POLICIES FOR SOLID WASTE MANAGEMENT

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NATIONAL ACADEMY OF ENGINEERING–NATIONAL ACADEMY OF SCIENCES
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FOREWORD

Within months following passage of the Solid Waste Disposal Act of 1965, the fledgling Federal solid wastes program was carefully but steadily awarding grant monies as authorized--for research, training, demonstrations, and planning. Earlier Public Health Service solid-waste-related activities were gathered into the new program. The range of even these early grant titles indicates the diverse fields in which solutions to the Nation's mounting solid waste problem were being sought.

Under authority of the Act, and because of the program's limited in-house research capabilities, the deepening and a broadening of the baseline of the early investigations would depend heavily on the contract mechanism. Funds authorized by the Act were not large, and, as with the grants, the new Federal program had to exercise a high degree of selectivity in selecting contracts from a wide range of projects judged to have the greatest possibility for pay off in developing the most useful information.

It was just at this time that the Spilhaus report *Waste Management and Control* became available.[1] "Descriptively, qualitatively, and comprehensively," the National Academy of Sciences and its National Research Council had set forth the challenging pollution problem--of the Nation's waters, air, and land--in all its pervasive complexity. For the first time, the full array of discrete groups of factors that relate to pollution were identified; areas where science and technology could

[1]National Academy of Sciences--National Research Council, Committee on Pollution. Waste management and control; a report to the Federal Council for Science and Technology. Publication 1400. Washington, NAS-NRC, 1966. 257 p. [Athelstan Spilhaus, chairman of the committee.]

effectively assist in controlling pollution were determined. The impact of the NAS-NRC report was far-reaching. Its affirmation of waste management contributed to changes in our concept of the intrinsic value of waste, making more positive our attitude toward waste handling. Perhaps the report's most significant influence was the impetus given to the ecological approach to environmental impairment--how much pollution can the environment absorb without detrimental, or even irreversible, effect upon the balance of nature? Today, four years later, President Nixon has voiced the Nation's growing concern in his State of the Union message:

> The great question of the seventies is, shall we surrender to our surroundings, or shall we make our peace with nature and begin to make reparations for the damage we have done to our air, our land, and our water?
>
> Restoring nature to its natural state is a cause beyond party and beyond factions. It has become a common cause of all the people of this country. It is a cause of particular concern to young Americans--because they more than we will reap the grim consequences of our failure to act on programs which are needed now if we are to prevent disaster later.

At the time of publication, in 1966, the relevance of *Waste Management and Control* to the work of the young Federal solid wastes program was quickly recognized. The NAS-NRC's comprehensive assessment of the pollution problem was a key project already accomplished, which would inevitably influence the direction of the solid waste mission. In the program's quest for contract work with greatest potential for pay off, what could be more fruitful than a contract with the National Academy of Sciences stemming from its epochal pollution study? To this end, the program (now the Bureau of Solid Waste Management), contracted with NAS to establish a committee on solid waste management in the National

Research Council's Division of Engineering. In particular, the Committee would be asked to advise the Bureau on the feasibility of implementing the NAS-NRC recommendations as they related to solid wastes.

The present volume is the result of that contract effort. In this study the Committee chose to concentrate on solid wastes generated from urban areas, although, of course, the interests of the Bureau of Solid Waste Management and the Congress include the wastes generated from all sources. The contract has resulted in a new set of recommendations, with far-reaching implications, for policies for solid waste management. These are national in scope, for the Committee had in mind the opening up of leadership towards solving the Nation's solid waste problem beyond the Federal program. We too would stress that there are contributions to be made by individuals and by government of all levels.

--RICHARD D. VAUGHAN, *Director*
Bureau of Solid Waste Management

PREFACE

Matter can be neither created nor destroyed. Man processes and uses matter. In so doing he may change its chemical form or alter its physical state; but, in some combination of gases, liquids, or solids, all of the original material continues to be a part of the world about us. As a nation we are proud of the products of our agricultural and industrial activities. As individuals we use this output mostly to our benefit so long as it is useful to us--then we discard it. By such discarding, the goods portion of our gross national product, plus a substantial portion of the residues of industrial processing, enters our air, water, or land environments as gaseous, liquid, or solid wastes.

Water and air have a natural cleansing or assimilative capacity. Until fairly recently, they were generally capable of self-renewal so there was little noticeable deterioration of their utility or appeal to man, or effect on natural ecosystems which in one way or another contribute to the well-being of man. However, this assimilative capacity is now too often exceeded and national, state, and local programs are underway to achieve through regulatory measures a restoration of the quality of our air and water resources.

This report deals with the management of solid wastes. Solid wastes are significantly different from air and water pollutants and require unique environmental-control measures. In preparing this report, the Committee has attempted to evaluate the problems and place them in proper perspective. An attempt has been made to outline an action program based on problem definition, a study of need, a study of constraints, and an analysis of engineering requirements and alternatives. No attempt has been made to cover the entire spectrum of solid wastes; rather, attention is directed to the urban-generated portion and its resulting urban-centered problems, and to some effects of related agricultural, industrial, and commercial activity.

It is hoped this report will provide a logical basis for substantially increased governmental and public understanding and direct attention to the nation's problems of solid waste management and control.

Donald N. Frey, *Chairman*

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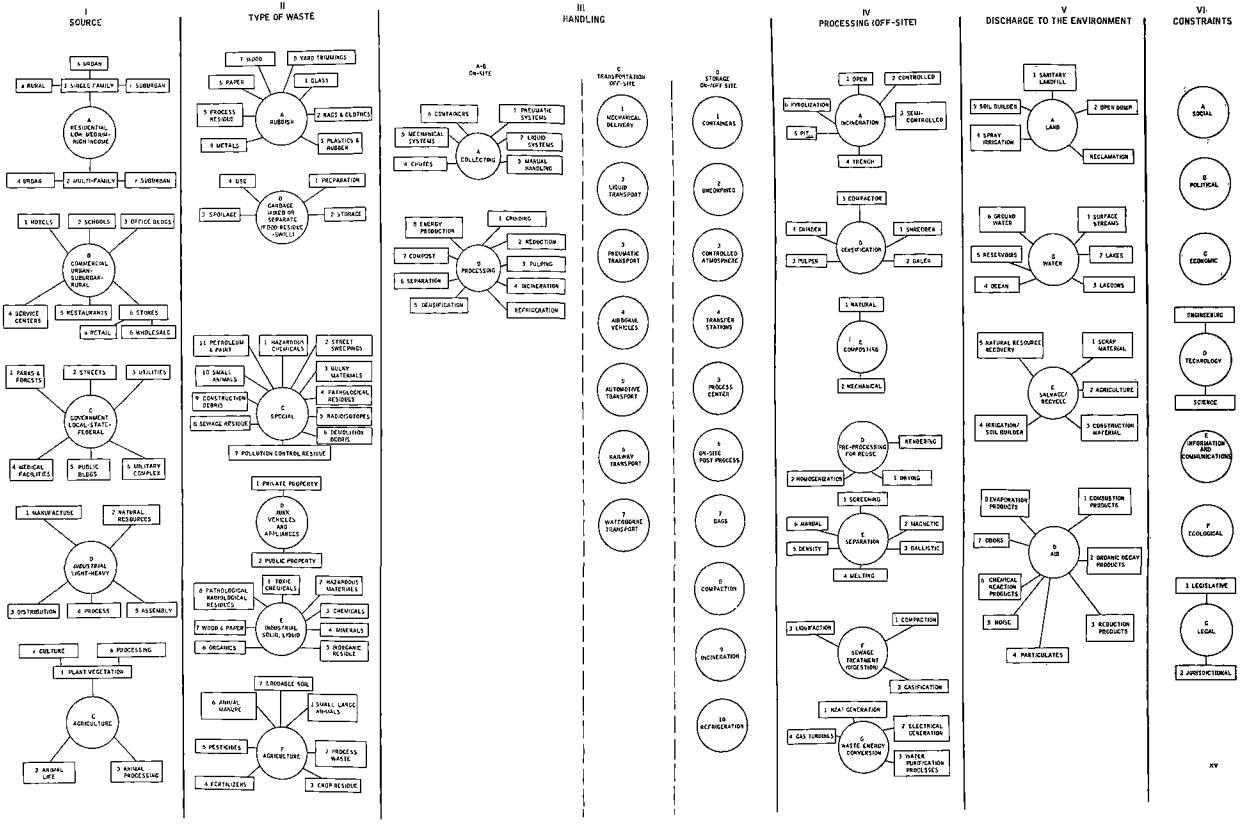
FIG. 1. SOLID WASTE MANAGEMENT STUDY MATRIX



SUMMARY AND CONCLUSIONS

Solid waste management differs in important respects from air- and water-pollution control. The difference derives from the fact that there are two pollutant transport systems: natural (air and water) and artificial (vehicular transport). In general, air and flowing water carry pollutants across political boundaries in response to natural laws that are not subject to legislative repeal. In contrast, solid wastes must be left where they are generated or transported by mechanical means.

The bulk of solid wastes are deposited on land, and disposal tends to be a local problem. Thus, *the principal solutions to solid waste management lie in providing operational systems that employ physical procedures rather than in regulation. Such handling, along with reclamation and reuse as the solid waste management goal, offers the ultimate solution.*

This report deals with the management of solid wastes generated in urban areas. Such wastes amount to more than 200 million tons per year of out of place materials that everyone helps to generate and almost no one wants. Refuse storage, collection, transportation, and processing directly and intimately affect some 80 percent of the population, largely in urban areas. Storage represents the average person's most intimate contact with refuse and is the most direct and personal result of the individual's effect upon his own environment. Adverse effects range from minor irritations to significant contributions to the degeneration of entire neighborhoods and are usually almost directly related to the concentration of people. As is true of all services, costs of waste handling are rising, and when this is combined with concentration of the problem in dense, revenue-limited urban areas, the efficiency of solid waste management is of major importance. However, historically solid waste management has been characterized by minimum attention, minimum funding, and minimum application of technology.

Much of the problem of solid waste management derives from the continued reluctance of those concerned to come to grips with it and apply existing technology, systems, and organizational know-how to its solution--above all, to pay for these services.

In general, people have been willing to pay the cost of removing refuse from their premises, and once it has been removed from sight, they have been unconcerned with the system's complexities, constraints, and costs of collection, transportation, processing, reuse, and disposal.

The present annual direct national costs for solid waste collection and disposal are in excess of $4.5 billion. This figure does not include such important costs as the internal costs to industry and agriculture for solid waste management, householder and institutional costs for storage and handling of refuse, losses in property values due to inadequacies in collection and disposal of solid wastes, the value of

potentially reusable fractions, or individual medical or loss-of-health costs from the various forms of pollution and inadequate control of vectors (flies, rats, mosquitoes, etc.).

Nationally, an estimated 337,000 people are directly employed full-time in the collection, transportation, processing, and disposal of urban solid wastes. The administrators and personnel of these systems have long been plagued by high rates of accidents, illness, absenteeism, and labor turnover. Reliable figures for comparison are not available, but the Committee believes these rates in total are probably the highest for any major occupational group in the nation.

The 200 million tons per year of solid waste material represent a national resource and will in time be a major one. Return of fractions of solid wastes to economical reuse must in the long run become common practice and must be a national objective. Some mineral fractions of the total solid waste stream are recycled today--notably steel and copper. But lesser value fractions in the aggregated waste streams must eventually be recycled.

The Committee believes, therefore, that there should be four principal objectives of solid waste management:

1. *To improve the quality and coverage of the service;*

2. *To improve efficiency of operation through increased mechanization and reduced labor requirements of the system;*

3. *To reduce the accident rate and improve the skills of operating personnel through manpower-development programs;*

4. *To economically recover and adequately process for recycle increasing portions of the solid waste streams.*

With these objectives in mind, the Committee re-examined the 1966 recommendations of the NAS-NRC Committee on Pollution (which helped lead to the original Solid Waste Disposal Act), and with the benefit of the intervening years' perspective, found them only partially applicable to current conditions and needs.

To arrive at new recommendations, the Committee then examined the management of solid waste from a systems-engineering point of view, which makes possible an analysis of the solid waste disposal system as a whole, the parts of the system (subsystems), and the interrelationships between parts and the whole.

In studying such subsystems parts as collection, transportation, processing (including incineration and separation), and salvage or disposal, the Committee found great potential for new technology, and new operating and management methods, but suggests that progress is unlikely to come from a massive breakthrough that will simultaneously solve a wide range of problems More likely, it will come from a series of step-by-step efforts that solve or reduce one problem at a time.

Improvements of any single part of the system are likely to be small and undramatic. But, in the aggregate, a series of small improvements systematically applied can bring substantial progress. The same applies to components, or hardware, that will better serve specific requirements or increase the options available to engineers in designing and operating systems to meet local or regional conditions and objectives.

In addition to the need for new technology and management concepts, the Committee concluded that sufficient technology is now available to permit progress toward solution of many current solid waste management problems. It is suggested that, in general, local operating agencies are not applying available technology on a systematic basis. This is possibly caused by: (1) lack of a basic policy decision to provide the service, (2) lack of broad recognition or acceptance of the problem, (3) political and jurisdictional limitations, (4) inadequately trained personnel, (5) limitations in funding and funding methods, or (6) inadequate information on available technology that might be applied. These limitations are recommended for detailed study by the Bureau of Solid Waste Management.

The Committee, therefore, confirmed that a strong federal program is needed to carry on a variety of activities beneficial to local, regional, state, and private solid waste management groups. These activities would include: (1) dissemination of technical, operational, and management information, (2) encouraging and supporting research and development on equipment and systems, (3) demonstration of improved solid waste handling systems, subsystems, and components, and (4) development of funding systems, planning procedures, and personnel-training programs.

The Committee also made the following recommendations to guide the Bureau of Solid Waste Management in the accomplishment of its responsibilities under the Solid Waste Disposal Act of 1965.

1. *That there be established a solid waste management information center to accumulate, evaluate, and disseminate all applicable information, both foreign and domestic, with the general objective of increasing the rate of application of present and future technology and implementing improved waste management at all levels (see page 46; 7 specific objectives).*

2. *That research, development, and large- or full-scale demonstrations of solid waste systems and components be carried out with demonstrations in metropolitan areas where solid waste problems derive from the several sectors of the community--these activities to include the technological, operational, and economic factors for the newest and best approaches to storage, separation, collection, transportation, salvage, processing, preparation for recycle, and deposit (see page 47; 7 specific objectives).*

3. *That there be substantial effort to improve system business management, planning, and manpower training including coordination with other federal, state, regional, and local government groups and with private operators (see pages 47-48; 10 specific objectives).*

Excellent work consistent with these recommendations has already been started in many specific areas by the Bureau of Solid Waste Management and the Bureau of Mines. The Committee recommends some redirection of emphasis, particularly towards improving the efficiency of the collection and transportation subsystems of solid waste handling, recycling for economic recovery, improved training of personnel, and increased emphasis on solid waste information services.

The Committee recommends almost a tripling of funds for the federal Bureau of Solid Waste Management program over the next 5 years from the present level of about $14 million, to cover recommended increases in breadth of the work and to cover the transition from purely research and development of solid waste systems and subsystems to the more costly demonstration phases of the most promising new developments (pages 49-51).

Specifically excluded from the recommended funding levels are grants or cost sharing for installation of essentially conventional or normal advances in the state-of-the-art facilities and equipment. Also excluded are funds for study of problems predominantly related to agricultural and industrial activities.

The Committee is aware of the possible use of economic incentives or penalties to further the national development of good solid waste management practices. However, such questions are considered to be beyond the scope of this study.

CHAPTER I. INTRODUCTION

BACKGROUND OF STUDY

The urban-industrial-agricultural activities of man have in recent decades resulted in a progressive degradation of the overall environment in the United States. The ordinary citizen is increasingly aware of this. He is aware also that government concern exists and finds expression in a multiplicity of agencies, districts, and boards dealing with health, air pollution, water pollution, refuse disposal, and related matters. Without attempting to evaluate the degree to which the citizen's awareness of pollution effects is the result of governmental interest, or vice versa, it may be said, in truth, that a need to measure the dimensions of the national pollution problem and to reduce its degrading effects on human environment to acceptable levels is recognized at every level from the voter to the President.

Pursuant to this need, the Federal Council for Science and Technology in 1964 arranged with the National Academy of Sciences and its National Research Council (NAS-NRC) to prepare a report on the national problem of pollution. Accordingly, the NAS-NRC, with the support of the Department of the Interior and the Department of Health, Education, and Welfare, established an *ad hoc* Committee on Pollution under the chairmanship of Dr. Athelstan Spilhaus. This committee in 1966 published its now well-known report *Waste Management and Control.*[*] In the words of the report, it represented "an effort to determine areas in which science and technology could effectively assist in reducing and controlling pollution." It drew attention to the interactions between air, water, and land pollution and to the effects of these complex relationships on living systems; and it identified a framework within which a coordinated attack on pollution might be launched. It did not, however, seek to blueprint the specific investigations or the legal, socioeconomic, and engineering activities that such an attack might entail.

The committee noted that a greatly expanded program of study and research is needed to identify and evaluate options, generate new technology, and improve design concepts. To this end, it concluded that the federal government "might serve as a catalyst to action," not only in relation to technical and economic problems, but also in answering a host of legal questions.

Finally, the committee made five major recommendations as to how the federal government might proceed (see Chapter III) through establishment of appropriate agencies and programs.

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[*] *Waste Management and Control*, Publication 1400 (Washington, D.C.: National Academy of Sciences-National Research Council, 1966), 257 pp.

NATURE AND SCOPE OF STUDY

Implementation of the recommendations of the NAS-NRC Committee on Pollution first required an examination of the institutions to determine whether appropriate agencies, policies, and programs already existed within the structure of the federal government. The Public Health Service elected to have some of its activities evaluated in relation to the committee's recommendations. To this end, the Solid Wastes Program (now the Bureau of Solid Waste Management) of the Public Health Service in 1967 enlisted the service of the National Academy of Sciences-National Academy of Engineering-National Research Council to conduct this study. Specifically, it contracted to establish a Committee on Solid Waste Management in the National Research Council's Division of Engineering with the following objectives:

A. To advise the Bureau of Solid Waste Management on:

   1. The feasibility of the recommendations of the NAS-NRC report *Waste Management and Control* as they relate to the handling and disposal of solid wastes.

   2. Whether other similar courses of action are feasible or should be studied.

   3. A priority rating for the courses of action under (1) and (2), and the estimated costs of implementing these actions.

   4. Criteria for the selection of sites for actual studies or demonstrations of the recommendations.

B. To advise on research and development efforts in the solid waste field which are necessary for developing required indexes and parameters for implementation of a systems concept.

Shortly after the Public Health Service asked for this study, the National Academy of Sciences and the National Academy of Engineering decided to establish a joint Environmental Studies Board (ESB) to coordinate all activities of the two Academies in the environmental field. One of the first acts of this Board was to set up four committees within the Division of Engineering of the National Research Council, one each on air, water, noise, and solid waste management. These groups have an engineering orientation and are to be available for advice and assistance to the Congress and to those agencies of the executive branch having responsibility in the areas of air, water, noise, and solid waste. Needed interaction and cooperation of the committees in these four overlapping fields is to be provided through liaison activities of the ESB. The initial Committee on Solid Waste Management was established as an *ad hoc* committee with its membership chosen for their potential to achieve the specific objectives of the study requested by the Bureau of Solid Waste Management.

NATURE OF THE REPORT

To the NAE-NAS-NRC *ad hoc* Committee on Solid Waste Management, the objectives of the study seemed logically to fall into two major categories--one dealing with those aspects that concern the realities and institutional activities of the present and the recent past; the other, with appropriate courses of action for the future. The first of these is dealt with in Chapter III, which is concerned with the pertinence of the recommendations of the NAS-NRC *Waste Management and Control* report to the activities and functions of the Bureau of Solid Waste Management; and with reinterpretations of those recommendations that the *ad hoc* Committee on Solid Waste Management deems necessary to make them directly relevant to the Bureau. The second is the subject of Chapter IV, which deals with the principal objectives to which solid waste management should be directed in the future, Chapter V, which includes priorities and recommendations, and Chapter VI, which details the estimated costs of implementing the recommended actions.

So that its evaluation of the five NAS-NRC recommendations might be of value to a wider audience than the contracting agency's technical staff, the Committee on Solid Waste Management has in Chapter II presented a section summarizing pertinent historical and conceptual aspects of solid waste management as an environmental problem.

As pointed out in Chapter II, the technology of solid waste management is different than the technologies needed for air- and water-pollution control. Even the concepts of standards and control are different.

CHAPTER II. SOLID WASTES AS AN ENVIRONMENTAL PROBLEM

A clear understanding of the emergence of solid wastes as a national problem in environmental management and of the growth of governmental interest in solid waste management is a necessary background to an evaluation of any recommended program intended to resolve the problem. Of particular significance to the subject of this report are two pertinent historical and conceptual aspects:

1. The changing role of the Public Health Service (and the Consumer Protection and Environmental Health Service) in pollution control.

2. Solid waste as a problem in environmental management.

Role of the Public Health Service

In the early 1960's, prior to the *Waste Management and Control* report of the NAS-NRC, the Public Health Service was the principal federal agency responsible for protecting man from air and water pollution. However, as waste management in relation to environmental protection problems became increasingly critical, the Congress began passing a series of bills and appropriating funds to strengthen and broaden the effort for improvement and correction of the pollution situation.

A Federal Water Pollution Control Act and a Federal Water Quality Improvement Act were passed in 1961. A Clean Air Act was passed in 1963. On October 20, 1965, President Johnson signed amendments to the Clean Air Act, Title II of which is now referred to as the Solid Waste Disposal Act [P.L. 89-272]. These three acts, in particular, tremendously broadened the scope and the role of the federal government in the fields of waste management and environmental quality.

The Solid Waste Disposal Act directed two federal departments to the particular problems of management of solid waste. The Department of Health, Education, and Welfare was given the principal responsibility for implementation of the act; and the Department of Interior was given the responsibility for solid waste problems resulting from the extraction, processing, or utilization of minerals or fossil fuels. Other activities of the Department of Interior related to the result of the nonrenewable resources portion of residues of the national resources inventory were delegated by earlier legislation.

Both agencies were charged with concern for the environment, but environmental goals were to be achieved through the management of solid waste to minimize pollution and improve the reuse and recycle of discarded materials.

Prior to the passage of the Solid Waste Disposal Act of 1965, the Public Health Service had a limited program in the solid waste field dating back over a long period of minimal budgetary support.

However, with the passage of the act, the Department of Health, Education, and Welfare-Public Health Service activity in that field was given added status. An Office of Solid Wastes was first created. In January 1967, it was redesignated as the Solid Waste Program within the Center for Urban and Industrial Health, which has its headquarters in Cincinnati, Ohio.

On January 19, 1969, the Solid Waste Program was redesignated the Bureau of Solid Waste Management in the newly formed Environmental Control Administration of the Consumer Protection and Environmental Health Service, Public Health Service, U.S. Department of Health, Education, and Welfare.

Role of the Bureau of Mines

The Bureau of Mines has had a modest research program in secondary waste metals for more than 20 years, but these studies have generally concerned high-value metallic wastes, such as scrap metals, drosses, and residues from metallurgical processing. After the passage of the Solid Waste Act, the Bureau of Mines initiated a program on research and development of methods to recover, utilize, or stabilize the wastes generated by the mineral and associated industries. The primary objective of the program is the development and demonstration to industry of new or improved techniques for the economic recovery and reuse of valuable metal and mineral constituents from solid wastes produced during mineral and metal mining, refining, and utilization.

Solid Wastes as a Problem in Environmental Management

The distinction between goals and methods is particularly important to any study of the relevance of the recommendations of the NAS-NRC report *Waste Management and Control* to the Bureau of Solid Waste Management and to feasible alternatives to such recommendations. The recommendations of the NAS-NRC Committee on Pollution were based on a consideration of pollution in general--air, water, and land--and the vast interrelationships of the three, as well as of scientifically possible ideas for achieving environmental goals of pollution control. The objectives of Chapter III of the study reported upon here concern the feasibility of those recommendations "as they relate to the handling and disposal of solid waste." This introduces engineering factors that, although not necessarily constrained by current concepts of economic feasibility, must inevitably be related to the price tag on any scientifically possible solution. Moreover, it makes the management of specific physical matter, rather than manipulation of the overall environment, the means by which any desired environmental quality is to be obtained. Three aspects of particular significance in the management of solid wastes are:

1. The relation of solid waste management to environmental control objectives and techniques.

2. The spectrum of problems involved in solid waste handling.

3. Changes in national environmental goals and in political, economic, and technological goals that have occurred since the NAS-NRC report and that might modify the recommendations if the committee were to restudy the national problem of pollution in 1969.

Solid Waste versus Environmental Control. The term "solid waste" is defined as those presently unwanted residues of used natural or man-made resources, and of human activity, which are handled or managed in the solid state. From this definition it is evident that solid wastes are significantly different from other so-called pollutants and so affect environmental quality-control measures in unique ways.

Many "pollutants" are solids. When dispersed in the atmosphere as smoke or other particulate matter, however, they are, along with gaseous and liquid materials that are air transported, called "air pollutants." When suspended or dissolved in water, they are called "water pollutants." Both air and water pollutants are subject to special control techniques, some of which may separate out some fraction for handling as solid wastes. Similarly, management of solid wastes may involve techniques in which the air- and water-pollution-control standards become the constraints. This fact, however, only underscores the interrelationship of air, water, and land resources in the matter of environmental control. It does not reveal the fundamental differences that derive from the concept of transport systems versus sinks.

In general, the earth's atmosphere and flowing water are natural transport systems, whereas the land and the oceans are basically sinks. Thus, if wastes are discharged into the air or the streams, they may be transported across political boundaries in response to natural laws. In contrast, although the land may sometimes serve as a reservoir for natural transport systems, solid wastes deposited on it tend to remain a local problem of the area in which they were generated. The same is true of material deposited on the ocean floor. Exceptions occur when combustibles are incinerated, food wastes are ground to the sewer, or refuse is discharged directly into water. But, for the most part, the movement of solid wastes upon the earth depends upon controllable man-made systems of transportation, rather than on the whims of nature. Hence transportation is a part of the overall solid waste management problem and is subject to administrative and legal control. However, much of the existing legislation based on interstate considerations is not applicable, except in a few specific instances such as agricultural regulations governing the interstate shipment of raw garbage for swine feeding.

From a historic viewpoint, the national approach to control of water quality, and ultimately of the water environment, evolved

from enabling legislation aimed at interstate waters. Later on, air-pollution control followed to a large degree the water-pollution-control precedent and from the similarity of air and water as regards natural flow across state boundaries. In both cases, control of pollution, and alleviation of the environmental degradation resulting from pollution, came under a regulatory concept aimed at limiting the quantity of waste material that would be tolerated in the atmosphere or in the water. Because of mixing or dispersion in the air or water medium, the concentration of pollutants was a valid measure and relatable to some concentration known or presumed to be detrimental to living systems. In contrast, solid wastes discharged upon the land do not, with only minor exceptions, disperse and mingle with the soil mass. The amount of waste to be disposed of as solids is affected markedly by the amount incinerated or mixed into sewage. It is difficult, therefore, to support any concept of "land pollution" comparable to that of air and water pollution. Further, the total problem of interstate shipment of refuse, while locally significant in some instances, is relatively small. If man is not satisfied to live with his solid waste, he must either effect some acceptable degree of control over the generation of such wastes--an extremely difficult task--or undertake to collect, transport, process, and recycle or sequester them in high concentration at some point on the earth. Thus, *the principal solutions to solid waste management lie in physical procedures rather than in federal-state regulation. Such physical procedures coupled with recycling and reclamation as the solid waste management goal offer the ultimate solution.*

This does not mean that local regulation is unnecessary. The task of physical management from the point of collection to final containment of wastes must be accomplished in a manner acceptable to the locality in all aspects from aesthetics to land use. But regulation in this context is a matter quite different than in air- and water-pollution control. Although very high levels of environmental quality may derive from planning organizations, zoning boards, and County Boards of Supervisors, *all regulating* where a community can or cannot discharge wastes, these agencies are in reality regulating land use--where and how the wastes are put--not the actual wastes. Their regulations can have meaning only as methods of enforcing solid waste management techniques found by others to be feasible and desirable.

Considerations in Solid Waste Handling. In differentiating between the problem of solid waste management and air-pollution or water-pollution control, it is sufficient to use the word "management" in the general sense of physically handling solid material in an organized and systematic manner that is efficient, economical, noninjurious to health, and aesthetically acceptable to people. However, when the objective of evaluating scientifically feasible recommendations is approached, it becomes necessary to consider that the term "solid waste" more nearly describes a physical state of matter and engineering technology, plus a human attitude toward it, than the material that is to be managed. The word "management" is equally unrevealing of the spectrum of activities involved.

To remind the reader of what is involved in solid waste management, Figure 1 has been prepared. It summarizes in graphic form the source and types of materials commonly known as solid wastes, together with the types of hardware and engineered subsystems associated with the storage, collection, transportation, processing, salvage, and disposal of solid waste.

Changes in Environmental Goals. Closely related to the inherent difference between solid waste and air and water pollutants is the matter of goals of public policy in environmental control. While it now seems that air and water pollution might have been approached from either a regulatory or management point of view, the choice was a matter of policy goals adopted by man. The regulatory approach was deemed most logical at the time because "pollution control" was the stated objective of public policy. Under this regulatory concept, water and air "pollutants" *per se* were the factors to be controlled; standards were developed to describe in quantitative terms the maximum amount of each pollutant that would be tolerated in the water and air resources; and criteria were adopted by which to judge the suitability of the resource for beneficial use.

This regulatory approach to environmental control is not directly applicable to solid waste management because the concept of concentration of pollutants in the land was not valid. As long as pollution control by regulation of pollutants dominated public policy, any national attack on the solid waste problem was infeasible on rational grounds. At least a long interval elapsed between the productive research on solid wastes in the early 1950's and the onset of the solid waste program of the Public Health Service in the 1960's, which cannot be fully explained by public unawareness of the solid waste problem. However, it should be noted that when specific regulatory measures were needed, in 1953, to control the spread of the swine disease, *vesicular exanthema*, a requirement that garbage be "pasteurized" before it was fed to hogs was accomplished in all of the then 48 states within a 2-year period.

The factor that resulted in formation of the Bureau of Solid Waste Management was a shift from "pollution control" to "quality of the environment" as the objective of national policy. This objective was developed in recent years and finds expression in such goals as clean air, pure water, and quality of life--goals that have derived more from desired effects and idealistic and aesthetic considerations than from the stubborn realities of pollutant removal from waste discharges.

The tendency to place greater emphasis on what the environment should be, rather than on to what the materials discarded in it should measure up to is reflected in the report of the NAS-NRC Committee on Pollution. During the 3 years that have ensued since the committee's deliberations, objectives of clean air, pure water, and quality of life have increasingly dominated public policy. These objectives have wide popular support, and because they can be approached only by minimizing, controlling, or setting levels of "pollutants" permitted to be

discharged to the air, water, and land, the effect on waste management is profound.

Changes in environmental goals have been reflected in changes in institutional arrangements within government. The concept that environmental concern for water transcends considerations of public health has already changed the federal program in water pollution that prevailed at the time the NAS-NRC Committee on Pollution prepared its recommendations. In 1969 solid wastes are as much a matter of resource management and land use as of health and aesthetics, and may require new institutional arrangements of importance in terms of the appropriateness of the Committee's recommendations to the Bureau of Solid Waste Management.

CHAPTER III. EVALUATION OF *WASTE MANAGEMENT AND CONTROL* RECOMMENDATIONS

The purpose of this chapter is to evaluate the five recommendations of the NAS-NRC report on *Waste Management and Control (WMC)* for pertinence to the Bureau of Solid Waste Management under 1969 conditions.

Rational and Criteria for Evaluation

From the considerations discussed in Chapter II, the rationale from which the *ad hoc* Committee on Solid Waste Management (hereinafter designated as the Committee) proceeded to evaluate the foregoing recommendations may be summarized as follows:

1. Solid wastes are in some significant degree different from other so-called pollutants and affect environmental quality and quality-control measures in predictable and unique ways.

2. The main problem of solid wastes is one of *physical management* as opposed to *regulation*. Some regulation of storage, point of collection, and other aspects of solid waste management must be enforced, but such regulation is peripheral to the principal factor of management.

3. Any program of solid waste control must start from a systems-management rather than a regulatory viewpoint.

4. Air and water as receivers of waste move across state lines largely in response to natural laws, while solid wastes discarded on land tend to be a local problem of the area in which they are generated and discarded.

5. The national goals in air- and water-pollution control have shifted from pollution control to control of the quality of the environment.

6. Although the Bureau of Solid Waste Management is concerned primarily with one segment of the pollution problem, it is oriented to environmental-quality objectives, and so must consider the related questions of air and water quality.

The Committee evaluated the five recommendations within the foregoing framework, as follows.

Specific Evaluations

Recommendation No. 1

"That a full-scale experimental residue-control system be planned, designed, and constructed in a new city--this system to embody the newest and best principles of recycling, re-using, and recovering

residues, and to serve as demonstration model."

Discussion

The needs upon which this recommendation is based are as valid in 1969 as they were in 1966, when the *Waste Management and Control* document was written. As a specific guide for action for the Bureau of Solid Waste Management, however, the recommendation must be interpreted somewhat broadly.

The recommendation calls for an advanced solid waste management system to be incorporated into a "new city," to serve as a demonstration model. There are very few completely new cities being designed or constructed. Disneyland, Florida; Valencia, California; Columbia, Maryland; and Co-op City, New York, might be so considered, and the Committee contacted officials involved with these efforts. It was pointed out that the nature of those private-venture programs is not conducive to experiments in advanced wastes-management technology. Understandably, developers will not choose to install unproven systems.

The possibility of installing an advanced waste-management system in a federally sponsored new city such as the NASA Center, or a new military base was also examined. However, here again, the purpose of the new city is contrary to demonstrating an innovative system of waste-management technology.

The "Experimental City" concept of the University of Minnesota seemed to the Committee to most closely fulfill the intent of the *WMC* recommendation. Its goal of creating an urban environment in which the way of life is commensurate with the level of our technology is in line with the *Waste Management and Control* recommendation. In preparing for its construction in the 1970's, the University of Minnesota has evaluated the concept of a completely new collection, transport, and storage system for the management of solid wastes from the commercial and residential sectors. This has included such innovations as hydraulic or pneumatic pipelines. The Public Health Service, in participating in the design, has thus been active within the spirit of the recommendation.

The term "new city" should be viewed broadly. The nation is embarked upon a massive urban-renewal program and innovative solid waste management systems--or subsystems--might be incorporated into some of these reconstruction projects. This can, of course, be done although possibly at some subsidy cost. The urban-renewal program in itself is subsidized, thus a subsidy for an innovative solid waste management system would be appropriate.

The basic recommendation refers to the "full-scale experimental residue 'control systems'...this system to embody the newest and the best principles of recycling, re-using, and recovering residues..." Again the Committee interpretation of the wording is broad. A full-scale system may mean either community-wide, or may mean complete--from storage through ultimate disposal or reuse. In either case, "full-scale" and "newest and best" may not be the most appropriate. The Committee can conceive of

pilot installations, and installations demonstrating only one or two parts of the total solid waste management system, as being more appropriate a beginning than a complete system.

In evaluating these factors, the Committee found it necessary to differentiate between two aspects of solid waste management--collection and transportation on the one hand, and salvage and disposal on the other. The Committee noted that although 80 percent of the present cost of solid waste management is in the collection and transportation phases, most of the money being spent by the Bureau of Solid Waste Management is directed to disposal activities. The explanation found for this priority from public-works officials is that the public will provide money to purchase trucks and to employ men rather than tolerate wastes in the streets; but finding any place in the environment where the public will permit the trucks to be unloaded is the critical operation problem.

In the case of the collection phase of solid waste, the recommendation is presently of limited applicability because there are few systems ready for demonstration on a city-wide scale. Pneumatic systems of collection and problems of logistics and economics might be evaluated through demonstration, but, as later noted in Chapter IV of the report, *the need in this area is for the development of mechanized, low-labor, highly reliable systems of a type unique in the field of public utilities.* Such systems are not currently ready for demonstration.

To an important degree there is also only a limited opportunity to demonstrate a disposal system that has application to more than one unique situation. In the judgment of the Committee, an experimental plant should develop the technology, evaluate the performance of the necessary hardware, and establish the economics of residue-management systems involving the most imaginative new ideas and principles which will promote public acceptance. The funding of such projects is a proper function of the federal government.

In the judgment of the Committee, the development of design parameters and economic factors needed by consulting and city engineers in designing systems for a particular situation; the stimulation of appropriate attention to land-use needs; and a program to assure adequate operational performance should be carried out at the expense of the federal government. In the spirit of Recommendation No. 1 and its underlying rationale, this would cast the Bureau of Solid Waste Management in the role of catalyst and initiator of solutions to problems. It would demonstrate what others need to know in solving their problems as contrasted with demonstration of the applicability of a given system to any individual situation. To this end, Recommendation No. 1 should be rephrased.

Conclusions

Relative to Recommendation No. 1 of the *Waste Management and Control* report the Committee on Solid Waste Management reached the following conclusions concerning its pertinence to the Bureau of Solid Waste Management:

1. The recommendations as written must be interpreted rather broadly.

2. The most likely and appropriate place to install and demonstrate innovative components or subsystems of solid waste management systems is in urban-redevelopment projects where subsidy financing is an integral part of the project.

3. Neither "full-scale" nor "newest and best" is the key phrase to the recommendation; rather the underlying rationale is to demonstrate--and to prove out--better solid waste management techniques.

4. In funding research on methodology and systems, the Bureau of Solid Waste Management is carrying out a part of the recommendation through development of new methods and procedures.

5. By research and development on components of both the collection and disposal systems, design parameters and economic factors can be developed with which engineers can design and operate new components and systems with confidence. It is possible that in many cases the nature of collection systems can strongly influence the nature of disposal systems, e.g., high-pressure compaction, separation or other processing at the source could affect design of incinerators.

Recommendation No. 2

"That one or more experimental, regional, environmental design groups be established to:

a. Develop residue-management plans in concert with comprehensive land-use plans.

b. Advise agencies and bureaus of the several federal departments as to information, data, instrumentation, and other needs of local (state, city, subregional) bodies to design and construct plans and systems.

c. Assist local planners and authorities with needed data, services, and techniques to develop subplans compatible with regional design."

Discussion

In the judgment of the Committee, the ideas, intentions, and expectations behind this specific recommendation are particularly pertinent to the Bureau of Solid Waste Management. Some reinterpretations, or perhaps rephrasing, seem necessary, however, to adapt it to an activity such as that of solid waste management.

One of the serious problems of solid waste management derives from the fact that land-use planning has seldom been of a comprehensive

nature and has essentially never included solid waste disposal among its objectives. Local planners, once they become aware of this deficiency, are in urgent need of information and data such as the recommendation is intended to provide, as well as assistance in incorporating it into plans that treat with solid wastes realistically. What, one may inquire, is an experimental environmental-design group? And what type of experiments might it perform? If the experiments are conceptual, it must be noted that numerous highly imaginative proposals have already been developed by environmental designers but the inertia of custom and the marketplace has prevented their becoming a reality. As a result, there are very few examples of "greenbelt" communities, experimental cities, discrete communities of optimum size, and the like. Moreover, the prospects for such, as discussed in relation to Recommendation No. 1, are not bright, at least, within a reasonable time span.

Since the recommendation was prepared, the government has actively implemented the regional concept through the interstate and interlocal cooperation provisions of the 1965 Solid Waste Disposal Act. Twenty-six Demonstration Grants for study and investigation have been awarded. These have used federal support to undertake comprehensive, interjurisdictional planning and action on the total solid waste problem of certain areas. Thus, they carry out the spirit of Recommendation No. 2 as applied to solid waste problems, although they do not in fact represent environmental design groups of the federal government.

The research program supported by the Bureau of Solid Waste Management, its own in-house studies, and, to some extent, its demonstration grant program--all these are generating and assembling the kind of data needed by planners, designers, and others concerned with solid waste systems.

Conclusions

In relation to Recommendation No. 2, the Committee finds that:

1. The Bureau of Solid Waste Management is presently carrying out the concepts of Recommendation No. 2 at a level substantially below optimum compared with the problems of the management of solid waste.

2. The degree of its efforts should be intensified by measures such as the following:

   a. Substantial expansion of the technical services, planning, and manpower-training assistance already being rendered by the Bureau of Solid Waste Management to state, regional, and other local authorities and their consultants.

   b. Intensified coordination of the research, development, training, and technical activities of the Bureau of Solid Waste Management with similar activities of other

federal agencies involved in environmental control (such as the Department of Housing and Urban Development, Department of Agriculture, Federal Water Pollution Control Administration, Bureau of Mines, National Air Pollution Control Administration, and similar agencies.) The Bureau of Solid Waste Management is urged to take the initiative in developing this coordination.

c. Expansion of federal financial aid "risk capital" for development of solid waste management facilities. Such risk capital support in the solid waste management field, both public and private, could underwrite the field-scale testing and demonstration of experimentally and bench-scale proven system components, as suggested in relation to Recommendation No. 1.

d. An improved and expanded public-information effort to increase public knowledge of specific solid waste management schemes, such as neighborhood sanitary landfilling, reuse versus disposal of paper and packaging materials, litter control, and understanding the costs of solid waste management.

Recommendation No. 3

"That there be provided within the structure of the fed-government:

a. A Center for Criteria and Standards, to collect, compile, and issue critical data from national and international sources on acceptable levels of residue concentrations for guidance of regional and local bodies.

b. A Development Center for the testing and evaluation of system and subsystem components, with strong ties to professional associations, industry, and state and municipal authorities."

Discussion

The first section of this recommendation (item a) seems inappropriate to the Bureau of Solid Waste Management and the concept on which it is founded. Clearly it applies to the regulatory concept underlying the air- and water-pollution programs, in which the ability of the resource to accept pollutants is to be quantified. As discussed in Chapter II of this report, the Bureau of Solid Waste Management emerged from the rationale that it is wastes themselves that are to be managed. Hence, the Bureau of Solid Waste Management becomes a service organization rather than a regulatory agency. As previously noted, there is evidence that air- and water-pollution-control programs are becoming resource oriented and will likewise move in the direction of management. In any event, there is no sound rationale on which to generate a concept of "land pollution" comparable to that of air and water pollution and to

control it by establishing standards specifying the concentration of wastes in the land. *In such a context Recommendation No. 3(a) must be ruled infeasible.*

There is, however, a place for guidelines and criteria, although probably not for standards in the regulatory sense. In relation to such aspects of solid wastes as on-site storage, processing, and handling, some control measures are already in existence. For example, the household garbage can is quite rigidly specified; household garbage grinders have been subjected to controls exercised by regulatory agencies for the purpose of insuring nuisance-free, safe, sanitary, efficient operation, or in some cases have denied their use. Basically such "standards," although not necessarily beyond improvement, concern hardware that might more appropriately be considered in relation to Recommendation No. 3(b). In a somewhat different context 3(a) might be reworded to concern minimum requirements for such things as on-site incineration, on-site processing such as grinding, pulping, and baling, and on-site storage and conveying systems. Certainly there is need for information of this type in the engineering, planning, and design of solid waste management systems. Therefore, *the Committee recommends that federal activity be concerned with developing guidelines for satisfactory components of solid waste management systems.*

Conclusions

In the judgment of the Committee, Recommendation No. 3 is generally infeasible in relation to the Bureau of Solid Waste Management, and to the extent that it is appropriate to that Bureau, it is covered by Recommendations Nos. 2 and 4.

Recommendation No. 4

> "That there also be provided, within the structure of the federal government, a program including contract work, to support the following:
>
> a. A legal study on legislative precedents and needs, including questions of equity, simplification of access to courts, and development of model legislation relating to society's use of national resources of air, inland and coastal waters, and land.
>
> b. Biological and ecological studies.
>
> c. Engineering studies, including economic considerations, relating to residue management.
>
> d. All relevant studies toward closing the loop from resource to user to reuse as a resource."

Discussion

This recommendation covers a very wide spectrum of activities that the Committee concludes to be appropriate to the in-house and out-of-house activities of the Bureau of Solid Waste Management. Institutional changes since the recommendation was made, however, may have limited the feasibility of including in a single program all aspects envisioned under item (a) of the recommendation. Therefore, it is concluded that although the Bureau may not encompass the entire field suggested in the *Waste Management and Control* report, all sections of the recommendation are appropriate to the Bureau. It was also concluded that a fifth area of study be included, covering psychology and sociology of waste generation and psychometric research devoted to analyzing the reasons why we do not meet the problem of solid waste management.

Section (a). The emphasis in the original recommendation upon contract work is particularly appropriate for legal and legislative studies, at least in the initial phases, because the Bureau of Solid Waste Management is not presently staffed with legal experts. The authors of *Waste Management and Control* who were responsible for the recommendation note that "the law of pollution is a specialized and technical subject." There is a considerable body of legal precedent in the air, water, and land spheres, but the specific ordinances and past legal decisions governing solid waste systems seem to be related to local political levels, based on long existing public-health and nuisance statutes. It seems appropriate that the Bureau support a basic study on the legal aspects of solid waste management. This study should include a review of past legal actions, local and state, and should propose possible legislation and ordinances for the future. The study should relate the legal problems of solid waste management with the body of legislation and legal decision-making that controls the use and management of land, water, and air resources and the operation of community systems.

Section (b). In evaluating the biological and ecological aspects of solid waste management, it may be useful to identify the type of study that would be particularly appropriate in these broad fields.

The most pertinent biological studies perhaps are those directed to objectives such as the following:

1. The feasibility of utilizing biological systems in the degradation, stabilization, recycling or reclamation, or disposal of solid wastes or of any individual fraction of the total mass of solid wastes.

2. The isolation and culturing of organisms capable of degrading or fractionating organic wastes or any individual fraction of the total; or the establishment of environmental conditions under which such biological activity is optimized.

3. Method of exploiting known biological or biochemical reactions by engineered systems adapted either to a wide range of solid wastes or to individual components thereof, including

the development of design parameters.

Similarly, ecological studies might be concerned with:

1. The ultimate fate of any dangerous component of solid wastes or of the products of degradation of such wastes entering into plants or animals.

2. The significance to local communities of the production of flies, rats, and other disease vectors generated in solid wastes.

3. The pathways by which any dangerous components or products of solid wastes move through the ecosystem.

4 The significance to man of the concentration of toxic compounds, originating in or derived from solid wastes, in any ecological stream.

5. The effect of solid waste disposal aside from toxicity, on ecosystems such as swamps and tidal flats.

To a very marked degree the Bureau of Solid Waste Management is already supporting research in the biological and ecological aspects of solid waste management. A review of the 49 Bureau of Solid Waste Management demonstration grants and 41 research grants in effect on January 1, 1968, gives some idea of the status of biological and ecological studies. Of the 49 demonstration grants, three involved biological studies within the definition set forth in a preceding paragraph. Of the research grants, however, 27 of the 41 involved biological studies. Of this 27, five are identifiable as being ecological in nautre. The nature of these biological studies ranged from the application of the composting process to municipal refuse, animal manures, or agricultural wastes to the science and technology of biofractionation of organic wastes to produce useful resource materials. They include such problems as the movement of fractions and degradation products of solid wastes into the soil and water around landfills, the management of pesticide containers, and the public-health implications of numerous components of solid wastes going into all types of disposal and treatment methods.

Section (c). A major shortcoming in solid waste management has been the lack of accurate quantity and composition information and reliable cost data, making it very difficult to evaluate alternate methods. From an engineering viewpoint, one of the greatest risks derives from the inability to identify wastes and to determine the concentration of various fractions that will upset handling and disposal methods. The Bureau of Solid Waste Management, however, together with the states, is completing a survey and inventory of wastes and present practices. Thus, the Bureau is already embarked on studies of engineering-related data of the type needed under the concept of both Recommendations Nos. 2 and 4. To some extent, the demonstration grant activity is also in the context of engineering studies. These, however, relate to the cost of existing systems in standard practice and fail to yield information on the cost of achieving

optimum levels of performance from existing disposal systems. Engineering and economic studies are required, for example, in waste-heat utilization from incineration and marketing of products developed from waste processing. Of particular importance is the development of systems techniques that yield new engineering management approaches. This is discussed further in Chapter IV. In all these aspects the Bureau of Solid Waste Management is making some impact and failure to achieve the full potential of the recommendation lies in the scale of activities of the Bureau under existing financing, rather than in its orientation or the vision of its leaders.

Section (d). *The ideal ultimate resolution of the solid waste management problem is the development of a closed system in which all residues are reprocessed or otherwise made suitable for return to the national resources.* The recommendation has particular relevance to solid wastes because they are earth-bound in nature and, unlike air or water pollutants, are not associated with any natural transport system by the act of discarding. Recycling, however, is to some degree dependent upon transport and a defining of the path the waste traces from its point of generation until its final reuse. This same factor is inherent in disposal methods as well and so has relevance also to the economic and engineering studies of Section (c).

Throughout the research activity of the Bureau of Solid Waste Management and the Bureau of Mines, there is attention to and awareness of the need to complete the refuse-to-resource link. However, significant technological progress directly pertinent to Recommendation 4(d) is to a major degree dependent upon achievement in research, development, and demonstration projects related to Recommendations such as Nos. 1, 2, 4(a), and 4(c). Progress in these areas is more limited by levels of funding than by the imagination and technical competence of personnel of the Bureau of Solid Waste Management and the Bureau of Mines.

Section (e). This recommendation suggested by the Committee envisions study of the social and psychological reasons why people litter their environment, how solid wastes contribute to urban deterioration, what are the attitudes toward waste-management costs and practices, how the attitudes of people are reflected in feasibility of disposal or recycle procedures, and why people oppose the acquisition of sites for facilities. Like the legal problems, [Section 4(a)], the study should probably be done by contract with knowledgeable specialists. Its results, although conceptual and qualitative in nature, should be useful in the planning and design of local collection and disposal systems and in achieving the environmental goals of solid waste management.

Section (f). Like Section (e), this section is suggested by the Committee, which notes that much of the problem of solid waste management derives from a continued reluctance of those concerned to come to grips with it and to apply existing technology, systems, and organizational know-how to its solution--above all, to pay for these services. To some extent the social and psychological attitudes noted in Section (e) are involved. Similarly, the legal and economic aspects noted in Sections (a) and (c) are relative. However, there is no particular program aimed at analyzing why we have not realistically faced these problems. Such a study might well be made by contract with knowledgeable specialists in a

variety of disciplines.

However, as in Section (e), in many respects the solutions to these problems lie more in the "getting started" and doing than in further study.

Conclusions

The Committee finds that:

1. Recommendation No. 4 is generally appropriate to the Bureau of Solid Waste Management.

2. For a maximum degree of pertinence to solid wastes, the recommendations might be rephrased to be more specific and to include studies in the areas of sociology and political science.

Recommendation No. 5

"That a National Commission for Environmental Protection be established under presidential appointment to:

a. Promote national awareness of the need and opportunities to preserve the health and beauty of our national environment.

b. Promote better use of the resources we mine and consume.

c. Draw attention to notable progress in innovation, design, and practice developed by national and local authorities and industry.

d. Monitor progress of the composit national program.

e. Advise the President and people of needed remedies and desired goals."

Discussion

The Committee strongly supports the view that public information activities relative to solid waste management and environmental-quality improvement should be strengthened.

The recommended commission, if organized, would unquestionably relate to the total environment, and, hence, to the management of all wastes, not merely solid wastes. It might be expected that personnel from the Bureau of Solid Waste Management would, along with representatives of other federal environment-management agencies, inform the commission--but they would not constitute the commission. If the objectives of environmental quality for which the Bureau of Solid Waste Management was established are to be realized, there must be developed the type of public and governmental awareness of the problems of solid waste management that

the NAS-NRC Committee on Pollution had in mind when the recommendation was written.

Public awareness and support of solid waste management systems and solutions are frequently not at a sufficiently high level for better systems to be demanded and the costs accepted. This is particularly true at the local or regional level--the level of action in most cases. Such local support (assuming the problems merit the solutions) is an integral part of the larger management of solid wastes. The Bureau of Solid Waste Management can be of assistance to local authorities through making available the accumulated experience of other successful local efforts.

Conclusion

The Committee concludes that establishment of a national commission for environmental protection is outside the purview of the Bureau of Solid Waste Management. However, the Committee strongly endorses the need for achieving the proposed objectives of such a commission, particularly those related to increased public knowledge and information.

CHAPTER IV. THE FUTURE

An evaluation in Chapter III of the 1966 recommendations of the NAS-NRC Committee on Pollution, and suggestions as to how they may now be made pertinent to solid waste management led to evident activities that might be undertaken by the Bureau of Solid Waste Management. In further advising the Bureau on future research-and-development efforts and to clearly distinguish between goals and methods, the objectives of solid waste management were first established and then the systems concept was used to analyze the complex solid waste disposal system to arrive at methods to achieve the goals. Use of the systems concept was also responsive to objective B, Chapter I, of the study requirements.

SOLID WASTE MANAGEMENT OBJECTIVES

The Committee envisions the Bureau of Solid Waste Management as the principal source of information in the field of solid wastes; as the federal unit, which in close cooperation with other federal agencies, is responsible for planning, coordination, and communication; and the source of direction and funds for research, development, and demonstration of broadly acceptable systems, subsystems, and components as required. Its overriding objective is to improve environmental quality by bringing together the disciplines and technology necessary to give well-planned objectivity and emphasis to the random efforts that are evident in present solid waste storage, collection, reuse, and disposal activities.

So that the Bureau may effectively perform its leadership role in achieving its main objective, the Committee concluded that it must be concerned with four primary objectives in relation to the urban-generated portion of solid wastes:

1. *To improve the quality and coverage of the service;*

2. *To improve efficiency of operation through increased mechanization and reduced labor requirements of the system;*

3. *To reduce the accident rate and improve the skills of operating personnel through manpower-development programs;*

4. *To economically recover and adequately process for recycle increasing portions of the solid waste streams.*

Objective No. 1 is general enough probably to be acceptable at face value. However, the Committee concluded that general lack of quality and coverage of the service is an important factor in the deterioration of many major parts of metropolitan areas. Lack of "quality" disposal is a common source of citizen complaint from adjacent neighborhoods. The current limitations in on-site storage methods are also an aggravation to people generally and to operators of retail, commercial, and institutional establishments in particular.

Improvement in quality and coverage of service will inevitably cost money. In addition, in common with other services, the costs of solid waste disposal are rising rapidly. The need for reducing unit costs of operation is imperative through such means as mechanization and further optimization of operating patterns. The Committee believes that possibilities to do this are very real and that important progress can be made.

Training in the safe way to do a job and training in the efficient technical performance of a job are in most important respects parallel and complementary. High accident rates, high rates of labor turnover, high rates of absenteeism, and high equipment-maintenance costs all indicate the serious need for a broad-based, comprehensive training program for all levels of solid waste operating personnel.

Recycle of some values in solid wastes is practiced today. Salvage of worn-out automobiles and the recovery of lead and copper from discarded equipment are examples. The Committee was impressed, however, by the extensive values potentially salvageable in today's urban solid wastes,* even though these "conglomerate" wastes are normally considered very highly degraded. To the Committee, the development of technology to economically restore these values is of paramount importance.

SYSTEMS ANALYSIS AND MANAGEMENT

The systems approach is a useful and disciplined way of looking at a total system and analyzing the interrelated subsystems as well as the interrelationships with other systems. Although first developed on the basis of mathematical models into which quantitative inputs are necessary to permit "hard" solutions, the concept is increasingly applied to systems in which many of the interrelationships and constraints are qualitative in nature. Thus, while a mathematical solution independent of human value judgments may not be possible, or is impractical, the systems discipline does facilitate and demand: evaluation of feasible alternatives, prediction of present and future consequences of specific action, evaluation of impact of change in one or another element of the system, indication of priorities, and selection of the most acceptable course of action.

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* Approximately 25 million tons of paper and paper products, 14 million tons of glass, 12 million tons of assorted metals (excluding junk automobiles), 2.2 million tons of rubber, plus other potentially reusable fractions, represent a significant portion of our national material wealth.

SYSTEMS APPROACH TO SOLID WASTE MANAGEMENT

The urban-generated* fraction of the solid waste management problem was singled out by the Committee for particular attention because it directly and adversely affects the most people and is the most urgent portion of the total problem. Similar analyses could be made relative to other sources or combinations of sources shown in Figure 1. Lack of information characterizes many of these sources of waste and evaluation of their role in the total waste-management system is a matter beyond the scope of this report. This, however, identifies a study area to the Bureau of Solid Waste Management, discussed in Section 4-D, Communication and Information (pages 43-44).

In studying solid waste systems, the Committee suggests that progress in the field of solid waste management is unlikely to come from a massive breakthrough that will obliterate difficulties and simultaneously solve a wide range of problems. More likely, it will come from a series of step-by-step efforts that solve one problem at a time. Gains in the management of any single part of the system are likely to be small and undramatic. But in the aggregate, a series of small improvements systematically applied will bring substantial progress.

Although the principles of the systems approach are simple, a systematic analysis of the total solid waste problem is exceedingly complex. The proper management of a solid waste system is dependent upon the input of knowledge from many disciplines. Legal, social, medical, and economic factors introduce myriad qualitative inputs and constraints upon the free functioning of the system. Engineering considerations include the source, composition, storage, collection, transportation, separation, salvage, processing, and reuse or final deposit of solid wastes. These comprise the principal subsystems to be analyzed. They are subject to quantification in physical and numerical terms. Yet solutions based on engineered subsystems and components are themselves constrained by social, economic, political, technological, ecological, and legal constraints. Moreover, the total solid waste problem is but one aspect of an overall waste problem that includes airborne and waterborne wastes, hence the interrelationships between land, water, and air systems would be fully considered when the solid waste system is examined in detail.

Employment of the techniques of systems analysis and highly advanced mathematical modeling in solid waste management systems depends upon accurate information on all elements of the system. The National Solid Wastes Survey (which is being conducted by the states with the assistance of funds provided under the Solid Waste Disposal Act) is designed to provide a portion of the needed information on such aspects of the problem as sources, quantity, composition, collection, transportation,

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* In this context, urban is defined as a geographical area that has a population density of 1,500 per square mile or greater. Waste sources may include residential, commercial, industrial, governmental, and agricultural activities.

reuse, and disposal of wastes.

Both qualitative and quantitative information is important in the detailed planning of new components and systems. However, considerable additional data on these activities, plus data on processing-equipment operation and costs, will be required before application of operations-research-computer-programming techniques to complete systems operation will be practical.

Additional cost and operating data are particularly important, both for systems analysis and evaluation of alternatives, and for evaluation of future needs. Solid waste disposal, even in the public sector, is already big business and promises to become larger. Two and one-half billion dollars is estimated as the current annual public cost of solid waste collection, transportation, processing, and disposal. The total national costs are in excess of $4.5 billion. This represents the direct cost of solid waste management, which is distributed through the present tax structure, or is payable by special user charges to public or private groups. It does not include such important costs as the internal costs to industries for solid waste management, householder and institutional costs for storage and handling of wastes, losses in property value due to inadequacies in collection and disposal of solid wastes, the value of potentially reusable fractions of solid wastes, or individual medical or loss-of-health costs from the various forms of pollution and inadequate control of vectors (flies, rats, mosquitoes, etc.).

In the future, solid wastes are going to change in both magnitude and type in this increasingly market-oriented, large metropolis-concentrated, affluent society. Input-output analysis can show the details of recycling with changing mixes and future capacity needs.

Despite the magnitude of the task of assembling the necessary quantitative data, including cost data, for fully applying the systems approach to solid waste management, and despite the limitations of present data, *the Committee urges that the Bureau continue to accumulate and evaluate solid waste systems data and, at the same time, proceed without undue delay in the preparation of simulation models that can make the best use of existing information and can be refined as the required additional information becomes available.*

The evaluation of constraints imposed by legal, social, cultural, and other qualitative considerations is probably not subject to rigid mathematical formulae and will likely have to be handled by some acceptable sensitivity rating determined by local conditions.

1. Development and Demonstration of Improved Engineering Subsystems and Components

Improvements in the performance of existing engineering components of waste-management systems; the demonstration of new engineering concepts in storage, collection, transportation, and disposal, to give improvements in costs, quality, and acceptability of systems performance; and the establishment of economically attractive processes for separation

and reuse of the resources now being discarded are the areas of major potential for satisfying the local and national objectives of solid waste management.

Information is particularly necessary on source, composition, and quantities. Engineering parameters are needed for better storage, collection, handling and transportation, processing (including separation), incineration, and final deposit of solid wastes.

A. Source, Composition, and Quantity

The source, composition, and quantity of refuse generated, particularly from residential sources, varies widely with seasons, economic levels, economic base of the area, ethnic background of the inhabitants, and the effects of technology on the neighborhood.

It is important to recognize the ever-changing composition of solid wastes. A continuous program of data gathering is needed, with changes in the primary factors influencing solid waste generation as the criterion. Among the most important of these factors are:

1. Design of products leading to accelerated obsolescence;

2. Broader distribution of higher real income that makes possible the increased manufacture and sale of consumer items;

3. Packaging to improve sales appeal, prolong shelf life, and reduce marketing costs per unit;

4. Increasing concentration of people in urban areas;

5. Changes in individual economic levels and aspirations, which contribute to rapid style changes and desire for status, convenience, comfort, or a sense of well-being that can be achieved by accumulation of goods that are easily used and discarded.

Because of the dynamic nature of these data, it is particularly important to establish at least six carefully selected locations where the long-term trends in per capita generation of refuse can be determined.

Detailed information from various types of sources will also be particularly useful when reuse decisions are being made. *To this end, the Committee endorses and encourages the Bureau in its program of gathering data of source, composition, and quantity, and suggests that the program be expanded to include all solid waste streams.*

B. Storage

Storage represents the average person's most intimate contact with solid waste and is the most direct personal result of man's effect upon his environment. Storage of refuse at the point of generation is

usually a prelude to collection. For reasons related to collection techniques and often the value of building floor space, the storage aspect of solid waste management is characterized by limited volume of containers, limited space, unsightliness, and quite commonly, by flies, odors, rats, and fire hazards.

The needs fall generally into the following categories:

1. Substantially broadened concepts of health, convenience, space, and access requirements;

2. Provision for separate storage of potentially reusable waste materials;

3. Development of low-cost domestic and commercial incinerators that will meet all air and water quality standards, health and safety regulations, and require only minimum technical competence for their efficient operation;

4. Improved stationary compaction equipment.

For resolution of the problems of on-site storage, attention should be paid to the physical premises themselves. In only a few instances have builders, planners, owners, architects, developers, or others concerned made adequate provisions in terms of space and access for on-site storage of refuse. Further, there has generally been no compelling need for separation of the potentially reusable portions. Both these matters will have to be given greater attention in the future.

Components used under any particular set of conditions will be determined by individual objectives, local ordinances, and local services and economics. However, components of common interest to improved storage include the conventional garbage can and larger containers. Alternative or adjunct systems include domestic incinerators; commercial-sized incinerators for apartments, hotels, hospitals, offices, and business establishments; on-site compaction equipment; and systems that continually scavenge the premises of wastes or facilitate the transfer of wastes to collection systems.

Pneumatic and hydraulic collection systems and mechanical loading equipment are in need of particular attention to reduce space requirements for on-site storage.

In relation to on-site storage *the Bureau of Solid Waste Management should assist in the development and demonstration of systems that will minimize local storage and at the same time expedite the solution to collection and transportation problems.*

C. Collection, Handling, and Transportation

The collection, handling, and transportation of urban solid

wastes directly, intimately, and, in most cases, adversely affect the senses of sight, smell, touch, and well-being of some 80 percent of the population, and requires about 80 percent of the total systems-operating costs. Adverse effects, which range from minor irritation to important contribution to the degeneration of entire neighborhoods, are in almost direct relationship with the concentration of people.

Complaints on collection and handling center mostly on noise and the creation of unsanitary conditions at the point of collection, delays in pickup, required packaging, infrequency of pickup, and restrictions on what will be picked up. There have, however, been better organized and more serious complaints about processing and discharge to the land from citizens who object to having the required facilities near their homes or who live along main transportation routes to the facilities. In addition, more restrictive air- and water-pollution-control standards have resulted in requirements for increased engineering attention to the incineration and final components of the system. The result is that the major portion of research and development funds were assigned to processing and discharge studies.

The Bureau presently assigns about 7.5 percent of its research, development, and demonstration funds to the collection, handling, separation, and transportation components of the system. On the other hand, the discharge to the environment portions of the system--incineration, sanitary landfills, composting, transfer stations, etc.--is presently requiring about 20 percent of the systems-operating costs and is assigned about 90 percent of the available research, development, and demonstration funds.

The rationale for this division of funds is easy enough to understand. People have been willing to pay the high labor cost of removing refuse from their premises, and once it has been removed from sight, they have simply put it out of mind. Except for those who live near processing or disposal facilities, people have been unconcerned with what happened to their refuse once it left their premises.

Labor-management developments over the past few years lend additional urgency to the need for substantial improvements in the collection and transportation components of the systems.

Other problems related to transportation by truck, rail, and water are high maintenance costs and less than optimum performance of the equipment. These problems are usually the result of some combination of the following: (1) equipment inadequately designed or inadequately sized for the job, (2) purchasing on inadequate specifications rather than rigid performance, and (3) inadequate training of the maintenance and operating crews. Objectives should be to improve equipment reliability and reduce unit costs of wastes handled by increasing density of the compacted load, reduce labor required for loading, reduce maintenance costs, improve the utility of the vehicles for the specific function and area to be served, and improve safety for personnel.

Several projects are presently under way to develop rail

transport of compacted refuse from urban centers to areas in need of fill material resulting from strip mining, land erosion, or reclamation of submarginal lands. Well-managed reclamation projects of this type are a very real benefit to all concerned: (1) They result in improvement of local land resources in the receiving area; (2) they utilize existing transportation systems that bring material into urban areas; and (3) they provide a solution to a critical portion of the urban solid waste management objectives.

Other forms of local transport that are being considered include pneumatic and hydraulic transportation. Both these methods deserve adequate assignment of resources to develop new technology, assure proper application of the best technology presently available, and determine the operating characteristics including capital and operating costs, advantages and disadvantages of each method. The Bureau's New Haven project (Appendix A, page 52) is a good example of this activity. *The Committee strongly endorses and encourages increased emphasis on new concepts of hardware and equipment, including demonstration, directly related to specific solid waste storage, collection, and transportation problems.*

The primary equipment used in residential storage and collection is, and will continue in the foreseeable future to be, the refuse container, paper and plastic bags, and the compactor truck. Thus, so that this equipment and its operation can be improved in acceptability and efficiency and the costs of providing this service reduced, the *Committee recommends that technical studies of the highest priority begin forthwith to increase the mechanization, improve productivity per unit of labor, upgrade the skills required, and improve health and safety.*

D. Processing

The concept of processing may be applied to a number of steps in the management of solid wastes and be directed to a number of objectives. For example, such processes as compaction, baling, shredding, and other size-reduction procedures may serve to preprocess wastes for ready segregation of its components for further processing into resource materials. On the other hand, they may prepare wastes for incineration, composting, or landfill, which are normally considered to be disposal systems. These subsystems, however, may also be recovery processes. Incineration is now sometimes used for recovery of minerals; composting is used to salvage organic humus; and landfill is being conceived as a storage of resource materials pending the time when it may be economical to recover them. Each of these processing steps require components that serve specific requirements and broaden the selection of options available to engineers in designing to meet local or regional conditions and objectives.

1. Separation

Virtually all the urban-generated solid wastes (approximately 200 million tons per year) will have to be processed in some manner to make progress in recovering the contained resource materials and reducing the systems-operating costs. Although some materials such as newspaper, for example, may be kept separate by the householder, it is unrealistic to

expect much separation at the source. Thus, there is a massive materials-handling problem. This means that a large quantity of material of highly variable composition must be separated into identifiable parts with the useful fractions returning to the resource inventory and the residue deposited on land in an acceptable manner.

Methods of mechanical processing or separation that deserve attention include screening, air tables, flotation, magnetic and heavy media separation, vibration, and chemical treatment.

Economic advantages of separation may well go beyond the value of reusing resources. Lower cost of disposal can result from a decrease in residue left after separation. Upstream separation can significantly reduce the costs and problems of final handling, reuse, and disposal. For example, the problems and costs of disposal could be greatly reduced if reusable paper, glass, other inorganic refractory materials, rubber products, metals, and plastics were removed, separated, processed, and returned to industry.

In past years efforts have been made to separate selected materials by hand, usually from conveyor belts prior to incineration or deposit. Because of rapid increases in labor rates and low job appeal these efforts have now been almost totally discontinued. Therefore, it must be assumed that mechanical separation will be necessary and that the feasibility of separation will be finally determined by the economics and efficiency of the operation and the utility and marketability of the product.

2. Compaction, Size Reduction, and Baling

Compaction is required to reduce volume and increase the density of refuse in order to reduce transportation costs or facilitate final deposit. There is need for greater compaction in stationary storage and wheeled collection equipment to reduce the volume requirements and reduce the number of trips. Progress along these lines has been reported in Europe. The Bureau's press project in Chicago is designed to determine the feasibility of compressing refuse to about 75 pounds per cubic foot, to reduce sanitary landfill volume requirements and to reduce rail and other types of long-haul costs.

Some methods of shredding, crushing, or other forms of size reduction have a wide variety of application related to preparation of the material for shipping, storage, disposal, or further processing.

Baling is the final step in compaction of salvaged materials such as paper, rags, etc. Requirements for these applications appear to be provided where needs are adequately defined. Baling as a method of retaining density of mixed refuse after compaction for deposit needs additional development work to improve the long-term stability and assure prevention of air and water pollution.

E. Incineration

Even with the most optimistic assumptions for separation and

utilization of certain portions of the urban waste streams, there will be need in the indefinite future for incineration with sanitary landfill of a considerable fraction of the solid waste stream. Much has been written and said about the high costs, inefficiency, undesirable location, unsightliness, and contributions to air and water pollution of incinerator operations. In most cases these adverse comments are richly deserved. However, it is the opinion of the Committee that adequate technology is available to make possible the construction and operation of acceptable incinerator facilities, provided the following conditions are met:

1. Public acceptance of financing that provides for design, construction, and operation based on rigid minimum-performance standards.

2. Public recognition and acceptance of minimum critical-size requirements to make possible lowest practical cost per unit of throughput.

3. Site selection fully recognizes local conditions and objectives.

4. Professional engineering is employed in the establishment of specifications, design, construction, and operation.

5. Competent supervisory and operating personnel are employed.

6. Acceptable performance standards based on present and projected local composition and quantity of solid waste with full recognition of requirements for prevention of air and water pollution.

F. Landfill and Final Deposit

Landfill is widely used as a method of land reclamation. In addition, landfill as a solid waste management system component of the future may be viewed in two contexts. It may represent a stockpiling of material until such time as the contained values become sufficiently important to justify segregating and reprocessing. Or it may represent the final deposit of worthless residue, such as broken ceramics and concrete. Concerted efforts to reduce the waste streams by salvage of usable fractions and greater compaction or incineration of the economically unusable portions will reduce the volume requirement for final deposit. However, there will be, in the foreseeable future, a continuing need for final deposit sites.

The problems involved in sanitary landfill or final deposit of wastes are more involved with siting and public acceptance than with technology, although known technology is by no means fully employed. Available records indicate that there are about 90,000 more or less recognized land-disposal sites in the United States. Of this number, about 19,000 were planned, and some 12,000 are subject to a degree of local control that

identifies them as "sanitary." Less than 14 percent of these partially controlled sites enjoy any degree of local acceptance. There is no question as to the low esteem in which the remaining 78,000 are now held by the public. The National Solid Wastes Survey has detailed information on about 6,000 sites, and finds that only 6 percent of these meet the minimum requirements for designation as "sanitary landfills." The Committee feels that this condition has developed more from a lack of use of available information and training than for any other reason.

Final deposit sites are becoming increasingly difficult to establish, not only in urban areas, but also in areas where stringent control of past operations has not been exercised.

The Committee stresses the importance of continued research-and-development effort directed to the technology of producing landfills with a minimum of land requirements and a maximum of flexibility of subsequent land use; and the need for measures to inform the public and its representatives of the guidelines that lead to fully acceptable landfilling operations.

2. Reuse of Resources

There can be no reasonable doubt that a major long-term objective of any waste management system must be to return the value fractions to the resources inventory. Determination of the value of the various fractions will depend upon the normal economics of utility, time, and place. Moreover, the Committee concludes that there can now be only limited determination of values until separation of the various fractions are made on a demonstration basis and specific technical and marketing research projects directed toward their utilization.

The utopia of a totally closed-resource cycle with 100 percent recycling will, of course, never be achieved. *Nevertheless, the Committee believes major fractions of virtually all solid waste streams can have utility, but long-term-development plans recognizing this need for conservation and for upgrading the quality of the environment must be implemented.*

Progress in salvage of various fractions of solid waste streams will be accelerated by the success of separation as far upstream as is practical. *This will require, on one hand, specific and determined efforts in educating people at all levels to understand the needs and advantages of adequate separation at the point of generation, and, on the other, the development of mechanical equipment to make separation at the closest downstream point after the refuse is mixed.*

Economic reuse of salvaged materials will finally depend on preparation of well-characterized and useful products and delivery of these products at a competitive price to the point where they are acceptable as a resource or process material by industry. *Worthwhile accomplishment along these lines will require determination, close coordination, and understanding between waste-management groups in providing usable materials*

to industry and industry groups in providing processing methods and determining product specifications that will accept the salvaged material.

It is quite probable that many salvage and recycle activities will not be self-supporting during the process, pilot, and marketing-development stages. Significant development funds will thus be needed, as well as hard-headed realism in eliminating quickly from further development those schemes that will ultimately fail.

Of the potentially reclaimable fractions, paper and paper products and certain metals now seem the most likely in terms of volume of material and known technology of recovery. However, recycle of glass, rubber, and plastics should be studied in the research-and-development phases.

A. Paper and Paper Products

Approximately 50 million net tons of paper and paper products were used in the United States in 1967. The best figures available indicate that more than 80 percent of this production goes into one-time use and discard applications. Of this quantity, about 10 million net tons were reused. A substantial portion of the remainder became solid waste and contributed some 35 to 50 percent of many domestic and commercial solid waste collections. Newsprint usage was about 9 million net tons, paperboard products about 24 million net tons, nonpackaging printing paper about 5.6 million net tons,* and miscellaneous about 11.4 million net tons.

Of the 10 million net tons of paper and paper products reused, a substantial portion is generated as scrap from printing and publishing activities, manufacturing scrap, and industrial and large commercial and government establishments. A relatively small percentage is collected from domestic, schools, smaller government, office, and smaller commercial sources. These last sources account for a substantial portion of the waste-paper accumulation. Collection from these sources is almost exclusively by churches, civic groups, and Boy Scouts, and does not presently constitute a reliable raw-materials source for a large paper mill designed to operate on a high percentage of recycle material.

There are no major technological limitations to the reuse of newsprint and paperboard.

There are technological and economic problems in the reuse of magazines and most miscellaneous grades because of filler materials, such as clay, resins and starches, hot-melt adhesives, certain types of inks, and noncellulosic inserts and staples. None of these problems appears to be of overwhelming magnitude.

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* This figure breaks down approximately as follows (in thousands of net tons): magazines 1,954; commercial printing 1,956; catalogs and directories 655; books 642; and converting (stationery, tablets, tape, etc.) 433.

In addition to what appear to be solvable technological reuse problems, there is the problem of separate accumulation and storage by the housewife, the office staff, and the smaller commercial and industrial manager, and the separate collection, processing, and transportation to the point of further processing or the point of reuse. Initial separation, accumulation, storage, and collection will depend on habit, willingness to cooperate, and a thorough understanding of the problems. The Committee believes that the motivations of good housekeeping and other social and economic factors may elicit the support of a well-informed public. But realism also says that *development of mechanical equipment to separate paper from mixed refuse deserves a very high priority.*

The growth rate of the paper and paper-products industry is projected by the industry at 100 percent in the next 16 years or production of 100 million net tons by 1985. *A goal of supplying at least 50 percent of this growth from the increased usage of recycled material seems to the Committee to be a realistically attainable, technologically possible, and economically feasible objective.* Success in attaining this objective would release 91.5 million acres of forest land for other beneficial uses. The percentage of production that is recycled is historically about 20 percent. If, in addition, the annual recycle can be increased by 50 percent of the projected growth, or 25 million net tons by 1985, the saving would be equivalent to 31 million cords of wood--more than two and one-half times the present total annual production of the four leading states--Georgia, Washington, Alabama, and Florida. Even including 25 million ton increase in recycling, the projected 1985 production will require an additional 55 million acres of forest lands. The potentials are staggering and the national benefit to risk payoff is many thousands. This is in addition to reducing the waste load in the selected areas by perhaps as much as 25 percent.

The Committee believes that the recycle of paper and paper products presents a timely opportunity. The need is well identified, the paper industry seems interested, technological problems appear to be of manageable size, economics seem to be favorable, and market development does not appear to present any overriding problems. The Committee, therefore, *urges that the Bureau of Solid Waste Management sponsor a broad-based study of the social, technological, and economic problems involved in increasing the recycle of paper and paper products to supply a major portion of the increased pulp-wood requirements during the next 16 years.*

B. Metals and Minerals

Of the metals and minerals in solid wastes, junk-auto scrap and incinerator residues seem most worthy of attention, beyond the normal handpicking and metal-salvage operations currently in practice.

Junk-Auto Scrap

In 1966, it was estimated that about 6 million scrap cars were processed and sold to the steel and other metalworking industries for reuse, nearly equaling the number of cars being junked. This was the first time that reuse of scrapped automobiles equaled the scrapping rate, but the way

in which the record was achieved is unique. Large, high capital cost auto-shredding plants, constructed in the large urban centers in recent years, processed more automobile hulks from the accumulated backlog of cars in the urban centers than were junked in those same areas. At the same time, however, more scrapped automobiles were being added to the accumulation of junk cars, estimated at 10 to 20 million units, scattered in wrecking yards throughout the United States, in some areas where operation of the high-cost shredding plants is impractical. Thus, although the accumulation of junk cars near urban centers decreased, the number of cars added to junk yards in other areas increased. This pattern of scrap-automobile accumulation threatens to continue. Furthermore, the rising quality standards for ferrous scrap will, in the near future, probably again cause autos to accumulate in excess of their scrapping rate.

Atmospheric-pollution laws by many communities now prohibit the open burning of auto bodies. Small yards cannot afford the capital investment necessary to install an incinerator with the required air-pollution-control equipment. The increasing need for cleaner auto scrap has had a noticeable effect on the collection of unusable automobiles. Salvage yards often offer nothing for delivered, unstripped cars, and in many parts of the country the wrecking operators refuse to tow cars away unless they are paid to do so. Scrap yards offer as little as $7 per ton for clean, stripped or burned auto bodies delivered to the yards. Autos are now being left on city streets, highways, and vacant lots in ever-increasing numbers, as owners find it cheaper to abandon the old cars than to have them towed to a collection point. In 1968, 43,000 cars were abandoned in New York City and 24,500 were abandoned in Chicago. In rural areas, cars are left along roads and in the fields. Nationwide, over half a million cars were abandoned in 1967. In many states the abandoned junk car must be held for a period of 30 to 90 days while an attempt is made to locate its owner. All these factors have contributed to the present problem of disposal and utilization of scrap automobiles.

The Committee strongly supports the continuation of work leading toward the efficient private-sector production of usable scrap from junked cars and appliances. The Committee also recommends studies on the administrative or legislative possibilities for further control of, or provision for, scrap-automobile transport and processing for disposal at the end of their economic life.

Incinerator Residues

The Bureau of Mines has reported that metal mineral resources are present in incinerator ash in such amounts as to justify exploration of the technology and economics of their recovery. It is estimated that if all refuse were burned in properly designed incinerators, the residue might contain some 10 million tons of iron; almost 1 million tons of nonferrous metal including aluminum, lead, zinc, copper, and tin; 14 million tons of glass; lesser amounts of nonmetallic minerals; and small quantities of precious metals such as tungsten, silver, and gold. *The Committee supports an intensification of work leading to an estimate of the economics of removal of mineral values from solid waste streams both*

before and after incineration.

C. Organic Matter

The recovery of organic matter represents a long-term rather than immediate reuse of an important fraction of solid wastes, although it may well decline in importance if paper is otherwise recycled from the wastes stream. Nevertheless, the technology of recycling organic resources by use of the composting process is well established.

Composting is a method of processing that produces from the organic fraction of urban wastes a humus suitable for use as a soil conditioner. Because of its potential to salvage organic matter, in contrast with incineration, which oxidizes it, compost has had wide public appeal to conservation-minded citizens, but little success in the marketplace. It requires generally that wastes be preprocessed by segregating and grinding or shredding and so may be worth re-evaluating where segregating is being practiced for other reasons.

Failure of composting as an economical method of waste reprocessing has stemmed largely from the concept that marketability must be a feature of the system. However, in more recent studies sponsored by the Bureau of Solid Waste Management in Fresno, California, in which the systems approach was applied to solid waste management, composting emerged as a feature of the most economical systems. In this context, the process was used to prepare wastes for landfill and so also represented a stockpiling of recovered resource materials in the earth until such time as they might become economically exploitable.

In general, however, concern with the composting process itself does not offer a particularly fruitful avenue of commercial development. *Modest attention should be given to the place of the composting process in the overall waste-management system in the context of recycling of resource materials.*

3. Other Changes in the Waste Stream

The Committee considered several other possibilities of changing the waste streams, including the problems of: development of biodegradable plastics, reclamation of aluminum cans, and design of consumer hard goods, such as automobiles, for easier salvage.

Increased attention by government agencies and the threats of legislation could act as further incentives for the private sector to solve these problems, much as the nondegradable detergent problem was solved.

The Committee concluded that little economic incentive for design changes exists. Other pressures are thought more likely to accomplish such ends, including design for easier servicing--a pressing consumer need.

4. Selected Administrative Considerations

A. Business Management

The Committee found that there is much need for improvements in the business management of solid waste disposal systems. There are individual systems both public and private that are very well managed indeed, but they represent a relatively small fraction of the total number of systems.

Part of the problem lies with operating methods of personnel charged with managing a waste-disposal system, and part lies with the ambivalent nature of the system itself. Many systems are partly a service business and partly a political fief. The operator of the system is expected to run an efficient service, but he has numerous other political constraints.

One product of ambivalence toward objectives is a serious shortage of good cost accounting. In many instances there is no accounting of the total cost of operating the entire system. Cost may be scattered among several different departments or imposed on the householder in many instances.

The Committee recommends implementation of a project to design a cost-accounting system. It should be developed in a simplified form that will give operators a realistic periodic review of costs of operating each segment of the system as well as an overall picture of costs. This effort to obtain good cost control is part of the attack on a larger problem--the lack of good operations planning. *The Committee encourages the efforts of the Bureau of Solid Waste Management in developing better cost and management planning data.*

B. Public-Utility Concept

In most metropolitan areas, organization for solid waste disposal leaves much to be desired. Political fragmentation is a serious problem. Adjacent political subdivisions many times prefer to go it alone, and too often the effect is as if the lord of each fief has a vested interest in maintaining his autonomy.

Regional authorities for handling solid waste offer one avenue for improvement. However, many local political groups object strenuously to yielding control of local affairs to regional authorities. The very term "regional authority" appears in some respects to have become a politically polarizing word. Many local political leaders have become extremely concerned about the establishment of regional authorities, which they feel may not be adequately responsive to the electorate.

The Committee believes that as the volume of solid wastes increases and problems of disposal mount, more viable systems of organization must be devised if chaos is to be avoided. Such systems should be planned before the problem reaches a crisis stage.

Most political subdivisions have had experience with service utilities and have found them an acceptable system of organization. The Committee believes that a regulated solid waste utility might well become the organizational vehicle that could bring increased order, efficiency, and economy to the field of solid waste management. Such an organization could solve the problem of political fragmentation because it would be able to cross political boundaries and organize service on an efficient and economical area wide basis. It would have no vested interest in inefficiency. On the contrary, it would have strong incentive to become as efficient as possible. It could attract personnel who understand and can apply modern management techniques. Although regulated by governmental authority, it would be far enough removed from day-to-day political exigencies to resist those who are tempted to bend operating procedures to meet political objectives. Policies for a utility would be established by the political process but operations would be left in the hands of qualified professional managers.

The Committee recommends that a study be launched to determine how a solid waste disposal utility might be organized, financed, regulated, and operated in a metropolitan area. The study should delve into such questions as government ownership versus investor ownership, source and type of regulation, and whether a utility should attempt to operate the entire system from collection through final disposal, or whether it should manage only the processing and disposal segments of the system. The study should concern itself with legal bases for such an organization and explore techniques for obtaining the revenues that would be necessary to ensure successful operation. *The Committee recommends a study of the public-utility concept of solid waste management.*

C. Health, Safety, and Training of Operating Personnel

Nationally, there are an estimated 337,000 people directly employed full time in the collection, transportation, processing, and disposal of urban solid wastes. The administrators and personnel of these systems have long been plagued by high rates of accidents, illness, absenteeism, and labor turnover. Reliable figures for comparison are not available, but the Committee believes these rates in total are probably the highest for any major occupational group in the nation.

Labor turnover rates have been reported to range from 5 percent to 480 percent per year. The Committee has no firm idea what the national experience is but strongly suspects that the average is somewhere in the 200 percent range. By any yardstick this is a most difficult problem, which emphasizes the critical need for a comprehensive program designed to train employees at *all* levels in the safe and efficient performance of their jobs, prepare them for acceptance of more highly skilled jobs, and develop pride in the safe and efficient performance of a worthwhile job.

Along with even modest progress in the improvement of solid waste management, the equipment in use will become more sophisticated and efficient, maintenance and operations planning and performance should improve by several orders, and job requirements will be substantially upgraded. The skills of the people who manage and operate the system must be

upgraded if the investments in equipment and facilities are to have a commensurate public benefit.

In 1967, the National Safety Council and the American Public Works Association conducted a survey of municipal safety experiences. Of the 245 cities that reported an active safety and training program, only 39 reported usable data on accident ratings. Of the 39, 12 were chosen as supplying data that could be reasonably well matched and representative of national experience. The condensed results were:

	Frequency*	Severity**
Refuse handling and disposal	60.77	2,012
All industry	6.91	689
Underground mining	36.64	6,165

This is an appalling safety record.

The Manpower Development and Training Act of 1962 was enacted to appraise the manpower requirements and resources of the nation and to develop and apply the information and methods needed to deal with problems of unemployment resulting from automated and technological change. There is little evidence that the intent of this Act has been brought to bear on the needs of employees in the labor systems of community waste-collection or disposal agencies. Both the Department of Labor and the Department of Health, Education, and Welfare have been designated responsible for the administration of the Act. Considerable benefit to workers and the public and private agencies concerned with basic community services could be realized if this already available resource is brought to bear on the problem.

The Committee urges that the Bureau of Solid Waste Management take the initiative in securing the assistance of appropriate divisions of the Department of Health, Education, and Welfare, Department of Labor, and possibly other agencies in planning and executing a comprehensive technical-training and safety program to upgrade the skills and supply adequately trained personnel for all levels of local and regional solid waste management activities.

D. Communication and Information

In its deliberations, the Committee found a discouraging but understandable lack of communication at virtually all levels between groups who, by law, profession, or avocation, should be making significant

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* Frequency rate = $\frac{\text{Number of disabling injuries x 1,000,000}}{\text{Employee hours of exposure}}$

** Severity rate = $\frac{\text{Total man days charged x 1,000,000}}{\text{Employee hours of exposure}}$

contributions to the solution of all types of solid waste management problems. This condition is particularly apparent at the federal government and local official levels. However, it is a major problem at all levels of interest and activity.

In a technically oriented activity, the question of communication and dissemination of information among the diverse disciplinary groups and even within the same discipline usually is, or rapidly becomes, a critical problem as objective activity is broadened and expanded.

In addition to the scientific and engineering disciplines, the improvement of environmental quality requires interaction between social, political, legal, and medical sciences with heavy dependence on economists and industry.

Because of the lack of understanding of need, poorly defined market identification and potential, and inadequate research, development, and prototype funding; there has been a critical lack of public, scientific, engineering, and industrial attention directed toward accomplishment of solid waste management objectives. It is hoped that all groups will recognize the opportunities for improvements in systems performance and the recovery and reuse of the discards of our affluence as an opportunity to apply on a complete cycle basis, the full benefits of our technology.

An area of prime responsibility of the Bureau of Solid Waste Management must be one of collection, evaluation, and dissemination of information relating to solid wastes and solid waste management. *The Committee urges that as first priority a vastly expanded activity be established to amass, evaluate, and disseminate technical, economic, legal, social, and medical information on the source, quantity, nature, and management of solid wastes, with particular reference to the responsibility of local officials and the public in managing, reusing, and disposing of such wastes in conformity with environmental objectives.*

E. The Rural-Urban Interface

In addition to the consideration of all the urban solid wastes previously discussed, there is a significant nonurban waste-management problem that has an effect upon the metropolitan community. A city is generally surrounded by agricultural lands that supply the food for the city dwellers. Agriculture also generates wastes--animal manures, crop remains, and pesticide residues are three typical examples. There is often a most serious technological and social problem of agricultural waste management at the edge of the city and beginning of the farmland--at the rural-urban interface. The city edge often consists of suburban housing of higher than average income families that come to the area for its pastoral and aesthetic values; pollution of the environment from any source is dimly viewed. On the other hand, in response to the increased food demand of the expanding city, farmers intensify their farming operations. They cultivate their land more intensively, and they confine more animals on their acreage--they create more wastes per unit of time and unit of area. Since, in many instances, these wastes can no longer be disposed of on the farm, they are hauled to public disposal sites. These wastes,

and the environmental degradation they cause, are a serious source of friction at the city-rural area interface.

There is no single answer to the problem, and solutions will ultimately be as much political and economic as they will be technological. However, significant research and engineering has been conducted in agricultural waste management to minimize pollution from agricultural sources. Regrettably, such minimization has a significant cost, and the farmer must balance this against the financial result of moving to a more rural area where waste-management problems are less critical.

The Committee recognizes the solid waste management problems at the urban-rural interface, and encourages the Department of Agriculture and the Bureau of Solid Waste Management to undertake complementary research to minimize both the problems and the costs of agricultural waste handling. The Bureau should address itself to the problem with a realistic proportion of the funds available, concentrating on handling and management of agricultural wastes where they are disposed of at public sites rather than on the farmers' land.

CHAPTER V. PRIORITIES AND RECOMMENDATIONS

To accomplish the four objectives of solid waste management (page 26) and combining the conclusions of Chapters III and IV, the Committee makes the following recommendations, with items under each recommended action in order of priority:

Recommendation No. 1

That there be established a solid waste management information center designed to accumulate all applicable present and future information from both foreign and domestic sources, evaluate, and disseminate this information to various groups. The objectives of the center would include:

1. *Provision of technical news and information designed to inform elected and appointed officials and to assist them in solving their specific solid waste management problems.*

2. *Provision of technical information concerning the scientific, engineering, salvage, and manufacturing needs of solid waste management designed to inform universities, research institutes, inventors, news media, engineering, and industrial groups of opportunities in contributing to improvements in solid waste management.*

3. *Publication of engineering data, performance requirements, economic information, site requirements, and other pertinent information for those who plan, design, construct, and operate solid waste management facilities.*

4. *Publication of management data as developed under activities outlined in Recommendation No. 3.*

5. *Creation and distribution of general public information releases concerning solid waste management, particularly to local radio, TV, newspapers, and other mass media, as well as to schools, service clubs, and civic groups.*

6. *Give public-relations guidance to regional and local authorities to aid them in accomplishing local solid waste management objectives.*

7. *Planning and participating in symposia, professional meetings, conferences, and conventions as required to promote the accomplishment of solid waste management objectives and encourage participation by the private sector.*

Recommendation No. 2

That research, development, and large- or full-scale demonstrations on solid waste systems and components be carried out in metropolitan areas where solid waste problems derive from the several sectors of the community--these activities to include the technological, operational, and economic factors for the newest and best approaches to storage separation, collection, transportation, salvage, processing, preparation for recycle, and deposit. Specific objectives to include:

1. *To determine design parameters and economic factors required for the design and manufacture of improved equipment and demonstrate such improved equipment, with priority on increased mechanization, reduced labor usage, and improved safety, storage, collection, and transportation.*

2. *To determine design parameters and to demonstrate equipment for separation and salvage of the potentially useful components of solid wastes with first priority on paper and paper products, junked automobiles and major appliances, and on the mineral values before and after incineration. Reducing and improving local storage and encouraging upstream separation is of particular priority. Industrial participation in these determinations is vitally necessary.*

3. *To develop the necessary hardware, establish the engineering and economic requirements, and demonstrate residue disposal systems involving the most imaginative new ideas and principles that will promote public acceptance.*

4. *To develop data, information, and other needs for those who design and construct waste-management systems and facilities.*

5. *To develop specifications for minimum performance, including safety requirements, of solid waste systems hardware.*

6. *To conduct biological and ecological studies directly related to solid waste management.*

7. *To support and urge the solution by the packaging industry of the growing disposal problems of plastic and aluminum packaging materials.*

Recommendation No. 3

That there be substantial expansion of efforts to improve management information, planning, and manpower training including coordination with other federal, state, regional, and local government groups and with private enterprise along the following lines:

1. *Establishment of a simplified standardized cost-accounting*

system for use by local and regional authorities.

2. *Development of guidelines, techniques, and procedures for comprehensive regional land-use planning in which residue management programs are adequately considered.*

3. *Planning and executing a comprehensive technical-training program to improve the productivity, upgrade the skills, and supply adequately trained personnel for local and regional solid waste management activities.*

4. *Initiation of a study of the legal aspects (local, regional, state, federal, and international) of solid waste management including legislative needs, and institutional, jurisdictional, and legal roadblocks to resolution of problems.*

5. *Study of the feasibility of solid waste disposal utilities both government- and investor-owned.*

6. *Continuing and expanding the data-gathering activities of the state solid waste agencies that make possible the National Solid Wastes Survey.*

7. *Expanding of the systems analysis and modeling of solid waste systems for future capacity and cost planning.*

8. *Advising on legislation for local, state, or federal action to provide for recycle of junked automobiles and major appliances at the end of their economic life.*

9. *Conducting studies to determine if householders or businesses can be induced to separate their solid wastes at the point of storage. Particular reference should be made to paper and paper products.*

10. *Initiating a study of political, sociological, cultural, and economic aspects of solid waste management to determine the reasons solid waste problems are not being resolved at the level of technical capability.*

CHAPTER VI. RECOMMENDED FUNDING LEVELS

The question of minimum adequate funding of the federal responsibility under the 1965 Solid Waste Disposal Act (P. L. 89-272) and the costs of implementing the recommendations of this report were considered by the Committee from two points of view:

1. Based on the size of the total waste-disposal business (in the public sector), the level of technological maturity, the magnitude of the problem, and the number of people involved, what is the proper level of funding relative to the total costs of the activity?

2. Based upon an analysis of present identifiable disposal-system expenditures, the potential for improving the environment, improving the service, or reducing costs for each category of expenditure, and the urgency of each problem area relative to the present state of the art, what is the minimum realistic level of funding that should result in adequate progress toward solution of the complex of problems in a 5-year period of time?

In each of these analyses, the Committee restricted its deliberations to consideration of research, development, and demonstration needs to support the acquisition of basic data and information designed primarily to advance the state of the art, improve the dissemination of information, and support the legal and planning needs directly related to the recommendations of this report. *Specifically excluded are considerations of grants or cost sharing for installation of essentially conventional or normal advances in the state-of-the-art facilities and equipment.* Also excluded are funds for study of problems predominately related to agricultural and industrial activities.

1. FUNDING LEVELS BASED ON THE SIZE OF THE TOTAL BUSINESS

Estimates of the present total annual costs of solid waste management, both public and private, range somewhere between $4 and $6 billion with the average somewhere around $4.5 billion.

The Fresno study (Appendix B, page 55) in 1968 estimated the total expenditures for solid wastes management in Fresno County, California, were 0.93 percent of the gross county product. Fresno County has a substantial agricultural and industrial base and may not be representative of the nation. The Committee was not able to accurately judge the relativeness of the Fresno costs to the total national costs, but believes this figure may be somewhat high.

In considering the type of business, the low level of technological development, the potentials for reducing costs and increasing recycle of resources, and the potentials for significantly improving man's feeling of well-being and the quality of his environment, the

Committee suggests that annual federal expenditures of 2 percent of the waste-disposal business gross would be in line with good business practice. This would be an annual federal expenditure of about $90 million, assuming a total annual system's cost of $4.5 billion.

It may well be that the long-term costs of funding what the Committee feels is the proper federal government responsibility for research, development, demonstration, and information related to the adequate management of solid wastes could reach $90 million. However, the Committee cannot at this time recommend such a level. Even if funds were available, such expansion of the effort could probably not be efficiently carried out in a time period of less than 5 years unless a crash program were initiated.

2. FUNDING LEVELS BASED ON ESTIMATED COSTS OF IMPLEMENTING THE COMMITTEE'S RECOMMENDATIONS

The Committee reviewed the various individual recommendations, the present state of the art, the present level of support under the Solid Waste Disposal Act of 1965, the rate of buildup and the realistically attainable levels of progress in the next 5 years, given adequate funds. This to the Committee proved to be the more useful method of arriving at recommended funding.

The total costs of the recommended actions will rise to higher levels than the present costs under the Solid Waste Disposal Act. For example, the costs of demonstration will be largely incremental to the present program costs. Work on new concepts in solid waste management has up to now been largely concentrated in the research phase. Out of this will come a number of projects that will, in accordance with Recommendation No. 2, have to be piloted or demonstrated in nearly full scale on operational or "real world" sites in order to be properly developed and thus acceptable for local or regional use. (It should be noted that urban-development works of other federal agencies could include funds for carrying out some of the demonstration purposes of Recommendation No. 2.)

The annual rate of expenditures for solid waste management research and development cannot be increased indefinitely. A longer range balance between research and the more expensive demonstration or pilot operations should come about and cause a leveling out; ultimately the total level could be established as a percentage of the total public-sector solid waste disposal expenditures. As noted above, comparison with technically similar private-sector businesses suggests 2 percent per annum would be an efficient use of funds.

A table of minimum activity levels of funding major recommendations, endorsed and recommended by the Committee, is shown on the following page.

RECOMMENDED ALLOCATION OF FUNDS
BY
SPECIFIC CATEGORY OF NEED FISCAL YEARS 1970-1974 ($'000)

SOLID WASTE DISPOSAL ACT OF 1965, PUBLIC LAW 89-272
(BUREAU OF SOLID WASTE MANAGEMENT ONLY)

	1968	1970	1971	1972	1973	1974
Recommendation No. 1 Information and communication	-	500	1,500	2,000	2,500	3,000
Recommendation No. 2 Systems and components, research, development and demonstration	8,445	13,500	19,000	23,500	26,000	26,500
Recommendation No. 3 Management information, planning, and manpower training	2,925	3,000	3,500	3,500	4,000	4,000
Administrative costs	2,645	3,000	3,500	3,500	3,500	3,500
Total	14,115	19,500	27,000	32,000	35,500	36,000

Expenditures under Recommendation No. 2 are expected to be approximately one-fifth research and four-fifths demonstration within about 3 years.

Unexpected progress or failure in any particular area could, of course, substantially change the requirement for funds.

Greater participation of the private sector in the planning and design of new and innovative systems and components for present and future needs must also be fostered. It appeared to the Committee that more private-sector participation would now be timely. Public awareness of the degradation of the environment from solid wastes can be counted upon today. Dramatic (and dangerous) breakdowns in solid waste handling and disposal systems have also been demonstrated recently. All of this is to say that there is growing public concern for solid waste disposal, and there will be growing commercial markets for waste disposal equipment and systems thereby. These market forces should be tapped.

Private-sector participation could take two forms: (a) greater utilization and dissemination of know-how from private waste collection and disposal companies through the medium of conferences, and other appropriate information-exchange media; (b) interchange, including both personnel and information, between systems research and development personnel and private equipment makers and design firms. Recommendation 1-7 is intended to cover this (page 46).

APPENDIX A

Synopsis

of

New Haven, Connecticut, On-Site Solid Waste Research Program*

The need to dispose of the solid wastes generated each day by individuals and their families is a problem of major proportions for every city. The problem is accentuated as the cost associated with collection of solid wastes continues to increase with increasing population, traffic congestion, and demands of labor.

One means of simplifying the local and regional problems of handling and disposing of refuse would be to decrease the weight and/or volume of refuse at its source. In the past, incineration of refuse on the site of individual high-rise multifamily dwelling units has contributed significantly to this end. However, recently enacted or pending legislation aimed at mitigating the problems of air pollution within most of the nation's largest cities by limiting on-site incineration of refuse--either through prohibition or performance criteria--plus the attention now being given to the solid waste problem in general has resulted in development of alternative methods for on-site handling of the wastes as well as advances in the state of the art of incineration and attendant air-pollution-control equipment.

These events have led to repeated inquiries to both the Bureau of Solid Waste Management and the Building Research Advisory Board concerning the reliability and efficiency of the alternatives and improvements, concerning their capability to maintain aesthetically pleasing and healthful environmental conditions at the site, and concerning the impact their use would have on ultimate waste-disposal plans of municipalities or regions. Consequently, faced with the absence of reliable and useful field data in sufficient quantity to yield quantitative answers to such inquiries, the Bureau of Solid Waste Management requested the National Research Council through the Building Research Advisory Board to establish an advisory committee to undertake an extensive program involving collection and evaluation of data on the alternatives and improvements to provide an objective basis for responses to the technical inquiries.

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* For further information contact:

Building Research Advisory Board
National Research Council
2101 Constitution Avenue
Washington, D.C. 20418

The overall 3-year study that has evolved specifically is designed and intended to permit, through use of existing high-rise multifamily structures, concurrent on-site investigation of an incinerator system in one structure, a system of the compactor type in a second structure, and a wet pulper/presser system in a third structure. In addition, household garbage grinders will be investigated as a variable parameter with respect to these three different refuse-handling techniques. The overall objective of the 3-year program has been established to be:

> Study currently available equipment and/or techniques for handling solid waste within high-rise multifamily structures, considering user needs and acceptance, public-health concerns, and performance, with secondary concern for the interface between the on- and off-site system.

Specific objectives of the study include, but are not necessarily limited to, preparation of guidelines concerning:

1. Extent of contribution to air pollution of on-site incineration, utilizing sound combustion principles and pollution-control devices.

2. Effectiveness and efficiency of on-site incineration, compaction, and wet pulverization.

3. Weight, volume, and composition of solid waste before and after incineration, compaction, and wet pulverization.

4. Environmental conditions maintained with on-site incineration, compaction, and wet pulverization.

5. Power requirements, costs, and owner/tenant/custodian acceptance of on-site incineration, compaction, and wet pulverization.

6. Effects of separating putrescible wastes from rubbish with the use of garbage grinders on environmental conditions maintained by each of the different techniques for handling refuse.

7. Extent of contribution to building sewer system associated with incineration, compaction and pulverization, and the use of food-waste disposers.

8. Acceptable refuse collection-chute configurations, sizes, materials, and methods of cleaning.

9. Applicability and effectiveness of different methods of waste containerization (e.g., disposable paper and plastic sacks, metallic and plastic cans, wheeled containers, etc.).

10. On-site storage requirements for incineration, compaction, and wet pulverization, and effects thereon of the different

methods of waste containerization.

11. Training requirements of janitor/maintenance personnel for on-site incineration, compaction, and wet pulverization.

12. Guidelines for architects/engineers/builders in providing acceptable and convenient refuse collection, reduction, storage, and removal facilities.

13. Descriptive techniques demonstrating the manner in which a building owner could select between the alternatives available for handling refuse on the site.

APPENDIX B

Synopsis

of

A Systems Study of Solid Waste Management in the Fresno, California, Area*

This study was undertaken to develop a plan for the management of solid wastes in a rapidly urbanizing agricultural region of California on the premise that solid waste management involves such complexities and interdependencies that a sophisticated and systematic approach is needed if more than immediate and partial solutions are to be achieved.

The prime objectives of the study were: (a) to determine an optimum solution to the solid waste management problems of a specific region (the Fresno area), and (b) to develop a technology for study of the region that could be applied to solve solid waste management problems in other similar regions. Accomplishment of these objectives required the performance of three essential elements of work in such a manner that the methodology and the experience gained in its application might be readily applied elsewhere. These elements were:

- The development and documentation of a method of measurement by which the effectiveness of any system or means of managing solid wastes might be evaluated and compared with alternative systems in terms of the extent to which they solve the health, air, water, and land pollution, socioeconomic, aesthetic, and other problems engendered by solid wastes.

- An assessment of the effectiveness of the region's present solid waste management system and the concomitant identification of the magnitude of the present problem by means of the method of measurement, including an estimate of future problems if appropriate action is not taken now or in the near future.

- An evaluation of alternative systems by means of the method of measurement to identify the solution that will best provide, at reasonable cost, a solid waste management system for the study region.

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*Aerojet-General Corporation. *A Systems Study of Solid Waste Management in the Fresno Area; Final Report on a Solid Waste Management Demonstration.* Public Health Service Publication No. 1959. Washington, U.S. Government Printing Office, 1969. [411 p.]

The basic plan covered five major sequential steps. The first step developed a measure by which alternative proposed systems could be evaluated against a common criterion, so that superior systems could be recognized. The second step concentrated on the conceptual design of potentially good, alternative solid waste management systems. The performance score and cost of each alternative was identified in the third step. The fourth step compared the alternatives in terms of performance score and cost of other important factors to determine which alternative should be chosen for implementation. The fifth and final step of the study considered the data and methods developed for the study region to determine how they might be best applied to help solve solid waste management problems in other similar regions.

The 18-month effort has developed data and methods encompassing:

1. Identification of the solid wastes in the study region and the problems created, and identification of the groups, agencies, and agency representatives affected by these problems.

2. A procedure for measuring the effectiveness of any proposed system or means for managing solid wastes in the region in terms of the extent to which it solves solid waste problems.

3. Identification of the conditions under which any solid waste management system for the region must operate, including waste loads projected to the year 2000; regional topographical, geological, climatological, hydrological, economic, and demographic data; projected land-use, laws, and policy criteria; technical and cost data; and jurisdictional relationships.

4. Conceptual designs of alternative systems for the management of solid wastes in the region.

5. Provision of itemized and charted data relative to estimated performance-score ranges and costs of each alternative system concept considered, plus a list of application scores reflecting any adverse or beneficial effects the various systems would impose on the environment in which they would operate.

6. Provision of a rationale for the ranking of the alternative system concepts, with specific attention to the rationale for the highest ranking system for the study region.

7. A detailed description of the concept recommended for use in long-term management of solid wastes in the region, plus recommendations for immediate action to alleviate current problems (including legal, quasi-legal, jurisdictional, political, and financial considerations).

8. Generalization of the findings and procedures so they may be applied to similar regions.

9. Background data pertinent to the main body of the final report not previously published in the interim report.

10. Recommendations for further study and research needed to develop future techniques to solve problems for which current techniques are inadequate technically or economically.

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