Oregon	x	x	x
Pennsylvania			
South Dakota	x	x	
Tennessee			
Texas	x	x	x
Washington			
West Virginia			
Wisconsin	x	x	x
Wyoming			
Puerto Rico			

Source: Reference 4

TABLE 24. CLOSURE, POST-CLOSURE, AND FINANCIAL REQUIREMENTS FOR WASTE PILES

State	Closure	Post-closure	Financial assurance/responsibility requirements
Alabama	x	x	
Arkansas			
California	x	x	x
Delaware			
Florida			
Georgia	x		
Idaho			
Illinois	x	x	
Iowa			
Maine	x		
Maryland			
Minnesota	x		
Mississippi			
Missouri			
Nebraska	x		
Nevada			
New Jersey			
New York	x	x	x
Ohio	x	x	
Oklahoma	x		x
Oregon	x	x	x
Pennsylvania			
South Dakota	x	x	
Tennessee			
Texas	x	x	x
Washington			
West Virginia			
Wisconsin	x	x	x
Wyoming			
Puerto Rico			

Source: Reference 4