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Disposal of Hospital Wastes Containing Pathogenic Organisms

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DISPOSAL OF HOSPITAL WASTES CONTAINING PATHOGENIC ORGANISMS

Final Report

September 1979
(for the period June 1974 to November 1975)

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This study was conducted to determine the suitability of landfilling for the disposal of hospital solid waste containing pathogenic organisms. The various aspects of the subject that were examined include the regulatory background affecting hospital waste disposal (including the Resource Conservation and Recovery Act of 1976, regulations proposed by the U.S. Environmental Protection Agency and the responses to thereto, and state regulations); standard operating procedures for disposal of hospital infectious waste; characterization of solid waste from U.S. Army and civilian hospitals; the infectiousness of hospital solid waste; soil factors and other

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considerations in landfill design; soil factors affecting pathogen fate; case studies relevant to pathogenic contamination of groundwater; data gaps and recent research pertinent to the landfilling of hospital solid waste; and recommendations for U.S. Army RD&D.

On the basis of available information, the disposal of infectious hospital solid waste in sanitary landfills appears to be feasible and safe. Conditions within the properly constructed and maintained landfill make it unlikely that any pathogens would remain viable and be transported beyond the confines of the landfill.

The study was sponsored by the U.S. Army/USAMBRDL. This report was prepared in partial fulfillment of the requirements of Contract No. DAMD 17-78-C-8082.

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1.0 EXECUTIVE SUMMARY

The objective of this study was to determine the suitability of landfill disposal for infectious hospital solid wastes. The study was sponsored by the U.S. Army/USAMBRDL.

In the past, procedures for the safe disposal of hospital wastes in the United States have been determined by established hospital operating standards and applicable state and local regulations. Current interest in this subject resulted from passage of the Resource Conservation and Recovery Act (RCRA) of 1976, which requires the U.S. Environmental Protection Agency (EPA) to develop and enforce nationwide standards for the disposal of these wastes. EPA has been developing regulations in response to this mandate.

All civilian and military hospitals throughout the United States will be subject to the regulations ultimately adopted by EPA. EPA was under a court-imposed deadline to issue its final regulations for hazardous solid wastes, including potentially infectious hospital wastes, by 31 December 1979; however, EPA recently requested an extension of the deadline.

The regulations that have been proposed by EPA would require some substantial changes from the landfill disposal practices currently followed by many hospitals for disposal of their solid wastes. Accordingly, several key issues have been raised regarding the proposed regulations. Foremost among these are the following:

(1) the need for hospital waste disposal standards beyond those already required for accreditation of all military and civilian hospitals;

(2) the actual degree of hazard associated with particular hospital wastes;

(3) the ability of properly designed, constructed, and maintained sanitary landfills that meet EPA criteria and guidelines to safely contain any pathogenic microorganisms associated with hospital solid wastes; and

(4) the cost impact of the regulations.

The derivation of cost impacts was not within the scope of this study; however, quantitative impact estimates were derived for the volume of hospital solid wastes potentially affected by the proposed regulations. A mail survey of U.S. Army hospitals conducted for this study indicated that, on average, 35 percent of total Army hospital solid wastes could be affected by the proposed regulations. On an annual basis this amounts to approximately 17,000 tons. In addition, literature studies provided data on solid waste generation for U.S. civilian hospitals. Extrapolating the available data for the nearly 7000 civilian hospitals that would be covered under EPA's proposed regulations yielded an estimate of slightly over 3 million tons per year of hospital solid wastes potentially affected by the EPA regulations.

Hospital wastes that pose a potential hazard to human health because of possible pathogenic contamination are required under current Army and civilian operating standards to be autoclaved, incinerated in a pathological incinerator, or otherwise disposed of in accordance with special handling procedures. Although EPA has proposed that wastes rendered nonhazardous under given conditions would not be subject to further stringent disposal requirements, it was not possible based on the available data to ascertain the extent to which current practices would reduce the volume of hospital wastes potentially subject to EPA's proposed regulations.

In addressing the actual degree of hazard associated with particular hospital wastes, this study examined the existing evidence on specific pathogens identified in hospital and municipal wastes. While pathogens posing some risk to human health have been detected in hospital wastes, a relatively greater number of such pathogens also have been detected in municipal solid wastes and municipal wastewater. Neither municipal solid wastes nor municipal wastewater treated by land application, however, has been designated by EPA as hazardous waste subject to the same stringent disposal procedures as infectious wastes. In the absence of additional evidence it cannot be concluded that these hospital wastes pose any greater hazard to human health than common municipal wastes.

Finally, detailed consideration was given to the issue of whether sanitary landfills designed, constructed, and maintained according to EPA guidelines and criteria are suitable for disposal of hospital wastes that contain pathogenic organisms. The general technical characteristics of these landfills were considered, as well as actual case studies on pathogen survival and migration relative to potential groundwater contamination from landfill disposal sites.

The available evidence suggests that pathogenic organisms can be safely disposed of in sanitary landfills that meet EPA criteria.

The basic difficulty in providing for the safe and economical disposal of any wastes subject to pathogenic contamination is that no reliable scientific standard presently exists for establishing the infectiousness of such wastes. Thus, any definition of particular wastes--hospital or otherwise--based on a concern about their potential infectiousness/hazardousness, inherently will be an arbitrary definition. This situation will persist until additional research can shed more light on the factors that affect pathogen viability and virulence in the environment, and the accompanying risks thereby posed for human health. A number of areas in which further research is required were identified in this report.

The findings of this report support recommendations made by the U.S. Army Environmental Hygiene Agency (AEHA) concerning the classification and disposal of hospital wastes. This conclusion is based upon the following specific findings:

- Current hospital standards require incineration in a pathological incinerator or autoclaving infectious wastes from the autopsy, surgery, laboratory and isolation departments. It can be assumed that these are equivalent to the treatment specifications in Appendix VII of EPA's proposed regulations and therefore these wastes would be rendered nonhazardous.

- There is no evidence that the remaining hospital solid wastes contain any pathogens fundamentally different from the pathogens likely to be present in other common types of wastes.

- The proposed hazardous waste regulations for designated hospital wastes are inconsistent with less stringent federal standards for landfill disposal of municipal solid wastes and municipal sewage sludge.

- The conditions within a sanitary landfill are detrimental to the survival of pathogenic organisms that might be found in hospital and other common types of solid wastes.

- Case studies on landfilled hospital and municipal solid wastes, and land treatment of municipal wastewater, have not demonstrated problems of underlying groundwater contamination with pathogenic organisms.

- There is evidence that a properly designed, constructed, and maintained sanitary landfill is a satisfactory method for disposal of hospital wastes that contain pathogenic organisms.

It is recommended that AEHA continue to request that the proposed regulations be altered to consider hospital wastes that contain pathogens as special wastes. It is also recommended that:

- Until final regulatons are promulgated, the incineration of infectious waste in a pathological incinerator, as specified in Army Regulation 40-5-9, should be retained as the preferred disposal method.

- Incinerator residue and the remaining hospital waste should be disposed of in sanitary landfills in accordance with the criteria proposed under Section 4004 of RCRA.

- The U.S. Army should undertake research to determine the infectiousness of hospital solid wastes in general, and of the ten specified hospital sources in particular.

2.0 INTRODUCTION

The objective of this study is to determine the suitability of landfill disposal for hospital solid wastes that contain pathogens. The study was sponsored by the U.S. Army/USAMBRDL.

Until now, procedures for the safe disposal of hospital wastes in the United States have been determined by established hospital operating practices and applicable state and local regulations. Current interest in this subject has resulted from the Resource Conservation and Recovery Act (RCRA) of 1976 which requires the U.S. Environmental Protection Agency (EPA) to develop and enforce nationwide standards for the disposal of these and other wastes. In response to this mandate, EPA has proposed--and in one instance, promulgated--regulations concerning solid and hazardous waste disposal.

The EPA-proposed regulations would require some substantial changes from present landfill disposal practices followed by many hospitals for ultimate disposal of selected solid wastes. Associated with these changes are economic impacts of potentially major significance. The issue, therefore, is whether the EPA-proposed changes are necessary in terms of reasonable protection of the public health.

2.1 Scope

The landfill method of disposal for hospital solid wastes is the only disposal technology examined in depth in this study. Furthermore, the study basically deals only with landfilling per se.

Related concerns such as collecting, handling, storing, and transporting hospital solid wastes prior to landfilling were not addressed.

Section 3 of this report explores current standards for the disposal of hospital solid wastes, and the concerns raised about EPA's proposed regulations by various parties who would be directly affected. In addressing the landfill issue, the proposed EPA regulations and their relation to state regulations for the disposal of hospital solid wastes are also described in Section 3. Section 4 presents a characterization of the weight, composition, and present disposal methods for hospital solid wastes, while Section 5 discusses pathogens specifically identified in hospital wastes and other common types of waste. Soil factors affecting the fate of pathogens are described in Section 6.

In order to further explore the question of possible pathogen survival at landfill sites and the risks to human health that may be posed by such survival, Section 7 presents reviews of several relevant case studies concerning contamination of groundwater with pathogenic organisms from landfill sites. Data gaps, research in progress, and recommendations for further research are discussed in Section 8. Section 9 presents the conclusions of the study as well as recommendations to the Army concerning the disposal of hospital solid wastes. Relevant background information is included in a series of appendices to this study.

It has not been the intent of this study to present either a risk-benefit or cost-benefit analysis of the proposed regulations. Available data do not permit any quantification of the risks potentially associated with landfill disposal of hospital solid wastes. Neither was it within the scope of this study to develop estimates of the potential cost impacts of the proposed EPA regulations.

2.2 Approach

The analysis presented in this study is based upon a survey of the solid wastes generated by both military and civilian hospitals. For U.S. Army hospitals a mail questionnaire was used to obtain necessary background data; for other hospitals relevant information was obtained through a search of the available literature on hospital waste.

In addition, a review and analysis of the pertinent literature was conducted in order to evaluate the infectious nature of hospital solid wastes, the fate of pathogens in landfills, and the specific soil and related technical factors involved in the proper construction and operation of a sanitary landfill. Relevant studies in the literature on specific instances of pathogenic contamination of groundwater were also sought. Finally, the existing literature concerning landfill technology and hospital solid waste management was reviewed to identify areas in which additional data and research are needed and/or currently being pursued.

3.0 CURRENT AND PROPOSED STANDARDS AND REGULATIONS

3.1 Present Standards for the Disposal of Hospital Solid Wastes

Present hospital operating procedures for waste disposal follow the standards prescribed by the Joint Commission on the Accreditation of Hospitals (JCAH, 1979). In particular, Standard IV under Functional Safety and Sanitation in the JCAH's Accreditation Manual specifies that patient-care and laboratory animal-care wastes that are potentially hazardous (e.g., wastes from patients in isolation and materials contaminated with secretions, excretions, or blood) be sealed in impervious containers. The JCAH Standard also requires that certain other wastes be sterilized for disposal. Laboratory wastes (e.g., culture plates, sputum cups, and swabs) must be incinerated or sterilized by autoclaving; unpreserved tissues from surgical and necropsy specimens also must be sterilized, preferably by incineration.

For Army hospitals, the U.S. Army has developed a regulation for infectious waste disposal based on the above JCAH standard. The Army defines certain wastes as "infectious" and stipulates that incineration in a pathological incinerator is the preferred method for disposal of these wastes. When such incineration is not possible or feasible, the Army requires that these wastes be rendered noninfectious by autoclave sterilization; following such sterilization they may be disposed of along with general noninfectious hospital wastes. Should neither incineration nor sterilization be possible, special approval must be obtained through the Army command channels for disposal of these wastes by other means, such as appropriate landfilling.

Infectious wastes requiring treatment by the Army are defined as "wastes contaminated with disease organisms and/or offensive materials." Specifically included in this definition are "bandages, sacrificed animal carcasses, laboratory tissue specimens, dressings, surgical wastes, food service wastes from infectious disease wards, used disposable needles and syringes, materials contaminated with blood, body exudates or excreta, and infectious wastes incident to hospital and laboratory operation" (U.S. Army, 1974, AR 40-5-9).

In both civilian and Army hospitals, therefore, potentially hazardous/infectious wastes from the autopsy, laboratory, pathology and surgery departments, and all wastes from isolation rooms and wards are routinely incinerated in pathological incinerators or sterilized by autoclaving prior to ultimate disposal.

3.2 Federal Legislation

On 21 October 1976, the U.S. Congress enacted the Resource Conservation and Recovery Act (RCRA, PL 94-580), establishing broad federal regulatory responsibility for the safe disposal of solid waste materials in order "to promote the protection of health and the environment." To accomplish this objective, the Act mandates the development of guidelines and minimum standards for the collection, transport, separation, disposal and recovery of solid waste materials. Solid waste management facilities would be issued permits to operate under the Act only if they met the minimum standards outlined under these guidelines.

The Act created an Office of Solid Waste within the U.S. Environmental Protection Agency (EPA). This office was delegated primary administrative responsibility for promulgating federal regulations to implement the Act. In addition, the Department of Commerce was delegated certain conservation and recovery responsibilites under the Act. A number of other provisions were also specified pertaining to matters such as state and regional solid waste plans, and research, development, demonstration and information programs for solid waste management.

What is of basic importance to this study is the legislation's classification of waste as either solid waste or hazardous waste, and the attempt made by EPA to develop specific regulations for both of these categories of waste as mandated by the Act. The Act (Section 1004[5]) generally defines hazardous wastes as wastes that pose a hazard to human health and the environment because of their quantity, concentration, or physical, chemical, or infectious characteristics. Wastes not covered by this definition are regarded as not hazardous.

Subtitles A and D of the Act, which deal with solid waste management, and Subtitle C, which deals with hazardous waste management, are summarized in Appendix A.

3.3 EPA's Proposed Regulations

In seeking to fulfill its responsibilities under RCRA to develop regulations implementing the Act, the EPA has, to date, published one set of final regulations and two sets of proposed guidelines for the classification and management of solid and hazazdous wastes. These regulations and guidelines and their dates of publication in the Federal Register are:

- "Classification Criteria for Solid Waste Disposal Facilities," 13 September 1979 (Federal Register, 1979a);
- "Landfill Disposal of Solid Waste Proposed Guidelines," 26 March 1979 (Federal Register, 1979b); and
- "Hazardous Waste Proposed Guidelines and Regulations and Proposal on Identification and Listing," 18 December 1978 (Federal Register, 1978).

For the Hazardous Waste Proposed Guidelines, EPA was under a court-imposed schedule to finalize these regulations by 31 December 1979.* Final action on the Proposed Guidelines for Landfill Disposal is projected for January 1980. The regulations in each of these proposals, including any modifications made as a result of the present rule-making proceedings, will become formal administrative regulations upon final adoption by EPA. As such, they will be incorporated in the Code of Federal Regulations, Title 40, Parts 257, 241, and 250, respectively.

*EPA recently requested an extension on the date for promulgation. Final regulations under Sections 3001 (Identification and Listing) and 3002 (Standards for Generators of Hazardous Waste) are due to be promulgated by April and February 1980, respectively. Interim regulations for Section 3004 (Standards for Owners and Operators of Hazardous Waste Management Facilities) are due during April 1980.

3.3.1 Criteria and Guidelines for the Management/Disposal of Solid, Special and Hazardous Waste

EPA has been developing specific criteria and guidelines for the operation of solid waste disposal facilities in accordance with the requirements of RCRA. One proposal defines criteria establishing the minimum level of health and environmental protection that all landfill solid waste disposal facilities must achieve in order to be permitted to operate. Criteria are presented that address disease vectors and the protection of surface water, groundwater, air, and land used in crop production.

Some of the criteria directly establish environmental standards, while others focus on various control technologies or practices appropriate for the prevention of adverse environmental effects. There is no attempt, however, to develop specific design and construction requirements for individual landfill facilities; rather, the criteria are formulated as "performance standards" that must be met by all facilities. These criteria are briefly summarized in Appendix B.

States are responsible for determining compliance on the basis of site-specific evaluations of control techniques and practices. Existing facilities that do not presently meet these criteria would have to be upgraded. Failure to do so would result in their designation as open dumps; RCRA requires that all open dumps ultimately be eliminated (Section 4005). Facilities in compliance with the criteria would be considered sanitary landfills.

The Proposed Guidelines for Landfill Disposal of Solid Wastes identify and describe specific considerations for the location, design, construction, operation, and maintenance of landfill disposal facilities for nonhazardous solid wastes. They also provide guidelines for leachate, gas and runoff control. The proposed guidelines are intended to assist landfill facility operators and state compliance officials in determining how the criteria for sanitary landfills might best be met. They would apply to all facilities in which waste is buried. Agricultural and mining wastes, landspreading, and surface impoundment operations would not be covered. The proposed guidelines are also summarized in Appendix B.

The Hazardous Waste Proposed Guidelines and Regulations specify various types of guidelines for the management and disposal of hazardous wastes. This proposal presents a set of Human Health and Environmental Standards defining the overriding levels of protection to be achieved by all hazardous waste facilities. EPA proposed four sets of design and operating standards consisting of: (1) general standards for all types of hazardous waste facilities; (2) specific standards for storage; (3) standards for treatment and disposal facilities; and (4) standards applicable only to special wastes. The proposed design and operating standards for the landfill disposal of hazardous wastes include requirements for site location and design, operating methods, contingency plans, continuity of operation, compliance with the manifest system, construction and operation, closures and post-closure care.

These proposed design and operating standards have been formulated to be consistent with relevant existing standards promulgated by EPA for implementation of the Safe Drinking Water Act, the Clean Water Act, and the Clean Air Act. Together, these proposed standards are intended to provide maximum protection for the groundwater, surface water, and air.

Wastes that occur in very large volumes, pose relatively low potential hazards, and are not generally amenable to the control techniques specified for hazardous wastes have been designated as "special wastes" by EPA. An important factor in providing separate consideration of special wastes was that EPA had few data on the effectiveness or cost of imposing on these wastes the same stringent storage, treatment, and disposal standards for hazardous wastes.

3.3.2 Hazardous Waste Proposed Guidelines: Identifying and Listing Hazardous Wastes

In proposing its Hazardous Waste Proposed Guidelines, EPA has taken a bifurcated approach to designating certain wastes as hazardous. Some wastes would automatically be classified as hazardous if they possessed specific characteristics. These characteristics must: (1) generally describe the hazardous nature or attributes of a waste material; (2) establish a significant likelihood that a hazard will develop from mismanagement of the waste; and (3) permit reliable identification and/or testing to ascertain presence of the characteristic(s).

If this characterization is not possible, EPA will still list a waste as hazardous if it is defined as hazardous by RCRA. Under this approach, certain hospital wastes have been listed by EPA as hazardous since, in EPA's judgment, these wastes are infectious, and RCRA specifically calls for protection of the public from hazardous/ infectious wastes.

3.3.3 Hospital Wastes Classified as Hazardous

EPA's approach of listing certain hospital wastes as hazardous because it assumed they were infectious--rather than designating infectiousness per se as a characteristic for establishing hazardousness of certain wastes--was chosen because of the difficulty of ascertaining the actual infectiousness of any solid wastes. In a background document to the proposed guidelines, EPA specifically addressed the issue of infectiousness in formulating the guidelines, and concluded that testing methods for reliable identification and measurement of infectiousness are not currently available. In EPA's assessment, any attempt to specify a "safe" number of disease organisms allowable in a waste would ignore the many variables involved in disease transmission. A clinical response in a host may, for example, be elicited by a range of anywhere from one to several thousand pathogenic microorganisms (EPA, 1978b).

In view of the difficulty of reliably characterizing infectiousness, EPA decided to take the approach of listing certain hospital wastes as hazardous based on their department of origin within a hospital. EPA's rationale for this approach is that in certain hospital departments it is reasonable to presume a substantial presence of pathogenic organisms.* Wastes from these departments are, therefore, considered by EPA to be infectious and, hence, hazardous. EPA also felt that this approach was the most inclusive and enforceable (EPA, 1978b).

The wastes from ten hospital departments were so designated by EPA; these departments are indicated in Table 3-1. Wastes from such departments would be subject to EPA regulation as hazardous wastes when generated by general medical and surgical hospitals, and specialty hospitals (except psychiatric). The types of hospitals covered under the proposed guidelines are listed in Table 3-2. Both civilian and military hospitals are covered.

3.4 Concerns Expressed Regarding EPA's Proposed Guidelines

3.4.1 The U.S. Army Environmental Hygiene Agency (AEHA)

During the period in which EPA was formulating its proposed guidelines for the identification and disposal of hazardous wastes, the U.S. Army Environmental Hygiene Agency (AEHA) submitted a formal statement to EPA with specific recommendations for hospital solid

*Pathogenic (etiologic) organisms are classified by the Center for Disease Control (CDC), U.S. Department of Health, Education, and Welfare, according to their potential hazard to human health. Five classes have been established by the CDC, and these are defined in Appendix C. Organisms in classes 2 through 5 present the greatest human health hazards, and it is wastes that may contain these organisms that EPA has sought to identify for regulation as hazardous wastes (EPA, 1978b).

TABLE 3-1

HOSPITAL DEPARTMENTS DESIGNATED BY EPA
AS SOURCES OF HAZARDOUS WASTES

SOURCE	COMMENT
Autopsy Department	
Emergency Department	
Intensive Care Unit	
Isolation Rooms	
Laboratories (clinical)	
Morgue	
Obstetrics Department	Includes patients' rooms
Pathology Department	
Pediatrics Department	
Surgery Department	Includes patients' rooms

SOURCE: Federal Register, 1978

TABLE 3-2

HOSPITALS COVERED UNDER EPA'S PROPOSED GUIDELINES

SIC CODE[a]	SIC DESCRIPTION	TYPE
8062	General medical and surgical hospitals	General medical hospitals General surgical hospitals
8069	Specialty hospitals, except psychiatric	Children's hospitals Chronic disease hospitals Eye, ear, nose and throat hospitals Geriatric hospitals Maternity hospitals Specialty hospitals, except psychiatric Tuberculosis hospitals

[a]Standard Industrial Classification Code, U.S. Department of Commerce

SOURCE: <u>Federal Register</u>, 1978

waste disposal. The AEHA's basic position was that stringent hazardous waste disposal requirements are not necessary for most hospital wastes. Instead, the AEHA suggested a three-part approach for the disposal of hospital wastes as follows (Federal Register, 1978):

(1) for hospital waste that is not potentially hazardous/infectious, disposal at facilities that meet Section 4004 criteria is adequate;

(2) some potentially hazardous/infectious hospital wastes should be considered "special waste"; and

(3) for certain potentially hazardous/infectious wastes that pose substantial risks, disposal should be only at hazardous waste facilities capable of dealing safely with these wastes.

3.4.2 Comments in the Public Docket by Other Selected Parties

A number of private organizations as well as state and federal agencies also submitted formal responses to EPA's proposed definition and treatment specifications for infectious wastes which are part of the Public Docket (Public Docket, 1979). A review of the Public Docket was conducted for this study in order to identify concerns expressed by a cross-section of these parties regarding the proposed regulations. Included in this review were letters submitted by individuals representing 14 separate agencies and institutions including 4 hospital centers, 4 health and medical associations, 2 state government agencies, the Department of Defense, the U.S. Center for Disease Control, a major university, and a large medical products manufacturer.

The concerns expressed by the above commentators covered a number of issues. In particular, they (1) cited the overly inclusive nature of the proposed designation of hospital sources of potentially infectious wastes; (2) felt there was a lack of sufficient scientific justification for the proposed definition and listing of sources including insufficient documentation of the benefits to the public health of the proposed regulations; (3) questioned the necessity and expense of treating these wastes according to the proposed specifications for rendering infectious wastes nonhazardous; (4) opposed the extension of federal regulation to an area already adequately regulated through state regulations and private accreditory standards for proper hospital operating and waste disposal practices; and (5) felt that insufficient attention had been given to the cost impacts of the proposed regulations. The discussion below deals with these concerns in more detail and, in addition, presents several of the recommendations that were made regarding modification or elimination of the proposed regulations. Appendix D summarizes the specific comments of each of these selected commentators; Appendix E contains the complete written comments submitted by these parties.

In general, the commentators felt that the designation of potentially infectious hospital wastes should focus only on those wastes that realistically might pose a public health hazard. The lack of sufficient scientific justification for the proposed designation of potentially infectious hospital wastes was emphasized by several respondents. Dr. John Slade (New Jersey State Department of Health) stated, for example, that "I have found no epidemiological data which suggest that the usual ward-generated wastes require special handling outside of the hospital." Slade also stated that, "not all that is contaminated is infectious." Harold Buzzell, of the Health Industry Manufacturers Association, commented that the "vast bulk of hospital waste is not infectious" and that "infectious microorganisms will be inactivated by the environment of the landfill." Another commentator, Dr. Richard L. Parker, South Carolina Department of Health and Environmental Control, criticized the lack of consideration of the biological life of infectious agents when designating certain wastes as potentially infectious. Dr. J. Robert Flanagan, of the American Hospital Association, noted that in general, the background documents supporting the regulations did not provide the necessary rationale to support the conclusions and proposed regulations. Dr. Flanagan also asserted that the proposed regulations would not result in "any appreciable, and certainly no measurable, benefit to the public health."

The rationale for listing certain hospital departments as sources of infectious waste was further criticized in light of the common presence of particular pathogens in the environment. For example, Dr. Parker commented that "[this would include] organisms included in the genus _Salmonella_ and in the genus _Neisseria_ and many others that, while perfectly capable of causing infections in human beings, are so common in our everyday population that they are being introduced into normal sewage disposal systems in extensive numbers on a daily basis." George F. Mallisor (Center for Disease Control) criticized the proposed hospital waste regulations on the grounds that, "it is totally inconsistent to develop recommendations for handling of 'hazardous' and/or infectious wastes from health-care facilities on the basis that a hospital dumpster may have more potentially contaminated materials than a dumpster from, say, a small factory."

The proposed treatment specifications for rendering infectious waste nonhazardous elicited comments from several individuals. These comments included statements that the specifications: (1) are too stringent in that "there is no reason to autoclave general 'trash' from a hospital" and "only microbially contaminated reusable laboratory glassware need be autoclaved" (Mallison); (2) would cause the separation of all hospital wastes (McDonald, Duke University); and (3) call for autoclaving times that are "excessive and should be studied further" (Parker).

Many commentators also felt that insufficient attention had been given to the potential cost impacts of the regulations. One commentator, for example, said that the cost "will be astronomical" (Sweeney, National Association of Children's Hospitals and Related Institutions). Others stated that the proposed regulations.
(1) would impose prohibitive costs (Wonsmos, Guttenberg Municipal Hospital); (2) would place "an undue and unnecessary administrative and financial burden on the nations [sic] hospitals" (Engel, The Iowa

Hospital Association); (3) would "only serve to increase the ever rising cost of health care" (Baker, American Hospital Supply Corporation); and (4) would impose severe economic impacts in a time of hospital cost containment (McDonald, Duke University). Dr. Flanagan also noted that "although 17 industries were studied with regard to the economic impact of the proposed regulations, the EPA elected not to include either the hospital or the health care industry." One commentator (Wonsmos, Guttenberg Municipal Hospital) expressed the fear that the regulations could be "devastating" to smaller health care centers.

In lieu of the proposed regulations, a few specific definition and treatment alternatives were suggested. Several commentators recommended deleting one or more of the emergency, intensive care, morgue, obstetrics, pathology, pediatrics, and surgery departments from the list of sources of hazardous waste (Korn; Mallison; Sweeney). Dr. Merle Carter of the Baptist Medical Center of Oklahoma recommended an approach that would require the identification of infected patients and provide for the special disposal only of wastes generated by them. Finally, a number of commentators indicated that EPA should adopt or work with the infectious waste standards already established by the Joint Commission on Accreditation of Hospitals (JCAH), and/or should permit states to administer their own programs, with a concommitant exemption from any subsequent federal regulations for health care facilities already in compliance with existing state waste management programs (Baker; Buchanan; Buzzell; Flanagan; Marienthal; Wiggs).

3.4.3. Telephone Survey of Selected Federal Agencies

A telephone survey of selected federal agencies was conducted to determine their reactions to the proposed regulations. The results of this survey are summarized in Table 3-3.

The representative from the National Naval Medical Center said that no formal response to the proposed hazardous waste regulations was planned (Manifold, 1979). The National Naval Medical Center currently sorts its waste and solid wastes are incinerated or landfilled. Chemical wastes are sorted for compatibility in a specially designated chemical waste disposal facility, then packed in drums and incinerated. The classification of other wastes is determined by hospital personnel. Infectious wastes, including pathological wastes and bandages, are incinerated, and noninfectious wastes are landfilled.

The representative of the Office of the Surgeon General of the Air Force stated that the proposed regulations are too stringent and would be too expensive to implement (Pauls, 1979). The guidelines would have a severe short-term economic impact while the long-term environmental impact remains unknown. Furthermore, the proposed sources of infectious waste should be delineated more precisely to eliminate wastes that are not necessarily hazardous. The Air Force does not have a firm policy regarding hazardous waste disposal, and each Air Force hospital incinerates much of its waste.

TABLE 3-3

SELECTED FEDERAL AGENCY COMMENTS ON EPA'S REGULATIONS FOR HOSPITAL SOLID WASTES[a]

DEPARTMENT	AGENCY	CONTACT	POSITON	TELEPHONE	RESPONSE TO PROPOSED REGULATIONS
Defense	National Naval Medical Center	Rodney Manifold	Safety Manager, Occupational and Environmental Health Service	(301) 295-1731	No formal response from National Naval Medical Center
	Office of the Surgeon General of the Air Force	Major Chester Pauls	Bio-Environmental Staff Officer, Bio-Medical Science Corps	(202) 767-5078	Regulations generally too stringent and too expensive. Sources of infectious wastes are undefined.
	Office of the Deputy Assistant Secretary for Energy, Environment, and Safety/OSD	Art Wammel	Special Assistant to the Deputy Assistant Secretary	(202) 695-7820	Supports basic idea. Regulations should discern between varying degrees of hazardous infectious wastes.
Health, Education and Welfare	National Institutes of Health	Harvey Rogers	Senior Sanitary Engineer, Division of Research Services	(301) 496-3261	No comments on sections dealing with infectious wastes, but did express concern over definition.
	Public Health Service	William Platt, M.D.	Chief, Pathology Dept.	(301) 338-3120	Regulations will change blood disposal practices in laboratories.
	Center for Disease Control	George Mallison	Assistant Director, Bacterial	(404) 329-3120	Regulations too stringent.
	Veterans Administration	Edward Powell	Environmental Care Specialist, Building Management Service	(202) 275-1768	Problems in waste separation are causing trend toward total incineration.

[a]Telephone survey regarding Hazardous Waste Proposed Guidelines and Regulations and Proposal on Identification and Listing proposed on 18 December 1978 (Federal Register, 1978). Survey was conducted during March 1979.

A representative of DOD expressed the view that the degree of control associated with a particular hazardous waste should be commensurate with its potential for environmental harm (Wammel, 1979). He felt that EPA should recognize the different degrees of risk associated with hazardous wastes, and should not rely on a definition of hazardous waste that is too general to be meaningful.

The National Institutes of Health (NIH) has not yet formulated a formal response to the proposed regulations although an informal review was sent to EPA (Rogers, 1979). NIH is more concerned with the possible effect of RCRA on the disposal of chemical wastes, specifically with regard to chemical waste classification, than with the effect of RCRA on pathological or infectious waste disposal. At present, all pathological wastes at NIH are incinerated. The pathological waste classification includes all syringes, sponges, gauzes, and bandages; wastes from wards where pathogens may be generated or where exposure to pathogens may occur (the mental health ward, for example, is excluded); and all laboratory wastes. Pathological waste constitutes about 10 percent of the 30 to 33 tons of waste generated daily at NIH. It is packaged in single-use containers consisting of plastic bags sealed within cardboard boxes. The sealed boxes are handled by an automated system and are never touched or opened; they are conveyed to a high efficiency incinerator where they are burned on a daily basis. The residue from incineration and also the administrative and nonpathological/noninfectious waste are packed in heavy duty plastic bags and disposed of in a local landfill. NIH regards as safe the landfilling of incinerator residue but does not recommend that the residue be mixed with soils for landfill cover because incineration concentrates salts and heavy metals which could leach or be carried away in runoff with rainfall or flooding; in addition, the residue from an incinerator that is not as highly efficient as that at NIH will not be sterile and could be hazardous when used as cover material.

The Public Health Service (PHS) has made no formal response to the proposed regulations (Platt, 1979). However, waste disposal practices are being modified. For example, in the Pathology Department of the Baltimore Hospital, blood samples are now pooled and rinsed down a sink into the sewer. PHS is considering changing the disposal method to autoclaving followed by landfilling. All other wastes that are considered infectious are being disposed of properly.

The Center for Disease Control (CDC) had established its own regulations for careful disposal of infectious waste which predate the passage of RCRA in 1976; they provide for the incineration or autoclaving of most wastes (Mallison, 1979). The position of CDC is that the proposed hazardous waste regulations for infectious hospital waste are too stringent.

The representative of the Veterans Administration (VA) reports that the VA is attempting to follow the proposed regulations (Powell, 1979). All waste from VA hospitals is currently incinerated or landfilled. General wastes are landfilled; infectious wastes are either incinerated or autoclaved and then landfilled.

3.5 State Regulations

In arriving at its proposed classification of hospital wastes, EPA reviewed existing state laws and regulations pertaining to the classification and disposal of hospital solid wastes (EPA, 1978b). Eight states were identified that currently designate certain hospital wastes as hazardous/infectious; one state, New Jersey, also has developed a proposal to this effect in response to EPA's proposed regulations.

Four states (Illinois, New York, Oregon, and Pennsylvania) define infectiousness as a characteristic of waste, based on the definition for hazardous waste in RCRA (Section 1004[5]). Washington defines infectious wastes as hazardous by including them on hazardous waste lists. California and Minnesota define infectious wastes by identifying the sources of infectious waste and by specifying certain items from those sources that may be exposed to contagious or infectious disease. In Maryland, the regulation of infectious waste is the responsibility of two different agencies which use different definitions of infectious waste--the Department of Natural Resources classifies infectious wastes as hazardous by including them on a hazardous waste list, whereas the Department of Health and Hygiene identifies the sources of infectious waste and specifies certain items from these sources as infectious.

The New Jersey definition of infectious waste specifies sources of infectious waste and items that may be exposed to "infectiousness." While all of the states identified by EPA specify that wastes designated as hazardous be disposed by landfilling or incineration, New Jersey's disposal procedures include autoclaving or incinerating solid waste from the microbiological laboratory.

The state definitions and disposal requirements for infectious waste are detailed in Appendix F; Table 3-4 indicates specific types of hospital wastes designated by various of these state regulations as infectious, i.e., hazardous.

TABLE 3-4

HOSPITAL WASTES IDENTIFIED AS INFECTIOUS BY STATE

WASTE	STATE						
	CA	MD	MN	NY	PA	WA	NJ[a]
Autopsy Specimens	X		X				
Blood Specimens	X	X	X				X
Excreta	X	X	X				X
Obstetrical Waste			X				
Pathologic Specimens	X	X	X				X
Secreta	X	X	X				X
Surgical Specimens	X	X	X				X
Tissues	X	X	X				
Etiologic (infectious) Agent-Containing Items				X		X	
Disposable Fomites	X	X	X[b]				X
Disposable Diapers		X					
Disposable Instruments	X	X	X				X
I.V. Apparatus		X					
Perineal Pads		X					
Sharps	X	X	X				
Utensils	X	X	X				X
Dangerous Drugs	X	X					
Biological Solids					X		
Incinerator Ash from Infectious Waste			X				
Diseased Animals			X		X		

[a]From Public Docket (1979); see Appendix E-5.

[b]Includes wastes from persons in isolation for control and treatment of infectious diseases.

SOURCE: EPA, 1978b

4.0 ANALYSIS OF HOSPITAL WASTES

In order to establish the potential impact of EPA's proposed hazardous waste regulations relative to potentially hazardous/infectious hospital wastes, a detailed analysis was undertaken of the weight, composition, and specific treatment of hospital solid wastes. This analysis is based on a mail survey of Army hospitals conducted as a part of this study, as well as an extensive review of the available literature on hospital wastes generated by other military and civilian hospitals.

4.1 Solid Waste Generation in U.S. Army Hospitals

A detailed mail survey for the purpose of obtaining comprehensive data on the present volume of solid wastes generated by the 33 U.S. Army hospitals and medical centers* currently operating in the United States was conducted through the U.S. Army Health Services Command, and responses were received from all but 1 of the survey hospitals. A copy of the survey questionnaire is presented in Appendix G, and Appendix H consists of several tables listing the individual hospitals, their quantitative responses to questions 5 through 12 of the questionnaire, and various statistical analyses of these responses.

It should be noted that the validity of this analysis of the data obtained through the survey is limited by several constraints. Most of the Army hospitals provided estimated rather than measured

*These facilities do not include Army health clinics or hospitals operated by the Veterans Administration.

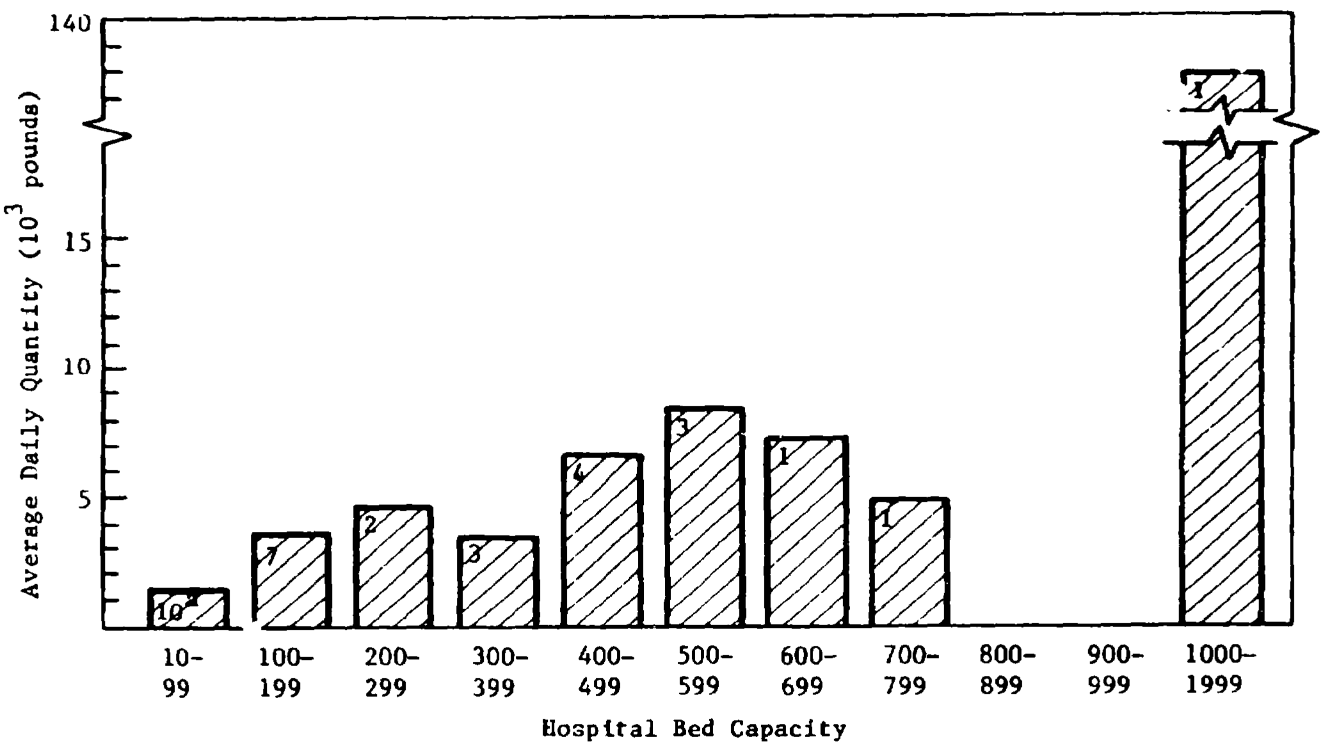
data, and the validity of the data is affected by the accuracy of the estimations. Furthermore, although most responses regarding solid waste quantities (question #9) were in terms of weight, some were reported only by volume. Conversion from volume to weight was based on assumed densities of 200 pounds per cubic yard for uncompacted solid waste (Swofford, 1972; Regan, 1977; data for Tripler Army Hospital) and 500 pounds per cubic yard for compacted solid waste (Regan, 1977); unless compaction was specified, it was assumed that the refuse was not compacted. The validity of the statistical analysis might also be affected by omission of data (responses to every question were not provided by every hospital) and by use of different classification schemes by the different hospitals (e.g., the sources of hospital solid waste in question #11 and the "miscellaneous" waste category in question #10). With these constraints, this analysis of the survey data provides reasonable quantification of the various aspects of solid waste generation in U.S. Army hospitals.

4.1.1 Weight of Solid Waste Generated

An analysis of the responses in Appendix H-1 provides insight into the weight of solid waste generated by the 32 hospitals individually and in aggregate. For example, the average weight of solid waste generated per hospital on a daily basis is 8150 pounds. Extrapolating this to an annual figure yields a weight of nearly 3 million pounds per hospital; for the 32 hospitals collectively, the annual amount of waste generated amounts to slightly over 95 million pounds or 47,500 tons.

In fact, there is some variation in the amount of solid waste generated according to hospital size, as shown in Figure 4-1. For hospitals with bed capacities in the range of 100 to 799 beds (21 of the 32 Army hospitals in the survey), the average weight of solid waste generated ranges from 3000 to 8000 pounds daily. The largest hospital in the survey, the Walter Reed Medical Center, has a capacity of nearly 1300 beds and reported 136,800 pounds of solid waste daily. The hospital did note, however, that during the reporting period extra solid waste was generated due to a move into a new building; the extent to which the move contributed to the overall waste quantity was not reported. At the opposite end of the size range, the 10 remaining hospitals in the survey had capacities of less than 100 beds and averaged approximately 1300 pounds of solid waste daily.

In addition to bed capacity, hospital size may also be measured by a variety of other indices relevant to solid waste generation. For example, when solid waste generation is calculated in terms of the average bed patient population (a function of hospital bed capacity and the average occupancy rate), the median for the 32 Army hospitals was 26 pounds of solid waste daily per bed patient. For five hospitals in the survey, rates of 90 to 346 pounds of solid waste generated daily per bed patient were calculated. Seventy



[a]The number in each column represents the number of hospitals in the sample.

FIGURE 4-1
TOTAL DAILY SOLID WASTE GENERATION IN ARMY HOSPITALS AS A FUNCTION OF BED CAPACITY

percent of the Army hospitals, however, fell within a range of 2 to 38 pounds per day per bed patient; for an additional 12 percent of the hospitals, estimated solid waste generation rates of 43 to 57 pounds per day per bed patient were calculated.

4.1.2 Composition of Solid Waste

In response to question 10 of the questionnaire, the 32 Army hospitals provided information on the composition of the solid waste generated (Appendix H-3). As can be seen from Table 4-1, paper items account for the bulk of the solid waste produced in these hospitals (up to 90 percent in 2 hospitals, although the average for the 32 hospitals is 58 percent). Plastic items are the next major component of hospital solid waste, with miscellaneous, glass, cloth, and metal items following in decreasing order. In terms of combustibility, 83 percent of the wastes, on average, are combustible while 10 percent (glass and metal items) are not. For the remaining 7 percent of miscellaneous items, it was not possible to determine what proportions fall into the combustible and noncombustible categories.

4.1.3 Solid Waste by Originating Department

Solid waste is not generated uniformly throughout a hospital; some departments produce much more refuse than others. This is shown in Appendix H-4, which is based on responses by 29 of the 32 Army hospitals to question 11 of the survey questionnaire. In one hospital, for example (Hospital #2), food service accounts for 28 percent of the hospital's solid waste; the dental, intensive care, and

TABLE 4-1

SUMMARY OF COMPOSITION OF SOLID WASTE FROM U.S. ARMY HOSPITALS[a]
(in weight percent)

COMPONENT	MEAN	STANDARD DEVIATION	RANGE HIGH	RANGE LOW
Combustibles	83	10	96	58
Paper	58	23	90	5
Cloth	3	3	15	0
Wood	1	2	10	0
Rubber	2	2	10	0
Plastic	19	18	80	0.5
Noncombustibles	10	8	29	0
Glass	7	6	25	0
Metal	3	3	10	0
Miscellaneous	7	7	25	0

[a]Based on the 1979 survey of 32 U.S. Army hospitals.

pharmacy departments each account for 16 percent of total waste; and departments such as pathology, pediatrics, radiology, surgery, general medical, and ophthalmology each account for only 1 percent of the total. On the other hand, in another hospital (Kimbrough) the general medical department accounts for the largest single percentage of total hospital waste (27 percent), followed by the clinical/laboratory department (16 percent) and surgery (14 percent); the dental and intensive care units in this hospital each contribute 4 percent to total waste, and food service only 2 percent.

Table 4-2 summarizes all the responses received from the individual Army hospitals on solid waste generation by department. While the standard deviations calculated for this summary data reflect some of the large variations among hospitals highlighted above, certain general observations nevertheless are possible. Food service, on average, appears to be a major source of hospital solid waste (19 percent), followed by clinical/laboratory (11 percent), and surgery, general medicine and pharmacy (8 percent each). The other departments listed generally contribute less, on an individual basis, to the total solid waste load of the hospitals surveyed.

In EPA's proposed regulations for classification of certain hospital wastes as potentially hazardous/infectious, the Agency specified that wastes from ten individual hospital departments be considered.* The ten departments listed by EPA were autopsy,

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*See Section 3 of this study for background detail on the proposed regulations.

TABLE 4-2

SUMMARY OF SOLID WASTE GENERATION BY DEPARTMENT IN U.S. ARMY HOSPITALS[a]
(in weight percent)

DEPARTMENT	MEAN	STANDARD DEVIATION	RANGE HIGH	RANGE LOW	SAMPLE SIZE[b]
Clinical Services (Laboratory)	11	8	30	2	27
Dentistry	5	5	20	0.4	26
Medicine	4	4	16	0.2	23
Obstetrics and Gynecology	4	4	15	0.8	25
Pathology	3	4	13	0.04	24
Pediatrics	3	3	12	0.2	26
Radiology	3	3	15	0.3	25
Surgery	8	6	25	1.2	25
General Medicine	8	7	27	0.3	21
General Surgery	5	5	20	0.2	19
Intensive Care	4	4	16	0.5	24
Ophthalmology and Otolaryngology	2	2	9	0.4	23
Pharmacy	8	5	20	0.7	28
Coffee Shop	2	2	7	0.4	20
Command and Administration	7	6	20	1	27
Food Service	19	14	49	1	26

[a]Based on the 1979 survey of 32 U.S. Army hospitals.

[b]Number of hospitals reporting waste from the department.

emergency, isolation, morgue, laboratories, obstetrics, pathology, pediatrics, surgery and intensive care.

Data for the last six of these departments are included in Table 4-2; for convenience the same data are broken out separately in Table 4-3.

As is clear from the latter table, EPA's proposed regulations could affect, on average, 35 percent of the solid waste presently generated by U.S. Army hospitals. (For certain hospitals, however, up to 85 percent of total solid wastes could be affected.) Since the average amount of solid waste generated by Army hospitals was calculated above (Section 4.1.1) at 8150 pounds daily, 35 percent of this total would be 2852 pounds daily per hospital. Aggregating this average for all 32 hospitals in the survey would yield nearly 91,300 pounds of waste daily or, on a yearly basis, approximately 33.3 million pounds (16,666 tons).

4.1.4 Current Methods of Disposal

In order to determine the extent of current methods used by U.S. Army hospitals for the disposal of their solid wastes, question 12 of the survey questionnaire specifically solicited information on four typical methods of disposal: garbage grinding incineration, incineration in a pathological incinerator, and landfilling. The responses of the 32 hospitals to this question are tabulated in Appendix H-6.

Analysis of these responses yields several relevant observations on the significance of landfilling relative to other disposal methods

TABLE 4-3

SUMMARY OF QUANTITIES OF ARMY HOSPITAL SOLID WASTE FROM DEPARTMENTS DESIGNATED AS SOURCES OF INFECTIOUS WASTE UNDER PROPOSED REGULATIONS[a]
(in weight percent)

DEPARTMENT	MEAN PERCENT	STANDARD DEVIATION	RANGE		SAMPLE SIZE
			HIGH	LOW	
Clinical Services (Laboratory)	11	8	30	2	27
Obstetrics and Gynecology	4	4	15	0.8	25
Pathology	3	4	13	0.04	24
Surgery	11	7	30	1.3	27
Intensive Care	4	4	16	0.5	24
Pediatrics	3	3	12	0.2	26
Total (%)	35	16	85	7	28

[a]Based on the 1979 survey of 32 U.S. Army hospitals.

for Army hospital waste. Foremost among these observations is that all but one of the Army hospitals currently rely upon landfilling for some portion of their current wastes. (The one hospital not using landfilling incinerates 100 percent of its waste). Eighty-three percent of the hospitals using landfill disposal rely upon this method for disposal of at least 70 percent of their wasteload; only one of these hospitals, however, disposes of 100 percent of its waste by landfilling. Of the five remaining hospitals (17 percent), one disposes of 16 percent by landfilling, and the other four dispose of 49 to 69 percent of their wastes in this manner.

Landfilling is, therefore, a highly important but not exclusive means of waste disposal for the great majority of all Army hospitals. Indeed, 94 percent of these hospitals also incinerate some portion of their wastes; on average 20 percent of hospital wastes are incinerated, usually in a pathological incinerator. In view of Army regulations requiring incineration as the preferred method of disposal for certain potentially hazardous wastes defined by Army regulations as "infectious," this widespread use of incineration is not surprising.*

Disposal of a portion of solid waste by garbage grinding rather than incineration is used by only one Army hospital. Garbage grinding as a means of disposal in addition to landfilling and

*For a discussion of Army hospital waste disposal regulations, see Section 3.1 of this study.

incineration is used by 12 (36 percent) of the Army hospitals, for an average of 2 percent of their total wasteload.

4.2 Solid Waste Generation in Other Military and Veterans Administration Hospitals

A limited amount of data on solid waste generation in other military hospitals were available in the literature. These data cover nine hospitals: six Navy hospitals, one Air Force facility, and two Veterans Administration hospitals. The data are presented in Table 4-4.

In general, these 9 military hospitals are larger than the 32 Army hospitals surveyed, with an average capacity of 483 beds for the former as opposed to 285 beds, on average, for the Army hospitals. Nevertheless, the reported quantity of solid waste generated daily (6952 pounds on average), is somewhat lower than the Army hospital average of 8150 pounds. Since data on factors such as average occupancy rate and gross population were not available for all but one of these nine hospitals, it is not possible to ascertain whether the lower average wasteloads were due to lower values for these factors, which have a direct influence on total hospital solid waste generation. The fact that data for these hospitals are not as current as for the Army hospitals also could be a factor in the lower waste volumes reported.

Data on the composition of the solid wastes from these other military hospitals were not available in terms of combustible versus

TABLE 4-4

DAILY SOLID WASTE GENERATION IN OTHER MILITARY HOSPITALS

DATA	NAVY 1	NAVY 2	NAVY 3	NAVY 4	NAVY 5	NAVY 6	AIR FORCE	VETERANS ADM.	VETERANS ADM.	SUMMARY AVERAGES[a]
Bed Patient Capacity	665	467	415	350	172	146	1000	646	---	483
Occupancy Rate (%)[b]	---	---	---	---	---	---	---	62	---	(62)
Average Bed Patient Population	---	---	---	---	---	---	---	400	---	(400)
Gross Population[c]	---	---	---	---	---	---	---	2204	---	(2204)
Equivalent Population[d]	---	---	---	---	---	---	---	1605	---	(1605)
Number of Meals Served	2630	4022	2300	938	717	775	---	2381	---	---
Total Solid Waste										
(lbs)	13560	9450	4010	2550	2700	2900	---	4445	16000	6952
(lbs/bed)	20	20	10	7	16	20	10	7	---	14
(lbs/bed patient)	---	---	---	---	---	---	---	11	---	11
(lbs/gross population)	---	---	---	---	---	---	---	2.02	---	2
(lbs/equivalent population)	---	---	---	---	---	---	---	3	---	3
Disposable Solid Waste[e]										
(lbs)	9240	6300	3410	2000	1600	2000	---	---	---	4092
(lbs/bed)	14	13	8	6	9.3	14	---	---	---	11
Location	Oakland, CA	Great Lakes, IL	Long Beach, CA	Jacksonville, FL	Newport, RI	Orlando, FL	Lackland, TX	San Diego, CA	Memphis, TN	N/A
Reference	Naval Facilities Engineering Command, 1972	Naval Facilities Engineering Command, 1972	Naval Facilities Engineering Command, 1972	Naval Facilities Engineering Command, 1972	Naval Facilities Engineering Command, 1972	Naval Facilities Engineering Command, 1972	McKenna, 1963	Ross Hofmann Associates, 1974	Handorf, 1965	N/A

[a] Summary averages in parentheses ( ) are applicable only for the San Diego Veterans Administration hospital.

[b] Average occupancy rate during the period of the study.

[c] The average *total number* of bed patients, outpatients, employees, and volunteer workers present daily.

[d] The population during an average 8-hour shift.

[e] The disposables component.

noncombustible portions of the total wasteload. A substantial proportion of the wastes for the six Navy hospitals, however, was reported as consisting of single-use disposable solid wastes (from 60 to 80 percent of the total solid wasteload). While it cannot necessarily be assumed that all of these disposable wastes also are combustible, there is no reason to believe that the bulk of these wastes would not be so.

No data on the origination of solid waste by hospital department were available for these hospitals, nor were data available on current methods of disposal. Nevertheless, there is no inherent reason to believe that there would be substantial differences from the patterns observed in the survey of the 32 Army hospitals.

4.3 Solid Waste Generation in Civilian Hospitals

4.3.1 Weight of Solid Waste Generated

Twenty different studies containing information on solid waste generation in over two hundred civilian hospitals were located in the literature. These studies were done over a 22-year period from 1956 through 1978. Pertinent information is presented in Appendix I; Table 4-5 presents a statistical summary of this information.

On average, these civilian hospitals were larger than the 32 Army hospitals surveyed. In terms of bed capacity and bed patient population, the civilian hospitals averaged 664 beds and 441 bed patients, in contrast to the averages of 285 beds and 171 bed patients for the Army hospitals. On the other hand, average solid

TABLE 4-5

SUMMARY OF DAILY SOLID WASTE GENERATION IN CIVILIAN HOSPITALS[a]

DATA	MEAN	STANDARD DEVIATION	RANGE HIGH	RANGE LOW	SAMPLE SIZE	TIME PERIOD
Bed Capacity	664	751	6134	30	145	1964-1977
Average Bed Patient Population	441	464	4185	13	169	1964-1977
Gross Population	3177	5280	21294	109	15	1970-1974
Equivalent Population	1605	1753	6220	217	10	1970-1974
Total Solid Waste						
(lbs)	7305[b]	8974	77700	187	167	1964-1978
(lbs/bed patient)	18[c]	14	126	2	168	1956-1978
(lbs/gross population)	4	2	6	1	14	1970-1974
(lbs/equivalent population)	11[d]	5	15	2	10	1956-1974
Disposable Solid Waste[e]						
(lbs)	6083	7452	23200	732	8	1970-1972
(lbs/bed patient)	8	4	17	4	8	1970-1972
(lbs/gross population)	1.3	0.4	2	1	8	1970-1972
(lbs/equivalent population)	4	1	6	2	8	1970-1972

TABLE 4-5 (CONCLUDED)

[a] Data on individual hospitals are presented in Appendix I.

[b] The mean is 7163 pounds if data from the 8- and 17-hospital surveys are included (N = 192).

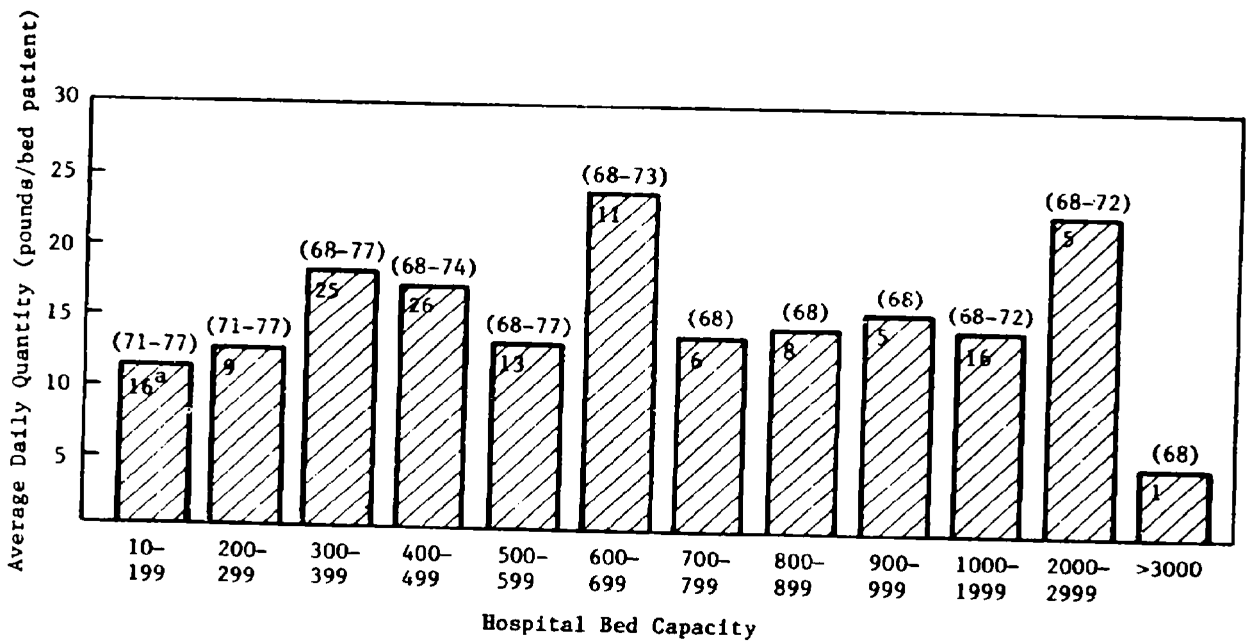
[c] The mean is 15 pounds per bed patient if data from the 17- and 29-hospital surveys are included (N = 214).

[d] The mean is 6.0 pounds per equivalent population if data from the 29-hospital survey are included (N = 39).

[e] The disposables (i.e., single-use items) component of the solid waste.

waste generation is somewhat less in the civilian hospitals than in the Army hospitals. For the former the total solid waste load averages 7305 pounds daily and 18 pounds per bed patient, while for the latter the data are 8150 total pounds and 51 pounds per bed patient (although 70 percent of the Army hospitals had per bed patient wasteloads of 2 to 38 pounds daily). In general, the rate of solid waste generation per bed patient in the civilian hospitals tended to fall within a range of 12 to 24 pounds daily, as illustrated by Figure 4-2.

The above statistics should not necessarily be interpreted to mean, however, that Army hospitals generate relatively more solid waste than civilian hospitals. The most appropriate indicator of the rate of solid waste generation in any hospital is average pounds generated per equivalent population. Equivalent population includes the total number of bed patients, outpatients, and employees (also, volunteer workers for civilian hospitals), during an average 8-hour hospital shift. Using this measure of hospital size, the average rate of solid waste generation for the Army hospitals was 6 pounds per equivalent population (Appendix H, Table H-2). For the 39 civilian hospitals on which study data reporting hospital equivalent population were available, the comparable ratio also was 6 pounds, if data from the 29-hospital survey are included (ESCO/Greenleaf, 1972; Burchinal, 1973; Ross Hofmann, 1974; Snow et al., 1956). If this ratio is typical of civilian hospitals in general, then there is no



[a]The number in each column represents the number of hospitals in the sample. The dates of the studies are indicated in parentheses.

FIGURE 4-2
DAILY SOLID WASTE GENERATION PER BED PATIENT IN CIVILIAN HOSPITALS AS A FUNCTION OF BED CAPACITY

real difference in the rate of solid waste generation for Army hospitals relative to civilian hospitals.

In other studies done on solid waste generation in civilian hospitals, an increasing trend has been observed in recent decades, with the impetus for this trend attributed to increased utilization of single-use disposable items (Vaughan, 1968; Litsky et al., 1972; Ross Hofmann, 1974). Schatzle (1970) estimated that hospital solid waste totaled 3 to 4 pounds daily per bed patient in 1955, 5 to 10 pounds in 1960, and 15 to 20 pounds in 1970. A study at one Canadian hospital revealed a similar trend: solid waste increased from 5 pounds daily per bed patient in 1965, to 7 pounds in 1967, and 12 pounds in 1972 (Schmidt, 1974).

The data in Appendix I, when averaged by decade, also indicate increasing amounts of hospital solid waste over time, although the principal increase appears to have occurred earlier than estimated by Schatzle. The averages were 7 pounds per bed patient daily in the 1950s (data for 29 hospitals), 16 pounds in the 1960s (93 hospitals), and 17 pounds in the 1970s (92 hospitals).

Using the mean of 7305 pounds of total solid waste generated daily for the 167 civilian hospitals reporting individual hospital data, an aggregate daily total of 1.2 million pounds of solid waste can be calculated for all of these hospitals. Extrapolation to an annual basis yields a solid waste total of approximately 2.7 million pounds per hospital, and 445 million pounds (225,000 tons) for the 167 hospitals collectively.

In fact, there are nearly 7000 civilian hospitals in the United States that would fall under EPA's proposed regulations for solid waste disposal (Shulman, 1979). If it is assumed that the average of 7305 pounds of solid waste daily is generally applicable for all of these hospitals, then a total annual amount of approximately 18.9 billion pounds of civilian hospital solid wastes would be affected by the EPA regulations. Adding this total to the annual wasteload of the 32 Army hospitals and 9 other military hospitals analyzed above would result in an overall total of nearly 19 billion pounds or 9.5 million tons of solid waste generated yearly by U.S. hospitals. Wastes from military hospitals for which data were not available could be expected to slightly increase this total.

4.3.2 Composition of Solid Waste

Of the 167 civilian hospitals in Appendix I for which individual data were available, data on the composition of solid wastes were available in only two studies for 3 of these hospitals. In addition, two other studies were found in the literature that contained some information on the composition of civilian hospital solid wastes. Table 4-6 displays the data available from these sources.

As can be seen in Table 4-6, paper items are generally the major component of solid waste for the hospitals studied. In three of the studies miscellaneous items were the next major component of solid waste, accounting for 18 to 40 percent of solid wastes in these studies. Rubber and plastic items were reported separately in all

TABLE 4-6

COMPOSITION OF SOLID WASTE FROM CIVILIAN HOSPITALS

Component	COMPOSITION (weight percent)			
	Los Angeles, CA Duluth, MN[a]	West Virginia Medical Center[b]	80-Hospital Survey[c]	*[d]
Paper	60	39		66
Cloth	8	9		---
Wood	1	---	50	---
Rubber	1	1		6
Plastic	21	5		
Glass	8	12	9	10
Metal		3		
Miscellaneous	1	30	40	18

[a]Ross Hoffmann, 1974.

[b]Burchinal, 1973.

[c]Iglar and Bond, 1973.

[d]Oviatt, 1967.

*Hospital not identified.

but one study, and accounted for 6 to 22 percent of the total wasteloads, while data on glass and metal items were available in all four of the studies, and ranged from 8 to 15 percent of the wasteloads for the hospitals studied.

Since both the level of detail and the number of civilian hospitals that have been studied regarding wasteload composition are relatively limited, it is not possible to make a definitive comparison of wasteload composition between civilian and Army hospitals. In general, however, the data patterns indicated in Table 4-6 seem to be compatible with the data reported by the 32 Army hospitals in Table 4-1. In terms of combustible versus noncombustible portions of solid waste, three studies in addition to the four discussed above provide some data for civilian hospitals. These data, presented in Table 4-7, indicate that 50 to 94 percent of the solid wastes are combustible. Where the miscellaneous component of wastes is 7 percent or less, the minimum percentage for combustible hospital wastes is 72 percent. For the 32 Army hospitals, on average, 83 percent of wastes were combustible.

4.3.3 Solid Waste by Originating Department

Data on solid waste generation by different departments within civilian hospitals were available in two studies (Iglar and Bond, 1973; Burchinal, 1973), and are presented in Table 4-8 along with comparable data from the survey of the 32 Army hospitals. In both of the civilian hospital studies, the one department accounting for the largest proportion of hospital total wasteload was food service, with

TABLE 4-7

COMBUSTIBILITY OF SOLID WASTES FROM CIVILIAN HOSPITALS

Hospital	TYPE OF WASTE (weight percent)[a]			Reference
	Combustible[b]	Noncombustible	Miscellaneous	
3 Hospitals	91	8	2	Ross Hofmann, 1974
West Virginia Medical Center Hospital	55	15	30	Burchinal, 1973
West Virginia Medical Center Complex	55	15	31	Burchinal, 1973
80 Hospitals	50	9	40	Iglar and Bond, 1973
Not identified[c]	73	21	7	Brewer, 1972
LAC/USC Medical Center	93	7	0	ESCO/Greenleaf, 1972
Long Beach General Hospital	93	7	0	ESCO/Greenleaf, 1972
Harbor General	94	5	<1	ESCO/Greenleaf, 1972
Rancho Los Amigos Hospital	86	14	<1	ESCO/Greenleaf, 1972
John Wesley	90	6	4	ESCO/Greenleaf, 1972
Olive View	93	6	<1	ESCO/Greenleaf, 1972
Mira Loma	85	12	3	ESCO/Greenleaf, 1972
Atlantic A	91	9	0	Kraus, 1968
Boston B	86	14	0	Kraus, 1968
Buffalo A	92	8	0	Kraus, 1968
Buffalo B	91	9	0	Kraus, 1968
Chicago A	72	28	0	Kraus, 1968
Chicago C	68	32	0	Kraus, 1968

TABLE 4-7 (CONTINUED)

Hospital	TYPE OF WASTE (weight percent)[a]			Reference
	Combustible[b]	Noncombustible	Miscellaneous	
Chicago D	91	9	0	Kraus, 1968
Dallas A	60	40	0	Kraus, 1968
Dallas C	78	22	0	Kraus, 1968
Denver A	1	99	0	Kraus, 1968
Denver C	7	93	0	Kraus, 1968
Denver D	11	89	0	Kraus, 1968
Detroit A	80	20	0	Kraus, 1968
Detroit C	88	13	0	Kraus, 1968
Houston B	80	20	0	Kraus, 1968
Houston C	67	33	0	Kraus, 1968
Indiana A	79	21	0	Kraus, 1968
Indiana B	33	67	0	Kraus, 1968
Kansas City B	56	44	0	Kraus, 1968
Los Angeles A	50	50	0	Kraus, 1968
Los Angeles C	78	22	0	Kraus, 1968
Miami A	75	25	0	Kraus, 1968
Milwaukee B	60	40	0	Kraus, 1968
Minneapolis A	77	23	0	Kraus, 1968
Minneapolis B	62	38	0	Kraus, 1968
Minneapolis C	90	10	0	Kraus, 1968
New Orleans A	55	45	0	Kraus, 1968

TABLE 4-7 (CONTINUED)

Hospital	TYPE OF WASTE (weight percent)[a]			Reference
	Combustible[b]	Noncombustible	Miscellaneous	
New Orleans B	55	45	0	Kraus, 1968
New Orleans C	63	38	0	Kraus, 1968
New Orleans D	50	50	0	Kraus, 1968
New York City B	38	62	0	Kraus, 1968
New York City C	29	71	0	Kraus, 1968
Philadelphia E	100	0	0	Kraus, 1968
Phoenix A	57	43	0	Kraus, 1968
Portland A	56	44	0	Kraus, 1968
Portland B	93	7	0	Kraus, 1968
St. Louis A	68	32	0	Kraus, 1968
San Antonio A	33	67	0	Kraus, 1968
San Antonio B	67	33	0	Kraus, 1968
San Antonio D	7	93	0	Kraus, 1968
San Diego B	65	35	0	Kraus, 1968
San Diego C	48	52	0	Kraus, 1968
San Francisco A	64	36	0	Kraus, 1968
San Francisco C	62	38	0	Kraus, 1968
Seattle B	69	31	0	Kraus, 1968
Seattle C	75	25	0	Kraus, 1968
Seattle D	75	25	0	Kraus, 1968
Washington, DC A	78	22	0	Kraus, 1968

TABLE 4-7 (CONCLUDED)

Hospital	TYPE OF WASTE (weight percent)[a]			Reference
	Combustible[b]	Noncombustible	Miscellaneous	
Washington, DC	89	11	0	Kraus, 1968
Not identified	72	10	18	Oviatt, 1967
29 Hospitals	84	16	0	Snow et al., 1956

[a]Rounded to nearest percentage point.

[b]In data from Kraus (1968), the combustible component is equivalent to the quantity that was incinerated.

[c]Data for infectious waste.

TABLE 4-8

GENERATION OF SOLID WASTE BY DEPARTMENT IN CIVILIAN AND ARMY HOSPITALS

SOURCE	CONTRIBUTION BY DEPARTMENT (%) 80-HOSPITAL SURVEY[a]	UNIVERSITY OF WEST VIRGINIA MEDICAL CENTER[b]	SURVEY OF 32 ARMY HOSPITALS
Clinical Service (Laboratory)	2	6	11
Dental Activity	---	---	5
Department of Medicine	20	4	4
Department of Obstetrics and Gynecology	4	5	4
Department of Pathology	0.04	---	3
Department of Pediatrics	1	2	3
Department of Radiology	1	2	3
Department of Surgery	4	15	8
General Medical Service	1	10	8
General Surgical Service	---	---	5
Intensive Care	0.7	3	4
Ophthalmology and Otoloaryngology Services	---	0.2	2
Pharmacy Service	0.7	1	8
Coffee Shop	1	1	2
Administration	4	6	7
Food Service Division	49	39	19
Other	11	6	---

[a]Data reported as means (Iglar and Bond, 1973).

[b]Calculated from data of Burchinal (1973).

Note: A dash (---) indicates data were not reported.

39 to 49 percent. The only other departments contributing 10 percent or more to the total wasteload were the department of medicine (20 percent) and "other" (11 percent) (Iglar and Bond, 1973), and the department of surgery (15 percent) and general medical (10 percent) (Burchinal, 1973). For the six departments that were included as sources of potentially hazardous/infectious waste in EPA's proposed regulations,* the total contribution from these departments in the two civilian hospital studies was 12 percent (Iglar and Bond, 1973) and 31 percent (Burchinal, 1973). For the 32 Army hospitals surveyed, the comparable statistic was 35 percent. The data available are not sufficient to draw any firm conclusions on whether Army and civilian hospitals are fundamentally similiar or distinct in their rate of generation of potentially hazardous/infectious wastes.

*Ten hospital departments were listed by EPA, but specific data are available only for the following six: clinical/laboratories, obstetrics, pathology, pediatrics, surgery, and intensive care.

5.0 PATHOGENS ASSOCIATED WITH HOSPITAL AND MUNICIPAL WASTES

In formulating its proposed regulations for the classification of certain hospital wastes as hazardous/infectious, EPA did so upon the presumption that wastes from specified hospital departments are particularly likely to contain pathogens which, when disposed of in a sanitary landfill, may pose a risk to human health (Federal Register, 1978).* Many of the microorganisms commonly found in hospital waste also are present in municipal solid waste and wastewater. Under EPA's proposed designation of hazardous wastes, however, neither municipal solid wastes nor municipal wastewater subject to treatment by land application are specified as potentially hazardous wastes. In fact, the treatment of municipal wastewater by land application is specifically excluded from regulation under RCRA (Federal Register, 1978). In this section, currently available information on pathogens present in hospital solid wastes will be discussed, along with a discussion of pathogens also present in municipal solid waste and wastewater.

The survey of U.S. Army hospitals conducted for this study specifically solicited information on any pathogens present in the solid wastes landfilled by these hospitals (Appendix G: Survey of U.S. Army Hospitals, question 13). However, few data were available. The available literature was also reviewed for information on

*For a background discussion of EPA's proposed regulations, see Section 3.3.

pathogens identified in hospital and municipal wastes. Table 5-1 presents an overview of this information for the pathogens identified in these wastes, and the pathogenic hazard classification of each of these organisms as established by the Center for Disease Control. Only pathogens in Classes 2 through 5 are regarded as posing hazards of concern to human health (Appendix C: CDC Classification of Etiologic Agents).

5.1 Hospital Solid Waste

As can be seen from Table 5-1, a total of 34 genera and groups of bacteria and fungi have been reported as associated with hospital waste. This listing includes those microorganisms detected in hospital air (Greene et al., 1962b) and in leachates from lysimeters filled with hospital refuse (Scarpino et al., 1979), as well as those isolated from hospital solid waste (Smith, 1970; Trigg, 1971; Scarpino et al., 1979).

As indicated in the table, the majority of these microorganisms (27 out of 34) are classified as Class 1 etiologic agents; only 7 pathogens of Class 2 were reported in hospital waste, and no pathogens of any classes higher than 2 were reported. However, this does not necessarily mean that no other pathogens are ever present in hospital wastes, only that studies have not yet been done that demonstrate either the presence or ab.ence of other pathogens. No viruses or higher parasites have been reported in hospital solid waste.

TABLE 5-1

PATHOGENS ASSOCIATED WITH HOSPITAL SOLID WASTE, MUNICIPAL SOLID WASTE, AND MUNICIPAL WASTEWATER

SOURCE / ORGANISM	HOSPITAL SOLID WASTE[a]		MUNICIPAL SOLID WASTE[b]		MUNICIPAL WASTEWATER[c]		
	Class 1[d]	Class 2	Class 1	Class 2	Class 1	Class 2	Class 3
BACTERIA							
Achromobacter sp.			X				
Acinetobacter			X				
Actinobacillus sp.		X					
Aeromonas sp.	X		X				
Bacillus sp.	X		X				
B. cereus	X						
B. subtilis	X						
Bacteroides sp.	X						
Citrobacter sp.	X		X		X		
Clostridium sp.			X				
C. fallax			X				
C. perfringens	X				X		
Coliform group	X		X		X		
Corynebacterium sp.			X				
Enterobacter sp.	X		X		X		
E. cloacae			X				
Enteroccus	X						
Escherichia coli		X		X		X	
Flavobacterium sp.					X		
Fusobacterium sp.	X						
Herellae sp.	X		X				
Klebsiella sp.		X		X		X	
Lactobacillus sp.	X						
Listeria monocytogenes				X		X	
Micrococcus sp.	X		X				
Mima sp.			X		X		
Moraxella sp.		X		X		X	

TABLE 5-1 (CONTINUED)

ORGANISM \ SOURCE	HOSPITAL SOLID WASTE[a]		MUNICIPAL SOLID WASTE[b]		MUNICIPAL WASTEWATER[c]		
	Class 1[d]	Class 2	Class 1	Class 2	Class 1	Class 2	Class 3
BACTERIA (Cont.)							
Mycobacterium sp.				X		X	
M. tuberculosis						X	X
Neisseria sp.			X		X		
Pasteurella haemolyticum						X	
Pneumococcus						X	
Proteus sp.	X		X		X		
P. mirabilis	X		X				
P. vulgaris	X						
Providance sp.	X		X				
Pseudomonas sp.	X		X		X		
P. aeruginosa					X		
Salmonella sp.		X		X		X	
S. enteritides				X			
S. heidelberg				X		X	
S. montevideo				X			
S. saint paul				X			
S. typhimurium				X		X	
Serratia sp.	X				X		
S. marcescens			X				
Shigella sp.				X			
Staphylococcus sp.	X		X		X		
S. albus					X		
S. aureus		X		X		X	
S. epidermidis	X						
Streptococcus sp.	X		X		X		
S. durans	X		X				
S. faecalis			X		X		
S. faecalis liquefaciens	X		X				

TABLE 5-1 (CONTINUED)

ORGANISM \ SOURCE	HOSPITAL SOLID WASTE[a]		MUNICIPAL SOLID WASTE[b]		MUNICIPAL WASTEWATER[c]		
	Class 1[d]	Class 2	Class 1	Class 2	Class 1	Class 2	Class 3
<u>BACTERIA</u> (Cont.)							
<u>S. faecium</u>			X		X		
<u>S. mitis</u>	X						
<u>S. salivarius</u>	X		X		X		
SUBTOTAL	18	6	19	8	12	10	1
<u>FUNGI</u>							
Actinomycetes		X					
<u>Allescheria boydii</u>			X				
<u>Alternaria</u> sp.	X						
<u>Asperigillus</u> sp.	X		X				
<u>A. fumigatus</u>	X		X				
<u>Candida</u> sp.	X						
<u>C. albicans</u>	X						
<u>Cephalosporium</u> sp.			X				
<u>Cladosporium</u> sp.			X				
<u>Fusarium</u> sp.			X				
<u>Mucor</u> sp.			X				
<u>Neurospora</u>	X						
<u>Penicillium</u> type	X		X				
Phycomycetes group	X						
<u>Rhizopus</u> sp.	X		X				
<u>Sepedonium</u> sp.			X				
<u>Torulopsis glabrata</u>	X						
Yeast	X		X				
SUBTOTAL	9	1	10	0	0	0	0

TABLE 5-1 (CONTINUED)

ORGANISM \ SOURCE	HOSPITAL SOLID WASTE[a]		MUNICIPAL SOLID WASTE[b]		MUNICIPAL WASTEWATER[c]		
	Class 1[d]	Class 2	Class 1	Class 2	Class 1	Class 2	Class 3
VIRUSES							
Adenovirus						X	
Enterovirus			X				
Coxsackievirus						X	
Echovirus			X		X		
Type 2			X				
Reovirus						X	
Hepatitis virus						X	
Poliovirus				X		X	
Type 1				X			
Type 2				X			
Type 3				X			
SUBTOTAL	0	0	1	1	1	2	0
PROTOZOA							
Entamoeba histolytica						X	
SUBTOTAL	0	0	0	0	0	1	0
HELMINTHS							
Ancylostoma duodenale					X		
Ascaris lumbricoides					X		

TABLE 5-1 (CONCLUDED)

ORGANISM \ SOURCE	HOSPITAL SOLID WASTE[a]		MUNICIPAL SOLID WASTE[b]		MUNICIPAL WASTEWATER[c]		
	Class 1[d]	Class 2	Class 1	Class 2	Class 1	Class 2	Class 3
HELMINTHS (Cont.)							
Necator americanus					X		
Taenia saginata					X		
Toxocara						X	
Trichuris trichiura					X		
SUBTOTAL	0	0	0	0	5	1	0
GRAND TOTAL	27	7	30	9	18	14	1

[a]Data from Green et al., 1962b; Smith, 1970; Trigg, 1971; and Scarpino et al., 1979.

[b]Data from Gaby, 1975; and Scarpino et al., 1979.

[c]Data from Johnson et al., 1977; Burge et al., 1977; Theis et al., 1978; Scarpino et al., 1979.

[d]Classification established by the Center for Disease Control (CDC). See Appendix C.

Individual studies indicate that relatively few types of organisms may comprise the majority of the microbial life identified in hospital solid waste. For example, Staphylococci are predominant in the waste generated within certain hospital areas.

Smith (1970) studied the solid waste of a teaching hospital for the presence of pathogenic microorganisms. Three areas of the hospital were examined: the incinerator room, blood bank, and general medicine areas. Bacillus sp. comprised 80 to 90 percent of the total number of microorganisms isolated, and Staphylococcus and Streptococcus accounted for the remainder.

In a follow-up study at the same teaching hospital, the refuse from 15 nursing stations was examined (Trigg, 1971). The study results are shown in Table 5-2. Staphylococcus aureus was the predominant pathogen in patient refuse, with spore-forming organisms not present in sufficient numbers to constitute a hazard. The opportunistic pathogens Staphylococcus aureus, Candida albicans, and Pseudomonas were present uniformly at the 15 nursing stations. The concentration of microorganisms ranged from 1×10^2 to 1×10^8 organisms per gram of refuse (Trigg, 1971).

No studies of the virulence of pathogens in hospital solid waste were available. Without such information, it is impossible to draw any conclusions about the infectiousness of hospital solid waste.

5.2 Municipal Solid Waste

The pathogens identified in municipal solid waste in Table 5-1 were isolated from municipal solid waste (Gaby, 1975; Scarpino et

TABLE 5-2

MICROBIAL CONCENTRATIONS IN REFUSE AT NURSING STATIONS[a]

Nursing Station Test	Sample Number	Medium[b]	COUNTS ($\log_{10}$) Total	Coliform	Fecal Strepto-coccus	Staphlo-coccus	Candida albicans	Pseudo-monas	Spores	Inhibitory Agent
12	1	BA	3.9	<1.0	<1.0	3.2	<2.0	<2.0	3.9	+
	2	PCA	3.6	<1.0	<1.0	<2.0	<2.0	<2.0	<1.5	-
	3	PCA	2.6	<1.0	<1.0	2.6	<2.0	<2.0	<1.5	-
82	1	BA	7.7	5.9	5.3	<6.0	<2.0	4.3	2.4	-
	2	PCA	8.5	5.4	5.3	<5.0	3.5	8.4	3.4	-
	3	PCA	4.5	<1.0	<1.0	4.1	<2.0	<2.0	1.6	-
36	1	PCA	2.5	<1.0	<1.0	<2.0	<2.0	<2.0	1.6	-
	2	PCA	2.5	<1.0	<1.0	<2.0	<2.0	<2.0	<1.5	-
	3	PCA	3.5	<1.0	<1.0	2.7	<2.0	<2.0	<1.5	-
32	1	PCA	1.7	<1.0	<1.0	<2.0	<2.0	<2.0	2.0	-
	2	PCA	7.9	<1.0	1.5	<7.0	<2.6	<2.0	3.9	-
	3	PCA	7.2	1.5	<1.0	<2.0	<2.0	7.2	<1.5	+
33	1	PCA	7.0	4.6	6.3	6.5	2.0	2.5	2.0	-
	2	PCA	6.3	6.3	3.4	2.3	<2.0	<2.0	1.6	-
	3	PCA	6.9	6.8	4.3	4.0	<2.8	<2.0	<1.5	+

[a]Data from Trigg, 1971.

[b]BA: blood agar; PCA: plate count agar.

al., 1979) and from the leachates of lysimeters filled with municipal solid waste (Scarpino et al., 1979). Of the 39 genera and groups of pathogens detected, 30 are Class 1 and 9 are Class 2 etiologic agents. No other hazard classes were observed.

5.3 Municipal Wastewater

The pathogens listed for municipal wastewater (Table 5-1) were detected in sewage sludge (Burge et al., 1977; Theis et al., 1978; Scarpino et al., 1979), in leachates from lysimeters containing sewage sludge (Scarpino et al., 1979), and in aerosols generated during spray irrigation of treated wastewater (Johnson et al., 1977). Of the 33 identified genera and groups of pathogens, 18 are classified as Class 1, 14 as Class 2, and 1 as a Class 3 etiologic agent.

5.4 Relative Hazardousness of Hospital Solid Waste

As can be seen from Table 5-1, more Class 2 pathogens have been identified in municipal wastes than in hospital solid waste. Furthermore, of the seven Class 2 pathogens identified in hospital waste, all but two (*Actinobacillus* sp. and Actinomycetes) were also detected in municipal wastes.

Six Class 2 bacteria are associated with hospital solid waste, and five of these are also present in municipal wastes.

One Class 2 fungus was identified in hospital solid waste, but it was not detected in the municipal wastes.

No viruses were reported as associated with hospital solid waste, although viruses have been detected in municipal solid waste and wastewater. The lack of detection of viruses in hospital solid waste does not necessarily indicate that viruses are absent. The studies may not have included isolation of viruses, or the techniques used may not have been sufficiently sensitive for virus detection.

No higher parasites have been reported in hospital solid waste, although these organisms have been detected in sewage sludge.

From the data that are available, it is concluded that the microorganisms found in all three types of wastes--hospital solid waste, municipal solid waste, and municipal wastewater--are generally similar. Some bacteria in CDC Class 2 are associated with hospital solid waste; however, all but one of these are also reported for municipal solid waste. Furthermore, although some microorganisms are unique to hospital solid waste, only two of these--one bacterium and one fungus--are Class 2 etiologic agents.

Few data are available on the concentrations of the pathogens in hospital solid waste, municipal solid waste, and municipal wastewater. No reports of pathogen virulence in these wastes were available. In the absence of such data, no conclusion can be drawn about the absolute or the relative infectiousness of hospital solid waste.

6.0 LANDFILL FACTORS AFFECTING PATHOGEN FATE

As discussed in Section 4.1.4, the majority of wastes generated at U.S. Army hospitals is currently disposed by landfilling. Included in this wasteload are wastes from the ten departments designated by EPA as generating hazardous wastes. Some wastes from these departments have not been incinerated in a pathological incinerator nor otherwise rendered noninfectious prior to landfilling. To comply with the proposed EPA regulations on Hazardous Waste (Federal Register, 1978), these wastes would have to be separated from the total wasteload and disposed in specially designated hazardous waste disposal facilities. Such facilities would have to meet more stringent design, construction and operating standards than are required for sanitary landfills. Additionally, designation of such wastes as hazardous would impose requirements for containerization, storage, and transportation in accordance with Department of Transportation regulations, as well as compliance with EPA standards for manifest, reporting, and recordkeeping. While a complete discussion of these additional requirements as they would apply to U.S. Army hospitals is beyond the scope of this report, it should be noted that they are integral components of a hazardous waste management program.

Of direct concern to the issue of landfilling potentially hazardous/infectious hospital wastes are the design, construction and operating criteria proposed for a sanitary landfill in comparison to standards proposed for a hazardous waste landfill. To that end, this section will discuss and compare the standards proposed for a sanitary landfill, a hazardous waste landfill and disposal of special waste.* The soil characteristics that affect landfilling are discussed in Appendix J-1. Information about sanitary landfill design, especially as related to soil characteristics, is presented in Appendix J-2.

6.1 Sanitary Landfills: Criteria and Guidelines

As discussed in Section 3, EPA has promulgated regulations that establish performance standards for solid waste disposal facilities (Federal Register, 1979a). These criteria define the level of health and environmental protection that must be achieved in order to avoid classification as an "open dump." In addition, EPA has proposed guidelines that recommend considerations and practices for the location, design, construction, operation, and maintenance of sanitary landfills. Applying practices recommended in the proposed guidelines will, in most cases, assure compliance with the proposed criteria (Federal Register, 1979b). The following discussion of sanitary landfills, in terms of recommendations for site selection, leachate control, operation, and monitoring, is based on the two documents mentioned above. These criteria are summarized in Appendix B-1.

*Special wastes are those wastes that occur in large volumes, the potential hazards are relatively low and they are generally not amenable to control techniques specified for hazardous wastes. EPA proposes to regulate such wastes with special standards.

6.1.1 Site Selection

The criteria for the location of solid waste disposal facilities require that specific design restrictions must be complied with in floodplain areas and with regard to endangered and threatened species of plants, fish, or wildlife.

In site selection, consideration must be given to ground and surface water conditions, geological and topographical features, waste type and quantities to be accepted, and social, geographic, and economic factors as well as to environmental impacts.

6.1.2 Leachate Control

Movement of landfill leachate to surface or groundwaters may contaminate such waters, and in the case of pathogen-contaminated wastes, may result in an adverse impact on human health. Leachate management is thus a vital aspect of landfill design and operation and entails control of leachate production, escape from the landfill, and impact on the environment.

Control of leachate production entails control of the amount of water that enters the landfill site either as rain or other forms of precipitation, as surface runoff, or as flooding. Sound solid waste management practices to control leachate generation include:

- Use of low permeability soils, such as clay, as a landfill cover to minimize infiltration. Such soils should have low shrink-swell potential to prevent cracking.
- Appropriate grading of the cover soil to facilitate runoff without causing erosion.

* Construction of ditches surrounding the landfill capable of diverting the runoff from a 10 year/24 hour storm.

* If the landfill is located in a 100-year floodplain, construction of a dike around the landfill capable of preventing inundation.

The need to control or, in some instances prevent, the escape of leachate is a function of the degree of protection necessary for the local groundwater, the distance of the landfill from groundwater, and the attenuating* capabilities of the naturally occurring soil system. If the naturally occurring soils are incapable or only partially capable of attenuating the leachate generated to maintain surface and groundwater quality, use of liners is necessary.

Landfill liners may be constructed of naturally occurring materials such as well compacted clays, of amended natural materials such as soil cements or asphaltic mixes, or they may be artificial materials such as polymeric membranes. The advantages and disadvantages of each type of liner material are summarized in Table 6-1.

When maximum leachate containment is desirable or necessary, single or multiple artificial liners are recommended in conjunction with constant removal of the collected leachate. A 1-percent grade is recommended to facilitate leachate collection and removal.

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*Attenuation is defined here as "any decrease in the maximum concentration or total quantity of an applied chemical or biological constituent in a fixed time or distance traveled resulting from physical, chemical, and/or biological reactor or transformation" (Federal Register, 1979b).

TABLE 6-1

THE ADVANTAGES AND DISADVANTAGES OF VARIOUS LINER MATERIALS

LINER	ADVANTAGES	DISADVANTAGES
Clay	Inexpensive if locally available Good sealant in thick beds Installation relatively simple	Cracks if not kept moist Expensive to truck Composition varies widely Low shear and tensile strength Difficult to handle when wet
Concrete	Ready availability Established technology High compressive strength	Transportation costly Steel reinforcement required Low tensile strength Expansion gap sealing Subject to corrosion
Asphalt	Ease of installation Established technology Good resistance to water Raw material readily available	Poor weathering and age resistance Tendency to crack Not resistant to oils, gasoline, solvents Low compressive strength Surface supports growth of bacteria and algae
Synthetic Rubber and Plastic	Ease of installation Good resistance to water Flexible Easy to repair	Numerous seams reduce reliability Limited site jointing procedures Low puncture resistance Limited UV and temperature range
High Density Polyvinyl Vestolen	Large single sheets--few joints Rugged and flexible High puncture and tear resistance Wide chemical resistance--acids, alkalies, oil and petroleum derivatives Automatic and homogeneous field welds	Sometimes uneconomic for small projects Sheet rolls are cumbersome

SOURCE: Adapted from Schlegel Area Sealing Systems, Inc., 1977.

EPA has recommended minimum standards for natural soil and artificial liners that are used to significantly restrict the flow of leachate:

- permeability of 1×10^{-7} cm/sec
- ability to resist physical and chemical attack by leachate
- maintenance of integrity throughout the design life of the landfill
- minimum thickness of
  - 12 inches for natural soil liners
  - 20 mils for artificial liners

The third element of leachate control is the management of its impact on surface and groundwaters. This applies to leachate that has escaped or has been drained from the landfill site.

The principal method of minimizing the impact of migrating leachate on the environment is adequate separation between the landfill site and surface or subsurface waters. Thus, EPA recommends that the bottom of a landfill structure should be, at a minimum, 5 feet above the seasonal high groundwater table. Depending upon the degree of protection necessary, devices may be installed in this unsaturated zone to monitor leachate passage. Facilities with the potential to discharge leachate to groundwater that is used as a drinking water source should monitor the quality of the groundwater and leachate by the use of wells. Monitoring should be used to establish background levels of water quality and, once the landfill is in operation, should be conducted at least annually.

Leachate that is collected and removed from the landfill site should be disposed in an environmentally sound manner, either by treatment, land application, or recirculation. Additionally, any point source discharges must comply with the National Pollutant Discharge Elimination System (NPDES) permit required by the Clean Water Act (PL 95-217) and any nonpoint source discharges must be controlled to minimize or prevent contamination of any off-site surface waters.

6.1.3 Operation

Recommended operating practices include regulation of the quantities and types of waste to be accepted to assure compatibility with landfill design, application of cover material, protection of the health and safety of employees, and recordkeeping. Recommended practices for the application of cover material are of direct relevance to the issues addressed in this study. Cover materials are applied, among other purposes, to minimize infiltration of precipitation.

A minimum of 6 inches of cover material should be applied daily to active landfill cells and a minimum of 12 inches should be applied to cells that will be inactive for 3 or more months. Once completed, the landfill should be covered with 6 inches of clay or other highly impermeable material. Upon this clay base, a minimum of 18 inches of soil capable of supporting vegetation is recommended.

6.2 Hazardous Waste Landfill Facilities: Criteria and Guidelines

Proposed regulations for hazardous waste management facilities include general facility guidelines and criteria applicable to landfill disposal sites. Specific performance guidelines are proposed for hazardous waste facilities whereas recommended practices are proposed for sanitary landfills.

General facility standards cover general site selection; security; contingency plans and emergency procedures; employee training; manifest system, recordkeeping and reporting; visual inspections; groundwater and leachate monitoring; and financial requirements. Standards directly applicable to landfills include site selection, construction, and operati n, as well as closure and post-closure. Relevant portions of these standards as they apply to site selection, leachate control, and operation will be discussed below to highlight the differences between a hazardous waste disposal facility and a sanitary landfill.

6.2.1 Site Selection

Proposed regulations prohibit the location of hazardous waste management facilities in the following locations: active fault zones, regulatory floodways, coastal high hazard areas, 500-year floodplains, wetlands, critical habitats, and recharge zones of sole source aquifers. Additionally, active portions of such facilities must be located a minimum of 200 feet from the property border. Deviations from these standards may be permitted if an equivalent degree of protection is assured.

6.2.2 Leachate Control

The major emphasis in leachate control is containment of leachate within the landfill. To that end, standards covering liners and leachate collection systems, among others, are proposed. Other standards deal with elements of landfill design and operation used to manage leachate generation and prevent or minimize contamination of surface or groundwaters.

Appropriate site selection is a major element in controlling leachate generation. Thus, avoidance of high hazard sites such as floodplains or coastal high hazard areas will limit the possibilities of inundation. Additionally, landfill design should incorporate diversionary structures (i.e., ditches) capable of containing the runoff from a 25 year/24 hour storm.

As noted above, leachate containment is a function of the landfill liner system in conjunction with a leachate collection or removal system, where necessary. Three types of liner systems are discussed in the proposed regulations, natural in-place soil barriers, soil liners, and artificial liners.

Natural in-place soil barriers may be used in areas where evaporation exceeds precipitation by 20 or more inches. Such barriers must be at least 10 feet thick and must have a maximum permeability of 1×10^{-7} cm/sec. Operators of landfills using natural in-place barriers have to demonstrate that there will be no leachate discharge to surface or groundwater.

In areas where the climate or site hydrogeology does not permit use of soil barriers, the bottom and sides of the landfill must be lined. A soil liner must be, at a minimum, 5 feet thick with a permeability not to exceed 1×10^{-7} cm/sec. A leachate collection and removal system, comprised of at least 1 foot of highly permeable soil and one or more sumps, must overlay the liner. Alternatively, a two-liner system may be used.

The two-liner system design consists of five separate soil layers and a membrane liner. The first soil layer, 6 inches of permeable soil placed on the natural soil base, functions as a leachate removal system that is capable of permitting leachate to move rapidly through the layer to leachate collection sumps at various low points at the bottom of the landfill. This first layer of soil is covered by an additional layer of permeable soil, also 6 inches thick, which is subsequently overlaid with a membrane liner. A third soil layer, also 6 inches thick and covering the membrane liner, is itself covered by a fourth layer of soil 3 feet thick and having a permeability of 1×10^{-7} cm/sec. A fifth and final soil layer is 1 foot thick, placed on top of the entire system, and acts as another leachate collection and removal system that permits rapid leachate movement through the layer into the leachate collection sumps. The two designs described above are suggested liner systems only. Different systems may be used, providing that they meet the minimum criteria proposed for soil and membrane liners as well as for leachate collection sumps as outlined in Appendix B-2.

The third element of leachate management is preventing the contamination of surface or groundwaters by any leachate that may migrate from the landfill. Site selection standards are proposed to minimize the potential of contact between landfill leachate and surface or groundwaters. Additionally, standards for monitoring groundwater and leachate are applicable.

In addition to the general facility site selection standards discussed in Section 6.2.1 above, standards applicable specifically to hazardous waste landfills are proposed. These standards prohibit direct contact between the landfill and navigable waters. Furthermore, the landfill must be at least 500 feet from any active human or livestock water supply and the bottom of the landfill liner or barrier must be at least 5 feet above the historical high water table. Finally, no landfill may be constructed over soil materials that have greater than 1 x 10^{-4} cm/sec permeability.

Landfills situated above groundwater that is used as a drinking water source must have both a groundwater and a leachate monitor system. The goundwater monitoring system, consisting of at least four wells, will be used to establish background water quality levels and water quality during operation and after closure of the landfill. Samples must be taken at least annually during operation and after closure. More frequent sampling may be necessary in areas with rapid groundwater flow rates. The leachate monitoring system, installed in the area between the bottom of the landfill and the top of the water table, will also be used to establish background levels and, at a minimum, annually monitor the extent and quality of any escaping leachate. Any significant deviations from background levels must be reported.

6.2.3 Operation

While proper design is the major factor in preventing surface or goundwater contamination, proper landfill operation is also important. To that end, EPA has proposed standards for the types of wastes that may be accepted and the manner in which they are to be handled. Additionally, standards for soil covers are proposed. These standards specify that at least 6 inches of cover material must be applied daily and at least 12 inches must be applied on portions of the landfill that will be inactive for at least one week. Additionally, standards for final soil cover composition and grading are specified.

6.3 Disposal of Special Waste

Standards applicable to facilities that handle special wastes may be written specifically for each type of special waste. Generally, these standards may encompass some, though not all, of the provisions applicable to hazardous and solid wastes. Standards proposed to date for specific special wastes have included general facility standards applicable to waste analysis, general site selection and security, and standards covering manifest, recordkeeping and reporting, as well as standards for visual inspections, closure and post-closure, and where applicable, requirements for groundwater monitoring.

6.4 Comparison of Sanitary and Hazardous Waste Landfills

The major difference affecting land disposal of potentially hazardous/infectious hospital waste between the recommended practices applicable to a sanitary landfill and the standards proposed for a hazardous waste landfill is the degree of leachate containment specified. The proposed guidelines for sanitary landfills recognize that containment techniques may not be necessary for all sites since the naturally occurring soil may provide some degree of attenuation. In addition, they imply that some escape of leachate, both controlled and uncontrolled, may be acceptable as long as the attenuating capabilities of the underlying soil are sufficient to prevent contamination of surface and groundwaters. Finally, these standards emphasize prevention of leachate generation as a means of avoiding contamination. On the other hand, the standards for hazardous material landfills emphasize the maximum containment of leachate within the landfill. To that end, specific standards for containment systems are proposed, varying with the climate and the hydrogeology of the site.

Additionally, site selection standards and associated landfill design considerations are more stringent for hazardous waste landfills than for sanitary landfills. Thus, hazardous waste disposal facilities must include provisions to prevent inundation from a 25 year/24 hour storm and a 500-year flood while sanitary landfills need to contain a 10 year/24 hour storm and a 100-year flood. Standards establishing a buffer zone around the hazardous waste facility and assuring adequate separation from surface or groundwaters are more specific and, in some instances, more stringent than for a sanitary landfill.

A decision regarding whether potentially hazardous/infectious hospital waste may safely be disposed in a sanitary landfill must take into consideration the differences between the two kinds of landfilling requirements, particularly those pertaining to leachate containment. At issue is whether such hospital wastes require maximum containment or whether they may safely be disposed in a sanitary landfill designed to permit some limited leachate migration. A discussion of soil factors as they apply to the mobility and fate of pathogens in a sanitary landfill is useful in addressing this issue.

6.5 Soil Factors Affecting Mobility and Fate of Pathogens

The ability of a pathogen to survive outside its host is determined primarily by its nature (i.e., whether it is a fastidious or an opportunistic pathogen) and by its condition (i.e., whether it was weakened by its previous environment so that new or additional stress would increase the die-off rate). When pathogen-containing solid waste is placed in a landfill, the fate of the surviving pathogens is affected by their interaction with the solid waste components, conditions within the landfill, effects of various soil factors on pathogens that may reach the soil layers within the landfill, and effects of landfill leachate.

Four soil characteristics are particularly important in determining pathogen survival and mobility in soil--soil type, moisture, pH, and temperature (Dotson, 1973); various other factors also affect pathogen fate in soil. The various soil factors that affect pathogen fate are discussed in this section. Data on the effects of these factors on specific pathogens and types of pathogens are presented in Table 6-2. Some additional information on the fate of pathogens in landfills and soils is included in the discussion of relevant case studies (Section 7).

6.5.1 Soil Type

Pathogen survival rates vary in different types of soil. The effect of soil type on pathogen survival depends on the species of pathogen (see Table 6-2).

The principal factor affecting pathogen mobility in soil is retention by the soil particles. Soil retention may only temporarily inactivate pathogens and does not necessarily result in pathogen destruction. Viruses are immobilized by adsorption onto the soil particles whereas bacteria and higher parasites are retained by filtering. A sufficiently thick layer of the proper soil would protect the groundwater from bacterial and viral contamination (Glotzbecker and Novello, 1975).

The adsorptive capacity of soil, i.e., the rate and degree of adsorption, depends on the surface area of the soil particles and on the thickness of the soil layer. Soil texture, as reflected in the surface area of the soil particles, is therefore the most important factor determining the soil's adsorptive capacity. (See Table 6-3 for the characteristics of soils of different textures.) A uniform soil with a very large surface area, such as colloidal soil and

TABLE 6-2

SOIL FACTORS AFFECTING THE FATE OF PATHOGENS

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Type	*Salmonella typhimurium*	Survival time: hot house sandy soil > sterile sand > garden soil	Rudolfs et al., 1950a
	Ascaris eggs	Survived in clay, loam, and humus soils; did not survive in sand or gravel	Rudolfs et al., 1950b
	Bacteria	Retained in soil by filtration; retention is inversely proportional to particle size	Gerba et al., 1975
	Viruses	Adsorbed onto soil particles; small particle size enhances adsorption: montmorillonite > silt > sandy loam > ottawa sand > musk	Moore et al., 1979
	Viruses	Adsorption is proportional to clay content of soil: sand retained 10^8 viruses per gram, soil with 5 to 37 percent clay retained 10^{10} viruses per gram	Eliassen et al., 1967
	Entamoeba histolytica	Survival time in soil: not longer than 8 days	Fitzgerald, 1979
	Entamoeba histolytica cysts	Immobilized by sand	Rudolfs et al., 1950b
Soil Moisture	*Pseudomonas*	Moisture essential for survival and growth	Labeda et al., 1976
	Salmonella typhimurium	Moisture essential for survival	Rudolfs et al., 1950a; Labeda et al., 1976
	Pathogenic bacteria	Most die off within 10 days in dry soil	Wolman, 1977

TABLE 6-2 (CONTINUED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Moisture (Concluded)	*Ascaris* eggs	Die more rapidly in dry soil	Rudolfs et al., 1950b
Soil pH	Pathogens	Killed by high pH	Rudolfs et al., 1950a; Dotson, 1973
	Pathogenic bacteria	Most die off within 10 days in acid soils	Wolman, 1977
	Viruses	Adsorption to soil particles enhanced by decrease in pH	Engelbrecht, 1973; Duboise et al., 1976; Schaub and Sorber, 1977; Burge and Enkiri, 1978; Moore et al., 1979
	Viruses	Adsorption more rapid at low pH	Bouwer, 1976
	Viruses	Sorption decreased as pH increased	Eliassen et al., 1967
	Viruses	In clay mineral, 97% of infectivity was lost at pH 4 to pH 9	Moore et al., 1979
Soil Temperature	Various pathogens	Survive prolonged exposure to cold	Dotson, 1973
	Brucella abortus	Destroyed by exposure to 55°C for 60 minutes[a]	Stern, 1975
	Coliforms	Population reduced 10-fold by exposure to 60°C for 2.0 minutes	Burge et al., 1977
	Corynebacterium diphtheriae	Destroyed by exposure to 55°C for 45 minutes[a]	Stern, 1975

TABLE 6-2 (CONTINUED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Temperature (Continued)	*Escherichia coli*	Destroyed by exposure to 60°C for 60 minutes[a]	Stern, 1975
	Fecal coliforms	Concentration reduced by 10^4 on exposure to 35°C[b]; concentration reduced by 10^5 on exposure to 47°C[b]	Stern, 1975
	Leptospira philadelphia	Survived less than 2 days at 49°C[c]	Gaby, 1975
	Mycobacterium tuberculosis	Destroyed within 2 weeks on exposure to 49°C	Gaby, 1975
	Proteus spp., *P. mirabilis*	Killed during refuse decomposition[c]	Gaby, 1975
	Pseudomonas aeruginosa	Concentration increased by 23% on exposure to 35°C[b]; concentration reduced to 11% on exposure to 47°C[b]	Stern, 1975
	Salmonella spp.	Survived prolonged exposure to cold	Rudolfs et al., 1950a; Glotzbecker and Novello, 1975
	Salmonella spp.	Concentration reduced to 10% on exposure to 35°C[b], destroyed on exposure to 47°C[b]	Stern, 1975
	Salmonella	Killed within 7 to 21 days on exposure to 49°C[c]	Gaby, 1975
	Salmonellae	Population reduced 10-fold by exposure to 60°C for 7.5 minutes	Burge et al., 1977

TABLE 6-2 (CONTINUED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Temperature (Continued)	*Salmonella newport*	Destroyed by exposure to 60°C for 30 minutes[d]	Stern, 1975
	Salmonella typhi	Destroyed by exposure to 60°C for 30 minutes[a]	Stern, 1975
	Shigella	Killed within 7 to 21 days on exposure to 49°C[c]	Gaby, 1975
	Staphylococci	Population reduced 10-fold by exposure to 60°C for 3.3 minutes	Burge et al., 1977
	Streptococci	Population reduced 10-fold by exposure to 60°C for 15 minutes	Burge et al., 1977
	Viruses	Persistence is temperature-dependent: Survival at 1°C > survival at 23°C or 37°C	Hurst et al., 1979
	Viruses	Survival increases as temperature decreases	Krone, 1968
	Viruses	Inactivation increased by elevated temperatures	Engelbrecht, 1973
	Viruses	Inactivated by temperature extremes: 95% of population inactivated at 2°C within 2 weeks; 99% of population inactivated at 37°C within 6 days	Sobsey et al., 1975
	Adenovirus	Population reduced 10-fold by exposure to 60°C for 0.15 minute	Burge et al., 1977

TABLE 6-2 (CONTINUED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Temperature (Continued)	Poliovirus	Survived prolonged exposure to cold	Glotzbecker and Novello, 1975; Wellings et al., 1975a
	Poliovirus	Population reduced 10-fold by exposure to 60°C for 1.5 minutes	Burge et al., 1977
	Poliovirus Type 1	Destroyed by exposure to 60°C for 5 minutes[d]	Stern, 1975
	Poliovirus Type 2	Inactivated after 3 to 7 days at 49°C;[c] do not survive the composting environment[c]	Gaby, 1975
	<u>Aspergillus fumigatus</u>	Killed at 49°C[c]	Gaby, 1975
	<u>Histoplasma capsulatum</u>	Killed at 49°C[c]	Gaby, 1975
	<u>Blastomyces dermatitidis</u>	Killed at 49°C[c]	Gaby, 1975
	Helminth larvae	Died within 1 week upon exposure to 0°C, in 12 weeks at 15°C, in 9 weeks at 27°C, within 3 weeks at 35°C	Rudolfs et al., 1950b
	Parasitic cysts and ova	Disintegrated after 7 days at 49°C[c]	Gaby, 1975
	<u>Ascaris lumbricoides</u>	Survived prolonged exposure to cold	Rudolfs et al., 1950b

TABLE 6-2 (CONTINUED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Soil Temperature (Concluded)	Ascaris lumbricoides eggs	Destroyed by exposure to 50°C for 60 minutes, to 55°C for 7 minutes[a]	Stern, 1975
	Ascaris ova	Population reduced 10-fold by exposure to 60°C for 1.3 minutes	Burge et al., 1977
	Ascaris lumbricoides	Destroyed by exposure to 60°C for 60 minutes[d]	Stern, 1975
	Entamoeba histolytica	Cysts destroyed by exposure to 60°C for 5 minutes[a]	Stern, 1975
	Trichinella spiralis encysted larvae	Infectivity lost after 96 hours at 35°C	Fitzgerald and Prakasam, 1978
Ionic Strength	Viruses	Retention by soil greater with high ionic concentration	Bouwer, 1976
	Viruses	Sorption increased as cation concentration increased	Eliassen et al., 1967; Lefler and Kott, 1974
	Viruses	Sorption greater with divalent cations than with monovalent cations	Lefler and Kott, 1974; Bouwer, 1976
	Viruses	Ionic strength is probably most important factor in adsorption onto soil particles	Duboise et al., 1976; Gilbert et al., 1976b; Vaughn et al., 1978
	Viruses	Sorption greater with electrolytes than in distilled water	Lefler and Kott, 1974
	Viruses	Adsorption increased as concentration of $CaCl_2$, Na_2SO_4, or NaCl increased	Moore et al., 1979

TABLE 6-2 (CONCLUDED)

FACTOR	ORGANISM	EFFECT	REFERENCE
Aerobic Conditions	Viruses	Inactivation much more rapid under aerobic than anaerobic conditions	Hurst et al., 1979
	Ascaris ova	Exposure to air or oxygen for 3 weeks necessary for ova to embryonate	Fitzgerald, 1979
Presence of Antagonistic Organisms	*Salmonella typhimurium* and *Bacillus dysenteriae*	*Pseudomonas fluorescens* is antagonistic	Rudolfs et al., 1950a
	Salmonella and dysentery bacilli	Growth suppressed by actinomyces	Bryanskaya, 1966
	Viruses	Survival affected adversely	Krone, 1968

[a] In sewage sludge pasteurized at given temperature.

[b] In sewage sludge in anaerobic digester operating at given temperature.

[c] In windrow composting of municipal solid waste-sewage sludge mixture.

[d] In composting of dewatered sewage sludge.

TABLE 6-3

CHARACTERISTICS OF DIFFERENT SOIL TEXTURES

TEXTURE* (Particle Size)	PARTICLE DIAMETER (mm)	NUMBER OF PARTICLES (per gram)	SURFACE AREA (cm^2/g)
Fine Gravel	2.00-1.00	90	11.3
Coarse Sand	1.00-0.50	722	22.7
Medium Sand	0.50-0.25	5,777	45.4
Fine Sand	0.25-0.10	46,213	90.7
Very Fine Sand	0.10-0.05	722,074	226.9
Silt	0.05-0.002	5,776,674	453.7
Clay	< 0.002	90,260,853,860	11,342.5

*U.S. Department of Agriculture classification.

SOURCE: Adapted from Fuller, 1977

clay, readily retains pathogens. Sand filters are used to treat water, and sandy soils are selected for use in the disinfection of wastewater by application to land (see Section 7). Coarser soils are less effective in preventing pathogen mobility. Shale, dolomite, limestone, and coarse sands and gravels do not effectively filter bacteria or higher parasites or adsorb viruses. Fractures in the weathered rocks and channels in the coarser soils act as conduits for leachate flow (Braids and Gillies, 1977) and do not allow retention of pathogens or attenuation of leachate. Table 6-2 provides data on the effect of soil type on survival and mobility of various pathogens.

6.5.2 Soil Moisture

Moisture is an important factor affecting pathogen survival and mobility in soil. Most pathogens require a minimum amount of soil moisture for survival, but soil saturation and seasonal precipitation cycles also affect the die-off rate. Most pathogens have difficulty thriving in dry soils, and saturated soils are detrimental to pathogen survival.

The rate at which a soil becomes saturated also affects pathogen mobility and survival. Gradual saturation of the soil induces a high level of virus inactivation but does not seem to affect bacteria (Glotzbecker and Novello, 1975). Rapid saturation may free absorbed viruses. Intermittent rather than continuous elution of soils enhances virus retention (Duboise et al., 1976; Benarde, 1973).

Virus migration patterns change with changes in the soil/water ratio because virus mobility is much greater in saturated than in unsaturated soils (Schaub and Sorber, 1977).

Conclusions concerning the effects of soil moisture on pathogen survival and growth are summarized in Table 6-2.

6.5.3 Soil pH

The pH value of the soil is another factor that determines pathogen survival and mobility by affecting pathogen growth, inactivation, and adsorption. Extremes of acidity and alkalinity in soil destroy most pathogenic organisms (Rudolfs et al., 1950a; Dotson, 1973; Wolman, 1977).

The capacity of soil particles to adsorb viruses is affected by the soil pH because viruses are amphoteric Acid soils (pH 5.5) enhance the retention of some viruses by soil particles (Duboise et al., 1976) whereas alkalinity (pH 9.0) generally enhances the release of viruses from soil particles, especially when rainfall is heavy (Duboise et al., 1976; Schaub and Sorber, 1977). Soils that do not adsorb viruses usually have a high pH (Burge and Enkiri, 1978). It should be noted that the pH of landfill leachate is generally within the range of 5.0 to 5.5 because of the production of organic acids during aerobic decomposition of the waste.

See Table 6-2 for additional data on the effects of soil pH on pathogens.

6.5.4 Soil Temperature

Soil temperature is an important factor in the growth and survival of microorganisms. Indigenous soil microorganisms are usually inactivated by low temperatures and killed by high temperatures. Indeed, the microorganisms that generate heat in compost systems sometimes produce such high temperatures that they are destroyed (Burge et al., 1977).

Moderate soil temperatures promote pathogen growth whereas temperature extremes are deleterious. Pathogen destruction at high temperatures and survival at low temperatures have been reported in numerous studies. Viruses are inactivated by colder as well as warmer soil temperatures. Pathogen inactivation is high at 55°C, a temperature that often occurs in landfills during the early phase of landfill operation (Engelbrecht, 1973). Data on the effects of soil temperature on pathogen growth, survival, and inactivation are presented in Table 6-2.

6.5.5 Other Factors

Other factors that affect pathogen survival and mobility in soil include salt and pollutant concentrations, and the presence of other microorganisms. See Table 6-2 for data on the effects on pathogens of ionic strength, aerobic conditions, and the presence of antagonistic organisms.

The concentration of salt (ionic strength) in soils is probably the most important factor in the adsorption of viruses onto soil particles (Duboise et al., 1976; Gilbert et al., 1976b; Vaughn et al., 1978). High ionic strength and the presence of divalent cations increase the adsorption and retention of viruses.

Conditions in natural soils differ from those in soils polluted by, for example, the application of sewage sludge. Because of these differences, survival and adsorption of viruses differ in these two types of soils. Long-term survival of viruses is greater under natural soil conditions than under polluted conditions (Wellings et al., 1975a; Rudolfs et al., 1950a). However, natural soils are more effective in adsorbing viruses (Duboise et al., 1976; Schaub and Sorber, 1977).

The survival of pathogens introduced into the soil also depends on the presence of other microorganisms. The interrelationships of different populations of exogenous and/or indigenous microorganisms in soil range from antagonism to synergism. For example, *Pseudomonas fluorescens* is antagonistic toward the pathogens *Salmonella typhimurium* and *Shigella dysenteriae* (Rudolfs et al., 1950a). No specific example of synergism involving a pathogenic microorganism in the soil was identified; however, an exogenous pathogen might be able to utilize a substrate provided by, for example, indigenous cellulytic bacteria.

6.5.6 Summary of Factors Affecting Fate of Pathogens in Soil

The fate of pathogens in soil has various aspects including survival, growth, and inactivation as well as retention by soil particles. Soil factors that affect pathogen fate are soil type, temperature, moisture, chemical composition, pH, and nutrient availability. Another factor is the condition of the pathogen at the time it is applied to the soil (i.e., the degree of debilitation, if any, that results from its previous environment). The presence of other organisms can also affect pathogen fate.

Temperature and pH are the principal factors that affect pathogen survival. The high temperatures and low pH that are characteristic of landfills during and after waste decompostion, respectively, enhance the inactivation and/or destruction of pathogens.

Bacteria and higher parasites are trapped in the soil by filtration, and they remain in the interstitial spaces between soil particles because of their large size. Bacteria cannot migrate more than a few feet through soil unless channelling or flooding occurs. Viruses are retained in the soil by adsorption onto soil particles. The adsorptive capacity of soil increases with increases in the surface area of the soil particles, the clay content, and the cation exchange capacity of the soil. Virus adsorption is not necessarily accompanied by virus destruction, and adsorbed viruses can retain their virulence and be infectious if they are released from the soil particles.

On the basis of the available data on pathogen fate in soil and in landfills (see Section 7), it can be concluded that conditions in a sanitary landfill are detrimental to the survival of pathogenic organisms that may be present in hospital solid waste. The high temperatures an acidity that result from waste decomposition in a landfill would kill or inactivate all, or nearly all, the pathogens contained in the landfilled waste. Surviving pathogens would be retained by the soil layers that are integral parts of a landfill and ultimately would be kept within the bounds of the landfill by the landfill liner (see Appendix J for a discussion of landfill design). Furthermore, landfill leachate, by virtue of its composition and characteristics (e.g., pH), enhances pathogen inactivation and death as well as retention by soil particles.

7.0 POTENTIAL PATHOGENIC CONTAMINATION OF GROUNDWATER: RELEVANT CASE STUDIES

The principal safety consideration associated with landfilling wastes containing pathogens is the possible spread of disease through groundwater contamination. Pathogens present in the waste may be transported with the leachate (liquid that has percolated through or drained from the waste and contains dissolved or suspended components of that waste) and may, in the absence of adequate flow barriers, reach the groundwater. Only a few data are available on the fate of pathogens in landfilled hospital wastes. Consequently, case studies of possible groundwater contamination from municipal landfills and from land treatment of municipal wastewater were examined because of their relevance to the landfill disposal of hospital waste containing pathogenic organisms. The pathogens that are present in municipal solid waste and municipal wastewater are similar to those present in hospital solid waste. Furthermore, these studies are relevant because they involve landfilling (of municipal solid waste) and the direct application of pathogens (in the municipal wastewater) to the soil.

7.1 Municipal Landfill Studies

Pathogen survival and fate in municipal landfills has been studied in seeding experiments, in lysimeter leachate studies, and in studies of leachate from operating and inactive landfills. Many of these experiments were sponsored by EPA's Municipal Environmental

Research Laboratory (Brunner, 1979) and by the Proctor and Gamble Company.

Seeding experiments in landfills have demonstrated that the high temperatures generated in landfills during aerobic degradation are sufficient to kill most microorganisms (Brunner, 1979). No bacteria were recovered from municipal solid waste seeded with Salmonella. The rate of virus die-off was temperature-dependent--no viruses were recovered when the landfill temperature reached 57°C,* and when the maximum temperature was 27°C, die-off was significant within 90 days (about 10^2 PFUs of poliovirus were recovered from a seed of 10^8 PFUs). Virus debilitation and/or die-off probably continues beyond the 90 days that constituted the test period in these experiments. It should be noted that field capacity, a condition necessary for leachate generation, is not reached in a well-operated landfill for about 18 months (Brunner, 1979), and therefore few, if any, microorganisms would be viable at that time for transport with the leachate.

The findings from lysimeter studies have been inconsistent; this verifies that lysimeters cannot duplicate the conditions in *in situ* landfills, and therefore that data from lysimeter studies should not

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*A maximum temperature of 57°C was recorded when the waste was landfilled in midsummer whereas the maximum was 27°C when the ambient temperature was about freezing at the time of landfilling.

be extrapolated to actual landfills. In some experiments, bacteria and viruses were recovered from municipal solid waste saturated with water, i.e., in the lysimeter leachate (Cooper et al., 1975; Scarpino et al., 1979; Brunner, 1979). In other experiments, no viruses were detected in the leachates collected for 4 months from lysimeters seeded with poliovirus type 1 and echovirus type 7 (Sobsey et al., 1975). Experiments also demonstrated that viruses are rapidly adsorbed onto various components of municipal solid waste in the presence of a salt solution (similar in composition to leachate) and that viruses are inactivated in leachate (Sobsey et al., 1975).

Twenty-one municipal landfills in the United States and Canada were studied to determine if viruses were present in the leachates (Sobsey, 1978). All the landfills contained municipal solid waste; some also contained hospital solid waste and/or sewage sludge. The landfills that were selected for inclusion in the study were characterized by differences in type (not all were sanitary landfills), age, depth of fill, frequency of cover, status (i.e., active or inactive), and presence or absence of impervious liners. Most of the landfills selected for inclusion in the study were located in colder climates in order to maximize the possibility that microorganisms had survived in the landfills and leachates. Leachate samples were collected from seepage points and from wells of different depths within and at various distances from the landfills.

Hospital waste was present in 7 of the 21 landfills, and 1 also contained digested sewage sludge. Of these seven landfills, six were sanitary landfills, two of which were inactive. No viruses were detected in any of the leachates from the seven landfills that contained hospital waste. Fecal coliforms were present at high concentration only in the leachate from the one nonsanitary landfill.

Viruses, identified as poliovirus types 1 and 2, were isolated from only one of the leachate samples collected from the 21 landfills. This leachate was produced by an active nonsanitary landfill that contained only municipal solid waste; the leachate sample was collected at a large seep from the inadequately sealed face of refuse that was newly placed on a hillside.

Based on this study, it appears that viruses will not be present in the leachate if the landfill is designed and operated as a sanitary landfill. Furthermore, the type of waste disposed in the landfill (i.e., hospital or municipal solid waste) does not seem to affect the presence of viruses in the landfill leachate. It should be noted that there are no reports of biological contamination of groundwater attributable to landfilled solid waste.

From this study, Sobsey concluded that, "considering the low concentrations of enteric viruses in raw leachates and the opportunities for further virus reductions by thermal inactivation, removal in soil and dilution in ground or surface waters, it would seem that leachates from properly operated sanitary landfills do not constitute an environmental or public health hazard due to enteric viruses" (Sobsey, 1978). This position is supported by the absence in the literature of reports of biological groundwater contamination attributable to municipal landfills.

7.2 Land Treatment of Municipal Wastewater

The principal area of concern with landfilled hospital waste is the possibility of pathogen contamination of groundwater. Relevant to this problem is land treatment of municipal wastewater, a technique by which treated effluent is applied to land. This procedure results in direct application to the soil of the pathogenic organisms that are present in the effluent as well as large volumes of water. Case studies of land application of municipal wastewater would demonstrate whether pathogens move through the soil with the wastewater and whether groundwater contamination has resulted.

Approximately 700 communities in the United States use land application as a method of disinfecting municipal wastewater (Thomas and Reed, 1978). Other benefits of this technique are reduction of the costs of treating wastewater, reduction of the discharge of wastewater to surface water, economic utilization of the water and the nutrient content of wastewater, and removal of toxic substances from the wastewater (Van Donsel and Larking, 1977). Three different methods are used for wastewater land treatment: slow-rate, rapid infiltration, and overland flow. Table 7-1 presents the major characteristics of each method.

TABLE 7-1

CHARACTERISTICS OF THE MAIN METHODS OF LAND TREATMENT OF SEWAGE EFFLUENTS[a]

CHARACTERISTIC	METHOD: SLOW RATE	METHOD: RAPID INFILTRATION	METHOD: OVERLAND FLOW
Soil Permeability	Moderately slow to moderately rapid	Rapid (sands and sandy loams)	Slow (clays and clayey loams)
Wastewater Loss	Evapotranspiration and percolation	Mainly percolation	Surface runoff and evapotranspiration with some percolation
Vegetation Required	Yes	No	Yes
Weekly Application Rate (in/wk)	0.5-4	4-120	2.5-16
Annual Application Rate (ft/yr)	2-20	20-560	10-70
Land Required[b] (acres/mgd)	56-560	2-56	16-110
Application Technique	Sprinkler or surface	Usually surface	Sprinkler or surface

[a]Adapted from Crites and Pound (1976) and Thomas and Reed (1978).
[b]Field area only; does not include buffer area, roads, or ditches.

The rapid infiltration method of wastewater application to land was selected for consideration because it involves the coarsest soils and the largest volumes of water--i.e., the worst conditions from the aspect of landfilling. Rapid infiltration sites that were/are being monitored for adverse effects on the local groundwater include Vineland, New Jersey (Koerner and Haws, 1979), Fort Devens, Massachusetts (Schaub and Sorber, 1977), and Phoenix, Arizona (Bouwer, 1976; Gilbert et al., 1976a, 1976b). Other case studies are compiled in the EPA Process Design Manual for Land Treatment of Municipal Wastewater (EPA, 1977c).

The Vineland system has been used for approximately 50 years to treat primary effluent, and there is now an extensive monitoring program. Viruses and fecal coliforms were detected in 1977 immediately beneath the application basin, but none were detected in monitoring wells located around the site. Therefore, although some microorganisms are present directly beneath the application site, none have migrated beyond the site perimeter.

At Fort Devens, a site composed of unconsolidated silty sand and gravel has been used since 1942 for rapid infiltration. Observation wells are situated at the periphery of the application site and at various locations downgradient toward a nearby river, and there have been no reports of groundwater contamination resulting from operation of the system. When the wastewater was spiked with f_2 bacteriophage at the high concentration of 10^5 plaque-forming units per milliliter of applied wastewater, tracer was detected at the periphery of the application site and occasionally in downgradient wells. This finding does not necessarily indicate that the system is inadequate because the experiment did not duplicate operating conditions and laboratory tests demonstrated that f_2 bacteriophage would not be adsorbed by this soil under the experimental conditions.

In Phoenix, secondary effluent has been applied since about 1967 at the rate of 230 to 330 feet annually. After 7 years of operation, neither viruses nor bacteria were detected in the sampling wells (located 20 to 30 feet from the application basin).

Although the 1978 Report to Congress of the Office of Drinking Water (EPA, 1978c) raised some questions about the possibility of pathogenic contamination of groundwater by land treatment of municipal wastewater, it is the contention of experts in the field that wastewater treatment by application to land is an adequate and safe method of disinfection that does not pose a groundwater contamination hazard (Reed, 1979). In addition, the EPA Policy on Land Treatment of Wastewater of 3 October 1977 (EPA, 1977b) is based on the premise that land treatment is capable of achieving treatment levels comparable to those achieved by the best of the advanced wastewater treatment technologies (Thomas and Reed, 1978).

The data on land application of municipal wastewater can be extrapolated to landfilling hospital solid waste. The rapid infiltration system involves the application of large volumes of wastewater to coarse, textured soils (i.e., sand). The clays that are used in landfill construction are much more effective than sandy soils in retaining microorganisms. Furthermore, the volume of leachate that would be generated in a sanitary landfill is very small (compared with the volume of wastewater percolating through the soil at a rapid infiltration site) because conditions in the sanitary landfill minimize leachate generation. Therefore, inasmuch as sandy soils are effective in disinfecting wastewater, the clay layers within and bordering/lining the anitary landfill would be effective in retaining any pathogens from landfilled hospital solid waste that may remain viable.

7.3 Conclusions

The data on pathogen fate that are available from experiments and from case studies of municipal landfills and land treatment of municipal wastewater provide evidence that hospital solid waste containing pathogens can be safely disposed in sanitary landfills. The principal factors are:

- Most if not all pathogens will not survive the high temperatures that are generated in the landfill during aerobic degradation of the waste.
- It is probable that any surviving pathogens would be retained by the waste and the soil layers that are within the landfill--viruses by adsorption onto the waste components and the soil particles, bacteria and higher parasites by filtering.
- It is unlikely that pathogens would survive for prolonged periods in landfill leachate.
- It is unlikely that pathogens in leachate would be transported through the liner, beyond the borders of the sanitary landfill, to the groundwater.

Therefore, on the basis of the available information, it is concluded that landfilling hospital solid waste containing pathogens in sanitary landfills is a safe procedure that poses no threat to human health or the environment through contamination of groundwater.

8.0 DATA GAPS, RESEARCH IN PROGRESS AND RECOMMENDATIONS FOR FURTHER RESEARCH

On the basis of the available evidence, it is concluded that landfilling is a safe and suitable method for disposal of hospital solid waste that contains pathogenic organisms. Data gaps--that are not sufficient to undermine these conclusions--are identified in this section as required by the scope of the project. Current research relevant to landfill disposal of hospital solid waste containing pathogens is summarized. Recommendations are made for research that would advance the state-of-the-art. The willingness of federal agencies to participate in joint research efforts in this field is also reviewed.

8.1 Data Gaps

Although conclusions can be drawn about the safety of landfill disposal of hospital solid wastes containing pathogenic microorganisms, there are data gaps in the available information relevant to this subject. The identified data gaps pertain to many aspects of the problem, including characterization of the pathogens associated with hospital solid wastes, disease causation, landfill dynamics and the effects on microorganisms, microbial interactions, sampling methods and selection of indicator organisms, disinfection techniques, landfill site selection and operation, and groundwater monitoring.

8.1.1 Characterization of the Pathogens Associated with Hospital Solid Wastes

Because of the paucity of data about the pathogenic organisms that are contained in hospital solid wastes, tentative conclusions about the infectiousness of these wastes must be inferred from information about hospitals and disease. In addition, it is not known if hospital solid wastes are unique in types of associated pathogens and degree of infectiousness. It is important that data be obtained about types of pathogens in hospital solid waste and their numbers, viability, and virulence. Sampling methods are discussed in Sections 8.1.5 and 8.2.5.

8.1.2 Disease Causation

More information about causation of disease is needed in order to assess the risk to human health that is posed by hospital solid waste containing pathogenic microorganisms. The relation of pathogen virulence and numbers to degree of infectiousness must be ascertained. The effects of the solid waste and landfill environments on pathogen virulence and ability to transmit/cause disease are not known. Current research projects on health risks associated with waste disposal (Section 8.2.1) may provide some of the missing information.

8.1.3 Landfill Dynamics and the Effects on Microorganisms

.iere is a lack of definitive information about the dynamics of the landfill, the changes that occur (in temperature, pH, moisture content, and aeration), and the effect of the changing conditions on microbial fate over the short and long terms. Current research projects in this area are discussed in Sections 8.2.2 and 8.2.3.

8.1.4 Microbial Interactions

Information is needed about microbial populations and their interactions. Data gaps include information about the interactions among microbial populations indigenous to soil and between indigenous populations and populations of exogenous microorganisms introduced by land disposal of wastes. It is important to know if the interaction is antagonistic and whether such antagonism can be enhanced to increase the rate of pathogen die-off. There is some ongoing research on microbial interaction (see Section 8.2.3).

8.1.5 Sampling Methods and Selection of Indicator Organisms

Sampling methods and isolation procedures for the quantitative determination of microorganisms from environmental sources have not been perfected. Techniques are needed that are applicable to sampling solid waste, leachate, and/or groundwater. One problem is selection of representative microorganism(s) that will be reliable indicator(s) of pathogenic contamination. The selected indicator organism(s) must be present in the hospital solid waste in sufficient numbers to be easily detected and must have a prolonged survival in the landfill that at least equals that of most pathogens. Many current research projects pertain to sampling methods and indicator organisms (see Sections 8.2.5 and 8.2.6).

8.1.6 Disinfection Techniques

Information about various disinfection techniques is important because disinfection renders the infectious hospital wastes non-hazardous and their disposal would therefore not be regulated under Section 3004 of RCRA. Another approach would be to disinfect landfill leachate if it were found to be infectious. Various current research projects are evaluating techniques for disinfecting waters; the disinfection methods under study include chlorination, ozonation, ultraviolet irradiation, and electrochemical treatment (see Section 8.2.4).

8.1.7 Landfill Site Selection and Operation

Information about landfill dynamics and the effects on microorganisms (Sections 8.1.3 and 8.2.3) can be applied in developing criteria for site selection and in developing operation procedures in order to maximize microbial die-off through a combination of natural and induced conditions.

8.1.8 Groundwater Monitoring

Groundwater monitoring would verify that the pathogens in hospital solid waste are killed and/or contained within the confines of the landfill. Appropriate sampling techniques are needed as well as selection of indicator organisms (see Sections 8.1.5, 8.2.5, and 8.2.6). In addition, more information is needed about the infectious dose, i.e., the minimum number of pathogenic microorganisms that must be present in the water supply to transmit disease (see Section 8.1.2).

8.2 Research in Progress--1975 to 1978

Recent research projects that are relevant to landfill disposal of infectious hospital solid wastes were identified by computer search of the Smithsonian Science Information Exchange (SSIE) (see Appendix K). The SSIE search identified 32 such projects that were in progress between 1975 and November 1978. The projects pertain to health risks associated with waste disposal, land disposal of wastes, microbial fate, the control of pathogenic organisms, techniques for sampling microorganisms in water, air, and soil, and selection of indicator organisms.

In the following brief discussions of selected projects, the numbers in parentheses refer to the projects as listed in Appendix K.

8.2.1 Health Risks Associated with Waste Disposal

The handling and disposal of solid wastes and wastewater present potential health hazards to workers as well as to the general population living near the treatment plants and disposal sites. Epidemiological studies of exposed populations and studies of the health aspects of waste disposal are relevant to this study because of the information they may provide about the pathogens associated with different wastes and the assessment of the risk involved.

Only one research project, however, pertains to hospital solid wastes. It is a study of the hygiene and welfare aspects of solid waste management at United States Army hospitals (K-4).

Several epidemiological studies are being conducted to determine the health risks associated with wastewater and wastewater aerosols.

The subjects include sewer maintenance workers (K-20), and operating personnel and the general population in the vicinities of a wastewater treatment plant (K-26), and the site of spray application of wastewater to land at Army installations (K-6).

Other studies are concerned with the potential contamination (of groundwater) and potential human health risk accompanying land disposal of municipal wastewater sludges. In these research projects, bacteria (K-16) as well as viruses (K-28, K-29) are being studied.

The presence of microorganisms in the environment that is attributable to the wastes is also being determined. The aqueous media being examined include wastewater (K-2, K-7, K-19, K-20), surface runoff from soils to which municipal wastewater sludge has been applied (K-29), and water within 3 miles of a wastewater treatment plant (K-26). Aerosols in sewers (K-20), in and near wastewater treatment plants (K-19, K-26), and near the site of spray application of wastewater to land (K-6, K-7) are being analyzed. The presence of pathogens originating from a wastewater treatment facility is being sought in the soil within a 3-mile radius of the site (K-26).

No studies were found in the available literature attributing incidents of infectious disease to landfilling hospital wastes.

8.2.2 Land Disposal of Wastes

Many of the identified research projects pertain to various aspects of the land disposal of wastes. These studies of different factors that determine the effectiveness and safety of land disposal and evaluations of particular disposal techniques are applicable to landfilling hospital solid wastes. (Studies that relate to microbial fate are discussed in Section 8.2.3.)

Data obtained in a study of drainfields will be used to develop criteria for the suitability of soils for waste disposal (K-31). Determination and quantification of soil and climatic factors that affect the performance of drainfields will permit evaluation of alternatives in the design and management of disposal systems. The effects of soil texture and the level of soil moisture on the rate of water movement are also being studied in this research project. In another project on drainfields, the relation of soil type to bacterial movement through the soils, which are intermittently saturated, is under study (K-15).

Another study is evaluating the virus- and bacteria-removing capabilities of a groundwater recharge system in order to determine its ability to return microbiologically acceptable waters to the aquifer (K-17). Two studies pertain to land application of wastewater. One is a microbial evaluation of wastewater application to land by rapid infiltration and overland flow (K-7). The other project is a study of the response of fecal coliforms to overland flow conditions, the effects of storms on treatment efficiency, and mobility of microorganisms from the overland flow system (K-5).

The infiltration of precipitation into land disposal sites can lead ultimately to the generation of leachate which could convey microorganisms beyond the confines of the landfill. One current research project--a study of low-level radioactive hospital wastes buried in trenches--is collecting information about and examining techniques for controlling the infiltration of precipitation into land disposal sites (K-24).

8.2.3 Microbial Fate

Many of the current research projects are examining the effects of environmental and biological factors on the survival and mobility of microorganisms in wastes. Microbial fate as determined by soil, air, water, and climatic factors and microorganism populations is being studied in these projects.

The soil factors under study include soil type, texture and structure, pH, temperature, moisture, organic loading, and cation exchange capacity. Projects pertain to the effects of soil type on adsorption of viruses (K-2, K-10, K-14), inactivation of viruses (K-10, K-14), transport and migration of bacteria (K-16) and viruses (K-28, K-29), and survival of bacteria (K-16) and viruses (K-9, K-17, K-28, K-30). Other studies include:

- the effects of soil pH on viral adsorption (K-2), viral (K-28) and microbial (K-7) migration, and pathogen survival (K-3, K-7, K-28)

- the effect of soil temperature on survival of bacteria (K-3, K-16)

- the effects of soil moisture on viral adsorption (K-28), pathogen mobility (K-7, K-15), and pathogen (K-7) and bacterial (K-3, K-15, K-16) survival

- the effects of organic loading on pathogen mobility and survival (K-7)

- the effects of the type of cation present and the cation exchange capacity of the soil on viral transport and survival (K-28).

Microbial viability in aerosols from wastewater is the subject of two studies. One study is sampling airborne pathogenic viruses and bacteria from wastewater effluent applied to soil by spray irrigation (K-7). In the other study, the ambient air downwind of a wastewater treatment plant is being examined for the presence of pathogenic microorganisms (K-19).

There are two on-going research projects that pertain to microbial fate as affected by water factors other than soil moisture. One is a study of the effect of the ionic strength of wastewater effluent on adsorption of viruses by clay (K-2). The other is a study of the mechanism of bacterial debilitation in natural waters and the biochemical/biophysical causes of bacterial injury and stress (K-18).

The virucidal effect of indigenous soil bacteria on viruses introduced into the soil with municipal wastewater and wastewater sludge is being studied (K-30). Similarly, another study is examining the interactions of enteric viruses applied to the soil in wastewater (K-9). The bactericidal and bacteriostatic effects on *Shigella* of other microorganisms in polluted water are under study in another research project (K-27).

8.2.4 Control of Pathogenic Organisms

Research on the control of pathogenic microorganisms deals primarily with disinfection of water and wastewater. The findings of these studies would be relevant to disinfection of landfill leachate. The disinfection techniques being studied include chlorination, ozonation, ultraviolet irradiation, and electrochemical treatment. (Research projects on treatment of wastewater by land application are discussed in Section 8.2.2.)

The effectiveness of ultraviolet irradiation, ozonation, and chlorination--individually and in combination--in treating runoff from animal holding areas is being evaluated (K-1, K-32). The dynamics of ozone inactivation of enteric viruses are being studied in order to establish guidelines for dosage and contact times during ozonation of wastewater secondary treatment effluents (K-2, K-12). The rates of chlorine inactivation of reovirus and MS-2 coliphage are also under study (K-10). Another research project (K-8) is examining the feasibility of using an electrochemical process to disinfect wastewater and water in reuse water systems for Army hospitals and laundries; waters contaminated with bacteria, viruses, and fungi are being used in order to ascertain the reliability of the biocidal effects of the process.

8.2.5 Techniques for Sampling Microorganisms

Techniques are being developed/improved for use in the sampling, detection, identification, and enumeration of viruses and bacteria in the environment. Most of these research projects pertain to the isolation of microorganisms from various water samples, but air-sampling techniques and isolation from soils are also under study.

Rapid methods of identifying and quantifying bacteria in water are based on resonance Raman spectroscopy (K-13), on the release of ^{14}C-carbon dioxide from labeled ^{14}C-mannitol (K-23), and on pH colorimetric changes (K-23). The Bactometer is being used in a method that rapidly determines the growth of bacteria in treated water (K-11). Two other studies involve the recovery and enumeration of *Shigella* in polluted water (K-27) and enumeration of fecal and nonfecal *Escherichia coli* (K-18).

Methods that may be applicable to screening water and wastewater for viruses are the fluorescent virus precipitin test (K-10, K-14), immunoenzymatic method (K-21), and the use of laser-excited fluorescence with a tunable acousto-optical filter (K-25).

Quantitative methods of sampling airborne pathogenic viruses and bacteria in wastewater aerosols are being developed and evaluated (K-7).

A method of recovering viruses from soil is being assessed (K-29). Sonication is being evaluated as a method of determining virus adsorption onto particulate matter (K-22). Another research project is perfecting the use of antibiotic-resistant fecal bacteria as biological tracers to indicate bacterial movement from applied wastes through the soil (K-31).

8.2.6 Indicator Organisms

The selection of appropriate indicator organisms is essential in order to obtain a valid indication of the presence of pathogenic microorganisms in various media. Indicator organisms can also provide information about the responses of pathogens to waste treatment practices and waste disposal environments.

One study involves quantification of viruses and coliforms in untreated surface waters in order to determine if the number of total or fecal coliforms can be used to indicate quantitatively the presence of viruses (K-22).

Some studies are endeavoring to identify the bacterium that is most suitable for use as the indicator of pathogenic bacteria in soils. Among the organisms being tested for this purpose are fecal coliforms (K-15, K-16), fecal enterococci (K-16), salmonellae (K-15, K-16), and fecal streptococci (K-15).

The use of reovirus as a standard test virus in virological investigations of virus inactivation and removal in water has been proposed (K-10, K-14).

8.3 Recommended Research

The available evidence is consistent in supporting the conclusion that landfill disposal of hospital solid waste containing pathogenic microorganisms is safe. Nevertheless, data gaps do exist and research could advance the state-of-the-art and provide additional supportive data. Of first priority is the characterization of the infectiousness of hospital solid waste. If it is ascertained that general hospital waste* is sufficiently infectious to constitute a hazard to human health, additional research in two areas would be important: landfill dynamics and the effects on microbial fate, and microbial interactions. Research in another area, disinfection techniques, should be given lower priority.

8.3.1 Characterization of the Infectiousness of Hospital Waste

The extent to which hospital waste actually is infectious is not known and, therefore, research in this area should be given first priority. For example, information concerning the types and quantities of pathogens in the waste and the viability and virulence of these organisms must be available before the extent of the associated hazard, if any, can be ascertained. This information is needed to determine suitable waste disposal management practices and the areas in which additional research may be required. Research areas that could provide the missing data include:

- identification and quantification of the pathogenic organisms contained in hospital solid wastes at the time of waste collection
- identification and quantification of pathogens in the solid wastes generated by each hospital department
- determination of pathogen survival in the waste; therefore, identification and quantification of pathogens in the waste at the time of disposal
- determination of the infectiousness of hospital solid wastes

*That is, excluding potentially infectious wastes from pathology, surgery, autopsy, and clinical laboratories, as well as all wastes from infectious disease wards that are routinely incinerated in pathological incinerators or sterilized by autoclaving prior to ultimate disposal.

One approach to these research projects involves the direct sampling and isolation of the microorganisms. Another approach utilizes epidemiological studies of handlers of hospital wastes; immunological changes in the exposed population should be indicative of occupational exposure to pathogens.

8.3.2 Landfill Dynamics and the Effects on Microbial Fate

Research on the dynamics of the landfill, the changes that occur with time, and their effects on the fate of the pathogens would provide information about the fate of pathogens within the landfill and the soil under various specific conditions. Suggested research in this area includes:

- elucidation of the mechanism of microbial adsorption by soil particles, its extent, and the factors that affect it (including determination of the adsorptive capacity of soils in terms of soil type, loading, and time)
- elucidation of the patterns and factors that determine pathogen migration and transport through different types of soil
- determination of the survival rates of pathogens in landfills and soil
- studies of the factors, natural as well as induced, that are responsible for microbial inactivation or death in soil
- development of a model for viruses and bacteria to predict survival rates under different sets of conditions
- determination of landfill operating conditions that would maximize pathogen inactivation and death

In addition to studies using soil columns and lysimeters, it is necessary to study soil core samples from *in situ* landfills in order to obtain information on pathogen viability in landfills under operating conditions.

8.3.3 Microbial Interactions

Research on the interactions that occur between/among microbial populations would determine if the interactions of exogenous pathogens (i.e., those added to the soil with the landfilled hospital solid waste) with the indigenous microbial populations are antagonistic and, if so, how the antagonism can be enhanced to increase the rate of pathogen die-off. Specific study areas include:

- the interactions of exogenous pathogens with the indigenous microbial populations
- factors that effect microbial antagonism to the detriment of the pathogenic microorganisms
- methods of enhancing such microbial antagonism

8.3.4 Disinfection Techniques

One approach to the management of infectious solid waste is disinfection prior to disposal. Certain types of hospital wastes that are highly infectious (i.e., wastes from pathology, surgery, autopsy, clinical laboratories, and infectious disease wards) are now routinely disinfected by incineration in pathological incinerators or by autoclaving. Research could provide feasible alternatives to these two disinfection methods that might be readily applicable to other, less infectious solid wastes. The objectives of research in this area should be:

- evaluation of various treatment techniques applicable to infectious hospital solid waste (e.g., autoclaving, X-ray irradiation, ultraviolet irradiation, electron treatment, gas sterilization)

- development of an efficient and economical method of destroying pathogens in solid waste

Alternatively, media that might be contaminated by the landfilled infectious waste (i.e., landfill leachate) could be disinfected. Research in this area should examine the various applicable disinfection techniques (e.g., chlorination, ozonation, ultraviolet irradiation, electrochemical treatment), evaluate the effectiveness of each, and develop methods of large-scale, low-cost application.

8.4 Opportunities for Joint Research with Other Federal Agencies

Opportunities for joint research with other federal agencies regarding the disposal of potentially infectious hospital wastes were investigated. Since formal proposals were not offered to the agencies, their comments were necessarily noncommittal. The following federal agencies were contacted by telephone: the National Naval Medical Center, the Office of the Surgeon General of the Air Force, and the Office of the Deputy Assistant Secretary for Energy, Environment and Safety in the Department of Defense; the National Institutes of Health (NIH), the Public Health Service, and the Center for Disease Control (CDC) in the Department of Health, Education, and Welfare; and the Veterans Administration. The persons contacted are listed in Table 3-3.

Two of the seven agencies contacted indicated a willingness to discuss possible joint research projects. Mr. Harvey Rogers, Senior

Sanitary Engineer at NIH, said that NIH would also consider joint research possibilities. Mr. Edward Powell, Environmental Care Specialist at the Veterans Administration, indicated a willingness to consider proposals for joint research, particularly because problems in the separation of hospital wastes were creating a trend toward incineration of all hospital wastes. Mr. George Mallison, Assistant Director of the Bacterial Diseases Division of the CDC, claimed that no additional research in the field of hospital waste disposal is necessary because landfilling has been demonstrated to be a safe and suitable disposal technique. Representatives of the other four agencies contacted had no comment about possibilities for joint research on the disposal of hospital wastes.

It was suggested that an appropriate joint activity for federal agencies potentially affected by the EPA-proposed regulations would be to sponsor panel discussions on the disposal of hospital wastes. Both Mr. Mallison of CDC and Mr. Rogers of NIH expressed a willingness to participate on such panels.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

9.1.1 Suitability of Landfill Disposal of Infectious Hospital Waste

The disposal of infectious hospital waste* in sanitary landfills appears to be a feasible and safe method of disposal. This conclusion is based on available information in the literature pertaining to experimental studies, in situ landfills, and land treatment of municipal wastewater. It also takes into account the opinions of experts in the fields of public health and microbiology.

Conditions within the properly constructed and maintained landfill make it unlikely that any pathogenic organisms would remain viable and be transported beyond the confines of the landfill. In addition, there is no evidence of adverse effects on human health or the environment caused by landfilled hospital wastes containing pathogenic organisms. Nor has there been any reported contamination of groundwater--or even of landfill leachate--that is attributable to landfilled hospital waste. Furthermore, land treatment of municipal wastewater is a demonstrated disinfection technique that affects

*In this discussion, the term "infectious hospital waste" refers to hospital solid waste that may have become contaminated by exposure to etiologic agents. It does not include the inherently infectious waste that is routinely disinfected prior to ultimate disposal in accordance with the standard operating procedure in U.S. Army and civilian hospitals as stated in U.S. Army regulations (U.S. Army, 1974) and in the standards of the Joint Commission on Accreditation of Hospitals (JCAH, 1979).

pathogen removal by passage through soil; there is no evidence of groundwater contamination caused by this procedure. The conclusion that proper landfill disposal (i.e., disposal in a sanitary landfill) of infectious hospital waste presents no risk to human health and the environment is supported by the public positions of many experts in the government as well as the private sector (Appendix E).

If proper landfill practices are used--i.e., those that meet the proposed performance standards for sanitary landfills--infectious hospital wastes can be safely landfilled without constituting a potential hazard to human health or the environment.

9.1.2 Proposed Definition of Infectious Waste

In response to RCRA, which included infectious waste in the category of hazardous wastes, EPA has proposed to define hospital infectious waste as all solid waste generated by ten specified hospital departments (Federal Register, 1978). However, this definition does not take into account standard hospital operating procedure whereby inherently infectious and potentially hazardous waste is disinfected (i.e., rendered nonhazardous) prior to ultimate disposal.

Many of the comments in the Public Docket that are relevant to infectious waste pertain to the proposed definition of infectious waste (Appendix E). The essence of these comments is that the proposed definition is too inclusive and that infectious hospital waste is not hazardous.

Classification of infectious hospital waste as a "special waste" is one alternative that is permitted under Section 3004 of RCRA.

This alternative seems to be more appropriate based on the available information. The requirement for disposal in accordance with the guidelines for hazardous waste disposal appears to be unnecessary, and classification of infectious hospital waste as a special waste would make it subject to different regulations for disposal.

9.2 Recommendations

It is recommended that the U.S. Army Environmental Hygiene Agency (AEHA) continue to recommend that EPA classify hospital waste containing pathogens as a "special waste." Furthermore, it is recommended that AEHA suggest that the "special waste" regulations for disposal of infectious hospital waste consist of:

- the requirement for disinfection by incineration or autoclaving of pathology, surgery, and autopsy wastes and the waste from isolation wards prior to ultimate disposal;
- the requirement that landfilled hospital waste be disposed in sanitary landfills, i.e., that landfilling be consistent with the criteria promulgated under Section 4004 of RCRA.

Disposal of hospital solid waste by the U.S. Army will continue unregulated by EPA until final regulations are promulgated and come into effect. The following practices for disposal of hospital wastes by the U.S. Army are recommended for implementation until such time as EPA regulations may necessitate modification of these disposal practices. The incineration of infectious waste in a pathological incinerator as the preferred method of disposal, as specified in Army Regulation 40-5-9, should be retained as standard operating procedure. Incinerator residue and the remaining hospital solid waste should be disposed of in sanitary landfills that are operated in accordance with the criteria for solid waste disposal facilities as promulgated under Section 4004 of RCRA (Federal Register, 1979a).

It is recommended that research be undertaken to ascertain the infectiousness of hospital solid waste in general, and of that generated by the ten specified hospital sources in particular. Information about the pathogens associated with hospital solid wastes, pathogen viability in the waste, and their infectiousness and virulence is needed in order to establish (1) if hospital solid waste is infectious at the time of disposal; (2) if so, the nature and degree of infectiousness; and (3) if such infectiousness constitutes a hazard to human health and/or the environment.

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APPENDIX A

SUMMARY OF SUBTITLES A, C, AND D OF THE RESOURCE CONSERVATION AND RECOVERY ACT OF 1976

I. Solid Waste Management Guidelines

Subtitles A and D of RCRA contain guidelines for solid waste management. Section 1008 (Subtitle A) requires EPA to publish guidelines to:

- provide technical and economic descriptions of the level of performance that can be attained by various available solid waste management practices which provide for the protection of public health and the environment

- describe levels of performance, including appropriate methods and degrees of control, that protect the public health and the environment, the quality of ground and surface water from leachates and from runoff, and ambient air quality, and that provide disease and vector control, safety, and aesthetics

- provide minimum criteria to be used by the states to define solid waste management practices which constitute the open dumping of solid or hazardous waste

The major objective of Subtitle D is to provide federal technical and financial assistance to state or regional authorities for the development and implementation of environmentally sound methods for solid waste disposal. The solid waste management plan is comprised of Sections 4002 through 4005.

Section 4002 requires the promulgation of guidelines designed to assist state and local authorities in developing solid waste management plans. Section 4003 describes the minimum requirements with which state or local authorities must comply in order to have a solid waste management plan approved by EPA. Section 4004 requires the promulgation of standards containing criteria for determining whether a solid waste disposal facility will be classified as a sanitary landfill or an open dump. Section 4005 requires EPA to publish an inventory of all open dumps, and requires each state to develop a plan to close or upgrade open dumps to comply with the Section 4004 criteria.

II. Hazardous Waste Management

Subtitle C of RCRA requires EPA to initiate a hazardous waste regulatory program designed to establish a comprehensive system for the safe disposal, treatment, storage, or reuse of hazardous waste. The details are specified in Sections 3001 through 3006.

Section 3001 (Subtitle C) requires EPA to develop and promulgate criteria for identifying the characteristics of hazardous waste and to list particular hazardous wastes, taking into account toxicity, persistence, degradability in nature, potential for accumulation in tissue, flammability, corrosiveness, and other hazardous characteristics.

Section 3002 establishes standards for generators of hazardous waste, including requirements for recordkeeping, labeling, and containerization, the use of a manifest (or tracking) system, and periodic reporting of hazardous waste generation. The manifest document will be used to record and assure the movement of hazardous wastes from the generation site to an authorized off-site treatment, storage, or disposal facility. Information to be recorded in the manifest includes the quantities, constituents, and disposition of the hazardous waste.

Section 3003 of the Act requires the promulgation of standards for transporters of hazardous waste. These include requirements for recordkeeping, labeling, compliance with the manifest system, and delivery of wastes only to designated facilities.

Section 3004 requires the promulgation of performance standards applicable to owners and operators of hazardous waste management facilities, as may be necessary to protect human health and the environment. This section also requires the promulgation of standards for the location, design, construction, and maintenance of treatment, storage, and disposal facilities. These standards also include requirements for recordkeeping, reporting, monitoring, inspection, compliance with the manifest system, contingency plans, personnel training, and financial responsibility.

Section 3005 of the Act requires EPA to promulgate regulations requiring the owners or operators of hazardous waste management facilities to obtain a permit. The facilities must be in compliance with the requirements of Section 3004 before a permit will be granted.

Section 3006 authorizes EPA to promulgate guidelines to assist states in the development of state hazardous waste programs. Each state that seeks to administer its own hazardous waste program must demonstrate that its program is equivalent to or stricter than the federal program, consistent with the federal or state programs applicable in other states, and provides adequate enforcement of compliance. An authorized state program is administered in lieu of the federal program.

APPENDIX B

SUMMARY OF EPA'S PROPOSED REGULATIONS

CONTENTS--APPENDIX B

APPENDIX B-1

SUMMARY OF PROPOSED AND FINAL REGULATIONS APPLICABLE TO LANDFILLS FOR SOLID WASTE DISPOSAL FACILITIES UNDER SECTIONS 1008(a)(1), 1008(a)(3) AND 4004 OF RCRA

Section 1008(a)(1): Proposed Guidelines for Landfill Disposal of Solid Waste	
Site Selection	
	Consideration of areal surface and groundwater conditions
	Consideration of geological and topographical features
	Consideration of social, geographic and economic factors
	Consideration of environmental impacts
	Avoidance of environmentally sensitive areas (e.g., wetlands, floodplains, permafrost zones, and recharge zones of sole source aquifers), fault zones, and karst terrain
	Application of proper engineering techniques for design and operation if landfill placement in unsuitable area is unavoidable
Protection of Environment and Health	
Surface Water:	Minimization of soil erosion caused by runoff Diversion of surface runoff away from or around the landfill Design of diversion structure to withstand a 10-year, 24-hour precipitation event
Groundwater:	Containment of disposed solid waste by placement of very low permeability (1×10^{-7} cm/sec) materials on the bottom and sides of the landfill and sealing the surface of the completed landfill Controlled or uncontrolled leachate release if the underlying soils demonstrate the needed attenuative capacity to avoid adverse effect on the groundwater Reduction of leachate generation by control of infiltration of precipitation Minimum thickness of 1 foot for soil liners Minimum thickness of 20 mils for membrane liners Continuous removal of leachate in order to minimize the head of leachate on the liner

APPENDIX B-1 (Continued)

Protection of Environment and Health (continued)	
Air:	Venting of gases Consideration of the consequences of selection of individual control techniques
Operation:	Application of daily and final covers Consideration of safety for landfill employees and users Consideration for monitoring landfill performance with caution against the installation of groundwater monitoring wells through the landfill proper
Sections 1008(a)(3) and 4004: *Classification Criteria for Solid Waste Disposal Facilities*	
Site Restrictions	
Floodplains:	Requirement that facilities or practices shall not restrict flow of base flood, reduce temporary water storage capacity, or result in washout of solid waste
Endangered and Threatened Species:	Assurance that no solid waste disposal facilities or practices cause or contribute to taking of endangered or threatened species of plants, fish, or wildlife Requirement that critical habits of endangered or threatened species not be destroyed or adversely modified
Protection of Environment and Health	
Surface Water:	Compliance of point source discharges of pollutants with NPDES permit requirements Prevention of non-point-source discharges of pollutants that violate an EPA-approved areawide or statewide water quality management plan Prevention of discharge of dredged material or fill material in violation of the Clean Water Act, as amended

APPENDIX B-3 (Concluded)

Protection of Environment and Health (continued)	
Groundwater:	Prevention of contamination of underground drinking water source beyond the solid waste boundary (outermost perimeter of the solid waste as it would exist at completion of disposal activity) or alternative boundary as designated in an EPA-approved state solid waste management plan Requirement not to degrade groundwater beyond levels established to protect human health nor to cause underground drinking water sources to exceed established drinking water standards
Disease:	Operation permitted only when cover material or other techniques are available to minimize on-site population of disease vectors Application to land surface or incorporation into soil of sewage sludge and septic tank sumpings allowed only after treatment by processes to significantly reduce or further reduce pathogens
Air:	Prohibition of open burning of residential, commercial, institutional, or industrial solid waste Compliance with requirements of the Clean Air Act, as amended
Safety:	Concentration of explosive gases at site not to exceed 25 percent of lower explosive limit for gases in facility structures nor the lower explosive limit for gases at property boundary Prevention of fire at site through compliance with Air requirements and through periodic application of cover material or other techniques Elimination of bird hazards to aircraft at sites located within 10,000 feet of any airport runway used by turbojet aircraft and within 5000 feet of any airport runway used only by piston-type aircraft Control of access to site to protect public from on-site exposure to health and safety hazards

SOURCE: Federal Register, 1979a, 1979b.

APPENDIX B-2

SUMMARY OF EPA-PROPOSED LANDFILL STANDARDS FOR HAZARDOUS SOLID WASTE DISPOSAL FACILITIES UNDER SECTION 3004 OF RCRA

Location

Requirement for a natural in-place soil barrier on the bottom and sides of the landfill that is greater than or equal to 10 feet in thickness, having a permeability less than or equal to 1×10^{-7} cm/sec.

Requirement that any functioning or private water supply or livestock water supply is greater than or equal to 500 feet away.

Requirement that the bottom of the liner or soil barrier is greater than or equal to 5 feet above the historical high water table.

Prohibition against placement of liners or soil barriers over earth materials having a permeability greater than or equal to 1×10^{-4} cm/sec.

Design and Construction

Prevention of contact between the landfill and navigable waters.

Minimization of erosion, landslides, and slumping.

Requirement that the liner or soil barrier be compatible with all waste to be landfilled.

Construction of diversion structures to control runoff and prevent it from entering the landfill.

APPENDIX B-2 (Continued)

Soil liner or soil barrier minimum criteria:

- requirement that soil be classified under the Unified Soil Classification System CL, CH, SC and OH
- requirement that passage of soil through a No. 2 sieve be greater than 30%
- requirement that the liquid limitation be greater than or equal to 30 units
- requirement of a plasticity greater than or equal to 15 units
- requirement that the pH be greater than or equal to 7.0
- requirement that the permeability not be adversely affected by anticipated waste

Synthetic membrane liner minimum criteria:

- requirement that the thickness be greater than or equal to 20 mils with a strength great enough to insure mechanical integrity
- requirement of compatibility with waste material
- resistance to soil bacteria and fungus
- resistance to extreme heat, freezing, and thawing
- requirement of a tensile strength capable of withstanding installation and use of machinery and equipment
- requirement of sufficient elongation
- requirement of uniform thickness
- placement on a stable base
- requirement of a permeability less than or equal to 1×10^{-12} cm/sec

Leachate collection sump criteria:

- requirement of compatibility with and impermeability to the leachate
- requirement of accessibility for leachate removal and sump repair
- requirement of a volume capacity greater than or equal to 3 months' expected volume of leachate and greater than or equal to 1000 gallons
- removal of leachate when necessary to maintain gravity flow and check collection sump monthly

APPENDIX B-2 (Continued)

Closure criteria:

- requirement that the final cover be greater than or equal to 6 inches of soil having a permeability less than or equal to 1×10^{-7} cm/sec underlying 18 inches (3 feet where trees or other deep rooted vegetation are to be planted) of soil capable of supporting vegetation underlying 6 inches of top soil
- requirement for the final cover grade to be less than or equal to 33%:
  - if >10%, construction of horizontal terraces of width and height capable of withstanding a 24-hour, 25-year storm
  - if < 20%, placement of terraces at 10-foot intervals
  - if > 20%, placement of terraces at 20-foot intervals

Design criteria alternatives where location standards cannot be met:

- Design I: Requirement for a leachate collection and removal system on top of soil liner; or a natural soil or mantle barrier greater than or equal to 5 feet thick with a permeability less than or equal to 1×10^{-7} cm/sec.

  Requirement for a liner system of 1% slope connected at all low points to at least one leachate collection sump.

  Requirement for a natural in-place soil liner greater than or equal to 12 inches with a leachate collection and removal system on top.

- Design II: Requirement of a double liner: soil liner at least 3 feet thick having a permeability less than 1×10^{-7} cm/sec over a synthetic membrane greater than 20 mils thick having a permeability less than or equal to 1×10^{-7} cm/sec.

  Requirement for a leachate collection and removal system on top of the soil liner.

APPENDIX B-2 (Continued)

Requirement for a leachate detection and removal system beneath the synthetic liner.

Requirement for a liner system of 1% slope connected at all low points to at least one leachate collection sump.

Requirement for a leachate detection and removal system on top of a base of at least 6 inches of natural permeable soil.

Requirement of a membrane liner system overlying the leachate detection and removal system that is equal to 6 inches of clean permeable sand or soil overlaid with a synthetic liner.

Requirement of a soil liner overlying the membrane that is greater than or equal to 3 feet having a permeability less than or equal to $1x10^{-7}$ cm/sec.

Requirement of a leachate collection and removal system on top of at least 12 inches of permeable soil.

Operation

Requirement to record the exact location of each hazardous waste, the dimensions of each cell, and its contents.

Disposal of incompatible wastes in separate cells.

Requirement to surround each container of liquid hazardous waste with enough sorbent inert material capable of absorbing the entire liquid contents of the container.

Prohibition against the landfilling of ignitable, reactive, or volatile wastes or bulk liquids, semi-solids, and sludges.

Application of greater than or equal to 6 inches of cover material daily.

APPENDIX B-2 (Concluded)

Operation (continued)

Application of greater than or equal to 12 inches of cover material on active portions not operated for one week or longer.

Maintenance

Maintenance for at least 20 years.

Maintenance of soil integrity, slope and vegetative cover, diversion and drainage structures, groundwater and leachate monitoring systems, surveyed bench marks, and gas collection and control systems.

Collection and analysis of leachate monthly.

Requirement to monitor the gas collection and control system.

Restriction of accessibility to the landfill as appropriate.

Prohibition against building construction for habitation over landfills containing radioactive wastes.

SOURCE: Federal Register, 1978

APPENDIX C

CENTER FOR DISEASE CONTROL (CDC) CLASSIFICATION OF ETIOLOGIC AGENTS

APPENDIX C

THE CENTER FOR DISEASE CONTROL CLASSIFICATION OF ETIOLOGIC AGENTS ON THE BASIS OF HAZARD

CLASS	DEFINITION
1	Agents of no or minimal hazard to human or animal health.
2	Agents of ordinary potential hazard. This class includes agents which may produce disease of varying degrees of severity from accidental inoculation or injection or other means of cutaneous penetration but which are contained by ordinary laboratory techniques.
3	Agents involving special hazard or agents derived from outside the United States which require a federal permit for importation unless they are specified for higher classification. This class includes pathogens which require special conditions for containment.
4	Agents that require the most stringent conditions for their containment because they are extremely hazardous to laboratory personnel or may cause serious epidemic disease. This class includes Class 3 agents from outside the United States when they are used in entomological experiments or when other entomological experiments are conducted in the same laboratory area.
5	Foreign animal pathogens that are excluded from the United States by law or whose entry is restricted by USDA administrative policy.

APPENDIX C

CENTER FOR DISEASE CONTROL (CDC)
CLASSIFICATION OF ETIOLOGIC AGENTS

CLASSIFICATION OF BACTERIAL AGENTS

Class 2

Actinobacillus - all species except A. mallai which is in Class 3
Arizona hinshawii - all serotypes
Bacillus anthracis
Bordetella - all species
Borrelia recurrentis, B. vincentii
Clostridium botulinum, C. chauvoei, C. haemolyticum, C. histolyticum,
C. novyi, C. septicum, C. tetani
Corynebacterium diphtheriae, C. equi, C. renale
Diplococcus pneumoniae
Erysipelothrix insidiosa
Escherichia coli - all enteropathogenic serotypes
Haemophilus ducreyi, H. influenzae
Herellae vaginicola
Klebsiella - all species and all serotypes
Listeria - all species
Mima polymorpha
Moraxella - all species
Mycobacterium - all species except those listed in Class 3
Mycoplasma - all species except M. mycoides and M. agalactiae, which
are in Class 5
Neisseria gonorrhoeae, N. meningitidis
Pasteurella - all species except those listed in Class 3
Salmonella - all species and all serotypes
Shigella - all species and all serotypes
Sphaerophorus necrophorus
Staphylococcus aureus
Streptobacillus moniliformis
Streptococcus pyogenes
Treponema carateum, T. pallidum, T. pertenue
Vibrio fetus, V. comma including biotype El Tor, V. parahaemolyticus

Class 3

Actinobacillus mallei
Bartonella - all species
Brucella - all species
Francisella tularensis
Mycobacterium avium, M. bovis, M. tuberculosis
Pasteurella multocida type B ("buffalo" and other foreign virulent strains)
Pseudomonas pseudomallei
Yersinia pestis

CLASSIFICATION OF FUNGAL AGENTS

Class 2

Actinomycetes (including Nocardia species and Actinomyces species and Arachnia propionica)
Blastomyces dermatitidis
Cryptococcus neoformans
Paracoccidioides brasiliensis

Class 3

Coccidioides immitis
Histoplasma capsulatum
Histoplasma capsulatum var. duboisii

CLASSIFICATION OF PARASITIC AGENTS

Class 2

Entamoeba histolytica
Leishmania sp.
Naegleria gruberi
Toxocara canis
Toxoplasma gondii
Trichinella spiralis
Trypanosoma cruzi

Class 3

Schistosoma mansoni

CLASSIFICATION OF VIRAL, RICKETTSIAL, AND CHLAMYDIAL AGENTS

Class 2

Adenovirus - human - all types
Cache Valley virus
Coxsackie A and B viruses
Cytomegaloviruses
Encephalomyocarditis virus (EMC)
Flanders virus
Hart Park virus
Hepatitis-associated antigen material
Herpesvirus - except Herpesvirus simiae (Monkey B virus) which is in Class 4
Coronavirus
Influenzavirus - all types except A/PR8/34 which is in Class 1
Langat virus
Lymphogranuloma venereum
Measles virus
Mumps virus
Parainfluenza virus - all types except Parainfluenza virus 3, SF4 strain, which is in Class 1
Poliovirus - all types, wild and attenuated
Poxvirus - all types except Alastrun, smallpox, monkeypox, and whitepox which, depending on experiments, are in Class 3 or Class 4
Rabies virus - all strains except Rabies street virus, which should be classified in Class 3 when inoculated into carnivores
Reovirus - all types
Respiratory syncytial virus
Rhinovirus - all types
Rubella virus
Simian virus - all types except Herpesvirus simiae (Monkey B virus) and Marbug virus, which are in Class 4.
Sindbis virus
Tensaw virus
Turlock virus
Vaccinia virus
Varicella virus
Vole rickettsia
Yellow fever virus, 17D vaccine strain

Class 3

Alastrun, smallpox, monkey pox, and whitepox, when used in vitro
Arbovirus - all strains except those in Class 2 and 4 (Arboviruses indigenous to the United States are in Class 3, except those listed in Class 2. West Nile and Semliki Forest viruses may be classified up or down, depending on the conditions or use and geographical location of the laboratory).
Dengue virus, when used for transmission or animal inoculation experiements
Lymphocytic chorimeringitis virus (LCM)
Psittacosis-Ornithosis-Trachoma group of agents
Rabies street virus, when used in inoculations of carnivores (See Class 2)
Rickettsia - all species except Vole rickettsia when used for transmission or animal inoculation experiments
Vesicular stomatitis virus
Yellow fever virus - wild when used in vitro

Class 4

Alastrun, smallpox, monkeypox, and whitepox, when used for transmission or animal inoculation experiements
Hemorrhagic fever agents, including Crimean hemorrhagic fever (Congo), Junin and Machupo viruses, and others as yet undefined
Herpesvirus simiae (Monkey B virus)
Lassa virus
Marbug virus
Tick-borne encephalitis virus complex, including Russian spring-summer encephalitis, Kyasanur forest diseases, Omsk hemorrhagic fever and Central European encephalitis viruses
Venezuelan equine encephalitis virus, epidemic strains, when used for transmission or animal inoculation experiments
Yellow fever virus - wild, when used for transmission or animal inoculation experiements

CLASS 5 AGENTS

A. Animal agents excluded from the United States by law.

Virus of foot and mouth diease

B. Animal agents excluded by USDA administrative policy.

African horse sickness virus
African swine fever virus
Besnoitia besnoiti
Borna disease virus
Bovine infectious petechial fever virus
Camel pox virus
Ephemeral fever virus
Fowl plague virus
Goat pox virus
Hog cholera virus
Louping ill virus
Lumpy skin disease virus
Nairobi sheep disease virus
Newcastle disease virus (Asiatic strains)
Mycoplasma mycoides (contagious bovine pleuro-pneumonia)
Mycoplasma agalactiae (contagious agalactia of sheep)
Rickettsia ruminatium (heart water)
Rift Valley fever virus
Sheep pox virus
Swine vesicular disease virus
Teschen disease virus
Theileria annulata
Theileria bovis
Theileria hirci
Theileria lawrencei
Theileria parva (East Coast fever)
Trypanosoma vivax (Nagana)
Vesicular exanthema virus
Wesselsbron diease virus
Zymonema farciminosum (pseudofarcy)

APPENDIX D

SUMMARY OF SELECTED PUBLIC DOCKET COMMENTS ON EPA'S PROPOSED REGULATIONS FOR HOSPITAL SOLID WASTES

APPENDIX D

SUMMARY OF SELECTED PUBLIC DOCKET COMMENTS ON EPA'S PROPOSED REGULATIONS FOR HOSPITAL SOLID WASTES

AGENCY	COMMENTATOR	COMMENTS: SEC. 250.14(b)(1)(i)(A): INFECTIOUS WASTE SOURCES	COMMENTS: APPENDIX VII: TREATMENT SPECIFICATIONS	COMMENTS: RECOMMENDATIONS	COMMENTS: OTHER COMMENTS
American Hospital Association	Bernard Korn, Staff Specialist	Delete obstetrics department (including patients' rooms) and pediatrics department from list of health care facilities			
Center for Disease Control, Public Health Service	George F. Mallison, Assistant Director, Bacterial Diseases Division, Bureau of Epidemiology	Almost no hazardous wastes from emergency department, surgery department, morgue, intensive care unit, and pediatrics department. To autoclave these wastes would be too expensive.	Regulation too stringent for trash. Only microbially contaminated reusable laboratory glass should be autoclaved.	Certain bacteriology lab wastes may be disposed of through regular systems using conventional vehicles and approved landfills if they have been sterilized first.	All "hazardous infectious" wastes from a hospital can be processed within the hospital to be made nonhazardous.
		Delete entire paragraph. Insert list of solid wastes that should be either sterilized, ground or drained to the sewer, properly packaged prior to conventional disposal, or incinerated.	Liquids should be poured down sink to sewer system. Autoclaving is expensive and unnecessary. Time allowed for animal sterilization can be too long or too short depending on the size of the animal. Prefer incineration. Time allotted for animal bedding sterilization is too long.	Materials capable of producing physical injury should be placed in rigid containers for handling in and disposal from the hospital	It is inconsistent to restrict the disposal of potentially hazardous wastes from hospitals when disposal of greater amounts of identical wastes in the community remains unrestricted.
New Jersey State Department of Health	Dr. John Slade	Pathological specimens are an aesthetic problem and do not pose an infectious hazard.	Method of disposal is too expensive and its benefits can never be assessed.	Solid microbiological laboratory wastes should be incinerated on site or autoclaved prior to disposal.	Not all that is contaminated is infectious. Hospital wastes pose no specific hazards outside the hospital.
				Sharps could be autoclaved and either ground up into the sewer or boxed in rigid containers.	Most pathogens are short-lived outside of their host or the laboratory.
				Consider New Jersey's approach to the definition of infectious hospital wastes.	No epidemiological data support special handling of ward-generated wastes.

APPENDIX D (Continued)

AGENCY	COMMENTATOR	COMMENTS: SEC. 250.14(b)(1)(i)(A): INFECTIOUS WASTE SOURCES	APPENDIX VII: TREATMENT SPECIFICATIONS	RECOMMENDATIONS	OTHER COMMENTS
American Hospital Association	Robert J. Flanagan, Vice President	Unnecessary. Already regulated by JCAH.	Unfeasible and unrealistic. Very few hospitals have on-site incinerators large enough to handle the volume of solid waste that would be classified as hazardous by proposed definition. Steam autoclave requirements are far too costly.	Accept JCAH regulations. Permit states to administer their own programs. Take into consideration cost containment.	No threat from hospital waste has been documented. Would increase cost with no appreciable benefit to public health. Background documents lack necessary rationale to support EPA conclusions and proposed regulations. EPA economic analysis of regulations excluded hospitals and the health care industry.
Baptist Memorial Hospital System	M.R. Wiggs, Associate Administrator				Regulations are duplicates of state laws and would add to hospital costs.
The Iowa Hospital Association	Bradley C. Engel, Director of Planning	Too inclusive.	Would place unnecessary administrative and financial burdens on hospitals.		
Duke University	E.J. McDonald, Vice President for Government Relations and General Counsel to the University	Would cause extensive and expensive changes in hospital waste disposal policy.	Would cause separation of all hospital wastes.	Raise minimum level of waste from 100 to 1000 kilograms for those whose hazardous waste is extremely diverse and who are not involved in commercial production. Write separate regulations for generators of medium amounts of diversified hazardous waste.	Economic impacts of regulations would be severe in time of cost containment.

APPENDIX D (Continued)

AGENCY	COMMENTATOR	COMMENTS: SEC. 250.14(b)(1)(A): INFECTIOUS WASTE SOURCES	COMMENTS: APPENDIX VII: TREATMENT SPECIFICATIONS	COMMENTS: RECOMMENDATIONS	COMMENTS: OTHER COMMENTS
Baptist Medical Center of Oklahoma, Inc.	Dr. Merle D. Carter, Chairman, Infection Subcommittee	Rendering material nonhazardous by this definition would require sterilization of virtually all material coming from a patient's room.		Identify infected patients and properly dispose of the waste generated by them rather than dispose of all wastes as if they were infectious.	
South Carolina Department of Health and Environmental Control	Richard L. Parker, D.V.M., M.P.H., Chief, Bureau of Epidemiology	Unnecessarily restrictive and would add to cost of health care. Separate the classifications of persons exposed/infected with an infectious disease from routine surgery patients.	Times are excessive and should be studied further. Autoclaving the contents of a receptionist's waste basket and similar kinds of wastes is unwarranted.	Hazardous waste list should be more specific and identify as hazardous only those items that can truly be considered a threat to public health. Biological life of infectious agents should be considered.	<u>Salmonella</u>, <u>Neisseria</u>, and others are so common in every day population that they are being introduced to normal sewage disposal systems in extensive numbers on a daily basis.
Guttenberg Municipal Hospital	Patty Wonsmos, R.N., Director of Nursing		Trash should be redefined as a category. Cost would be prohibitive.	Affected facilities should be redefined as to size (implied recommendation).	Use of present autoclave would mean transporting trash through a central sterile department and would negate the benefit of rendering waste nonhazardous. Regulations appear to be for larger centers; would be devastating to smaller ones.
American Hospital Supply Corp.	Donald E. Baker, Manager, Regulatory Affairs	Limit these departments to Class 2 Etiologic Agents	Would cause single-use products to become less cost effective.	Exempt all health care facilities that are in compliance with existing state waste management programs.	Would increase cost of health care.

APPENDIX D (Concluded)

AGENCY	COMMENTATOR	COMMENTS			
		SEC. 250.14(b)(1)(i)(A): INFECTIOUS WASTE SOURCES	APPENDIX VII: TREATMENT SPECIFICATIONS	RECOMMENDATIONS	OTHER COMMENTS
Health Industry Manufacturers Association	Harold O. Buzzell, President	Definition is too broad and too costly.		Delete hospital wastes from regulations. Allow disinfection procedures, in addition to sterilization, to be used to render potentially infectious waste harmless.	Scientifically unsupportable with respect to medical product and hospital waste. Vast bulk of hospital waste is not infectious. There already are standard procedures to segregate wastes that might be infectious. Infectious microorganisms will be inactivated by the environment.
Michael Reese Hospital and Medical Center	J. Robert Buchanan, President	Too costly and unnecessary.		Work closely with JCAH for hazardous waste identification and hospital accreditation for waste disposal.	Rules add nothing to prevention of illness and environmental protection.
National Assoc. of Children's Hospitals and Related Institutions, Inc.	Robert H. Sweeney, President	Would make the entire children's hospital a generator of hazardous infectious waste. Pediatric departments should be deleted from definition.	Cost would be astronomical.	Analyze other departments as to type and current handling of wastes.	It would be better to consider as infectious patients in isolation rather than the entire hospital.
Department of Defense	George Marienthal, Deputy Asst. Sec'y of Defense (for Energy, Environment and Safety)	Need better source delineation.		Let the Joint Commission on Accreditation of Hospitals be responsible for developing hospital-specific hazardous source designations.	Greatest risk is during handling. Degree of control associated with a particular hazardous waste should be commensurate with its potential for environmental harm.

[a]Comments from the Public Docket for the Hazardous Waste Guidelines and Regulations, Section 3001 (Appendix J).

APPENDIX E

PUBLIC DOCKET FOR THE HAZARDOUS WASTE GUIDELINES AND REGULATIONS SECTION 3001: SELECTED PUBLIC COMMENT LETTERS TO HAZARDOUS WASTE MANAGEMENT DIVISION, OFFICE OF SOLID WASTE, U.S. ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, D.C.

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9583

September 11, 1978

Alan S. Corson
U.S. Environmental Protection Agency
Office of Solid Waste
Hazardous Waste Management Division (WH-565)
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Corson

Many thanks for the information you gave me in our telephone conversation of September 8 regarding the planned publication date of the proposed Section 3001 in the Federal Register (January 2, 1979) and the circulation of a new draft of the "Criteria, Identification Methods, and Listing of Hazardous Wastes" during September.

Many members of the American Hospital Association's American Society of Hospital Engineers reported [illegible] they coordinated Section 250.12 (c), Infectious Waste, with their hospital [illegible] staffs. They recommended that Section 250.12 (c) (1)(A) be amended [illegible] the following sources, since they believed that waste generated from [illegible] sources was not infectious:

(i) [illegible] department including patients' rooms
(x) [illegible] Department

I am most appreciative [illegible] for your cooperation in coordinating proposed hazardous waste documents with me.

Sincerely

[illegible]
Staff Specialist
Division of Health Facilities & Standards

[illegible]

APPENDIX E-2

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333
TELEPHONE: (404) 633-3311

October 31, 1978

Dr. Ram Rakshpal, WH565
Room 2416-M
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Dr. Rakshpal:

It was a real pleasure to talk to you on the telephone the other day concerning safe disposal of solid wastes from hospitals. You asked me to confirm my statements in writing concerning CDC's evaluation of risks of and preferable handling methods for various types of hospital wastes that might be considered by some to be hazardous. I will not discuss hospital disposal of such materials as radioisotopes or hazardous chemicals; safety in such disposal is not an area in which we have great expertise, nor is it a problem unique to health-care facilities.

Probably the hospital solid wastes with the greatest potential hazard are from microbiology laboratories; such wastes may contain enormous numbers of highly pathogenic microorganisms. These wastes can easily be processed within the hospital so that remaining residue will be of no risk to a community disposal system. The preferable method is steam sterilization (autoclaving) of these wastes; or, if permissible (but certainly more expensive and/or potentially harmful from the standpoint of air pollution), they may be incinerated in the hospital.

Patients on isolation generate a minute amount of solid waste when compared to the rest of the hospital. We believe that isolation wastes that are to be discarded can be incinerated in the hospital or autoclaved; when treated in either fashion, they cannot be a risk of disease to the community.

Traditionally, all pathology wastes in a hospital are incinerated (but sometimes they are ground to the sewer); in either event, they are not a risk in the community solid-waste disposal system. Waste human blood is best handled by pouring down the drain, also removing any community health risk.

Non-contagious wastes that are capable of producing injury, such as needles and scapel blades, should be placed into rigid containers at the location where these wastes are generated. These rigid containers can then be handled safely within the hospital to the "dumpster"; from this point on they will create no health hazard if disposed in an approved sanitary land fill or incinerator.

I have seen no documentation of health risks in disposal of blood-, fecal-, or urine-contaminated objects generated in a health-care facility (or, in fact from other facilities, such as veterinary hospitals, doctor's offices, nursing homes; or from residencies). In fact, in most instances, material of this nature generally will be packaged in impervious plastic when disposed of from a hospital, whereas the larger amounts disposed from other community sources often will not be so wrapped.

In my view, it is totally inconsistent to develop recommendations for handling of "hazardous" and/or "infectious" wastes from health-care facilities on the basis that a hospital dumpster may have more potentially contaminated materials than a dumpster from, say, a small factory. Even if this were true, these materials may be packaged far better in the hospital waste (see above) than they will be from the myriad of other community sources. Further, it basically makes no difference (with respect to risk of disease) to individuals operating an approved municipal sanitary land fill or incinerator how much of what kind of waste comes in what truck or dumpster from what source, because all of it should promptly be either buried or burned without personal contact at the disposal site.

As I am sure you know, there are no documented risks of transporting hospital solid waste material through the streets to a disposal site when transportation is done in closed and leakproof vehicles.

I believe that there is no need whatsoever for any regulations for special methods of disposal of hospital solid wastes other than to assure that recommended in-hospital processing (*e.g.*, autoclaving or incinerating of laboratory microbiological wastes; incinerating pathology wastes; pouring blood waste to the drain; and appropriate packaging of sharp materials and urine-, fecal-, and blood-contaminated objects within the hospital) is carried out. If, however, hospital solid wastes were to be disposed in an open dump, these hospital wastes should be protected from scavenging, which would obviously be a health risk; water pollution might also arise from an open dump.

I would appreciate your comments on these recommendations. Our hopes at CDC are that EPA will not promulgate any unrealistic regulations that would increase the already enormous costs of institutional patient care in the United States.

Sincerely yours,

George F. Mallison
Assistant Director
Bacterial Diseases Division
Bureau of Epidemiology

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333
TELEPHONE: (404) 633-3311

November 6, 1978

Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
Washington, D.C. 20460

Gentlemen:

I recently received for comment a Draft document titled "Criteria, Identification, and Listing of Hazardous Waste", 33 pp plus 14 appendices, dated September 13, 1978. The purpose of this letter is to make a few comments on the contents of this Draft relating particularly to "infectious" solid wastes, but also on solid wastes that might cause injuries, from health-care facilities.

First of all, let me point out the errors in the document. On Page 21 of the text, there are almost never any hazardous (because of contamination with microbial pathogens) wastes from your categories (2) (i) (A)(I): i., ii., iii., ix., and x. As discussed in my letter to Dr. Rakshpal of your staff on October 31 (copy enclosed), those small portions of the waste from these particular hospital departments that might be hazardous can be handled in a satisfactory fashion (by packaging in impervious bags and/or rigid containers) to make them non-hazardous for transportation within the hospital (or they may be removed from the solid waste stream by incineration or by flushing down the sewer drain); the rest of the material will be no different than the remaining solid-waste generated in the hospital (in fact, no different with respect to the possibility of pathogenic microbial contamination than residential solid waste). To autoclave such wastes would be expensive as well as totally unnecessary.

There are serious, frank errors in Appendix VIII., page 16 of the appendices to your document, dated 7 September 1978 on my copy. First of all, there is absolutely no need to steam autoclave any soiled linens (1) from a hospital; in fact, steam autoclaving soiled linen will often ruin it so that it must be thrown away; soiled linen should be laundered, not autoclaved. There is no reason to autoclave general "Trash" (2) from a hospital; only some materials from isolated patients (see enclosed DHEW Publication (CDC) 76-8314) should be sterilized -- either by incineration or by steam autoclaving. Only microbially contaminated reuseable laboratory glassware (3) need be autoclaved, but the time and other aspects of the recommendation given are incorrect. If there are any contaminated liquids that must be disposed (4), they should be poured down the nearest drain and flushed to the sewer system; but, nothwithstanding, the recommendation for autoclaving (which provides for safe disposal per se, but is expensive and unnecessary) for one hour for each gallon is inherently incorrect. The recommendation on animal sterilization (5) is wrong because the size of the dead animal might make the time anywhere from too short to far too long; if potentially infectious dead animals from a research laboratory are to be disposed of from a hospital or any other source, it is best that they be incinerated in a pathology incinerator; but they might be autoclaved for an hour or two prior to incineration to make the surface less contaminated when moving the animal body (after, preferably, sealing it in 2 impervious plastic bags) to the pathology incinerator. Animal bedding (6) could be decontaminated in a fraction of 8 hours in a standard steam sterilizer, depending on the depth and degree of packing of the material. Most glaring of all, Appendix VIII omits the most hazardous infectious waste from hospitals in terms of weight and amount of contamination, that from microbiology laboratories.

In my view, parts of your "Criteria, etc." document set up a situation in which a series of definitions are made for solid waste that might be "hazardous"; then, after setting up the definitions, there is the implication (or, in this case, more probably the directive) that these wastes thus defined as hazardous must be in some fashion handled differently in transportation and/or disposal, whether or not rendered uncontaminated in the hospital and/or made safe for conventional transportation and conventional approved disposal.

In actual fact, as indicated in my letter to Dr. Rakshpal, it is entirely possible that essentially all "hazardous infectious" (because it may be contaminated with pathogenic microorganisms) waste from a hospital can be processed within the hospital to be made non-hazardous. If this is done, the processed waste material that then enters the solid-waste transportation and disposal system of the community would create no risk whatsoever when disposed of in an approved sanitary landfill or incinerator (see enclosure): a hazardous waste disposal facility is not necessary for hospital solid wastes unless they are chemically toxic or radioactive.

So, with respect to paragraph (2) on page 21 of your document, certain hospital solid waste may indeed be appropriately listed in whatever lists or criteria EPA develops. For instance, unsterilized, used, disposable petri dishes containing agar on which pathogens have been grown in a bacteriology lab could be a risk to human health if they are not disposed of properly. Because this is the case, EPA should state that such wastes may be disposed of through regular systems using conventional solid-waste vehicles and approved landfills or incinerators *if* such wastes have been sterilized prior to entering the community solid-waste disposal system. Since this is a reasonable as well as relatively inexpensive requirement (and is now almost exclusively carried out, using steam sterilizers), there should be no problem of compliance and no need for any special methods or locations for disposal.

However, to suggest that small quantities of other types of hospital waste that *might* be contaminated with pathogens be categorized as "hazardous" is, in general, patently unrealistic and unnecessary. It is additionally inconsistent with the way other sources of the same potentially "hazardous" waste (*e.g.*, disposable diapers, cut flowers, used syringes and needles, wound bandages, used facial tissue, razor blades, used drainage bags, and even disposable kidney dialyzers) might be disposed of in the community. As I discussed in my letter to Dr. Rakshpal, the possibility that a particular hospital dumpster load *may* have more potentially contaminated materials than in an industrial dumpster or a refuse truck from a residential area does *not* per se create any health risk during transportation or at or after disposal in an approved landfill or incinerator.

What we believe you should have in your document is a truly realistic list of potentially hazardous infectious waste from health-care institutions. But after you define something as "hazardous", requiring special methods of disposal because it is from a hospital when such a requirement is not made for, say, residences, is inconsistent and makes no sense whatsoever from the standpoint of either transportation or disposal using conventional current technology. So then you should give realistic methods that are recommended for in-hospital decontamination of microbially contaminated wastes such as from bacteriology and pathology and patient isolation. Additionally, you should specify that materials capable of producing physical injury (such as hypodermic syringes) should be placed in rigid containers for handling in and disposal from the hospital. If you do this, then hospital solid wastes will be completely safe for movement through the same solid-waste transportation and disposal (*e.g.*, leakproof trucks and dumpsters, and properly operated sanitary landfills or incinerators) systems that should be used for other community solid wastes.

You should be aware that our recommendations above are already being followed by most U.S. health-care facilities, <u>except</u> that solid wastes from an unknown but perhaps substantial number of such facilities are going to "dumps" that are not really operated as sanitary landfills.

Sincerely yours,

George F. Mallison
Assistant Director
Bacterial Diseases Division
Bureau of Epidemiology

Enclosures (3)

cc:
Dr. Ram Bakshpal

APPENDIX E-4

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333
TELEPHONE: (404) ~~XXXXXX~~ 329-3120

January 2, 1979

RECEIVED
JAN ... 1979

Mr. John P. Lehman
Director, Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Lehman:

The purpose of this letter is to make some comments from the Center for Disease Control (CDC) on your "HAZARDOUS WASTE--Proposed Guidelines and Regulations and Proposal on Ident ication and Listing," Federal Register 43:58946-59028, December 18, 1978.

Let me say first that the great majority of your recommendations are entirely reasonable and sorely needed. But, in our view, there is a lot of overkill in your proposed guidelines relating to health-care facilities.

I have sent two previous letters to EPA with comments on the same general subject, on October 31 and November 6; copies of these letters are enclosed. The purpose of this letter is to summarize and reiterate our previous comments with particular reference to the overall format and contents of your December 18 issuance.

First of all, with few exceptions I cannot imagine any significant risk to human health at or from a properly designed and operated conventional (by present standards) community sanitary landfill or municipal incinerator of any waste from a health-care facility taken, untreated and not imperviously bagged, to such disposal sites; the only exceptions (in addition to the obvious ones of radioactive materials and toxic or otherwise hazardous chemicals) are some types of microbiological and isolation wastes and dead animals from "hot" research facilities. Nor can I imagine any significant risk of infection associated with transport of hospital solid wastes to a disposal site, assuming that the dumpsters or trucks used do not leak.

Nonetheless, common sense makes certain reasonable and feasible recommendations entirely appropriate, to make sure that potential infection problems do not occur associated with hospital solid wastes, even under "Murphy's Law" circumstances.

Hospital solid wastes from microbiology laboratories must be incinerated or autoclaved in a hospital (or in a free-standing clinical lab); this has been our recommendation for years, and probably only a tiny number of microbiology labs do not follow this recommendation. The great majority of pathology wastes are incinerated in hospitals, even though the risk of transmission of disease from most such waste is essentially non-existent; handling of pathology wastes by undertakers and/or crematoriums, or grinding of them to the sanitary sewer also would be perfectly safe, but neither of the latter methods are widely used. We recommend disposal of waste human blood by simply pouring it down the nearest drain in the health-care facility, and most hospitals eirher do this or incinerate the blood. Small volumes of blood in disposable tubes or on slides can be double-plastic bagged and, with complete safety, thrown in with the rest of hospital solid wastes for conventional disposal.

The CDC has recommended for years that all solid wastes from patients in isolation categories of "strict" or "wound and skin" (see enclosure) be incinerated; this practice (or steam autoclaving) is essentially universally followed by U.S. hospitals today.

By far the greatest risk of hospital solid wastes is not outside the institution, but rather to hospital employees, who may hurt themselves lifting waste containers, injure themselves by needle or glass punctures or cuts, or infect themselves from contaminated objects not appropriately packaged. These disease problems, although serious in hospital operation, do not necessarily have anything to do with handling solid wastes once they leave the hospital. In the hospital, sharp wastes--broken glass, scapel blades, hypodermic needles, etc.--should immediately after generation be carefully placed at the source into rigid containers so that they will not injure anyone. (I personally see no health reason to break or destroy hypodermic syringes or needles, or to sterilize them prior to disposal--these procedures may have intrinsic health risks, and/or they are expensive.) Rigid containers of "sharps" should be collected from time-to-time and thrown into the dumpster; after they leave the hospital, disposal in any properly designed and operated sanitary landfill or municipal incinerator should pose no problem whatsoever of either disease or injury.

As I indicated in my letter of November 6 (copy enclosed) and in statements above, the great majority of hospital solid wastes from hospital departments listed on page 58958 of your document, paragraph 250.15 (b)(I)(i)(A), are not a risk in an existing approved community solid-waste transportation or disposal system. This paragraph should be deleted. In its place should be only a list of those solid wastes from health care facilities that should be either sterilized, ground or drained to the sewer, properly packaged prior to conventional disposal, or incinerated.

Some of the recommendations in your Appendix VII, page 58964, are not generally correct or advisable. Nonetheless, this appendix should be retained, but it needs revisions. Only (1) certain isolation solid wastes (see above) need be steam autoclaved (or incinerated--incineration in a pathology incinerator is a common way this material is handled in hospitals today because this method is cheap, and there is only a very small quantity of potentially infectious isolation trash that is generated by a hospital). The recommendations in (2) are excessive for treatment of reusable glassware from "hot" labs; actually, a washer sterilizer would be better, and an hour is more than enough time. Liquids (3) should be simply poured carefully down the nearest drain to the sanitary sewer. As I indicated in my letter of November 6, the recommendations (4) for autoclaving of infected animals may be either excessive or insufficient depending on the size of the animal; animals can be autoclaved for an hour or two and then transported to a pathological incinerator, or they may be ground to the sewer, but gas sterilization would be totally inappropriate; I would think only animals from certain Class 4 or Class 5 "hot" labs would really be potentially hazardous. The recommendations (5) for steam sterilization of animal bedding are probably excessive for most types of bedding, gas sterilization would probably be inadequate, and grinding to the sewer or incineration should be encouraged. I would guess that less than one percent of health-care facilities dispose of dead animals that might be contaminated with pathogens that have any practical possibility of infecting humans. Appendix VII should, in addition to sterilization by specified methods, or incineration, indicate whenever disposal into the sanitary sewerage system is satisfactory.

CDC believes that you should go even further than the USAEHA (Infectious Waste - your page 58992) recommendations. We believe that after sterilizing (or incinerating) disposable microbiology and hematology and certain isolation solid wastes, pouring waste blood to the sewer, incinerating (or grinding to the sewer) pathology wastes, packaging sharp items at the source, and handling certain infected research animals wastes properly, hospital solid wastes can go with complete safety to any present conventionally designed and properly operated community sanitary landfill or incinerator. It is our view that the total potentially infectious solid waste for the community (other than from health-care facilities), including animal and human feces, disposable tissues, dead animals, razor blades, wound dressings, ostomy bags, blood on pads or bandages, uncooked poultry or pork, disposable diapers, and used kidney dialyzer membranes, as well as medical and dental and veterinary clinic wastes, far exceeds the amount of potentially infectious solid wastes from hospitals.

Materials that support or amplify on points in this letter are enclosed. We welcome discussion with you and/or your staff on any of our comments.

Sincerely yours,

George F. Mallison
Assistant Director
Bacterial Diseases Division
Bureau of Epidemiology

Enclosures (4)

cc:
Dr. Ram Rakshpal, Rm. 2416-M, EPA

APPENDIX E-5

STATEMENT

ON

THE DEFINITION OF INFECTIOUS HOSPITAL WASTE AS PROPOSED FOR HAZARDOUS WASTE: GUIDELINES AND REGULATIONS

(Section 3001, Part 250-14, b, 1, i, A)
Federal Register 43 (243):58958, Dec. 18, 1978.

By

John D. Slade, M.D.

New Jersey State Department of Health
P.O. Box 1540, Trenton, NJ

EPA Hearing
February 20, 1979

Department of Commerce
Washington, D.C.

BAPTIST MEDICAL CENTER OF OKLAHOMA, INC. • 3300 NORTHWEST EXPRESSWAY • OKLAHOMA CITY, OKLAHOMA 73112

February 28, 1979

RECEIVED
MAR 05 1979

Mr. John P. Lehman
Director
Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
Washington, DC 20460

Re: Public Law 94-580
Section 3001 (b)

Dear Mr. Lehman:

The Infection Subcommittee of Baptist Medical Center of Oklahoma has been most concerned about the Environmental Protection Agency, Public Law 94-580, Section 3001 (b), regarding the Identification and Listing of Hazardous Waste. We are well aware of the sources which potentially generate hazardous, infectious, or potentially infectious problems secondary to contamination of waste material by microorganisms or helminths as defined by CDC.

We have set up in this hospital what we felt to be acceptable policies for recognition of and disposal of hazardous waste by each department. These policies have been accepted by the Joint Commission on Accreditation of Hospitals and the Oklahoma State Health Department, Health Facilities Service Licensure & Certification Division.

We take exception to the following statement from Section 3001 (b): "The following sources generate hazardous waste unless the waste from these sources does not contain microorganisms or helminths". To render material nonhazardous by this definition would require virtually sterilization of all material coming from a patient's room.

The Infection Subcommittee feels that the classification of nonhazardous materials as being free of microorganisms is an unrealistic goal. The

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J. P. Lehman 2-28-79
Hazardous Waste Management Division
Office of Solid Waste
U.S. Environmental Protection Agency

Subcommittee feels that the identification of infected patients and the proper disposal of waste generated by these patients is a positive approach to the problem.

Very truly yours,

Merle D Carter MD

Merle D. Carter, M.D.
Chairman
Infection Subcommittee

sw

cc: Infection Subcommittee

Mr. Alan Corson
Hazardous Waste Management Division
U.S. Environmental Protection Agency
Washington, D.C. 20460

APPENDIX E-7

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Albert G. Randall, M.D., M.P.H.
Commissioner

Sims Aycock Building
2600 Bull Street, Columbia, SC 29201

March 7, 1979

RECEIVED MAR 13 1979

Mr. John P. Lehman, Director
Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U. S. Environmental Protection Agency
Washington, D.C. 20460

Re: Section 3001

Dear Sir:

My comments are directed towards the proposed amendments to Title 40 CFR part 250 as published in the Federal Register, Volumne 43, Number 243, Monday, December 18, 1978. My specific comments relate to Section 250.14 Hazardous Waste List, (b) Hazardous waste sources and processes, (1) Health care facilities. The inclusion of Health care facilities, including both hospital and veterinary hospitals, as generators of hazardous waste because some of the organisms dealt with in these institutions would fall in Class 2 of CDC's list of etiological agents is unwarranted and unnecessarily restrictive and furthermore will add unnecessarily to the cost of not only health care but veterinary medical care for animals. Class 5 Agents would not be dealt with in either type of institution in all probability.

In the background statement provided by the Environmental Protection Agency and dated December 15, 1978, the second sentence of the third paragraph of the introduction says, "Instead of specifying a certain number of infectious agents allowed to be present in a waste, the Agency has chosen to define infectious waste by specifying the source where disease microorganisms may occur. After consultation with experts in the public health field and consideration of current State regulatory programs, the Agency has reached the conclusion that such source identification of the infectious waste is the most inclusive and enforceable method of regulation." I believe that this sets the stage for the broad and inclusive nature of the proposed regulations both at the State and Federal level. Unfortunately, the breadth of this type of introductory statement leads to such all inclusiveness in the proposed regulations that there is a significant risk of increasing cost for medical care in facilities so regulated. Furthermore, Class 2 Agents (CDC Hazardous Agent Classification Systems) include many agents that are nearly ubiquitous in today's society, for example, organisms included in the genus Salmonella and in the genus Neisseria and many others that, while perfectly capable of causing infections in human beings, are so common in our everyday population that they are being introduced into normal sewage disposal systems in extensive numbers on a daily basis.

The State regulations which are quoted in the background statement and are held up as being examples of need for control in some instances are quite specific and therefore would be quite acceptable, for example, the California regulations. Even so, I believe some of the California regulations as listed may be more extensive than would be necessary under ordinary circumstances. Additionally, other state regulations tend to be specific, for example, from the Minnesota Pollution and Control Agency, Division of Solid Waste, hazardous infectious waste includes but is not limited to material from a person or animal that may have been exposed to a contagious or infectious disease and lists various subjects. The simple fact that this identifie and separates those animals and persons exposed or infected with an infectious disease from routine surgery patients is, I believe, significant. Inclusion as does the Province of Ontario of waste from abattoirs as hazardous materials seems to me to be blatantly absurd. There is no question that waste from abattoirs should be disposed of properly but to imply that all animals slaughtered for human consumption are <u>a priori</u> infected with dangerous diseases and should be considered as potentially infectious would be ultimately to deprive, on a practical basis, human beings of animal protein as a source of nutrition. Coincidentally, it would seem then that the provisions might logically be extended not only to veterinary surgical theatres but to butcher shops since obviously there is little difference in the potential harm created by organs removed at surgery, for example, in a simple uncomplicated ovariohysterectomy (spay) and those tissues removed in an abattoir and sold in a meat market

In the definitions, animal waste includes bedding and inedible by-products of animal processing for food and fiber production. While there is no question but what bedding and tissues from animals used in infectious disease studies might well be hazardous and should be rendered non-hazardous before disposal, the broad inclusion in the definitions would be unnecessarily expensive and restrictive and would serve no identifiable public health purpose. My comment regarding abattoirs and spaying in veterinary hospitals would apply to the current definition as proposed for surgical and autopsy waste to some degree.

The rationale statement for regulation of health care facilities waste specifically indicates that from 2 to 8% hospital waste consists of potentially infectious material. To extrapolate from 2 to 8% and require virtually all hospital waste to be rendered non-infectious will, in my opinion, materially add to the cost of hospital care and can not be justified on public health grounds. It appears from page 27 of the background statement that patient care areas will include ward areas, doctor's offices, out-patient clinics and treatment rooms. Certainly if this logic is extended ultimately it will include not only doctors' offices in hospital settings but doctors' offices in free standing and separate facilities, again generating an excessive increase in medical care cost.

On the subject of veterinary hospitals, the list of diseases included is again broad and tends to encompass the zoonoses in general. I'm not personally aware and would doubt that anybody could document that the majority of the specific diseases mentioned have spread to human beings as the result of discharge of waste materials from veterinary hospitals. In fact, the listing of such infectious agents as Q Fever, Anthrax, Tuberculosis, Brucellosis and Tularemia as examples of diseases that might be spread from veterinary hospitals to an unsuspecting public strongly suggests a lack of understanding of the means of transmission of these diseases, of the zoonoses in general, or of the operation of veterinary hospital facilities.

In summary, I am restricting my remarks basically to the solid waste generated by health care facilities including hospitals and animal hospitals. I'm concerned over several major issues.

1. That an all inclusive approach is being utilized since the authors of the proposed Federal regulations appear not to have clearly understood the issues at hand and the true sources of potential hazard in such health care facilities. Obviously, truly hazardous materials should be properly and safely disposed of and means generally are in place for effecting such safe disposal. To indicate broadly that infectious material can not be adequately separated from non-infectious material for safe processing prior to disposal does not seem to be well documented, in my opinion.

2. Because of the language used in the background statement and in the proposals it appears to me that there is a real possibility of extension of these proposed regulations beyond hospitals and veterinary hospitals and might well ultimately include physicians' and dentists' offices and clinics Again, where truly hazardous materials are being handled, proper disposal should be assured, but not by requiring the waste paper basket contents of the receptionist's office be autoclaved at 121° centigrade for one hour (which if four times longer than is routinely used for the sterlization of surgical packs).

3. The times and temperatures proposed for autoclaving as a means of rendering material non-infectious appear to me to be excessive and should be studied further. While there can be no question that certain infectious agents packed in an autoclave in certain materials, i.e. "a bucket of rodent animal bodies stuffed in the autoclave" might well not be rendered non-infectious by autoclaving for eight hours, it is equally apparent that a single or limited number of properly packed animal carcasses could well be rendered non-infectious in under 1 hour in the autoclave. Similar comments could be made regarding the other time-temperature relationships proposed for other types of potentially hazardous material.

I believe that hazardous waste list should be redefined to be more specific and to identify as hazardous only those items which can truely be considered a threat to the health of the public. Futhermore, I believe the biological life of infectious agents should be considered since they are obviously different than those of chemical waste. I believe that the proposed list of hazardous wastes, as it relates to infectious diseases should not be published in final form until additional specific

Guttenberg Municipal Hospital

SECOND and MAIN • PHONE (319) 252 11..
GUTTENBERG, IOWA 52052

March 8, 1979

John P. Lehman, Director
Hazardous Waste Management Div.
Office of Solid Waste
U.S. Environment Protection Agency
Washington, D.C. 20460

Dear Sir:

I am writing in response to the proposed regulations for the disposal of hazardous waste which is under consideration at this time.

As the Director of Nursing and Infection Control Nurse in a small rural hospital, I would like to express my concern over these proposals, and what compliance would mean for us.

What is classified as "hazardous" waste? Surely not all trash, as the report I have seems to indicate.

The report I have mentions pathological incineration but seems to emphasize sterilization. The use of our steam autoclave is certainly out as transporting such waste through our central sterile department would certainly negate the benefit of rendering our waste "non-hazardous". Nor could we justify the cost of a second sterilizer, operating time, etc., in this day of cost containment and voluntary effort.

Presently we are complying with the recommendations of the Center for Disease Control, which allows us to incinerate such waste. We certainly appreciate our responsibility as a community health center, to protect our community.

However, in a small facility like ours, where a very limited number of people have the responsibility for disposing of any waste, the steps we take are effective and consistent. How great a threat can we be? It is my opinion that the proposed regulations are aimed more at the large centers, but could be devastating to us.

I would appreciate a reply. Thank you.

Sincerely,
Patty Wonsmos, RN, Director of Nursing
Guttenberg Municipal Hospital

Patty Wonsmos RN.

PW/ejh

March 12, 1979

Part marked
3/16/79

Mr. John P. Lehman
Director, Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U. S. Environmental Protection Agency
Washington, D. C. 20460

Re: Part 250 Subpart A - Hazardous Waste Guidelines & Regulations

Dear Mr. Lehman:

On December 18, 1978, the Environmental Protection Agency (EPA) published in the Federal Register proposed regulations prescribing regulatory programs designed to manage and control the country's waste from generation to final disposal.

Convertors, a division of American Hospital Supply Corporation, is a manufacturer and distributor of single-use disposable surgical and apparel products constructed from nonwoven medical fabrics. Our products are sold to health care facilities both domestically and internationally. Included among our products are a wide variety of surgical drapes, specialty sponges and apparel patient care items.

Convertors is proud of its nonwoven single use product line and experience in the health care industry and wishes to submit the following specific comments on this document.

Although these proposed regulations do not purport to regulate us, we feel that they could have a direct impact on our industry. Therefore, we trust that these comments will help the Agency further refine this very important document.

Specific Comments

Subpart A - Section 250.11 - Hazardous Waste Definition

For purposes of the proposed regulations, the term "other discarded material" in the solid waste definition Section 1004 (27) of the Act, is defined by EPA to mean any material which:

(1) Is not reused (that is, is abandoned or committed to final disposition), ...

AMERICAN HOSPITAL ASSOCIATION
840 NORTH LAKE SHORE DRIVE CHICAGO, ILLINOIS 60611 TELEPHONE 312-645-9400
TO CALL WRITER, PHONE 312- 280-6626

March 15, 1979

RECEIVED
MAR 16 1979

John P. Lehman, Director
Hazardous Waste Management Division
Office of Solid Waste (WH 565)
U.S. Environmental Protection Agency
Washington, DC 20460

Reference: Proposed rules under Sections 3001, 3002, and 3004 of the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (Public Law 94-580), Federal Register, Volume 43, no. 243, December 18, 1978.

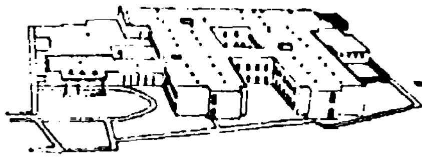
Dear Mr. Lehman

The American Hospital Association (AHA), representing over 6,400 hospitals and other health care institutions, welcomes the opportunity to comment on above referenced proposed regulations on the identification and listing of hazardous waste. The AHA recognizes the problems that the Environmental Protection Agency (EPA) had in attempting to write regulations that in effect set policy without clear congressional direction. The AHA also recognizes the difficulty in defining quantitatively that portion of solid waste that may be considered hazardous due to possible infectiousness.

However, the AHA believes that EPA's approach to a definition of hazardous infectious waste as stated in section of 3001 of the proposed regulations is incorrect according to leading authorities and will cause an undue financial burden on hospitals without a commensurate benefit to public health. Our concerns relate to the following of our major concerns:

1. No problem or threat to public health from hospital waste has been documented that warrants the promulgation of regulations that are as inclusive and as costly as those included in Section 3001, 3002, and 3004.

2. Sterilization and incineration requirements as specified in Appendix VII, p. 58964, for hospital waste are not feasible or realistic.



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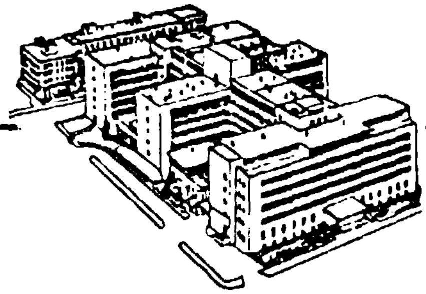

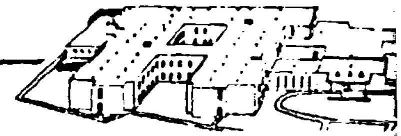

4214 E. Southcross Blvd.

BAPTIST MEMORIAL HOSPITAL SYSTEM ☐ 111 DALLAS STREET ☐ SAN ANTONIO, TEXAS ☐ 78286

David Garrett
Executive Director

March 15, 1979

RECEIVED
MAR 26 1979
Postmarked 3/16

EPA Regional Office
2404 Waterside Mall
401 M Street, S.W.
Washington, D. C.

Re: Part 250-Hazardous Waste Guidelines and Regulations, Federal Register, Vol. 43, NO. 243.

Gentlemen:

The proposed regulation set forth in the Federal Register, Vol. 23, NO. 243, defining hazardous waste from within hospitals, is not necessary since most of these functions of sterilization, labeling, etc., of waste materials are already being treated as preventative by other accreditation agencies, as well as state laws. These regulations would be superfluous and an added expense to hospitals since the main thrust of the U.S. Government, HEW is to reduce costs. Why is it necessary to duplicate?

Also, the section in which hospitals using incinerators must set up trust fund satisfactory to EPA to assure maintenance, closure costs and imposing fines. Again, this is duplication of already existing state, city regulations and again would be superfluous and duplication of efforts, adding to hospital costs.

Yours truly,

M. R. Wiggs

M. R. Wiggs
Associate Administrator

MRW:ach

En 1.

THE IOWA HOSPITAL ASSOCIATION

Suite R • 600 Fifth Ave. • Des Moines, Iowa 50309 • Phone (515) 288-1955

DONALD W. DUNN, President

March 15, 1979

RECEIVED MAR 22 1979

Mr. John P. Lehman, Director
Hazardous Waste Management Division
Office of Solid Waste
U.S. Environmental Protection Agency
Washington, D.C. 20460

Re: Hazardous Waste Guidelines and Regulations
(40 CFR Part 250) (6560-01-M)

Dear Mr. Lehman:

With regard to the proposed notice of federal rulemaking which appeared in the December 18, 1978, Federal Register, we wish to offer the following observations:

The detailing of sources generating hazardous waste which apply to health care facilities (page 58958 of the Federal Register) are far too inclusive. The inclusion of organisms defined as Class 2 by the CDC classification when combined with the inclusion of patient rooms suggests that virtually all wastes from such areas could be deemed hazardous. Hospitals should be allowed to dispose of such materials in a less costly manner. The required steam autoclave treatment procedure when combined with the proposed record-keeping requirements will place an undue and unnecessary administrative and financial burden on the nations hospitals.

It is our hope that the final regulations will take account of this problem.

Sincerely yours,

Bradley C. Engel

Bradley C. Engel
Director of Planning

BCE/ms

APPENDIX E-13

Duke University
DURHAM
NORTH CAROLINA
27706

March 16, 1979

Vice President for Government Relations
and
General Counsel to the University

TELEPHONE 919-684-3955

Mr. John P. Lehman, Director
Hazardous Waste Management Division
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
Washington, D. C. 20460

Post-marked 3/16/79

RE: Sections 3001 & 3002

Dear Mr. Lehman:

I am writing to share with you Duke University's comments on the proposed regulations written to implement Sections 3001 and 3002 of the Solid Waste Disposal Act. We feel that it is particularly important that EPA hear from universities since the regulations were not written with institutions like ourselves in mind. We expect that your office has not had the resources or the time to consider what effects these December 18 regulations could have on colleges and universities. We belong to the small number of institutions in the country that produce more than 100 kilograms of hazardous waste per month but still produce much less hazardous waste than do the prime targets of your regulations: business and industry.

We cannot argue with the principle that hazardous waste should be handled and disposed of properly. At the same time we know, as EPA knows, that if the efforts that regulations require cannot be realistically accomplished and do not seem reasonable to those who must undertake them, then nothing constructive results. In a country as large as this one, compliance must be essentially voluntary. Therefore regulations must be fairly reasonable to be effective.

As the regulations are now written, university researchers have two choices: test every new type of waste they generate which they have reason to believe is hazardous or assume it is hazardous and turn it over (properly stored and labelled) to the Safety Office.

Both choices pose problems. The problem with the first is that it is a practical impossibility to test all of the suspect waste. Unlike industries, which produce massive quantities of a particular waste, the waste from university laboratories differs from beeker to beeker, from test tube to test tube. Every day there are new types of hazardous waste to test.

The second alternative, while simplier for the researcher, makes much more work for the Safety Office and is much more costly to the University. It is difficult to say exactly how much more hazardous waste would be turned over to the Safety Office but it is not difficult to guess the rough proportions. We expect the amount to increase by 3 to 4 times, for two reasons: (1) researchers will turn over waste that may not be hazardous, rather than test it to find out; (2) EPA's definition of what is hazardous takes in much waste which has never been handled by the Safety Offices before.

A chemistry professor here at Duke, Professor James Bonk, has reviewed the sections 250.13 and .14 of the regulations for us. He reports that these wastes, among others, will soon be going to the University Safety Office for the first time if these regulations go into effect:

- Hydrochloric acid, sulfuric acid and nitric acid, all produced as waste in great quantities by laboratories on campus. Among other things these acids are used to clean test tubes and beekers. Last year Duke University purchased roughly 1000 gallons of these acids in concentrate.

- Chromate waste. This appears in the list in 250.14. Chromate waste is produced in quantities in university laboratories where it is used for cleaning.

- Containers for chloroform, formaldyhide, carbontetrachloride, analine, brucine, camphrine, benzene and phenol. (As we read the regulations, Duke has the choice of rinsing these containers, which are discarded in great numbers, three times and turning the waste liquids generated from the rinsing over to the Safety Office or of turning the containers themselves over. In either case the quantities are very great.)

Related to the problems posed by the necessity of collecting some of the wastes specified are the difficulties created by the labelling requirements set forth in section 3002 of the law and subpart B of the regulations. If our reading of the regulations is correct, the Safety Offices of universities are being asked to measure, package and label hazardous waste according to these categories: (1) the roughly 1000 hazardous wastes that have each been assigned a separate "shipping name" by the Department of Transportation regulations, 49 CFR 172; (2) the waste processes in the EPA regs in section 250.14, if there is no DOT shipping name.

We assume that this means that each of these wastes must be kept separately as it travels from the laboratory to the Safety Office. In order for the Safety Office to know which of these wastes it is, it would further need to be labelled in some way by the researcher. Hydrochloric acid is listed as a shipping name in the DOT regulations, as is sulfuric acid. Therefore laboratories would have to put these acids, as wastes, in separate containers. At present this is not done. Perhaps the task of measuring the amount could be given to the Safety Office. Even then, the amount of detailed work involved in preparing the hazardous waste for the Safety Office would be extremely burdensome. An additional very great expense would be to supply the great numbers of containers that would be needed to store the wastes (for pickup from the Safety Office). We conclude that the categories for labelling are far too specific. Many of these wastes which share a characteristic can be safely combined, by the chemist, who knows well enough what the reactions will be.

APPENDIX E-14

Health Industry Manufacturers Association

President
Harold O. Buzzell

1030 Fifteenth St., N.W.
Washington, D.C. 20005
(202) 452-8240

March 16, 1979

Mr. John P. Lehman
Director, Hazardous Waste Management Division
Office of Solid Waste (WH-565)
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Lehman:

Re: Hazardous Waste; FRL 1014.5

In the Federal Register of December 18, 1978, the Environmental Protection Agency (EPA) published proposed guidelines and regulations regarding hazardous waste. The Health Industry Manufacturers Association (HIMA, the Association), a trade association representing more than 250 companies that develop, manufacture, and market medical devices and diagnostic products, is an interested party with respect to this proposal because HIMA, its members companies, and their customers will be affected by implementation of the proposals.

These regulations were proposed pursuant to Sections 3001, 3002, and 3004 of the Resource Conservation and Recovery Act (RCRA) of 1976. RCRA requires EPA to formally designate those wastes that are considered to be "hazardous." After a list of hazardous wastes has been promulgated in final form, companies, institutions, and organizations will be given 90 days to notify EPA (or the states) of any hazardous waste that they may generate. Thereafter, generators of hazardous waste will be required to store, package, label, and ship such waste in accordance with specific EPA requirements. Part of EPA's hazardous waste program is a documentation system intended to monitor hazardous waste materials from point of generation through storage and transportation to final treatment and/or disposal.

HIMA, on behalf of its member companies, objects to this proposal for a number of reasons discussed in detail below. The proposal is too narrowly drawn, overly burdensome, highly inflationary, and scientifically unsupportable with respect to medical product and hospital waste. Broad categorization of hospital waste as hazardous will require complex and costly special disposal procedures that are not necessary to protect public health or the environment. Moreover, they will create significant new costs in a period when hospital cost containment and control of inflation are national concerns. We submit

An association representing the medical device and diagnostic product industry

Michael Reese Hospital and Medical Center

Office of Legal Affairs
29th Street and Ellis Avenue
Chicago, Illinois 60616
(312) 791-3717

March 16, 1979

Mr. John P. Lehman
Director
Hazardous Waste Management Division
Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

Part man kel
3/16/79

Dear Mr. Lehman:

I am writing on behalf of Michael Reese Hospital and Medical Center and the University of Chicago Medical Center to comment on the Environmental Protection Agency's proposed hazardous waste disposal regulations as published in the Federal Register (Volume 43, Page 58946, <u>et seq</u>.) on December 18, 1978.

The proposed regulations, which would implement Public Law 94-580, The Resource Conservation and Recovery Act of 1976, appear to be both reasonable and necessary for many areas. However, they are unrealistic and unnecessary in their application to hospitals and health care facilities. Section 250.14(b) (i) (A) specifically lists the following ten hospital departments as generators of hazardous wastes: Obstetrics Department including patient's rooms; Emergency Departments; Surgery Department including patient's rooms; Morgue; Pathology Department; Autopsy Department; Isolation rooms; Laboratories; Intensive Care Unit; Pediatrics Department.

Although the proposed regulations would not apply if wastes from the listed departments do not contain any of the microorganisms listed in Appendix VI, if the wastes are demonstrated to be non-hazardous according to Chapter 250.15, if the waste generated by the institution is less than 100 kilograms per month, or if the wastes are treated as specified in Appendix VII, it appears that, in fact, many hospitals would be deemed to be generators of hazardous waste under the proposed definitions. If hospitals are deemed to be generators of hazardous waste they are subjected to stringent disposal and record-keeping requirements. If, as an alternative to off-premises disposal, a hospital elects to incinerate waste materials on-site, an appropriate EPA permit must be obtained (in addition to meeting state and local requirements) and a separate "trust fund" must be established to cover the costs, probably quite high, of this approach.

NACHRI AN ASSOCIATION STATEMENT

March 16, 1979

Post marked 3/16/79

John P. Lehman
Director
Hazardous Waste Management
Division
Office of Solid Waste
(WH-565)
U.S. Environmental Protection
Agency
Washington, D.C. 20460

Re: Section 3001

Dear Mr. Lehman,

This Association's membership is comprised of 69 Children's Hospitals admitting 90% of the 363,164 children admitted to Children's Hospitals annually.

In the review of The Hazardous Waste Guidelines and Regulations, published in the December 18, 1978, Federal Register, the Association has identified several areas of concern which should be considered prior to the finalization of these regulations.

First, the format, organization, referencing, and syntax of the proposed rules make them extremely difficult to read, understand, and interpret. If, as indicated in the Supplementary Information introduction, some 270,000 waste generating facilities and 10,000 transporters will be regulated, it must be recognized that many non-technical persons will be responsible for adherence to the final regulations. These regulations will be effective towards the goals of the authorizing legislation only if they can be understood.

There exists today, a general cynicism towards Government's activities, fostered by the bewildering array of rules and regulations which impact increasingly on every aspect of life and which all too often indicate to those impacted, a lack of realism on the part of their drafters. It should not be necessary for the individual or organization so impacted to have to seek expert consultative services, in order merely to understand what requirements are being imposed. The proposed rules, as written, may well result in that need for all but the most sophisticated and technically conversant with their subject matter.

The National Association of Children's Hospitals and Related Institutions, Inc.
Suite 34, Independence Mall, 1601 Concord Pike, Wilmington, DE 19803

APPENDIX E-17

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, D. C. 20301

MANPOWER,
RESERVE AFFAIRS
AND LOGISTICS

16 MAR 1979

RECEIVED
MAR 16 1979

Mr. John P. Lehman
Director, Hazardous Waste
Management Division
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Lehman:

This is to provide the Department of Defense's (DoD) comments on the Environmental Protection Agency's (EPA) proposed "Hazardous Waste Guidelines and Regulations" (Sections 3001, 3002, and 3004) which were published in 43 FR 58946-59028, dated December 18, 1978.

The DoD has extensively reviewed these proposed regulations because of the substantial impact on our operations. The comprehensive scope of the regulations and the technical problems associated with the unique hazardous materials handled as part of DoD's military mission will have a significant economic effect on DoD.

We support both the principle to regulate hazardous wastes and the general "cradle-to-grave" management concept in the Resource Conservation and Recovery Act of 1976. We also appreciate the complexities associated with developing meaningful and realistic regulations. The regulations as proposed, however, are extremely complex, difficult to interpret, and will be very expensive to administer.

We have enclosed a number of substantive comments in an attempt to clarify key issues of concern to DoD. Enclosure 1 presents general comments, and Enclosure 2 is specific comments on individual referenced topics.

Overall, the definition of hazardous waste is itself too general to be meaningful. There is a definite need to recognize the varying degrees of risk associated with hazardous wastes, rather than any specific threshold value. Ideally, the degree of control associated with a particular hazardous waste should be commensurate with its potential for environmental harm, recognizing that in many cases there is limited knowledge of the risks involved. Monitoring, recordkeeping, and reporting are unnecessarily complicated and difficult to administer, and efforts should be made to minimize the unnecessary generation of paperwork.

Of particular concern is the need to recognize the special problems associated with federal compliance, particularly DoD. The inherent differences in the federal government structure and private industry preclude application of the same specific regulations in many instances. Separate regulations are necessary in such cases to allow actual implementation. DoD's operations involve a wide variety of unique hazardous materials (e.g., military munitions), and this special area needs to be addressed specifically in the regulations. Details are discussed in the enclosures.

We welcome the opportunity to discuss hazardous waste issues with EPA at any time. Some dialogue has already been initiated on this subject between military service and EPA representatives at the working level. We encourage this type of cooperation and offer the assistance of this office to support these efforts to the mutual benefit of DoD and EPA.

Please let me know if you have any questions on our comments, or if I can be of any further assistance.

Sincerely,

G Marienthal

George Marienthal
Deputy Assistant Secretary of Defense
(Energy, Environment and Safety)

Encls

APPENDIX F

STATE DEFINITIONS OF INFECTIOUS WASTE AND DISPOSAL REQUIREMENTS

APPENDIX F

STATE DEFINITIONS OF INFECTIOUS WASTE AND DISPOSAL REQUIREMENTS

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
California Department of Health Services	California Hazardous Waste Control Act - Title 22. California Administrative Code Div. 4, Chap. 2. Minimum Standards for Management of Hazardous and Extremely Hazardous Waste (First Revision, 11/21/78)	"Section 601. Infectious Waste. (a) Infectious waste means any waste material or article which has been, or may have been, exposed to contagious or infectious disease and shall include the following: (1) Pathologic specimens, tissues, specimens of blood elements, excreta, or secretions, and disposable articles attendant thereto from humans or animals at a hospital, medical clinic, research center, veterinary institution, or pathology laboratory. (2) Surgical operating room pathologic specimens and disposable articles attendant thereto which may harbor or transmit pathogenic organisms. (3) Pathologic specimens and disposable articles attendant thereto which may harbor or transmit pathogenic organisms. (4) Discarded equipment, instruments, utensils, sharps, and other articles which may harbor or transmit pathogenic organisms from the rooms of patients with suspected or diagnosed communicable disease."	"Section 60402. On-Site Disposal of Infectious Waste (b) Infectious waste shall be disposed of on-site by one or more of the following methods... (1) By incineration in an incinerator which provides complete combustion of the waste and which complies with existing air pollution control laws and regulations... (2) By burial at a Class I or Class II disposal site... except as prohibited by Subsection(d). (3) By discharge to a sanitary sewer through an on-site sewer appliance or other connection if the waste is liquid, semiliquid, or pulverized. (d) Infectious waste consisting of recognizable human body parts, tissues, or pathological specimens shall not be disposed of by burial at a landfill disposal facility, but shall be disposed of by incineration." "Section 60403. Off-Site Disposal of Infectious Waste (e) Ashes resulting from the incineration of infectious waste shall be disposed of at a Class I or Class II disposal site..."

APPENDIX F (Continued)

STATF AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
Illinois Environmental Protection Agency	Environmental Protection Act - Illinois Solid Waste Regulations (Adopted 7/19/73)	"Rule 104.(h). Hazardous waste - solid waste with inherent properties which make such waste difficult or dangerous to manage by normal means including but not limited to chemicals, explosives, pathological wastes, radioactive materials, and wastes likely to cause fire."	Part III: Sanitary Landfills Rule 310: Special Wastes.(b) Hazardous and liquid wastes - hazardous wastes or liquid wastes and sludges may be accepted at a sanitary landfill only if authorized by permit.
Maryland Department of Natural Resources	Hazardous Substance Control Law - COMAR 08.05.05. Control of The Disposal of Designated Hazardous Substances (Amended through 7/28/78)	.18 Designated Hazardous Substances. The List of Designated Hazardous Substances categorizes pathological and medical wastes from hospitals, laboratories, and similar operations under Class III. Class III substances pose a substantial threat to human health or the environment under certain conditions.	
Maryland Department of Health and Mental Hygiene	Interpretive Guidelines for the Disposal of Infectious Waste (Effective 7/1/78)	I. <u>Definition: Infectious Waste</u> Infectious waste consists of: (a) Laboratory wastes, including pathologic specimens and disposable fomites. Pathologic specimens include all body tissues, specimens of blood elements, excreta and secretions obtained from patients. (b) Operating room, out-patient areas, and emergency room pathologic specimens and disposable fomites, and other patient contact materials. (c) Equipment, instruments, utensils, disposable fomites and other wastes from the rooms of patients with suspected or diagnosed communicable disease.	II. <u>Disposal of Infectious Waste</u> The approved method of disposal of "infectious waste" is by incineration. Both off-site and on-site incineration is acceptable if they comply with the transportation and air quality requirements in the guidelines.

APPENDIX F (Continued)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
Minnesota Pollution Control Agency	Minnesota Statutes 1971: Chapter 115, 116, 400, 473 D - Solid Waste Disposal Regulations SW1-SW12 (Final Amendments through 9/26/73)	"SW1(12) Hazardous *Infectious Waste.* Waste originating from the diagnosis, care or treatment of a person or animal that has been or may have been exposed to a contagious or infectious disease. Hazardous infectious waste includes, but is not limited to: (a) All wastes originating from persons placed in isolation for control and treatment of an infectious disease. (b) Bandages, dressings, cases, catheters, tubing, and the like, which have been in contact with the wounds, burns, or surgical incisions and which are suspect or have been medically identified as hazardous. (c) All anatomical waste, including human and animal parts of tissues removed surgically or at autopsy. (d) Laboratory and pathology waste of an infectious nature which has not been autoclaved. (d) Any other waste, as defined by the State Board of Health, which, because of its hazardous nature, requires handling and disposal in a manner prescribed for (a) through (d)."	SW7 Incineration. "(n) All residue removed from the incinerator plant shall be promptly disposed of at an approved site, and in a manner that will prevent nuisances, pollution and public health hazards..."
Minnesota Department of Health	Interpretive Policies for the Physical Plant: Handling and Disposal of Infectious Waste (Existing DOH Guidelines)	Infectious waste is divided into two categories: (1) Hazardous Infectious Waste (same as above). (a) Bandages, dressing, casts, catheters, tubing, and the like, which have been in contact with wounds, burns, and the like, which have in contact with wounds, burns, or surgical incisions, but are not suspected or have been not medically identified as being of a hazardous infectious nature. (b) Discarded hypodermic needles and syringes, scalpel blades, and similar materials, when suspected or identified to be of a hazardous infectious nature.	

APPENDIX F (Continued)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
Minnesota Department of Health (cont.)		(c) Incinerator ashes from infectious waste.	
New Jersey Department of Environmental Protection	New Jersey Solid Waste Management Regulations (Effective July 21, 1977)	"7.26-1.4.38 Infectious Waste Includes: (1) equipment, instruments, utensils, and fomites (any substance that may harbor or transmit pathogenic organisms) of a disposable nature from the rooms of patients who are suspected to have or have been diagnosed as having a communicable disease and must, therefore, be isolated as required by public health agencies; (2) laboratory wastes including pathological specimens (i.e., all tissues, specimens of blood elements, excreta, and secretions obtained from patients or laboratory animals) and disposable fomites attendant thereto; (3) surgical operating room pathologic specimens and disposable fomites attendant thereto and similar disposable materials from out-patient areas and emergency rooms."	
New Jersey Health Care Administration Board	Amendments to Hospital License Manual (Passed Feb. 1, 1979)		Section 306. <u>Pathological and Infectious Waste Disposal</u> Each hospital must develop and implement policies and procedures for the collection storage, handling and disposition of all pathological and infectious waste. These policies must include: "306.1.1 Solid wastes from the microbiological laboratory shall be autoclaved or incinerated.

APPENDIX F (Continued)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
New Jersey Health Care Administration Board (cont.)			306.1.2 Liquid wastes from the microbiological laboratory shall be autoclaved prior to disposal into the laboratory sewage system. 306.1.3 All pathology specimens and wastes, including gross and microscopic tissue removed surgically or at autopsy, shall be incinerated unless otherwise provided by law. 306.1.4 Solid sharp or rigid items such as needles, syringes and scalpel blades shall be autoclaved prior to disposal. Needles and syringes shall be destroyed as stipulated in N.J.S.A. 2A:170-25.17 and they, along with other sharp or rigid items, shall be either ground and flushed into the sewage system or placed in a rigid contriner and disposed with other solid waste material. 306.1.5 Solid non-rigid contaminated waste material such as blood tubing and disposable equipment and supplies shall be autoclaved, incinerated or removed from the hospital and disposed of in a manner approved by the Department of Environmental Protection.

APPENDIX F (Continued)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
New Jersey Health Care Administration Board (cont.)			306.1.5.1 All such material not autoclaved or incinerated within the hospital shall be doubly packaged in impervious plastic heavy duty bags prior to removal from the hospital and disposal in a manner approved by the Department of Environmental Protection. 306.1.6 Fecal matter shall be flushed into the municipal sewerage system. 306.1.7 All containers used for storage of infectious wastes shall be sanitized by a method approved by the Department at least once every 24 hours."

APPENDIX F (Continued)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
New York Department of Environmental Conservation	New York Compilation of Rules and Regulations, Title 6, Chapter 360, Solid Waste Management Facilities	Section 360.1 General "(c)(12) "Hazardous Waste" means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or biological characteristics may: (i) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (ii) cause or significantly contribute to a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed or otherwise managed. Such wastes shall include but not be limited to wastes which are bio-concentrative, highly flammable, explosive, highly reactive, toxic, poisonous, radioactive, irritating, sensitizing, or infectious and shall include wastes that are solid, semisolid, liquid, or contained gases..." "(b) Criteria for Identifying Hazardous Substances. (6) Infectious. Materials containing infectious agents which are capable of causing death or severe illness, or which are highly contagious."	
Oregon Department of Environmental Quality	Oregon Laws 1971 (HB 1051), Chapter 648-Regulations Pertaining to Solid Waste Management Chapter 360(6)(1)	"Hazardous Solid Waste" is solid waste that may, by itself or in combination with other solid waste, be infectious...or otherwise dangerous or injurious to human, plant, or animal life..." Have not identified any waste as infectious as yet.	No special disposal regulations for infectious wastes. Disposal decided on a case-by-case basis.

APPENDIX F (Concluded)

STATE AGENCY	LEGISLATIVE AND REGULATORY AUTHORITY	DEFINITION	DISPOSAL REQUIREMENTS
Pennsylvania Department of Environmental Resources	Pennsylvania Solid Waste Management Act, P.L. 788 (No. 241), 6, (35 P.S. Sec. 6001) (6/27/77)	"Section 75.1(b) "Hazardous Waste"- A solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."	Hazardous wastes are disposed of on a case-by-case basis.
Washington State Department of Energy	Washington Administrative Code (WAC) Hazardous Waste Regulation, Chapter 173-303 WAC	Waste containing etiologic agents are toxic dangerous wastes. Etiologic agent means a viable microorganism or its toxin, which causes or may cause human disease, and is limited to those agents listed in 42 CFR 72.25(c) of the regulations of the Department of HEW.	Infectious wastes must be disposed of by incineration or in sanitary landfill.

APPENDIX G

SURVEY QUESTIONNAIRE FOR U.S. ARMY HOSPITALS AND MEDICAL CENTERS

DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY HEALTH SERVICES COMMAND
FORT SAM HOUSTON, TEXAS 78234

S: 20 April 1979

HSPA-P

SUBJECT: Questionnaire Survey of US Army Hospital Wastes

SEE DISTRIBUTION

1. Reference is made to Federal Register, Volume 43, Number 254, Monday, 18 December 1978, EPA (FRL 1014.5) Hazardous Waste Guidelines and Regulations.

2. At the request of the US Army Medical Bioengineering Research and Development Laboratory, this command is forwarding a questionnaire to selected MEDCEN/MEDDAC for use in determining the types and quantities of waste generated at US Army hospitals.

3. Data collected from this survey will be of use in a project to evaluate the feasibility of landfilling military hospital wastes in the context of proposed federal regulations (reference 1). This research could significantly affect the economics and management responsibilities associated with hospital waste disposal.

4. Request compliance in completing the questionnaire and returning it to Ms. J. G. Gordon, Principal Investigator, The MITRE Corporation, Metrek Division, 1820 Dolley Madison Blvd., McLean, VA 22102, NLT 20 April 1979. A copy should be furnished this command, ATTN: HSPA-P.

FOR THE COMMANDER:

Mariette Macdonald, 2LT
for H. L. COOP
LTC, AGC
Asst AG

1 Incl
as

DISTRIBUTION:

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CF:
Cdr, USAMBRDL, ATTN: SGRD-UBG-I
Cdr, USAEHA, ATTN: HSE-ES

Date ________

1. Name of Facility ________

2. Address ________

____

________ Zip Code ________

3. Designated contact ________

Title ________

Telephone Number ( ) ________

4. Type of facility (check one)

____ Research hospital complex

____ General hospital

____ Hospital-nursing home

____ Specialty hospital Explain ________

____ Clinical

____ Other Explain ________

5. Number of hospital beds ________

6. Average number of in-patients/day ________

7. Average number of outpatients/day ________

8. Total number of hosptial employees including both military and civilian personnel for each shift:

   First shift ___________

   Second shift ___________

   Third shift ___________

9. The actual or estimated amount of solid waste generated by your hospital each day:

   ______ lb/day or ______ cubic feet/day

   ______ actual or ______ estimated

10. The percentage by weight of each type of solid waste listed below. If complete data are not available, please estimate.

Type of Waste	Percentage by Weight	
	Actual	Estimated
Paper		
Cloth		
Wood		
Rubber		
Plastics		
Glass		
Metal		
Miscellaneous		
Total		

11. The percentage by weight of solid waste from each source. If complete data are not available, please estimate.

Source	Percentage by Weight	
	Actual	Estimated
Clinical Service (Laboratory)		
Dental Activity		
Department of Medicine		
Department of Obstetrics and Gynecology		
Department of Pathology		
Department of Pediatrics		
Department of Radiology		
Department of Surgery		
General Medical Service		
General Surgical Service		
Intensive Care		
Opthalmology and Otolaryngology Services		
Pharmacy Service		
Coffee Shop		
Command and Administration		
Food Service Division		
Other		

12. The disposal methods used at present

Method	Quantity	
	lbs/day	cu ft/day
Garbage grinder		
Incinerator		
Pathological incinerator		
Landfill		

13. Any information on types of microbial organisms present in your hospital solid waste that is landfilled.

14. Any additional information on the amount, type or source of solid waste generated by your hospital you wish to provide.

15. Any information you could provide to document the information supplied on this questionnaire would be helpful.

Please return within 15 days to:

Mrs. Judith G. Gordon
W-326
The MITRE Corporation
1820 Dolley Madison Blvd.
McLean, Virginia 22102

Telephone: 703/827-6654

APPENDIX H

TABULATION AND STATISTICAL ANALYSIS OF
RESPONSES TO THE SURVEY QUESTIONNAIRE

CONTENTS--APPENDIX H

TABLE H-1

DAILY SOLID WASTE GENERATION IN U.S. ARMY HOSPITALS

DATA	ARMY HOSPITAL							
	LYSTER	FOX	MUNSON	McDONALD	PATTERSON	BASSETT	CUTLER	KELLER
Bed Patient Capacity	39	40	42	42	49	60	65	65
Occupancy Rate (%)[a]	97	76	95	81	41	25	66	54
Average Bed Patient Population	38	31	40	34	20	15	43	35
Gross Population[b]	1066	713	772	1213	447	467	1126	813
Equivalent Population[c]	463	313	331	524	218	202	510	357
Total Solid Waste								
(lbs)	869	800	1122[f]	1156	1028	5185[f]	439	1500
(lbs/bed patient)	23	26	28	34	51	346	10	43
(lbs/gross population)	1	1	1	1	2	11	.4	2
(lbs/equivalant population)	2	3	3	2	5	26	1	4
Outpatients	496	330	284	580	335	215	639	375
Outpatients/Bed Patients[d]	13	11	7	17	17	14	15	11
Location	Fort Rucker, AL	Redstone Arsenal, AL	Fort Leavenworth, KS	Fort Eustis, VA	Fort Monmouth, NJ	Fort Wainwright, AK	Fort Devens, MA	West Point, NY
Data[e]	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated

TABLE H-1 (Continued)

DATA	ARMY HOSPITAL							
	#1[g]	RAYMOND W. BLISS	NOBLE	KENNER	DeWITT	KIMBROUGH	#2[g]	WALSON
Bed Patient Capacity	94	95	100	100	117	125	128	176
Occupancy Rate (%)[a]	45	52	30	65	90	40	63	72
Average Bed Patient Population	42	49	30	65	105	50	81	127
Gross Population[b]	1203	898	1016	1311	1360	1280	1723	2211
Equivalent Population[c]	554	427	442	614	695	560	764	1007
Total Solid Waste								
(lbs)	1100	1383	5519[f]	1000	4000	927	3665	1593[f]
(lbs/bed patient)	26	28	184	15	38	19	45	13
(lbs/gross population)	1	2	5	0	3	0.7	2	1
(lbs/equivalent population)	2	3	12	2	6	2	5	2
Outpatients	750	567	500	800	1027	600	813	1111
Outpatients/Bed Patients[d]	18	12	17	12	10	12	10	6
Location	Fort Stewart, GA	Fort Huachuca, AZ	Fort McClellan, AL	Fort Lee, VA	Fort Belvoir, VA	Fort Meade, MD	Fort Polk, LA	Fort Dix, NJ
Data[e]	Estimated	Measured	Estimated	Measured	Estimated	Measured	Estimated	Estimated

TABLE H-1 (Continued)

DATA	ARMY HOSPITAL							
	IRELAND	IRWIN	DARNALL	WOMACK	#3[g]	MADIGAN MEDICAL CENTER	MONCRIEF	SILAS B. HAYS
Bed Patient Capacity	188	200	285	325	331	396	410	440
Occupancy Rate (%)[a]	89	37	16	65	34	90	38	34
Average Bed Patient Population	167	74	46	212	114	358	157	148
Gross Population[b]	1570	1560	2486	3922	2241	4852	2178	2969
Equivalent Population[c]	822	725	1090	1797	1017	2313	1014	1346
Total Solid Waste								
(lbs)	9500[h]	2143	7037[f]	5269	3403	1750	13400[f]	300
(lbs/bed patient)	57	29	153	25	30	5	85	2
(lbs/gross population)	6	1	29	1	2	.4	6	0
(lbs/equivalent population)	12	3	6	3	3	1	13	0
Outpatients	1123	934	1381	2089	1164	2741	1100	1544
Outpatients/Bed Patients[d]	7	13	20	10	10	8	7	10
Location	Fort Knox, KY	Fort Riley, KS	Fort Hood, TX	Fort Bragg, NC	Fort Carson, CO	Tacoma WA	Fort Jackson, SC	Fort Ord, CA
Data[e]	Estimated	Estimated	Estimated	Estimated	Measured	Estimated	Estimated	Estimated

TABLE H-1 (Continued)

DATA	ARMY HOSPITAL							
	WILLIAM BEAUMONT MEDICAL CENTER	FITZSIMONS MEDICAL CENTER	GENERAL LEONARD WOOD	LETTERMAN MEDICAL CENTER	TRIPLER MEDICAL CENTER	BROOKE MEDICAL CENTER	DWIGHT DAVID EISENHOWER MEDICAL CENTER	WALTER REED MEDICAL CENTER
Bed Patient Capacity	463	475	500	550	552	610	769	1280
Occupancy Rate (%)[a]	86	72	35	68	87	86	42	62
Average Bed Patient Population	400	341	175	375	480	526	325	790
Gross Population[b]	4843	4705	1732	7995	4965	4350	3198	7890
Equivalent Population[c]	2262	2040	911	3153	2325	2206	1449	3340
Total Solid Waste								
(lbs)	5000[f]	7500	4500	6800	14000	7236	4850	136800[d]
(lbs/bed patient)	13	22	26	18	29	14	15	173
(lbs/gross population)	1	2	3	1	3	2	2	17
(lbs/equivalent population)	2	4	5	2	6	3	3	41
Outpatients	2275	1468	1300	1429	2099	2431	1000	1100
Outpatients/Bed Patients	6	4	7	4	4	5	3	1
Location		Denver, CO	Fort Leonard Wood MO	Presidio, San Francisco, CA	Moanalua, HI	Fort Sam Houston, TX	Fort Gordon, GA	Washington, DC
Data[e]		Measured	Estimated	Measured	Estimated	Estimated	Estimated	Estimated

TABLE H-1 (CONCLUDED)

[a]Calculated average daily occupancy rate.

[b]The average total number of bed patients, outpatients, and employees present daily.

[c]The population during an average 8-hour shift.

[d]Method used by respondents to quantify the total volume of hospital solid waste generated daily.

[e]The ratio of outpatients to bed patients (average daily number of each).

[f]Data reported as cubic feet or cubic yards; calculated value based on assumed density of 200 pounds per cubic yard (Swofford, 1972; Regan, 1977; and data for Tripler Army Hospital).

[g]Not identified by name.

[h]Data reported as cubic feet of compacted solid waste; calculated value based on assumed density of 500 pounds per cubic yard (Regan, 1977).

[i]Includes extra solid waste generated in 1978/79 during move to new building.

SOURCE: Based on responses to Questions 1 through 9 of the U.S. Army Survey Questionnaire (Appendix G).

TABLE H-2

SUMMARY OF DAILY
SOLID WASTE GENERATION IN U.S. ARMY HOSPITALS

DATA	MEAN	STANDARD DEVIATION	RANGE HIGH	RANGE LOW
Bed Capacity	285	274	1280	39
Occupancy Rate (%)	60	23	97	16
Average Bed Patient Population	172	185	790	15
Gross Population	2471	2001	7995	447
Equivalent Population	1119	862	3340	202
Total Solid Waste (lbs)	8149	23,743	136,800	300
(lbs/bed patient)	51	70	346	2
(lbs/gross population)	3	3	17	0.1
(lbs/equivalent population)	6	8	41	0.2
Outpatient Population	1081	663	2741	215
Outpatients/Bed Patients	10	6	30	1

SOURCE: Based on the survey of 32 U.S. Army Hospitals, 1979.

TABLE H-3

COMPOSITION OF SOLID WASTES FROM U.S. ARMY HOSPITALS[a]
(in weight percent)

COMPONENT	ARMY HOSPITAL							
	LYSTER	FOX	MUNSON	McDONALD	PATTERSON	BASSETT	CUTLER	KELLER
Paper	68	65	34	24	50	80	66	60
Cloth	2	7	1	15	2	0	0	7
Wood	1	4	0	3	2	0	1	1
Rubber	2	4	10	5	0	0	1	1
Plastic	16	5	26	24	20	15	8	10
Glass	6	6	12	8	3	0	13	18
Metal	2	4	2	2	3	0	2	1
Miscellaneous	3	5	15	11	20	5	9	2
Combustible	89	85	71	71	74	95	76	79
Noncombustible	8	10	14	10	6	0	15	19
Miscellaneous	3	5	15	11	20	5	9	2
Data	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Measured	Estimated

TABLE H-3 (Continued)

COMPONENT	ARMY HOSPITAL							
	#1	BLISS	NOBLE	KENNER	DeWITT	KIMBROUGH	#2	WALSON
Paper	5	77	81	74	15	73	50	64
Cloth	1	1	1	1	0	1	10	1
Wood	0	0	1	0	0	0	1	2
Rubber	2	1	2	1	0	1	4	2
Plastic	80	11	9	20	60	16	5	11
Glass	5	1	1	3	0	8	25	1
Metal	4	2	2	1	0	1	0	2
Miscellaneous	3	6	3	0	25	0	5	18
Combustible	88	90	94	96	75	91	70	80
Noncombustible	9	3	3	4	0	9	25	2
Miscellaneous	3	6	3	0	25	0	5	18
Data	Estimated	Measured	Estimated	Estimated	Estimated	Measured	Estimated	Estimated

TABLE H-3 (Continued)

COMPONENT	ARMY HOSPITAL							
	IRELAND	IRWIN	DARNALL	WOMACK	#3	MADIGAN	MONCRIEF	HAYS
Paper	49	85	70	30	81	25	90	67
Cloth	2	3	3	4	1	5	1	0
Wood	1	0	1	2	1	1	.3	0
Rubber	2	0	2	2	1	8	.3	7
Plastic	20	5	10	45	4	45	2	17
Glass	15	1	3	3	3	10	3	3
Metal	10	1	10	2	3	5	1	0
Miscellaneous	1	5	1	12	6	1	3	7
Combustible	74	93	86	83	88	84	93	90
Noncombustible	25	2	13	5	6	15	4	3
Miscellaneous	1	5	1	12	6	1	3	7
Data	Estimated	Estimated	Estimated	Estimated	Measured	Estimated	Estimated	Estimated

TABLE H-3 (Concluded)

COMPONENT	ARMY HOSPITAL							
	BEAUMONT	FITZSIMONS	WOOD	LETTERMAN	TRIPLER	BROOKE	EISENHOWER	WALTER REED
Paper	50	51	38	50	90	78	80	40
Cloth	1	2	3	10	0.4	3	1	3
Wood	0	2	3	5	0.4	0.3	1	10
Rubber	1	2	3	5	1	1	1	1
Plastic	30	6	38	20	1	12	10	4
Glass	10	10	9	5	1	2	1	20
Metal	3	7	7	5	0.4	2	1	9
Miscellaneous	5	20	0.3	0	7	1	5	14
Combustible	82	63	84	90	92	95	93	58
Noncombustible	13	17	16	10	1	4	2	29
Miscellaneous	5	20	0.3	0	7	7	5	14
Data	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated

SOURCE: As reported in response to Question 10 of the U.S. Army Survey Questionnaire (Appendix G). Totals do not always sum to 100 percent.

TABLE 9-4

GENERATION OF SOLID WASTE BY DEPARTMENT IN U.S. ARMY HOSPITALS

(in weight percent)

SOURCE	ARMY HOSPITAL								
	LYSTER	FOX	MUNSON[a]	McDONALD	PATTERSON	BASSETT	CUTLER	KELLER	#1
Clinical Service (Laboratory)	5	1	(30)	2	13	5	20	7	9
Dental Activity	7	3	(5)	.4	2	5	9	6	10
Department of Medicine	16	c	(0)	1	1	5	3	3	1
Department of Obstetrics and Gynecology	4	1	(2)	4	3	0	2	3	2
Department of Pathology	5	13	(0)	0	f	0	1	7	1
Department of Pediatrics	12	2	(1)	1	2	5	1	3	2
Department of Radiology	2	15	(0)	1	5	5	4	6	1
Department of Surgery	12	12	(10)	5	3	10	8	1	6
General Medical Service	4	12	(15)	20	0	0	0	7	2
General Surgical Service	2	d	(0)	d	0	0	0	3	1
Intensive Care	0	4.	(2)	0.5	3	0	0	3	1
Ophthalmology and Otolaryngology Services	1	c	(0)	0.5	2	0	1	2	1
Pharmacy Service	12	20	([illegible])	0.7	5	10	6	1.8	4
Coffee Shop	0	1	(0)	e	0	5	1	2	0
Command and Administration	5	2	(0)	2	3	10	1	8	3
Food Service Division	2	10	(0)	49	26	15	41	28	33
Other	11	5	(40)	14	33	25	0	[illegible]	25
Data	Estimated	Estimated	Estimated		Estimated	Estimated	Estimated	Estimated	Estimated

TABLE B-4 (Continued)

SOURCE	ARMY HOSPITAL										
	DARNALL	WOMACK	#3	MADIGAN	MONCRIEF	WOOD	LETTERMAN	TRIPLER	BROOKE	EISENHOWER	WALTER REED
Clinical Service (Laboratory)	10	10	5	20	16	2	5	5	8	5	12
Dental Activity	3	3	12	5	f	1	5	2	0.4	5	0.8
Department of Medicine	3	3	1	5	f	4	5	8	8	2	0.2
Department of Obstetrics and Gynecology	10	6	11	5	f	4	5	15	1	4	1
Department of Pathology	5	3	0.3	5	f	0	10	1	4	9	.4
Department of Pediatrics	5	3	7	10	f	1	5	7	2	2	0.1
Department of Radiology	3	3	3	2	f	1	5	1	0.4	3	0.3
Department of Surgery	10	10	h	25	f	5	5	15	13	2	4
General Medical Service	3	3	20	5	16	10	5	3	8	2	0.3
General Surgical Service	3	5	h	5	10	10	5	d	8	6	0.1
Intensive Care	5	2	7	5	4	0.4	5	6	12	7	4
Ophthalmology and Otolaryngology Services	3	2	4	5	f	0.4	5	1	0.4	2	1
Pharmacy Service	5	10	3	1	16	1	5	8	12	9	5
Coffee Shop	7	1	0	0	4	1	5	6	1	4	0.3
Command and Administration	3	20	11	0	8	2	5	8	3	9	15
Food Service Division	20	12	4	0	22	49	5	14	18	25	6
Other	2	4	15	0	4	9	15	8	3	9	51
Data	Estimated	Estimated	Measured	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated

TABLE H-4 (Continued)

SOURCE	ARMY HOSPITAL								
	BLISS	KENNER	NOBLE	DeWITT	KIMBROUGH	[illegible]Z	WALSON	TEEL D	IRWIN
Clinical Service (Laboratory)	10	15	2	10	16	12	6	20	30
Dental Activity	5	2	20	10	4	16	1	6	1
Department of Medicine	3	2	1	10	1	2	9	6	0
Department of Obstetrics and Gynecology	2	1	1	10	2	2	1	6	1
Department of Pathology	1	3	1	10	1	1	2	6	4
Department of Pediatrics	5	7	1	1	2	1	2	6	4
Department of Radiology	1	1	2	[illegible]	1	1	3	6	6
Department of Surgery	2	10	1	[illegible]	14	1	6	10	15
General Medical Service	10	1	6	[illegible]	27	1	4	6	4
General Surgical Service	20	1	6	10	1	2	8	6	4
Intensive Care	5	5	[illegible]	1	4	16	1	[illegible]	4
Ophthalmology and Otolaryngology Services	1	1	1	[illegible]	1	1	3	6	9
Pharmacy Service	10	9	2	10	8	16	5	15	9
Coffee Shop	1	2	1	1	2	0	1	5	0
Command and Administration	5	5	20	2	4	2	27	5	10
Food Service Division	20	20	13	1	2	28	6	20	0
Other	0	15	32	5	8	0	16	20	0
Data	Measured	Estimated	Estimated	Estimated	Measured	Estimated	Estimated	Estimated	Estimated

TABLE H-4 (Concluded)

[a]Data reported as the percentage of pathological solid waste from each department.

[b]Included in data for Department of Pathology.

[c]Included in data for General Medical Service.

[d]Included in data for Department of Surgery.

[e]Included in data for Food Service Division.

[f]Included in data for Clinical Service.

[g]Data not reported.

[h]Included in data for Other.

[i]Included in data for Command and Administration.

[j]Included in data for Department of Medicine.

SOURCE: Based on responses to question 11 of the U.S. Army Survey Questionnaire (Appendix C).

TABLE H-5

QUANTITIES OF ARMY HOSPITAL SOLID WASTE FROM DEPARTMENTS
DESIGNATED AS SOURCES OF INFECTIOUS WASTE
UNDER THE PROPOSED REGULATIONS

ARMY HOSPITAL	BED CAPACITY	CONTRIBUTION BY DEPARTMENT (%)						TOTAL	
		CLINICAL SERVICES	OBSTETRICS	PATHOLOGY	SURGERY	INTENSIVE CARE	PEDIATRICS	(%)	(lbs/day)
Lyster	39	5	4	5	14	0	12	40	348
Fox	40	a	1	13	12	4	2	32	256
Munson	42	(30)[b]	(2)[b]	-[c]	(10)[b]	(2)[b]	(1)[b]	0	0
McDonald	42	2	4	0	5	1	1	13	136
Patterson	49	13	3	d	3	3	2	24	232
Bassett	60	5	0	0	10	0	5	20	1037
Cutler	65	20	2	1	8	0	1	32	140
Keller	65	7	3	2	4	3	3	22	309
#1	94	9	2	1	7	1	2	22	237
Bliss	95	10	2	1	22	5	5	45	622
Noble	100	2	1	1	1	0	1	6	397
Kenner	100	15	1	3	11	5	7	42	420
DeWitt	117	30	10	10	10	1	1	62	2480
Kimbrough	123	16	-	-	15	4	2	40	371
#2	128	12	2	1	3	16	1	35	1242
Walson	176	6	1	2	14	1	2	26	400
Ireland	188	20	-	-	10	5	-	35	3325
Irwin	200	30	1	4	19	4	4	62	1329
Darnall	285	10	10	5	13	5	5	48	3378
Womack	325	10	6	3	15	2	3	39	2055

TABLE H-5 (CONCLUDED)

ARMY HOSPITAL	BED CAPACITY	CONTRIBUTION BY DEPARTMENT (%)						TOTAL	
		CLINICAL SERVICES	OBSTETRICS	PATHOLOGY	SURGERY	INTENSIVE CARE	PEDIATRICS	(%)	(lbs/day)
#3	331	5	11	10	-	7	7	31	1043
Madigan	396	20	15	5	30	5	10	85	1488
Moncrief	410	16	-	-	10	4	-	30	4020
Hays	440	-	-	-	-	-	-	-	-
Beaumont	463	-	-	-	-	-	-	-	-
Fitzsimons	475	-	-	-	-	-	-	-	-
Wood	500	2	4	0	15	1	1	23	979
Letterman	550	5	5	10	10	5	5	40	2720
Tripler	552	5	15	1	15	6	2	44	6160
Brooke	610	8	1	4	20	12	2	47	3350
Eisenhower	769	5	4	9	8	2	2	30	1455
Walter Reed	1280	12	1	1	4	4	1	23	28920

[a]Included in data for Department of Pathology.

[b]Data reported as the percentage of pathological solid waste from each department.

[c]Data not reported.

[d]Included in data for Clinical Services.

SOURCE: Based on responses to Question 11 of the U.S. Army Survey Questionnaire (Appendix G).

TABLE H-6

METHODS OF SOLID WASTE DISPOSAL AT U.S. ARMY HOSPITALS

ARMY HOSPITAL	BED CAPACITY	TOTAL QUANTITY SOLID WASTE[a] (lbs/day)	DISPOSAL FACILITY				
			GARBAGE GRINDER (lbs/day)	INCINERATOR (lbs/day)	PATHOLOGICAL INCINERATOR (lbs/day)	LANDFILL (lbs/day)	LANDFILL (%)
Lyster	39	869	46	0	400	423	49
Fox	40	800	60	0	0	740	93
Munson	42	1122	0	0	500	622	55
McDonald	42	1156	0	0	127	1029	89
Patterson	49	1028	50	0	40	938	91
Bassett	60	5185	0	185	0	5000	96
Cutler	65	439	0	61	sparingly	378	86
Keller	65	1500	0	150	60	1290	86
#1	94	1100	0	0	200	900	82
Bliss	95	1383	180	250	0	953	69
Noble	100	5547	0	35	1	5511	99
Kenner	100	1000	0	300	0	700	70
DeWitt	117	4000	0	120	0	3880	97
Kimbrough	125	927[b]	115	75	0	716	77
#2	128	3665	.1	245[c]	300[c]	3120	85
Walson	176	1593	0	0	444	1149	72
Ireland	188	8287	380	0	500	7407	89

TABLE H-6 (CONCLUDED)

ARMY HOSPITAL	BED CAPACITY	TOTAL QUANTITY SOLID WASTE[a] (lbs/day)	DISPOSAL FACILITY				
			GARBAGE GRINDER (lbs/day)	INCINERATOR (lbs/day)	PATHOLOGICAL INCINERATOR (lbs/day)	LANDFILL	
						(lbs/day)	(%)
Irwin	200	2553	19	2143	0[d]	400	16
Darnall	285	7072	45	0	360	6667	94
Womack	325	5269	0	1200	150	3919	74
#3	331	3403	200	0	12	3191	94
Madigan	396	1750	0	900	0	850	49
Moncrief	410	13600	100	0	100	13400	99
Hays	440	200	0	20	0	180	90
Beaumont	463	5280	0	0	80	5200	98
Fitzsimons	475	7545	0	775[c]	45	6725	89
Wood	500	4500	0	4500	0	0	0
Letterman	550	6800	0	0	0	6800	100
Tripler[e]	552	14185	0	0	111	14074	99
Brooke	610	7231	25	1000	0[d]	6206	86
Eisenhower	769	5090	240	0	1050	3800	75
Walter Reed	1280	136800	f	f	1044	126000	92

[a]As reported in question #12 of the questionnaire; sometimes differs from total reported in question #9 (cf. Table 5-1).

[b]21 pounds per day is sent to a meat-rendering plant.

[c]Infectious wastes only.

[d]Included in total for incinerator.

[e]Does not include waste from Schofield Barracks Clinic.

[f]Quantity "unknown."

SOURCE: Based on responses to Question 12 of the U.S. Army Survey Questionnaire (Appendix G).

APPENDIX I

DAILY SOLID WASTE GENERATION IN CIVILIAN HOSPITALS

APPENDIX I

DAILY SOLID WASTE GENERATION IN CIVILIAN HOSPITALS[*]

DATA / HOSPITAL	INGALIS MEMORIAL	DOOR COUNTY MEMORIAL	COMMUNITY MEMORIAL	NEW LONDON	COMMUNITY MEMORIAL	TWO RIVERS	CALUMET MEMORIAL	ALOGMA MEMORIAL	ST. MARYS	OCONTO MEMORIAL
Bed Patient Capacity	-[e]	125[*]	104[*]	83[*]	77[*]	74[*]	60[*]	44[*]	30[*]	40[*]
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	-	100[f]	83[f]	66[f]	52[f]	59[f]	48[f]	35[f]	24[f]	32[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-	-
Total Solid Waste										
(lbs)	6000[*]	350[g]	280[g]	187[g]	420[g]	513[g]	327[g]	280[g]	396[g]	280[g]
(lbs/bed patient)	8[*]	3.5[f]	3.4[f]	2.8[f]	6.8[f]	8.7[f]	6.8[f]	8.0[f]	16.5[f]	8.8[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-	-
Disposable Solid Waste										
(lbs)	-	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-	-
Location/Remarks	Harvey, IL	Door, WI	Door, WI	Waupaca, WI	Waupaca, WI	Kewaunee, WI	Calumet, WI	Kewaunee, WI	Kewaunee, WI	Oconto, WI
Reference	Rohr, 1978	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	ST. VINCENT	MERCURY MEDICAL CENTER	ST. AGNES	ST. ELIZABETH	APPELTON MEMORIAL	SHEBOYGAN COMMUNITY COUNTY HEALTH CENTER	ST. NICHOLAS	MANITOWOC HEALTH CARE CENTER	MARINETTE GENERAL
Bed Patient Capacity	520[*]	370[*]	326[*]	261[*]	239[*]	201[*]	200[*]	194[*]	175[*]
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	416[f]	296[f]	261[f]	209[f]	191[f]	161[f]	160[f]	155[f]	140[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	1306[g]	1190[g]	770[g]	863[g]	677[g]	327[g]	537[g]	256[g]	770[g]
(lbs/bed patient)	3.1[f]	4.0[f]	3.0[f]	4.1[f]	3.5[f]	2.0[f]	3.4[f]	1.7[f]	5.5[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Green Bay, WI	Winnebago, WI	Fond du Lac, WI	Outogamie, WI	Outogamie, WI	Sheboygan, WI	Sheboygan, WI	Manitowoc, WI	Marinette, WI
Reference	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977	Dobkoski and Kulibert, 1977

APPENDIX I (CONTINUED)

HOSPITAL / DATA	MARTIN LUTHER KING JR.	ST. MARY'S	A[h]	B[h]	E[h]	G[h]	H[h]	STANFORD UNIVERSITY HOSPITAL AND MEDICAL CENTER
Bed Patient Capacity	320*	419*	200*	40*	440*	215*	90*	612*
Occupancy Rate (%)[a]	64.4*	79.8*	70*	48*	64*	80*	71*	82.8*
Adjusted Bed Patient Capacity[b]	183*	335*	140	19	282	172	64	507*
Gross Population[c]	2961*	1460*	798	109	1133	1179	340	-
Equivalent Population[d]	2200*	1033*	-	-	-	-	-	-
Number of Meals Served	1318*	1743*	-	-	-	-	-	-
Total Solid Waste								
(lbs)	3678*	2273*	1000-4000*	700[g]	2200[g]	6000[g]	419[g]	17286*
(lbs/bed patient)	20.1*	6.8*	7.1-28.6	36.8	7.8	34.9	6.5	34.1
(lbs/gross population)	1.24*	1.6*	1.25-5.01	6.42	1.94	5.09	1.23	-
(lbs/equivalent population)	1.67	2.20	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Los Angeles, CA	Duluth, MN	San Francisco Bay Area, CA	San Francisco Bay Area, CA	San Francisco Bay Area, CA	San Francisco Bay Area, CA	San Francisco Bay Area, CA	Palo Alto, CA
Reference	Ross Hofmann Associates, 1974	Ross Hofmann Associates, 1974	McKee et al., 1973	McKee et al., 1973	McKee et al., 1973	McKee et al., 1973	McKee et al., 1973	Gonda et al., 1973

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	1[h]	2[h]	3[h]	4[h]	5[h]	6[h]	7[h]	8[h]	9[h]
Bed Patient Capacity	-	-	-	-	-	-	-	-	-
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	13*	19*	22*	31*	50*	55*	62*	64*	65*
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	300[i]	252[i]	764[i]	1428[i]	1300[i]	1700[i]	360[i]	2140[i]	1370[i]
(lbs/bed patient)	23.1	13.3	34.7	46.1	26.0	30.9	5.8	33.4	2.1
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA	Seattle,King County, WA
Reference	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	10[h]	11[h]	12[h]	13[h]	14[h]	15[h]	16[h]	17[h]	18[h]
Bed Patient Capacity	-	-	-	-	-	-	-	-	-
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	65*	81*	90*	109*	113*	119*	120*	140*	157*
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	1372[i]	2500[i]	4290[i]	5028[i]	2860[i]	1280[i]	2500[i]	4290[i]	1860[i]
(lbs/bed patient)	21.1	30.9	47.7	46.1	25.3	10.8	20.8	30.6	11.8
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location Remarks	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA
Reference	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	19[h]	20[h]	21[h]	22[h]	23[h]	24[h]	25[h]	26[h]
Bed Patient Capacity	-	-	-	-	-	-	-	-
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	177*	193*	236*	222*	253*	257*	292*	371*
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs)	3300[i]	8600[i]	5430[i]	10700[i]	21400[i]	7540[i]	8300[i]	11000[i]
(lbs/bed patient)	18.6	43.4	26.5	43.2	[illegible]	29.3	28.4	29.6
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA	Seattle, King County, WA
Reference	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972	Swofford, 1972

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	LAC-USC MEDICAL CENTER	LONG-BEACH GENERAL	HARBOR GENERAL	RANCHO LOS AMIGO	JOHN WESLEY	OLIVE VIEW	MIRA LOMA	DEACONESS	8-HOSPITAL SURVEY
Bed Patient Capacity	2300*	428*	688*	1540*	259*	699*	232*	600*	59-900*
Occupancy Rate (%)[a]	87.4*	70.5*	78.6*	60.3*	65.5*	80.4*	62.1*	-	-
Adjusted Bed Patient Capacity[b]	2018*	302*	541*	929*	170*	540*	144*	480[f]	-
Gross Population[c]	21294*	1246*	5512*	5471*	1124*	2452*	453*	-	-
Equivalent Population[d]	6220*	526*	1645*	1982*	392*	1012*	217*	-	-
Number of Meals Served	10,000*	-	1600*	4000*	800*	-	-	-	-
Total Solid Waste									
(lbs)	77700*	6238*	25062*	25064*	5050*	12506*	2452*	9000*	11066[j]
(lbs/bed patient)	38.8*	20.5*	46.3*	28.1*	29.7*	22.3*	17.0*	18.8[f]	5.5-10*
(lbs/gross population)	3.7*	5.0*	4.5*	4.8*	4.5*	5.1*	5.4*	-	-
(lbs/equivalent population)	12.50*	11.82*	15.30*	13.30*	12.85*	12.40*	11.30*	-	-
Disposable Solid Waste									
(lbs)	23200*	1098*	9062*	5544*	1350*	4376*	732*	-	-
(lbs/bed patient)	11.6*	3.6*	16.7*	6.0*	7.9*	7.8*	5.1*	-	-
(lbs/gross population)	1.1*	0.8*	1.6*	1.0*	1.2*	1.8*	1.6*	-	-
(lbs/equivalent population)	3.75*	2.08*	5.57*	2.80*	3.44*	4.32*	3.37*	-	-
Location/Remarks	Los Angeles, CA	South Bay, Los Angeles, CA	Los Angeles, CA	Los Angeles, CA	Los Angeles, CA	San Fernando Valley, Los Angeles Co., CA	Antelope Valley, Los Angeles County, CA	Evansville, IN	London, Ontario, Canada
Reference	ESCO/ Greenleaf, 1972	ESCO/ Greenleaf, 1972	ESCO/ Greenleaf 1972	ESCO/ Greenleaf, 1972	ESCO/ Greenleaf, 1972	ESCO/ Greenleaf, 1972	ESCO/ Greenleaf, 1972	Judge, 1972	Anon, 1972

APPENDIX I (CONTINUED)

HOSPITAL / DATA	DECATUR MEMORIAL	17-HOSPITAL SURVEY	ST. VINCENTS	A[h]	B[h]	C[h]	D[h]	E[h]
Bed Patient Capacity	500*	6134[j]	500*	152*	250*	406*	367*	236*
Occupancy Rate (%)[a]	-	-	-	77	100	81	85	66
Adjusted Bed Patient Capacity[b]	400[f]	-	-	177*	250*	330*	312*	156*
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs)	1300*	44640[j]	-	1980*	2060*	2293*	779*	1140*
(lbs/bed patient)	3.3	7.27*	20*	16.9*	8.25*	8.82*	4.65*	5.85*
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Decatur, IL	Data for 17 Hospitals	Jacksonville, FL	Washington, DC	Washington, DC	Washington, DC	Washington, DC	Washington, DC
Reference	Moore, 1971	Anon., 1971a	Anon., 1971a	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971

APPENDIX I (CONTINUED)

HOSPI[illegible] / DATA	F^h	G^h	H^h	I^h	J^h	K^h	L^h	WEST VIRGINIA MEDICAL CENTER HOSPITAL	WEST VIRGINIA MEDICAL CENTER COMPLEX
Bed Patient Capacity	85*	1100*	523*	335*	447*	80*	396*	438*	438*
Occupancy Rate (%)[a]	31	95	86	90	84	63	81	92	92
Adjusted Bed Patient Capacity[b]	[illegible]9*	1045*	450*	300*	375*	50*	322*	402*	402*
Gross Population[c]	-	-	-	-	-	-	-	2121*	4170*
Equivalent Population[d]	-	-	-	-	-	-	-	825*	1298*
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	[illegible]*	12390*	1640*	1160*	4077*	1370*	2876*	12930*	14840*
(lbs/bed patient)	12.6*	11.85*	10.42*	7.20*	10.87*	25*	12.47*	32.1*	36.9*
(lbs/gross population)	-	-	-	-	-	-	-	6.1*	3.6*
(lbs/equivalent population)	-	-	-	-	-	-	-	15.1*	11.4*
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	3300*	4700*
(lbs/bed patient)	-	-	-	-	-	-	-	8.2*	11.7*
(lbs/gross population)	-	-	-	-	-	-	-	1.6*	1.1*
(lbs/equivalent population)	-	-	-	-	-	-	-	4.0*	3.6*
Location/Remarks	Washington, DC	Washington, DC	Washington, DC	Washington, DC	Washington, DC	Washington, DC	Washington, DC	Morgantown, WV	Morgantown, WV
Reference	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971	EPA, 1971	Burchinal, 1973; Wallace, 1970	Burchinal, 1973; Wallace, 1970

APPENDIX [illegible] (CONTINUED)

HOSPITAL / DATA	LUTHERAN GENERAL	C[h]	D[h]	E[h]	F[h]	A[h]	B[h]	A[h]	A[h]
Bed Patient Capacity	590*	432*	432*	770*	488*	600*	300*	820*	458*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	472[f]	346[f]	346[f]	616[f]	390[f]	480[f]	240[f]	656[f]	366[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	6249*	8000*	8000*	15000*	7500*	7000*	1200*	6000*	9000*
(lbs/bed patient)	13.2[f]	23.1[f]	23.1[f]	24.4[f]	19.2[f]	14.6[f]	5.0[f]	9.1[f]	24.6[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Park Ridge, IL	Philadelphia, PA	Philadelphia, PA	Philadelphia, PA	Philadelphia, PA	Phoenix, AZ	Phoenix, AZ	Pittsburgh, PA	Portland, OR
Reference	Jacobsen, 1969	Kraus,1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

HOSPITAL / DATA	C[h]	A[h]	B[h]	C[h]	D[h]	A[h]	B[h]	A[h]
Bed Patient Capacity	1700*	300*	1066*	321*	924*	724*	951*	2500*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	1360[f]	240[f]	853[f]	257[f]	739[f]	579[f]	761[f]	2000[f]
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs)	22000*	2500*	14000*	3500*	12000*	6000*	5500*	25000*
(lbs/bed patient)	16.2[f]	10.4[f]	16.4[f]	13.6[f]	16.2[f]	10.4[f]	7.2[f]	12.5[f]
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Baltimore, MD	Boston, MA	Boston, MA	Boston, MA	Boston, MA	Buffalo, NY	Buffalo, NY	Chicago, IL
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	B^h	C^h	D^h	A^h	A^h	B^h	A^h	B^h	A^h
Bed Patient Capacity	660*	939*	2064*	463*	1000*	800*	434*	800*	650*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	528[f]	751[f]	1651[f]	370[f]	800[f]	640[f]	387[f]	640[f]	520[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	8500*	15500*	33000*	5500*	12000*	7000*	10000*	15000*	18000*
(lbs/bed patient)	16.1[f]	20.6[f]	20.0[f]	14.9[f]	15.0[f]	10.9[f]	25.8[f]	23.4[f]	34.6[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Chicago, IL	Chicago, IL	Chicago, IL	Cincinnati, OH	Cleveland, OH	Cleveland, OH	Dallas, TX	Dallas, TX	Dallas, TX
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	D^h	A^h	B^h	C^h	D^h	A^h	B^h	C^h	D^h
Bed Patient Capacity	978*	317*	350*	390*	436*	1116*	705*	390*	846*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	782[f]	254[f]	280[f]	312[f]	349[f]	893[f]	564[f]	312[f]	677[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	14000*	32000*	3000*	6000*	9500*	10000*	7000*	4000*	9500*
(lbs/bed patient)	17.9[f]	126.0[f]	10.7[f]	19.2[f]	27.2[f]	11.2[f]	12.4[f]	12.8[f]	14.0[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Dallas, TX	Denver, CO	Denver, CO	Denver, CO	Denver, CO	Detroit, MI	Detroit, MI	Detroit, MI	Detroit, MI
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

HOSPITAL / DATA	A[h]	B[h]	C[h]	D[h]	A[h]	B[h]	A[h]	B[h]	A[h]
Bed Patient Capacity	1266[g]	843[g]	626[*]	616[*]	1200[*]	717[*]	419[*]	363[*]	585[*]
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity	1013[f]	674[f]	501[f]	493[f]	960[f]	574[f]	335[f]	290[f]	468[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	10000[*]	15000[*]	8000[*]	10500[*]	14000[*]	3000[*]	5000[*]	7500[*]	3500[*]
(lbs/bed patient)	9.9[f]	22.3[f]	16.0[f]	21.3[f]	14.6[f]	5.2[f]	14.9[f]	25.9[f]	7.5[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Houston, TX	Houston, TX	Houston, TX	Houston, TX	Indianapolis, IN	Indianapolis, IN	Milwaukee, WI	Milwaukee, WI	Minneapolis, MN
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	B[h]	C[h]	A[h]	B[h]	C[h]	D[h]	A[h]	B[h]	C[h]
Bed Patient Capacity	1014[*]	461[*]	525[*]	365[*]	591[*]	403[*]	1218[*]	550[*]	766[*]
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	811[f]	369[f]	420[f]	292[f]	473[f]	322[f]	974[f]	440[f]	613[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	13000[*]	5000[*]	11000[*]	5500[*]	4000[*]	5000[*]	10000[*]	6500[*]	9000[*]
(lbs/bed patient)	16.0[f]	13.6[f]	26.2[f]	18.8[f]	8.5[f]	8.5[f]	10.3[f]	14.6[f]	14.7[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	Minneapolis, MN	Minneapolis, MN	New Orleans, LA	New Orleans, LA	New Orleans, LA	New Orleans, LA	New York, NY	New York, NY	New York, NY
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	D[h]	E[h]	A[h]	B[h]	A[h]	B[h]	A[h]	B[h]	C[h]
Bed Patient Capacity	1060*	815*	1350*	935*	473*	385*	404*	405*	2105*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	848[f]	652[f]	1080[f]	748[f]	378[f]	308[f]	323[f]	324[f]	1684[f]
Gross Population[c]	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-
Total Solid Waste									
(lbs)	10000*	8000*	7000*	10000*	3000*	8000*	3000*	5000*	50200*
(lbs/bed patient)	11.8[f]	12.3[f]	6.5[f]	13.5[f]	7.9[f]	26.0[f]	9.3[f]	15.4[f]	29.8[f]
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Disposable Solid Waste									
(lbs)	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-
Location/Remarks	New York, NY	New York, NY	Philadelphia, PA	Philadelphia, PA	Kansas City, KS	Kansas City KS	Los Angeles, CA	Los Agneles. CA	Los Angeles, CA
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

HOSPITAL / DATA	B[h]	C[h]	A[h]	B[h]	C[h]	D[h]	A[h]	B[h]
Bed Patient Capacity	420*	563*	600*	319*	1200*	679*	300*	500*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	336[f]	450[f]	480[f]	255[f]	960[f]	543[f]	240[f]	400[f]
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs)	7500*	7500*	11000*	2000*	12000*	4500*	3600*	6000*
(lbs/bed patient)	22.3[f]	16.7[f]	22.9[f]	7.8[f]	12.5[f]	8.3[f]	12.5[f]	15.0[f]
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Portland, OR	Portland, OR	St. Louis, MO	St. Louis, MO	St. Louis, MO	St. Louis, MO	San Antonio, TX	San Antonio, TX
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

HOSPITAL / DATA	C[h]	D	A[h]	B[h]	C[h]	A[h]	B[h]	C[h]
Bed Patient Capacity	850*	1111*	342*	450*	2400*	500*	440*	391*
Occupancy Rate (%)[e]	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	680[f]	889[f]	276[f]	360[f]	1920[f]	400[f]	352[f]	313[f]
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs)	3500*	7000*	2500*	10000*	24800*	7000*	2000*	6500*
(lbs/bed patient)	5.1[f]	7.9[f]	9.1[f]	27.8[f]	12.9[f]	17.5[f]	5.7[f]	20.8[f]
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	San Antonio, TX	San Antonio, TX	San Diego, CA	San Diego, CA	San Diego, CA	San Francisco CA	San Francisco CA	San Francisco CA
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	A^h	B^h	C^h	D^h	A^h	B^h	[illegible]	[illegible]
Bed Patient Capacity	376*	493*	327*	330*	450*	702*	830*	5.31*
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	294[f]	394[f]	262[f]	240[f]	360[f]	562[f]	664[f]	4185[f]
Gross Population[c]	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-
Total Solid Waste								
(lbs.)	4000*	8000*	4000*	2000[f]	4500*	8000*	9500*	20000*
(lbs/bed patient)	13.6[f]	20.3[f]	15.3[f]	8.3[f]	12.5[f]	14.2[f]	14.3[f]	4.3[f]
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Disposable Solid Waste								
(lbs)	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-
Location/Remarks	Seattle, WA	Seattle, WA	Seattle, WA	Seattle, WA	Washington, DC	Washington, DC	Washington, DC	Los Angeles, CA
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968

APPENDIX I (CONTINUED)

DATA \ HOSPITAL	A[h]	B[h]	A[h]	B[h]	A[h]	B[h]	TEACHING	GRANDVIEW	BAYLOR UNIVERSITY MEDICAL CENTER	29-HOSPITAL SURVEY
Bed Patient Capacity	400[*]	484[*]	309[g,*]	580[*]	1200[*]	300[*]	1100[*]	300[*]	-	-
Occupancy Rate (%)[a]	-	-	-	-	-	-	-	-	-	-
Adjusted Bed Patient Capacity[b]	320[f]	387[f]	247[f]	464[f]	960[f]	240[f]	460[f]	240[f]	-	-
Gross Population[c]	-	-	-	-	-	-	-	-	-	-
Equivalent Population[d]	-	-	-	-	-	-	-	-	-	-
Number of Meals Served	-	-	-	-	-	-	-	-	-	-
Total Solid Waste										
(lbs)	2000[*]	4000[*]	6000[*]	5500[*]	17000[*]	3000[*]	-	500[k]	7405.7[*]	-
(lbs/bed patient)	6.3[f]	10.3[f]	24.3[f]	11.9[f]	17.7[f]	12.5[f]	19[*]	-	-	7.13
(lbs/gross population)	-	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-	-
Disposable Solid Waste										
(lbs)	-	-	-	-	-	-	-	-	-	-
(lbs/bed patient)	-	-	-	-	-	-	-	-	-	-
(lbs/gross population)	-	-	-	-	-	-	-	-	-	-
(lbs/equivalent population)	-	-	-	-	-	-	-	-	-	-
Location/Remarks	Miami, FL	Miami, FL	Atlanta, GA	Atlanta, GA	Baltimore, MD	Baltimore, MD	Teaching Hospital	Dayton, OH	Dallas, TX	Data for 29 Hospitals
Reference	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Kraus, 1968	Holbrook, 1966	Anon., 1964	Paul, 1964	Snow et al., 1956

[*] Reported Data

[a] Average occupancy rate during the period of the study.

[b] Average bed patient population.

[c] The average total number of bed patients, outpatients, employees, and volunteer workers present daily.

[d] The population during an average 8-hour shift.

[e] Data not available.

[f] Assumes an average occupancy rate of 80 percent (Iglar and Bond, 1973).

[g] Data reported as cubic yards of compacted waste; calculated value based on assumed density of 500 pounds per cubic yard.

[h] Hospitals were identified only by code.

[i] Data reported as cubic yards with a density of 200 pounds per cubic yard.

[j] Total for all the hospitals in the survey.

[k] Quantity incinerated daily.

APPENDIX J

SOIL AND OTHER FACTORS AFFECTING LANDFILL DESIGN

CONTENTS--APPENDIX J

APPENDIX J-1

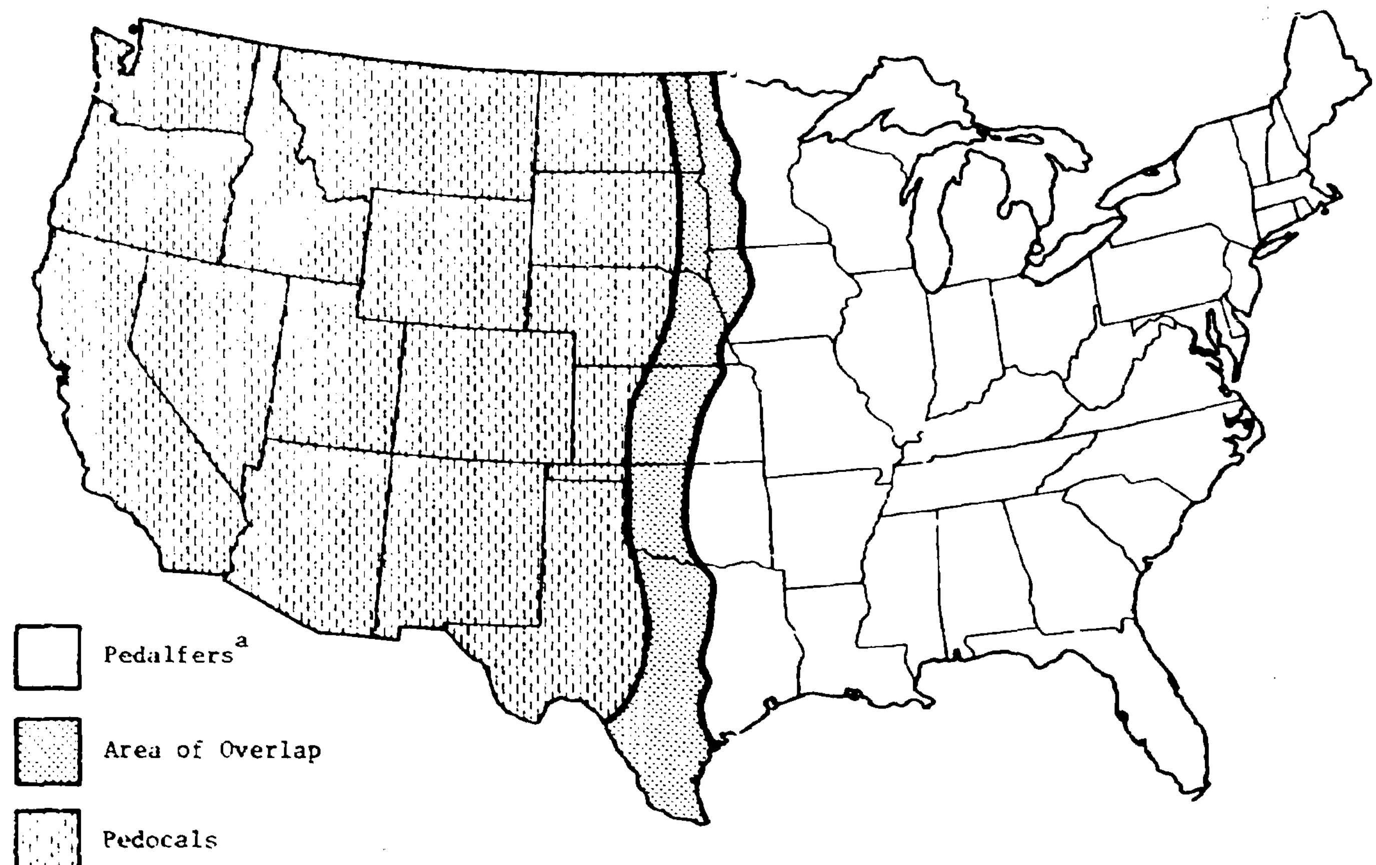
SOIL CHARACTERISTICS AFFECTING LANDFILLING

Soils are complex, dynamic, biological, chemical and physical systems that can transform applied matter by waste incorporation, attenuation, and evaporation. Soil characteristics and solute attenuation by soil are affected by soil type, climate, particle size distribution and soil texture, pH value, and soil moisture.

Soil Type

There are two general classes of soil in the United States. One is present in the eastern part of the country, the other in the western, and they divide the continental United States in half from north to south (Figure J-1). The division occurs almost exactly along Thornwaite's regional moisture index that separates the United States into moist and dry regions (Figure J-2). In the western half of the United States are the calcified soils of dry climates called "pedocals." In the eastern half (and also Hawaii and Alaska), soils containing accumulations of aluminum and iron ("pedalfers") typical of moister climates dominate (Muller, 1974).

The pedalfer and pedocal soils are further divided into ten orders, known as the Seventh Approximation Soil Order Classification that was adopted by the United States Department of Agriculture (USDA). Table J-1 gives a brief description of each order and Figure J-3 shows their location in the United States.



SOURCE: Adapted from Muller, 1974.

[a]Also in Hawaii and Alaska.

FIGURE J-1
MAJOR SOIL CLASSES

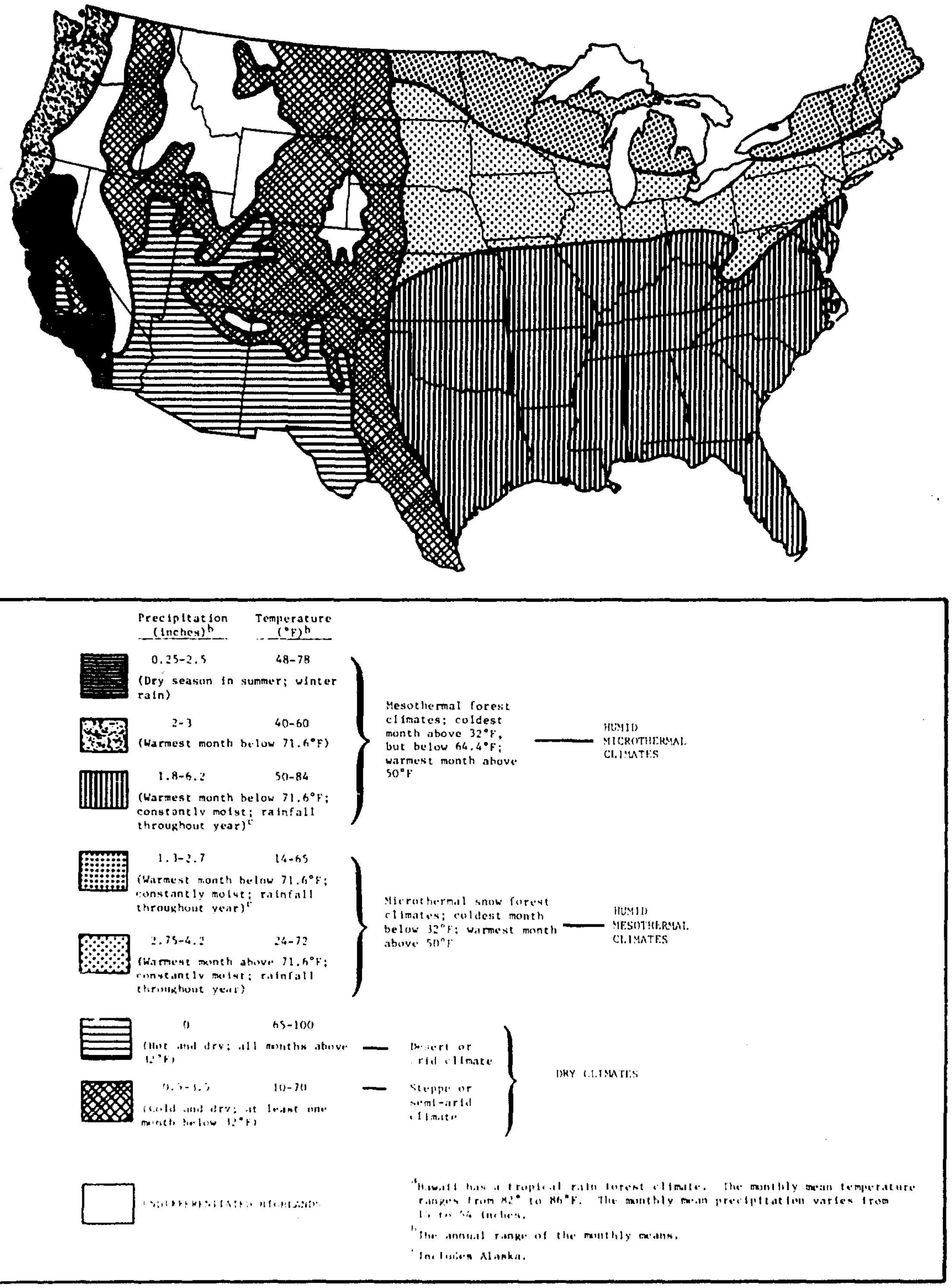


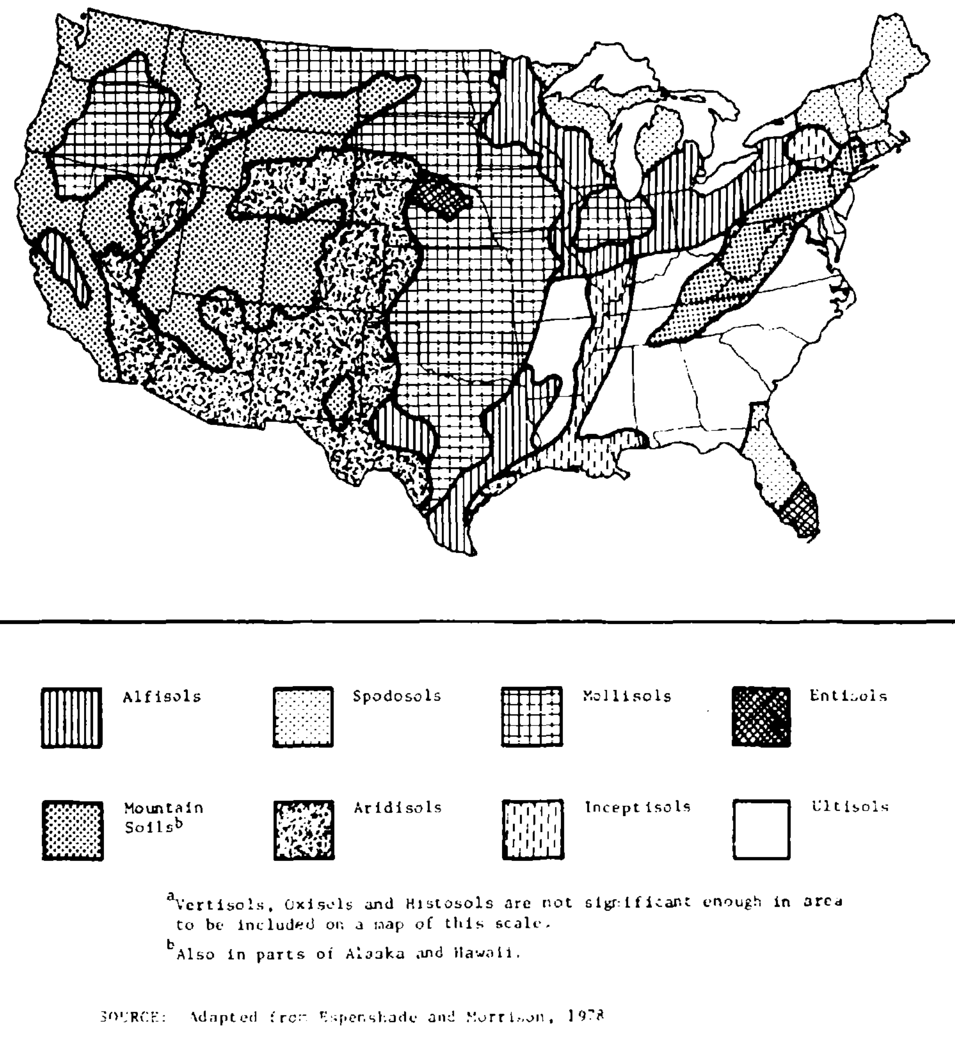
FIGURE J-2
CLIMATE REGIONS IN THE UNITED STATES [a]

TABLE J-1

THE 7TH APPROXIMATION SOIL ORDER CLASSIFICATION

ORDER	DESCRIPTION	pH	WATER RETENTION
Alfisols	Gray surface horizon. Subsurface clay.	Moderate to high	Usually moist; dry for part of warm season
Aridisols	Semidesert and desert soils with definite horizons. Low in organic matter. Salts may occur on or near the surface.	Neutral to high	Never moist for more than 3 consecutive months
Entisols	No definite horizon. Sands, generally azonal.	Neutral	Varies
Histosols	Wet organic peat and muck soils. Formed in swamps and marshes.	Low to very low	Constantly wet
Inceptisols	Weakly developed horizons. Materials have been altered or removed but not accumulated.		Usually moist except for part of warm season
Mollisols	In subhumid and semiarid warm to cold climates. Dark surface horizon rich in organic matter.	Very high	Moderately permeable
Oxisols	In tropical or subtropical lowlands. Mixtures of kaolin (aluminum clay) and silicon dioxide. Low in weatherable material.	Moderate	Highly permeable
Spodosols	In humid, mostly cool, midlatitude regions. Compounds of aluminum or iron.	Low	Usually moist
Ultisols	Subsurface horizon of clay.	Moderate	Usually moist; dry for part of year
Vertisols	Clay soils. Wide deep cracks form when dry.	Moderate to high	Usually dry

SOURCE: Muller, 1974; Fuller, 1977.



[a]Vertisols, Oxisols and Histosols are not significant enough in area to be included on a map of this scale.

[b]Also in parts of Alaska and Hawaii.

SOURCE: Adapted from Espenshade and Morrison, 1978

FIGURE J-3
DOMINANT SOIL ORDERS IN THE UNITED STATES

Soil Texture

Different soil types have different soil textures determined by particle size distribution. In Table J-2, the characteristics of different soil textures are compared. Figure J-4 depicts a textural classification of soils and the different particle sizes that are included in each soil texture. Soil texture is determined by measuring the proportions of clay, silt, and sand in the inorganic part of the soil. For example, a soil that contains 60 percent silt and 20 percent clay would be classified as a silt loam.

The particle size distribution of soil determines the amount of surface area available for adsorption per unit weight of soil. Silts, clays, and colloids offer more surface area than do sands and gravels. If the surface area is large, adsorption and filtration are more effective, and attenuation is therefore greater than if the surface area is small.

A fine, tightly compacted soil, particularly a colloidal clay (upper part of texture triangle) inhibits rapid permeation and increases attenuation. However, if clumps of soil stick together, soil channeling occurs, forming cracks or channels through which water can flow. Coarser soils (such as sands and gravels--lower left corner of textural triangle) have high permeation rates and less effective attenuation.

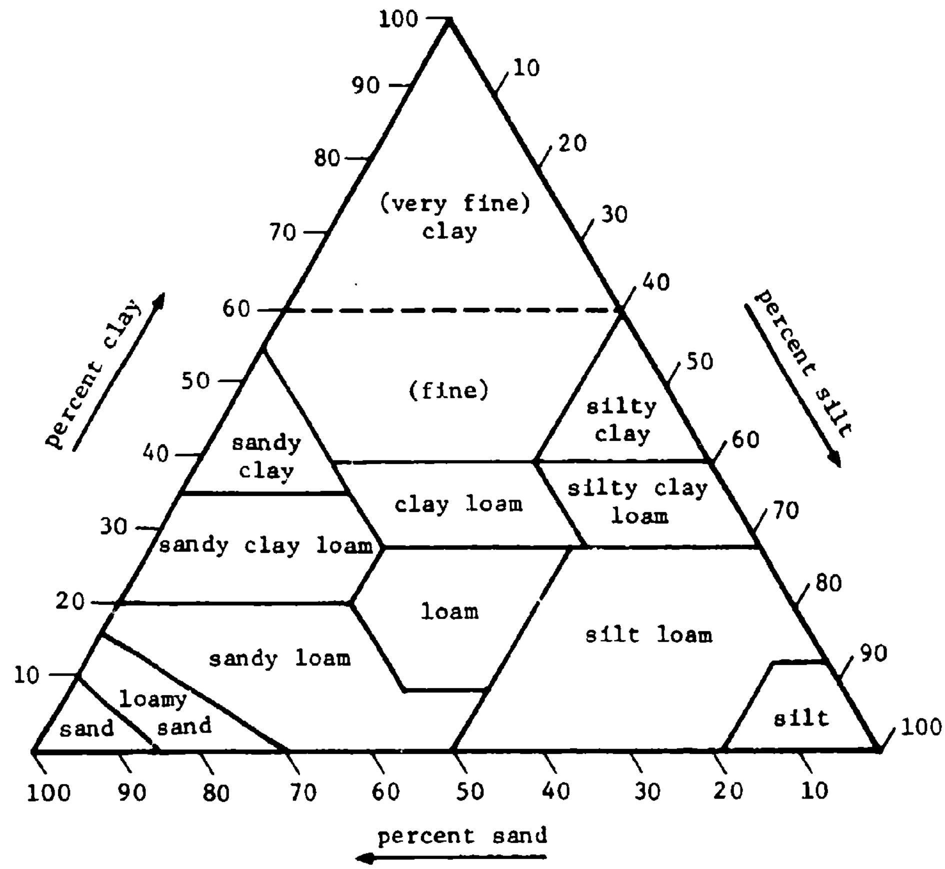
TABLE J-2

CHARACTERISTICS OF DIFFERENT SOIL TEXTURES[a]

TEXTURE[b] (Particle size)	PARTICLE DIAMETER (mm)	NUMBER OF PARTICLES (per g)	SURFACE AREA (cm^2/g)
Fine Gravel	2.00-1.00	90	11.3
Coarse Sand	1.00-0.50	722	22.7
Medium Sand	0.50-0.25	5,777	45.4
Fine Sand	0.25-0.10	46,213	90.7
Very Fine Sand	0.10-0.05	722,074	226.9
Silt	0.05-0.002	5,776,674	453.7
Clay	<0.002	90,260,853,860	11,342.5

[a]Adapted from Fuller, 1977.

[b]U.S. Department of Agriculture classification.



SOURCE: Adapted from Fuller, 1977

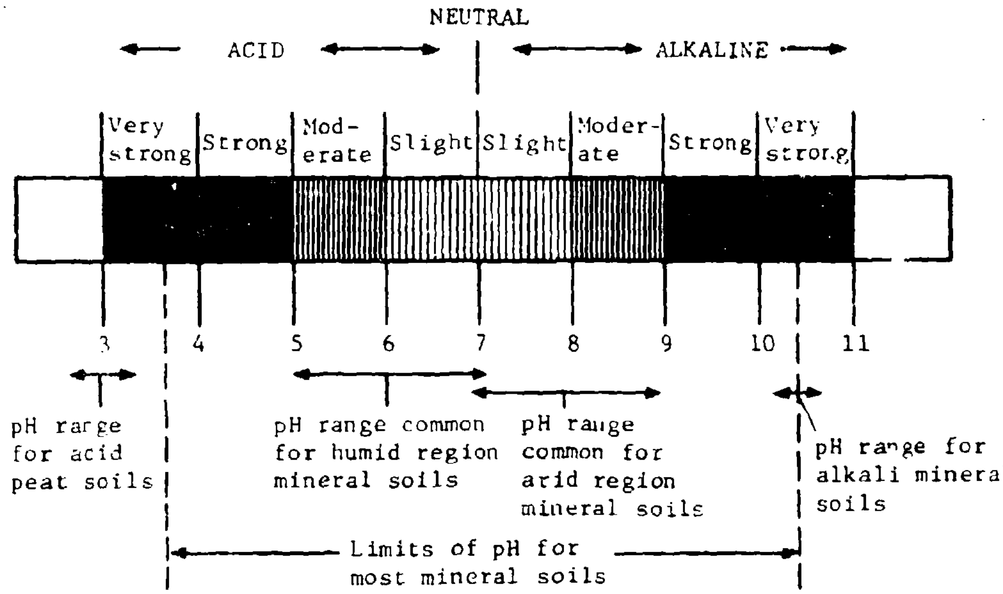
FIGURE J-4
TEXTURAL CLASSIFICATION (USDA) OF SOIL BASED ON THE CONTENT OF DIFFERENT SIZES OF PARTICLES

The pH Value

Soil acidity is measured in terms of the concentration of hydrogen ions. Natural soils have a pH value between 3 and 10 (Figure J-5). Soils with a pH value greater than 7 are alkaline soils; those with a value less than 7 are acidic soils. Peat soils and humid region mineral soils are highly acidic whereas arid region mineral soils are alkaline. However, the chemistry of the soil may be changed when solutions such as rain water or landfill leachates percolate downward through the soil. The upper layers of soil sometimes become more acidic as the more alkaline materials move downward.

Soil Moisture

Soil moisture is the amount of water held by soil. It is a function of the availability of precipitation as related to evapotranspiration and the water-holding capacity of the soil. The capacity of soils to hold water depends on the type of soil. Sands have more space available in which to retain water effectively without elution (pore size distribution) than do gravels. Clays have an even greater pore size distribution than do sands and therefore retain water better.



SOURCE: Fuller, 1977; Burge and Enkiri, 1978

FIGURE J-5
CLASSIFICATION OF SOIL pH RANGE

APPENDIX J-2

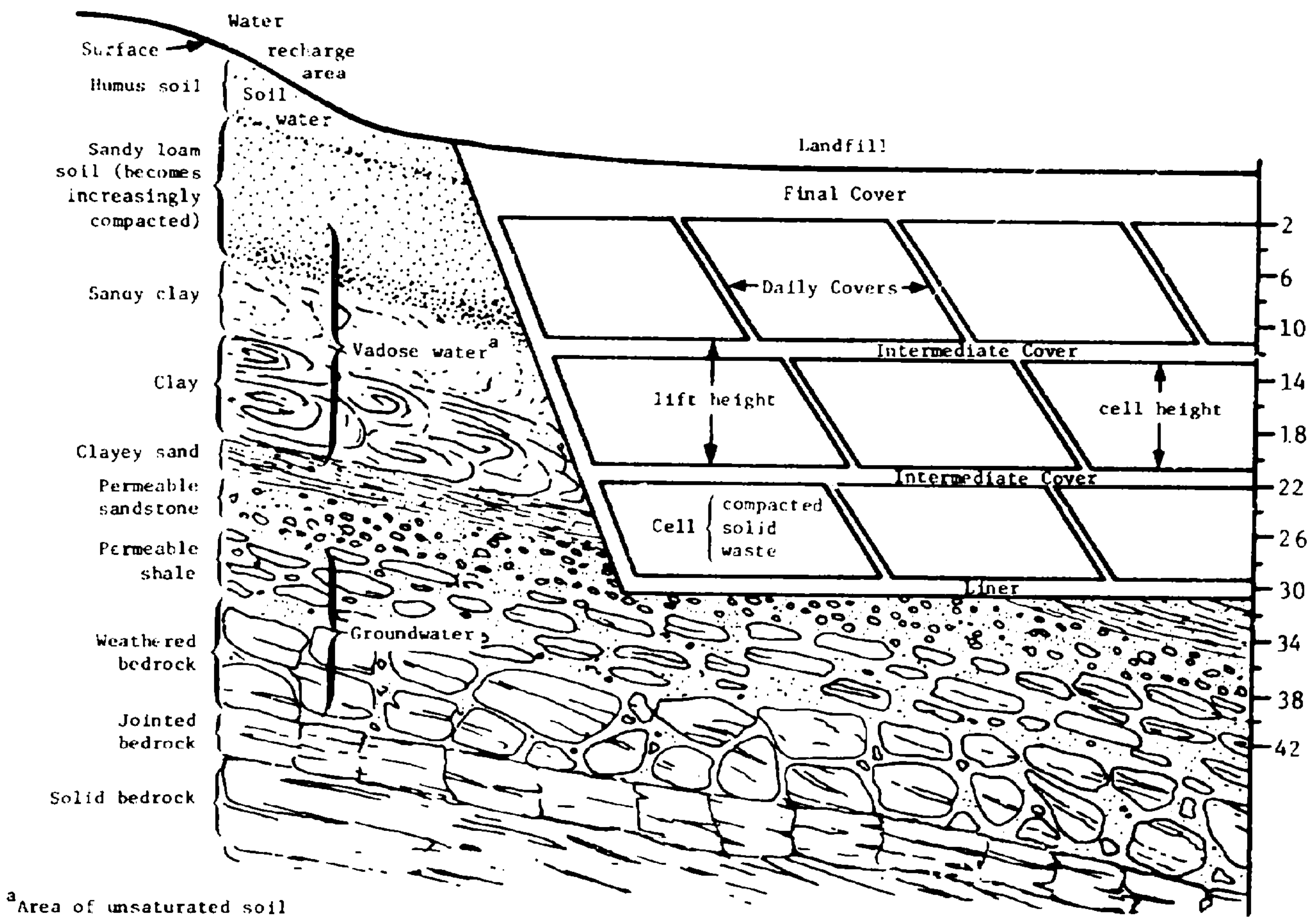
SANITARY LANDFILL DESIGN

The sanitary landfill is specified under Section 4004 of RCRA as the proper disposal facility for the landfilling of solid wastes. In this discussion, therefore, the term "sanitary landfill" refers to a landfill which meets the proposed criteria (Federal Register, 1979a), in design, construction, operation, and maintenance.

In a well-designed sanitary landfill, soil is usually used for three different purposes: the original ground on which the landfill is located; the landfill liner; and the daily, intermediate, and final cell covers (Brunner and Keller, 1972). Figure J-6 is a schematic diagram of an *in situ* landfill. It depicts the landfill sections and soil uses as well as the original soil base and its soil water. Table J-3 is a classification of various soils by characteristics that apply to landfill construction.

The Original Soil Base

One of the most important considerations in selecting the site of a sanitary landfill is the hydrology of the soil, specifically how it relates to the groundwater (zone of soil saturation). The zone of saturation, the direction and rate of flow of the groundwater, and the quality of the aquifer directly affect the subsequent water quality after landfill construction. The permeability of the soil strata and the external hydraulic forces acting upon the groundwater determine the vertical and horizontal movement of subsurface water, factors which are important in determining landfill location and depth



[a]Area of unsaturated soil

FIGURE J-6
SCHEMATIC DIAGRAM OF SOIL STRATA AND LANDFILL

TABLE J-3

SOIL CLASSIFICATION SYSTEM AND CHARACTERISTICS PERTINENT TO SANITARY LANDFILLS

SOIL TYPE	DESCRIPTION	POTENTIAL FROST ACTION	DRAINAGE CHARACTERISTIC[a]	VALUE FOR EMBANKMENTS	PERMEABILITY (cm/sec)	COMPACTION CHARACTERISTICS	REQUIREMENTS FOR SEEPAGE CONTROL
COARSE-GRAINED SOILS Gravel and Gravelly Soils	Well-graded gravels or gravel-sand mixtures, little or no fines	None to very slight	Excellent	Very stable, pervious shells of dikes and dams	$>10^{-2}$	Good	Positive cutoff
	Poorly graded gravels or gravel-sand mixtures, little or no fines	None to very slight	Excellent	Reasonably stable, pervious shells of dikes and dams	$>10^{-2}$	Good	Positive cutoff
	Silty gravels, gravel-sand-silt mixtures	Slight to medium	Fair to poor	Reasonably stable, not particularly suited to shells, but may be used for impervious cores or blankets	10^{-6} to 10^{-3}	Good	Toe trench to none
	Clayey gravels, gravel-sand-clay mixtures	Slight to medium	Poor to practically impervious	Fairly stable, may be used for impervious core	10^{-8} to 10^{-6}	Fair	None
Sand and Sandy Soils	Well-graded sands or gravelly sands, little or no fines	None to very slight	Excellent	Very stable, pervious sections slope protection required	$>10^{-3}$	Good	Upstream blanket and toe drainage or wells
	Poorly graded sands or gravelly sands, little or no fines	None to very slight	Excellent	Reasonably stable, may be used in dike section with flat slopes	$>10^{-3}$	Good	Upstream blanket and toe drainage or wells
	Silty sands, sand-silt mixtures	Slight to high	Fair to poor	Fairly stable, not particularly suited to shells but may be used for impervious cores or dikes	10^{-6} to 10^{-3}	Good	Upstream blanket and toe drainage or wells
	Clayey sands, sand-clay mixtures	Slight to high	Poor to practically impervious	Fairly stable, use for impervious core for flood control structures	10^{-8} to 10^{-6}	Fair	None
FINE-GRAINED SOILS Silts and Clays	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Medium to very high	Fair to poor	Poor stability, may be used for embankments with proper control	10^{-6} to 10^{-3}	Good to poor	Toe trench to none
	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	Practically impervious	Stable, impervious cores and blankets	10^{-8} to 10^{-6}	Fair to good	None
	Organic silts and organic silt-clays of low plasticity	Medium to high	Poor	Not suitable for embankments	10^{-6} to 10^{-4}	Fair to poor	None
	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Medium to very high	Fair to Poor	Poor stability, core of hydraulic dam, not desirable in rolled fill construction	10^{-6} to 10^{-4}	Poor to very poor	None
	Inorganic clays of high plasticity, fat clays	Medium	Practically impervious	Fair stability with flat slopes, thin cores, blankets and dike sections	10^{-8} to 10^{-6}	Fair to poor	None
	Organic clays of medium to high plasticity, organic silts	Medium	Practically impervious	Not suitable for embankments	10^{-8} to 10^{-6}	Poor to very poor	None
HIGHLY ORGANIC SOILS	Peat and other highly organic soils	NOT RECOMMENDED FOR SANITARY LANDFILL CONSTRUCTION					

SOURCE: Brunner and Keller, 1972.

[a]Values are for guidance only; design should be based on test results.

(Brunner and Keller, 1972). The types of soil as they might appear at a landfill site and the relationship of water within them are depicted in Figure J-6.

Soil characteristics at a landfill site affect the quality of the landfill leachate which may eventually reach the underlying aquifer. The accumulation of leachate in soil below a landfill can change the environment from aerobic to anaerobic and strongly reducing, thereby promoting the solubility and movement of metals. If the depth of soil thus affected includes a water-bearing formation, the disposal site can contaminate potable water supplies. On the other hand, if there is a sufficient depth of soil beneath the site, a partially aerobic, oxidizing zone may remain above the water-bearing formation and the soil can effect attenuation. This possibility must be considered when soil type is used as a factor in site selection (Fuller, 1977).

The Landfill Liner

The main purpose of the landfill liner is to prevent contact between the landfill and landfill leachate and the underlying groundwater. The liner can be constructed of natural soil (e.g., clay), of mixed materials (e.g., asphalt, concrete, masonry), or of synthetic materials (e.g., poly[vinyl chloride]). Table J-4 lists the advantages and disadvantages of various types of liner materials.

Usually a liner of well compacted natural clay soil 1 to 3 feet thick is sufficient to prevent highly polluted leachate from

TABLE J-4

THE ADVANTAGES AND DISADVANTAGES OF VARIOUS LINER MATERIALS[a]

Liner	Advantages	Disadvantages
Clay	Inexpensive if locally available Good sealant in thick beds Installation relatively simple	Cracks if not kept moist Expensive to truck Composition varies widely Low shear and tensile strength Difficult to handle when wet
Concrete	Ready availability Established technology High compressive strength	Transportation costly Steel reinforcement required Low tensile strength Expansion gap sealing Subject to corrosion
Asphalt	Ease of installation Established technology Good resistance to water Raw material readily available	Poor weathering and age resistance Tendency to crack Not resistant to oils, gasoline, solvents Low compressive strength Surface supports growth of bacteria and algae
Synthetic Rubber and Plastic Membranes	Ease of installation Good resistance to water Flexible Easy to repair	Numerous seams reduce reliability Limited site jointing procedures Low puncture resistance Limited UV and temperature range
High Density Polyvinyl Vestolen (HDPV)	Large single sheet - few joints Rugged and flexible High puncture and tear resistance Wide chemical resistance - acids, alkalies, oil and petroleum derivatives Automatic and homogeneous field welds	Sometimes uneconomic for small projects Sheet rolls are cumbersome

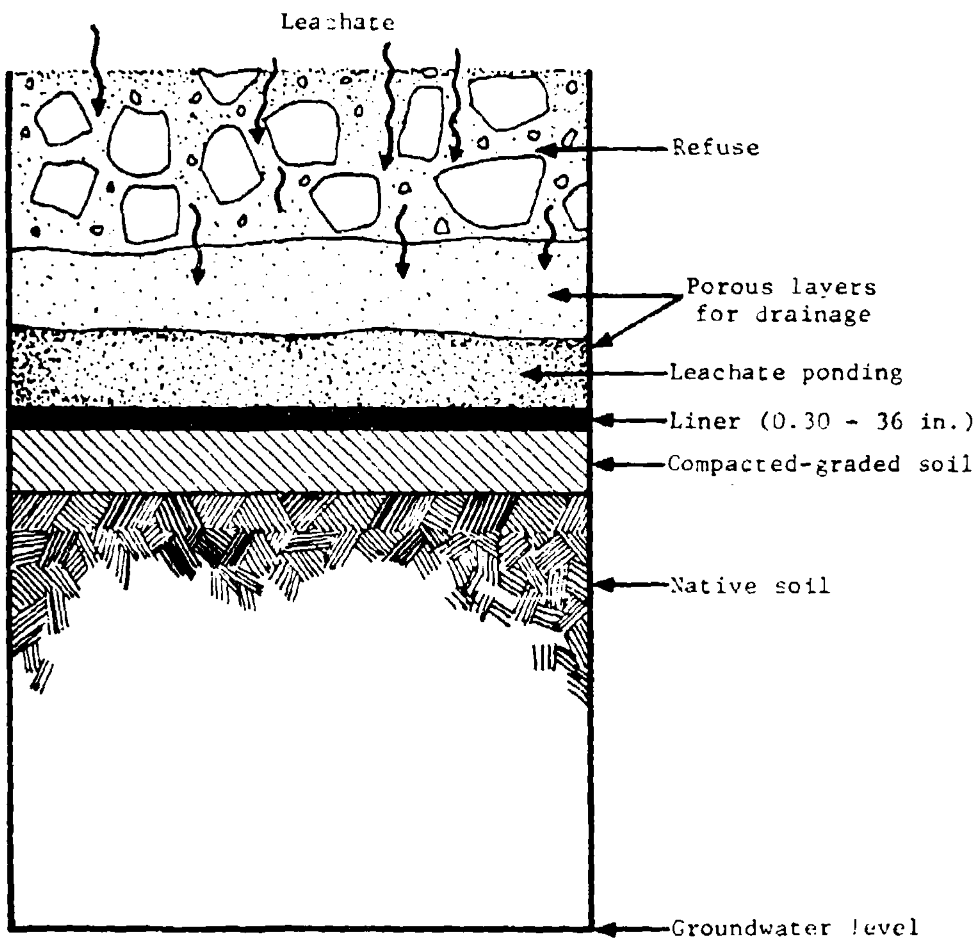
[a]Adapted from Schlegel, 1977.

penetrating to the groundwater. The clay liner allows drainage of the landfill leachate by slow permeation and leachate attenuation through adsorption. However, clay liners can become saturated or cracked and channelled, thereby allowing seepage of leachate to the soil base and eventually to the groundwater.

If suitable clay is not available, additives can impart to the natural soil the characteristics needed for use as a landfill liner. One example of a soil additive is sodium bentonite (sodium montmorillonite--a Vertisol) which is molecularly similar to clay. However, unlike clay, sodium bentonite can swell from 10 to 15 times its bulk weight when saturated with clean water. Contact with water containing high levels of dissolved salts, acids or alkalies greatly reduces the swelling capacity, and failure of the liner seal will occur. Chemical sealants can be added to the natural sodium bentonite to reduce the effects of contaminated water, but care must still be taken to avoid contact with certain kinds of contaminated fluid. Sodium bentonite-soil mixes can be effectively used as landfill liners if approximately 18 inches of a protective soil buffer is placed on top to separate the liner from the fill material. This buffer helps to protect the liner during compaction and to prevent its drying out. A chemically treated sodium bentonite liner is contaminant-resistant and usually will not deteriorate when in contact with landfill leachate (American Colloid Company, 1979).

Concrete, masonry, and asphalt--all of which form rigid structures--are sometimes used as liners. Because of their rigidity, these liners do not stretch and conform to the changes in the shape of the soil base that are brought about by weathering and shifting. They are also likely to crack when heavy objects that exceed the limits of weight resistance of the liner are dumped on them. The lack of elasticity of these liners can result in cracking and faulting which allow eventual seepage of leachate into the soil base.

Sometimes a totally impermeable liner underneath a landfill is desired. This can be attained by placing synthetic liners between layers of sand on top of asphalt; however, suitable leachate drainage must be provided. Figure J-7 is a schematic diagram of a landfill with a synthetic liner in place. Synthetic liners are usually flexible enough so that cracking and faulting are not problems. The materials that are used generally conform to changes in the shape of the soil base. However, since most membrance systems are constructed of many narrow strips that are joined with glue, solvents, or mastic compounds, seepage at the seams is probable. Another potential problem is that these thin membranes can be easily punctured during installation (Schlegel Area Sealing Systems, Inc., 1977). Materials used for synthetic liners include poly(vinyl chloride), synthetic rubber, and bitumen/fabric laminates, butyl rubber, chlorinated polyethylene, chlorosulfonated polyethylene, elasticized polyolefin, ethylene propylene rubber, neoprene, polybutylene, polyester



SOURCE: Haxo, 1979

FIGURE J-7
SCHEMATIC DIAGRAM OF A SYNTHETIC LANDFILL LINER

elastomer, low density polyethylene, plasticized poly(vinyl chloride), and poly(vinyl chloride) plus pitch. A relatively new type of synthetic membrane liner, high density polyethylene vestolen, is free from plasticizers and filler material and is resistant to a broad range of chemicals, wide changes in pH, mechanical abuse, punctures, rodents, termites, ultraviolet light, sunlight, fungus, and mold; it is three to six times the thickness of other membrane liners, is easy to maintain, and has fusion-welded joints that are stronger than the sheet material itself (Schlegel Area Sealing Systems, Inc., 1977).

Landfill Covers

A thin soil cover (at least 6 inches) should be placed daily on top of the disposed waste to keep waste from being blown away, to keep out pests and rodents, and to minimize odors. A thicker intermediate soil cover over several cells in a landfill serves to prevent immediate erosion of the compacted wastes and of the daily cover during construction, and provides a wall or base against or upon which to construct subsequent cells. The final soil cover over a filled landfill should have a minimum thickness of 2 feet. The final cover prevents erosion, controls pollution, has aesthetic value, and provides a base for future site uses.

The relative suitabilities of different soil types in relation to the specific functions of a landfill cover are tabulated in Table J-5 (Brunner and Keller, 1972). Each soil is rated for its suitability in fulfilling each of seven functions of a landfill cover. Each rating has a corresponding weighting factor, and the sum of the

TABLE J-5

SUITABILITY OF GENERAL SOIL TYPES AS LANDFILL COVER MATERIAL[a,b]

Function	Clean Gravel	Clayey-Silty Gravel	Clean Sand	Clayey-Silty Sand	Silt	Clay
To prevent rodents from burrowing or tunneling	G 3	F-G 2.5	G 3	P 1	P 1	P 1
To keep flies from emerging	P 1	F 2	P 1	G 3	G 3	E[c] 4
To minimize entrance of moisture into fill	P 1	F-G 2.5	P 1	G-E 3.5	G-E 3.5	E[c] 4
To minimize venting of landfill gas through cover	P 1	F-G 2.5	P 1	G-E 3.5	G-E 3.5	E[c] 4
To provide pleasing appearance and to control blowing paper	E 4	E 4	E 4	E 4	E 4	E 4
To grow vegetation	P 1	G 3	P-F 1.5	E 4	G-E 3.5	F-G 2.5
To provide permeability for venting decomposition gas[d]	E 4	P 1	G 3	P 1	P 1	P 1
Overall suitability weighting	15	17.5	14.5	20	19.5	20.5[c]

[a]Adapted from Brunner and Keller, 1972.

[b]Rating and weighting system: E, excellent (4); G, good (3); F, fair (2); P, poor (1).

[c]Except when cracks extend through the entire cover.

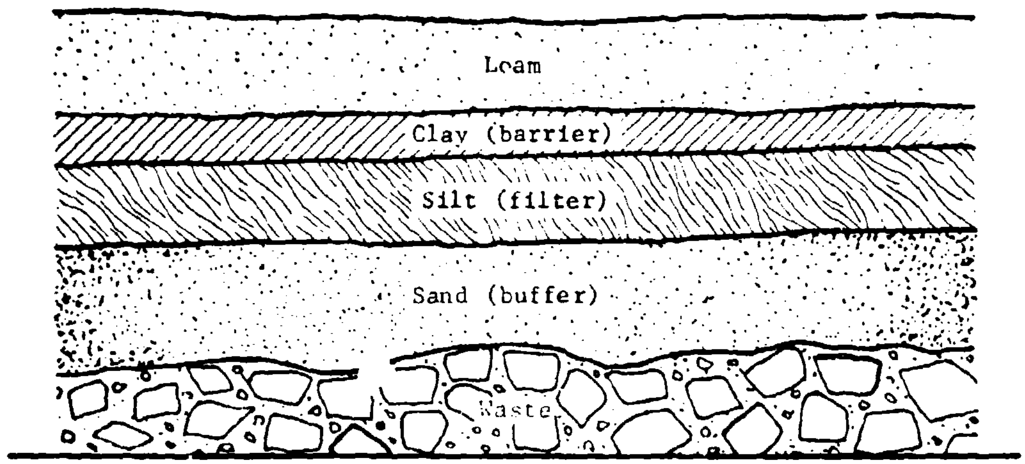
[d]Only if well drained.

weighting factors indicates the overall suitability of the soil for use as final landfill cover. The soil types that are the most suitable for use as cover material are clay, clayey-silty sand, and silt. Clean sand and clean gravel are least suitable because of their high permeability.

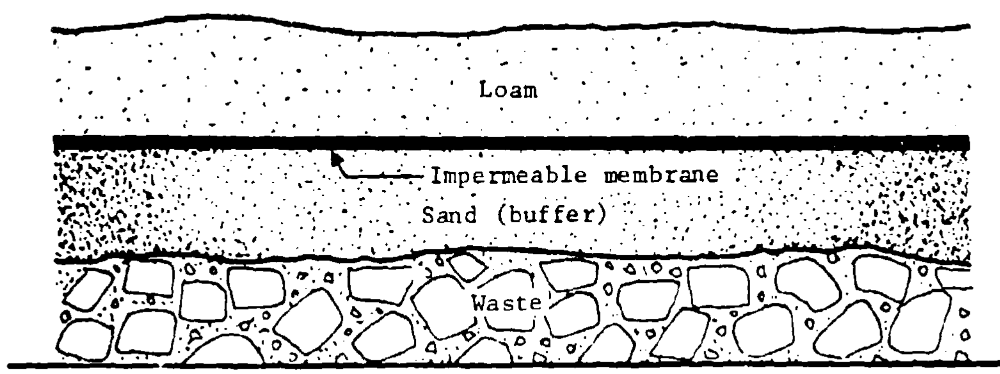
The amount of infiltration of precipitation that falls on a landfill is the major factor affecting the quantity of leachate that is generated (James, 1977). If a proper soil cover is not used, landfill infiltration and subsequent leachate generation will occur (sometimes delayed for as long as 20 years) when precipitation exceeds evapotranspiration in the area (Steiner et al., 1971). Rapid infiltration of precipitation causes rapid cell decomposition and landfill saturation. If landfill saturation does occur, heavy leachate flow may result which could saturate the liner and soil base; the leachate could then move directly through them so quickly that attenuation would not occur or would be slight. Therefore, it is important that the final landfill cover be constructed in such a way that decomposition and saturation be curtailed; this can be achieved by use of a highly impermeable soil cover that is also functional for the ultimate uses planned for the site.

As the slope of the landfill cover increases, infiltration decreases and erosion increases. A slope of 5 percent appears sufficient to promote runoff and minimize erosion. A slope of less than 5 percent retards runoff and prommtes water retention on the cover surface. Flat-bottomed ditches should be constructed outside the landfill to intercept outside water and on the landfill to control surface drainage; otherwise, a system of buried drains should be installed (Lutton, 1979).

A cover of layered material, rather than one homogeneous layer, helps to impede infiltration and percolation through the landfill. Where infiltration should be completely avoided, an impermeable membrane between soil layers can be used as a cover. Salt additives in the cover and tight compaction also improve impermeability (Lutton, 1979). Figure J-8 provides schematic diagrams of landfill covers. Vegetation is often planted on the landfill cover which should be designed to accommodate the final vegetation root system. Cover vegetation increases evapotranspiration, utilizes soil moisture thereby inhibiting percolation and saturation, prevents erosion, and is important aesthetically.



LAYERED SOIL COVER



MEMBRANE COVER

FIGURE J-8
SCHEMATIC DIAGRAM OF LAYERED SOIL AND MEMBRANE COVERS

APPENDIX K

RESEARCH IN PROGRESS--1975 TO 1978

APPENDIX K

RESEARCH IN PROGRESS—1975 TO 1978

SPONSOR	TITLE	INVESTIGATOR	AFFILIATION
U.S. DEPARTMENT OF AGRICULTURE			
1. Agricultural Research Service	Electrical Equipment for Treatment of Runoff Water	Stone	University of Tennessee, U.S.D.A. Agricultural Research Service, Knoxville, Tenn.
2. Cooperative State Research Service	Control of Microbial Contamination in the Environment	Chang/Yates	University of Rhode Island, Agricultural Experiment Station, Kingston, R.I.
3. Cooperative State Research Service	Microbiology of Sewage Sludge Amended Soils	Wolf	University of Maryland, Agricultural Experiment Station, College Park, Md.
U.S. DEPARTMENT OF DEFENSE			
4. Army, Corps of Engineers	Evaluation of Hygiene and Welfare Aspects of Solid Waste Disposal Practices	McCarthy	U.S. Army, Medical Bioengineering Research and Development Laboratory, Fort Detrick, Md.
5. Army, Corps of Engineers	Field Studies on Wastewater Treatment by Overland Flow	Lee/Eley	U.S. Army, Waterways Experiment Station, Vicksburg, Miss.
6. Army, Medical Research & Development Command	Evaluation of the Health Effects Associated with the Application of Wastewater to Land	Johnson	Southwest Research Institute, San Antonio, Tex.
7. Army, Medical Research & Development Command	Evaluation of Health and Environmental Effects of Land Application of Wastewater at Military Installations	Schaub/Bausum	U.S. Army, Medical Bioengineering Research & Development Laboratory, Fort Detrick, Md.
8. Army, Medical Research & Development Command	Electrochemical Biocide	Wynveen/See	Life Systems Incorporated, Cleveland, Ohio
U.S. DEPARTMENT OF THE INTERIOR			
9. Office of Water Research & Technology	Survival and Fate of Enteric Viruses in Soil Treatment Systems for Wastewater	Sobsey	University of North Carolina, School of Public Health, Chapel Hill, N.C.
10. Office of Water Research & Technology	Investigations of Virus Removal from Water with an Evaluation of a New Virus Detection Procedure	Spendlove/Sorenson/Torpy	Utah State University, Utah Water Research Laboratory, Logan, Utah
11. Office of Water Research & Technology	Rapid (6 to 8 Hour) Method for Determining Numbers of Sewage Pollution Bacteria in Water	Malaney/Tanner	Vanderbilt University, School of Engineering, Nashville, Tenn.
12. Office of Water Research & Technology	Ozonation for Control of Human Enteric Viruses in Secondary Sewage Effluent	Chang	University of Rhode Island, School of Resource Development, Wakefield, R.I.

APPENDIX K (Continued)

SPONSOR	TITLE	INVESTIGATOR	AFFILIATION
U.S. DEPARTMENT OF THE INTERIOR			
13. Office of Water Research & Technology	A Resonance Raman Method for the Rapid Detection, Identification and Quantitation of Bacteria in Sewage and Natural Waters	Nelson	University of Rhode Island, Chemistry, Kingston, R.I.
14. Office of Water Research & Technology	Investigations of Virus Removal from Water with an Evaluation of a New Virus Detection Procedure	Spendlove/Sorensen/Torpy	Utah State University, Biology, Logan, Utah
15. Office of Water Research & Technology	Subsurface Sewage Disposal - Survival and Translocation of Fecal Bacteria in Selected Terrace Soils Adjacent to the Willamette Valley	Hagedorn	Oregon State University, Microbiology, Corvallis, Ore.
16. Office of Water Research & Technology	Survival & Contamination of Groundwater by Fecal Indicator & Selected Pathogenic Bacteria Applied to Soils Amended with Sewage Sludge	Hagedorn/Jackson/Volk/Martin/Willrich	Oregon State University, Microbiology, Corvallis, Ore.
U.S. ENVIRONMENTAL PROTECTION AGENCY			
17. Office of Research and Development	The Fate of Human Viruses in Groundwater Recharge Systems Utilizing Tertiary Treated Effluent	Vaughn	Assoc. Universities, Inc., Upton, N.Y.
18. Office of Research and Development	Development of Improved Enumeration Methods Based on Physiological Studies of Indicator Bacteria Debilitation in Natural Waters	Stuart/Schillinger/McFeters	Montana State University, Microbiology, Bozeman, Mont.
19. Office of Research and Development	Environmental Monitoring of a Wastewater Treatment Plant	Johnson/Register/Harding/Sagik/Sorber	Southwest Research Institute, San Antonio, Tex.
20. Office of Research and Development	Health Risks of Human Exposure to Wastewaters	Clark/Cleary/Pnair/Schiff/Gartside/Dunn/Bjornson/Frame/Buncher	University of Cincinnati, School of Medicine, Cincinnati, Ohio
21. Office of Research and Development	Identification and Detection of Water-Borne Viruses by Immunoenzymatic Methods	Nichols/Herrmann	Harvard University, School of Public Health, Boston, Mass.
22. Office of Research and Development	Virus-Coliform Ratios in Untreated Water	Brashear/Burns	U.S. Environmental Protection Agency, Field Studies Division, Cincinnati, Ohio
23. Office of Research and Development	Indicator Measurements - Rapid Methods	Reasoner	U.S. Environmental Protection Agency, Water Supply Research Division, Cincinnati, Ohio

APPENDIX K (Concluded)

SPONSOR	TITLE	INVESTIGATOR	AFFILIATION
U.S. ENVIRONMENTAL PROTECTION AGENCY			
24. Office of Research and Development	Study Engineering & Water Management Practices to Minimize Infiltration of Precipitation into Trenches Containing Radioactive Waste	Ross/Wrigt/Phung/ Weaver/Cartwright	SCS Engineers, Long Beach, Calif.
25. Office of Research and Development	Instrumental Detection of Viruses	Wallace	NASA, Jet Propulsion Laboratory, Pasadena, Calif.
26 Office of Research and Development	Health Implications of Sewage Treatment Facilities	Johnson	Southwest Research Institute, San Antonio, Tex.
27. Office of Research and Development	Enumeration of <u>Shigella</u> in Polluted Waters	Olivieri/Noss	Johns Hopkins University, School of Hygiene and Public Health, Baltimore, Md.
U.S. NATIONAL SCIENCE FOUNDATION			
28. Division of Advanced Energy & Resources Research and Technology	Potential Health Risks Associated with Injection of Residual Domestic Wastewater Sludges into Soils	Sagik	University of Texas, Microbiology, San Antonio, Tex.
29. Division of Advanced Environmental Research and Technology	Virus Survival in Soils Injected with Municipal Wastewater Treatment Residuals	Sagik	University of Texas, Biochemistry, San Antonio, Tex.
30. Division of Advanced Environmental Research and Technology	Mechanism of Plant Virus Inactivation in Soils Injected with Municipal Wastewater and Treatment Plant Sludges	Cheo/Cheo	California Arboretum Foundation, Inc., Arcadia, Calif.
OREGON STATE GOVERNMENT			
31. Oregon State Government, Salem, Oregon	Sub-Surface Disposal of Household Waste	Harward	Oregon State University, Agricultural Experiment Station, Corvallis, Ore.
TENNESSEE STATE GOVERNMENT			
32. Tennessee State Government, Nashville, Tennessee	Electrical Equipment for the Treatment of Water	Stone/Sewell	University of Tennessee, Agricultural Experiment Station, Knoxville, Tenn.

SOURCE: Smithsonian Science Information Exchange, 1979.

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SUPPLEMENTARY

INFORMATION

Correction

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DISPOSAL OF HOSPITAL WASTES CONTAINING PATHOGENIC ORGANISMS

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