TECHNICAL REPORT

GUIDELINES FOR IMPROVING WASTEWATER AND SOLID WASTE MANAGEMENT

WASH Technical Report No. 88
August 1993

WATER AND SANITATION for HEALTH PROJECT

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GUIDELINES FOR IMPROVING WASTEWATER AND SOLID WASTE MANAGEMENT

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by

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EXECUTIVE SUMMARY

Pollution from wastewater and solid waste is a significant problem in developing countries, particularly in urban and peri-urban areas. It is estimated that in Latin America, for example, only two percent of wastewater is treated. The inability to manage these wastes effectively results in serious health and ecological hazards. The resolution of this problem is increasingly urgent as developing countries experience rapid population growth, become more highly urbanized, and recognize the damage that pollution is causing.

Many industrialized countries manage wastewater and solid waste through advanced technology backed by strict regulatory standards. Technological solutions primarily require municipal public works investments in treatment and disposal methods designed to meet effluent standards. Because developing countries do not have institutions strong enough to enforce regulations or the means to pay for conventional technologies, they have often been unable to follow this model. Improvements in waste management are severely hampered by the financial constraints that nearly every developing country faces.

To enable developing countries to find solutions within these limitations, WASH here presents a conceptual framework showing the points at which intervention for improvements is possible and offers a methodology for assessing the effectiveness of existing waste management systems. The conceptual framework and assessment go beyond the promotion of affordable technologies to stress the importance of supportive policy instruments and strengthened institutional capacity. The document also offers guidance in selecting the best option or combination of options embodying these three elements—technologies, policy instruments, and institutions.

Conceptual Framework

The framework shows the three possible points of intervention for controlling the effects of solid waste or wastewater: a change in the behavior of individuals and institutions responsible for pollution so as to alter the kind or quantity of residuals before they enter the environment; a change in the actions of those responsible for movement of residuals after they enter the environment (e.g., environmental resource managers and water treatment plant managers); and a change in policies and actions to diminish the adverse effects of pollution. The premise of the framework is that policy and management, most often the domain of government institutions, are the primary influences at each of the three control points, a concept that departs from the traditional reliance on end-of-the-pipe treatment exclusively.

Assessment Methodology

The framework is incorporated in a four-step assessment applicable to wastewater or solid waste management in any developing country. The outcome will be a preliminary strategy that eventually could form the basis of a national program or a project funded by an international agency to improve waste management. The strategy would also point out areas needing further study and analysis.

The steps in the assessment are:

- Determining the health, environmental, social, and economic impacts of poor waste management
- Identifying the key groups and institutions whose decisions and actions affect waste management
- Examining technologies, policy instruments, and institutions—the three components of any option for improving waste management
- Developing the preliminary strategy from the best combination of these three elements

Determining Impacts

Determining the impacts of poor waste management on health, the environment, the economy, and the social well-being of a community is the first step to improvement. Once the impacts are understood, it is possible to identify those places where interventions can most effectively reduce them. This step is not always simple because of the lack of reliable data.

Identifying Key Targets

If interventions are to be effective, they must have clearly defined targets. These targets cover a range of individuals and institutions: those responsible for generating pollution; those who provide services to collect, treat, and dispose of waste; those who manage environmental resources; and those who seek to mitigate the harmful effects of pollution.

Examining Option Components

Technologies, policy instruments, and institutions can be considered either separately or in combination to provide an option for improvement.

Technologies include those for wastewater and solid waste treatment, recycling, byproduct recovery, conversion to less polluting production processes, and habitat improvement.

Policy instruments are the means of influencing the behavior of individuals and institutions. They may be related to pollution prevention and control, resource management, and public health. Policy instruments are of four types: information and education campaigns; economic incentives such as rewards and penalties; regulations to proscribe certain activities; and the assignment of rights and responsibilities to different groups by government.

Both public and private sector institutions are necessary for the solution of pollution problems. They include service-delivery organizations such as wastewater utilities, non-governmental organizations (NGOs), and informal groups engaged in waste disposal; regulatory institutions such as environmental agencies; educational and informational institutions; public health institutions; advocacy institutions such as applied research organizations or citizen groups; and financing institutions such as banks or credit unions.

Developing a Strategy

The final step is developing a strategy that takes into account the impacts, targets, and range of options. It should be guided by five fundamental principles: reducing the risks of waste to public health and the environment; preventing pollution by reducing waste at the source or by recycling or reuse; providing efficient services; recovering costs from those who benefit; and selecting appropriate treatment and disposal technologies.

Developing a strategy is accomplished by ranking the negative impacts or problems; sorting and ranking the targets by effectiveness and likely receptivity to change, ranking key institutions by their potential as agents of change, designing options, and selecting the most promising options for more detailed study.

Uses of the Document

The document is intended to be applicable to all countries where A.I.D. works, regardless of the level of economic development, although solutions to the problems in each country will vary. It has an urban emphasis but is also suitable for small towns of 5,000-10,000. However, it does not provide all the information necessary for the full range of decision-making.

The primary audience will be teams composed of expatriate consultants, local experts, or both, who are responsible for carrying out assessments of solid waste and wastewater management. The other audience will be those responsible for managing these assessments and midlevel and senior government managers in waste management.

1

INTRODUCTION

1.1 Need for the Document

The management of wastewater and solid waste is an essential service associated with human settlements and economic activities. All human activities generate material and energy residuals that are discarded and must at least be collected and transported to appropriate sites for recycling, reprocessing, or disposal to protect public health. In developing countries, each individual uses less water and generates less solid wastes per day than in developed countries, but in aggregate these quantities already far exceed the management capacities of most municipalities. The quantity of waste may double by the end of the decade due to population growth, urbanization, and industrialization. Disposal costs are also rising rapidly, mainly because of increasing distances to disposal sites outside rapidly growing urban areas (United Nations 1992).

In the past, wastewater and solid waste management has been approached almost exclusively through investments in treatment and disposal technologies: sewerage systems and centralized treatment plants for wastewater; collection trucks; landfills; and sometimes incinerators for solid wastes. These technologies generally have been successful where they are properly sited, managed, and maintained; but even in industrialized countries they have not eliminated all risks, and in some cases they have created new ones (for instance, by mixing municipal and hazardous industrial wastes, processing them into higher concentrations, and transforming them into air or water pollution emissions). In this document, risks are defined as increases in the probability of diseases or ecological damage attributable to exposure to environmental pollution.

In developing countries, these technologies generally have been far less successful because of their high cost. Large populations are not served at all, and many who are served pay dearly for inefficient and ineffective services. Municipal agencies, hampered by shortages of operating capital, limited engineering and maintenance expertise, and a lack of foreign currency to replace parts for machinery from donor countries, are often unable to properly operate or maintain capital-intensive equipment and facilities.

Technological investments alone, therefore, do not ensure effective management of wastewater and solid wastes. What is required is a comprehensive approach that considers the following factors:

- the flows of both raw and recycled materials through all major economic sectors;
- the economic impact of these flows, and the behavior patterns that direct them;

- the influence of public policy, both intentional and inadvertent, on these flows;
- the roles of public, private, and informal organizations in waste management;
- the choices of waste management technologies;
- the potential for changing public policy to create better markets and incentives for those who manage these flows directly;
- the changes in public attitudes to support new approaches.

Developing countries have the same problems with wastewater and solid wastes as developed nations, but with far more severe constraints on financial and management capabilities. They must manage industrial as well as household, commercial, and institutional wastes and their waste management systems must cover both urban and rural areas. They must make choices among technological options, among public and private service providers, among local and regional scales of operations, and among combinations of risks and costs. They must make these choices in the context of existing laws, regulations, policies, traditions, and behavior patterns that sometimes impede proper waste management. However, because of financial constraints, they often cannot afford to reduce risks to the same levels as in developed countries.

Developing countries also face problems peculiar to them. Waste streams, for instance, virtually always have a higher volume of moist organic materials and correspondingly fewer high-value recyclable materials (as well as less paper and packaging). Public agencies often lack the expertise and even the authority to provide safe and efficient waste management. Capital-intensive equipment and facilities are far more scarce. In peri-urban areas, where rapidly growing populations must be protected from health hazards, physical facilities for waste removal are difficult to provide.

In Port-au-Prince, Haiti, for instance, recent studies have documented that only 24 percent of households, 40 percent of businesses, and no industries have public waste management services; more than 20 percent of households and 34 percent of businesses pay private entrepreneurs to remove their wastes; and the rest simply dump their wastes wherever they can. Most households and more than half the businesses are dissatisfied with this situation; most households would be willing to participate in a community waste management organization; and nearly half the households and almost 60 percent of the businesses would be willing to pay for more reliable waste collection services. A large fraction of the waste stream is suitable for composting, which would provide land reclamation benefits and reduce the volume of materials transported to the landfill, but composting currently is underutilized (Roark et al. 1991).

More generally, there is some evidence that improved wastewater and solid waste management in developing countries would not only have health and environmental benefits, but would reduce the cost of services by as much as 30 to 50 percent.[1]

Without the comprehensive approach that has been suggested, there is little chance that most developing countries will succeed with merely a conventional reliance on technological improvements.

1.2 Purpose of the Document

This document has two purposes. The first is to present a comprehensive approach to solid waste and wastewater management, based on the use of technologies, policy instruments, and institutions. The second is to present a methodology that an assessment team could use to determine the effectiveness of solid waste and wastewater management in a given situation.

1.3 Scope of the Document

The scope of the document should be understood with reference to five points: its technical focus, its applicability to a wide range of countries, its urban emphasis, the levels at which it can be used, and the depth of analysis it permits.

Technical Focus. The document focuses on solid waste and wastewater, the two areas that are receiving heightened attention in urban pollution in developing countries. Wastewater, in particular, has been brought to the fore by both donors and the countries themselves because of the outbreak of cholera in Latin America and the increasing severity of wastewater management problems in densely populated areas.

Applicability. The document is applicable to all countries where A.I.D. works, regardless of the level of economic development, although solutions to the problems in each situation, of course, will vary.

Urban Emphasis. The document has an urban emphasis, making it suitable for both large population areas as well as small towns of 5,000 - 10,000. However, the resolution of wastewater and solid waste problems is likely to be much more complex in large areas than in small towns.

Range of Levels. The document can be applied at several levels. It can be used for a specific municipality, although with certain limitations because options such as the use of some policy instruments are relevant only at the national level. It can also be applied to a watershed, especially for wastewater management. If, for example, the primary source of water pollution

[1] This assertion by Cointreau, 1989, is based on rationalizing the design of collection routes, selecting the most appropriate types of collection vehicles, reducing vehicle downtime through better maintenance, enforcing compliance with regulations, improving public education on waste management practices, and increasing the efficiency of supervision and workforce utilization.

is untreated sewage from a city upstream, wastewater management by one municipality will not solve the problem. The application of the approach will depend in part on the degree of autonomy that municipal or regional jurisdictions enjoy.

Depth of Analysis. The document contains only enough information for a preliminary assessment. A complete analysis will require more specialized assessments. A list of the references used to write this document appears following the text, and Appendix A offers an expanded list that the reader can refer to for more information.

1.4 Audience

The primary audience for this document will be teams composed of expatriate consultants, local experts, or both, who are responsible for carrying out assessments of solid waste and wastewater management practices.

The other important audience will be the people responsible for managing these assessments. In the case of donors, they will be project officers. For purely local assessments, they will be midlevel or senior managers in government ministries.

1.5 Uses

The document can be used in at least three ways: a preliminary assessment of wastewater or solid waste management at the municipal, provincial, basin, or national levels; an evaluation of a project already underway; and a workshop for training decision-makers in new approaches to waste management.

Team composition. The assessment should be carried out by a three- or four-person team representing several disciplines, of which each member should have a basic understanding.

Among these disciplines are:

- environmental engineering
- institutional analysis
- economics and finance
- anthropology/sociology
- public health
- policy (legal, regulatory, etc.)

The exact mix will depend on the individuals and each situation. Some individuals may be experienced in several of these disciplines.

Level of effort. If the assessment is uninterrupted, it should take three or four weeks. If it is done over time by a local agency, the assessment might not be carried out on a full-time basis.

1.6 Methodology Used to Develop the Document

An interdisciplinary team consisting of an institutional specialist, a policy expert, an environmental engineer, an anthropologist, and an economist, all of whom had previous experience in dealing with environmental pollution, used the following methodology to develop the document:

- A four-day meeting to discuss the framework for environmental pollution and to elaborate the content of each element in it
- Research and writing of inputs on the various elements
- A three-day meeting to review the inputs and to develop an outline of the document
- A draft of the document for review by the team and WASH
- Field test
- Review by outside experts
- Revision of the document based on the review

1.7 Organization of the Document

The document is organized into eight chapters.

- Chapter 1 is this introduction.
- Chapter 2 provides the conceptual framework on which the assessment is based.
- Chapter 3 discusses how the impacts of the solid waste or wastewater problem on both the environment and people are assessed.
- Chapter 4 describes the people who must be targeted in improving solid waste and wastewater management.
- Chapters 5, 6, and 7 outline the three main areas of assessment: technology options, policy instruments, and institutional capabilities, respectively.
- Chapter 8 offers guidance on how to use the findings of an assessment to develop a strategy for waste management.

2

CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter examines the components of the wastewater or solid waste management system and explains their interrelation. It describes important elements to be considered if improvements in wastewater or solid waste management are to be successful.

2.2 Wastewater and Solid Waste as Residuals: The Management Challenge

Human physical needs are satisfied by transforming materials into desired products. The process, whether carried out by the individual, the family, the community, or a large industry, is never 100 percent efficient and inevitably produces residuals as well. These residuals represent wasted resources and often cause environmental damage affecting human and other life forms. Harmful residuals are called pollutants; the others are usually ignored. Wastewater and solid waste are harmful residuals that cannot be overlooked and need to be managed sensibly.

2.2.1 Defining Wastewater and Solid Waste

Wastewater comes from domestic sources, agriculture, industry, or stormwater drainage and may contain organic or inorganic pollutants, either suspended or dissolved. Stormwater, especially in urban areas, picks up a number of these pollutants during flow.

Solid waste includes decomposing organic matter (kitchen and market wastes), some fecal matter, combustible organic matter (paper, textiles, bone), industrial products and byproducts (plastics, metals, glass, oil, grease, chemical compounds), and inerts (soil, ash, rock). Solid waste may contain pathogenic microorganisms and toxic chemicals. Its variety and magnitude are far greater in urban than in rural populations.

2.2.2 The Broad Management Task

Wastewater or solid waste can be managed through effective and equitable services that also reduce environmental damage, hazards to human health, and the costs of disposal. To identify ways in which improvements can be made, it is necessary to understand how solid waste and wastewater are generated and their effects can be mitigated, and the social and economic factors affecting waste generation and management.

Throughout the last four decades, there has been a persistent tendency to regard wastewater and solid waste problems in less developed countries as primarily or even exclusively amenable to technological solutions. As a result, many applications of waste management technologies imported from abroad have failed. It is now becoming increasingly clear that the range of waste management options should be far broader than end-of-line waste treatment alone. Waste reduction, changes in production technology, byproduct recovery, recycling, environmental resource management, and impact mitigation must be considered as well, for they are more economical, more acceptable, and more easily implemented in many situations. Technology must be evaluated within the institutional and cultural milieu in which it will be applied, not just for its technical and financial feasibility. Every waste management strategy should contain an appropriate mix of technical and policy elements suited to a specific institutional and cultural setting. Accordingly, this document begins with a description of the conceptual framework that should underlie such a comprehensive strategy and form the basis for its development.

2.3 The Wastewater and Solid Waste System

Figure 1 is a simple model of the wastewater and solid waste management system. This model shows the points at which control may be attempted. The organizations and individuals who apply these controls are the logical targets of policies and programs aimed at reducing the adverse effects of wastewater or solid waste. The model provides the general conceptual framework for this document.

Production processes draw materials from the environment and discharge residuals back into it. The bold arrow "Residuals Discharge" connecting the boxes labeled "Polluting Activities" and "Environment" shows the path of these discharges. These discharges also include the by-products of treatment, for example, the sludge from wastewater treatment plants. The bold arrows, the one labeled "Residuals Discharge" and the other labeled "Pollution Impacts," show that the flows occur in both directions (human beings cannot exist apart from the environment, and the environment is inevitably affected by human activities). People thus produce residuals and also feel their impacts. Sometimes the same population is involved and the relationship between discharge and impacts is direct (not mediated or transported by the environment) and immediate. At other times a production process in one place affects people elsewhere, through a complicated chain of consequences in the broader environment.

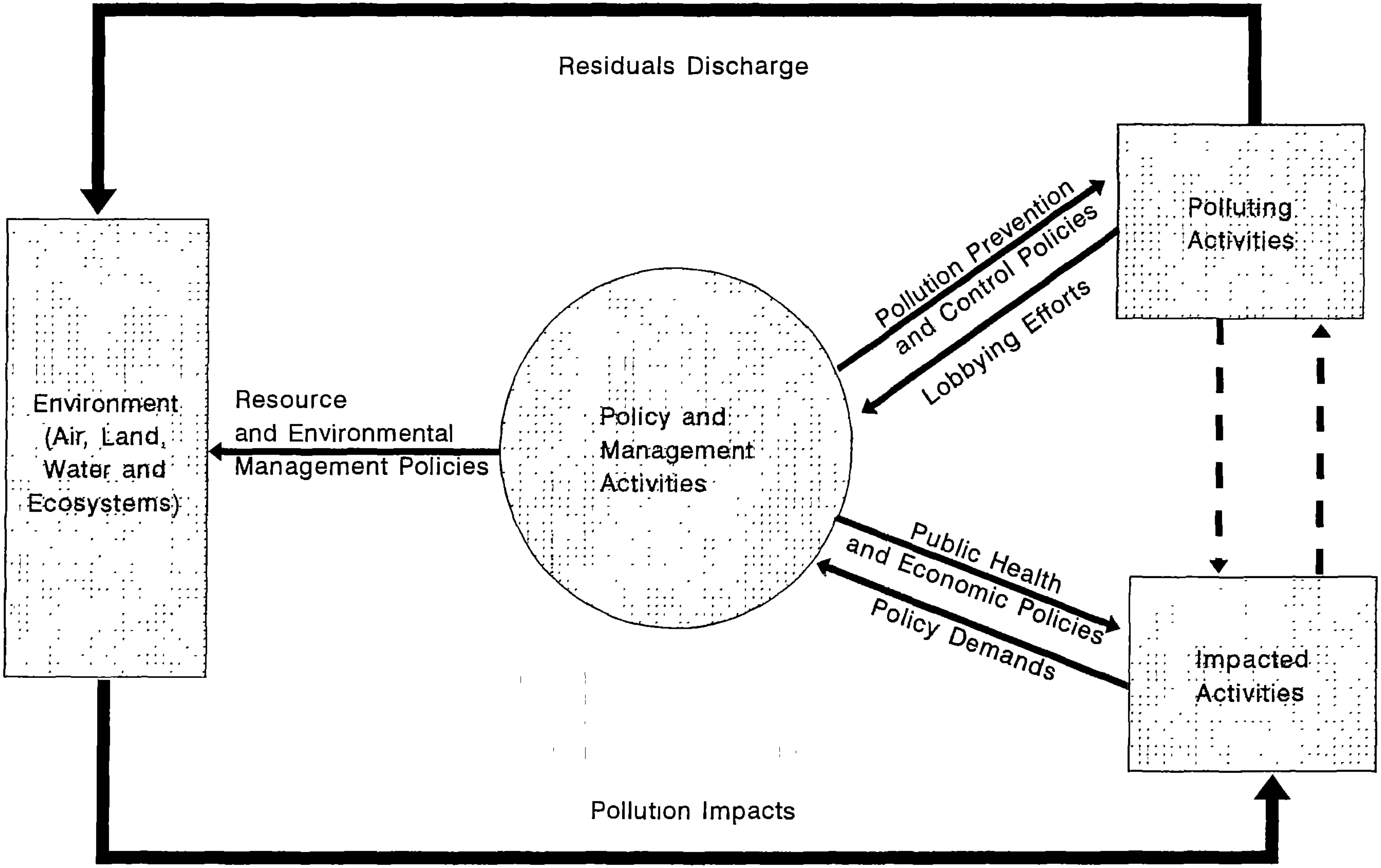

Figure 1

Comprehensive Approach to Wastewater and Solid Waste Management

Residuals discharged into the environment may undergo mixing, dispersion, chemical transformation, and other natural changes. Sooner or later, most of them will affect human activities because they have altered the characteristics of the environment.

The box labeled "Impacted Activities" includes the individuals, organizations, and communities that experience the health, economic, and social effects of pollution. The dotted lines between the boxes "Polluting Activities" and "Impacted Activities" are used to show that the relationship between the polluting activities and impacts, while often indirect, may be direct. Consumers might get together to boycott a certain manufacturer because it uses materials or processes that cause pollution. Similarly, an industry might conduct an advertising campaign to improve its image. The dotted lines show that those who are impacted may put direct pressure on those who pollute without any intervention by government.

The circle "Policy and Management Activities" in the center of Figure 1 indicates actions to influence or control the behavior of the broader system. The circle includes those organizations than can bring interventions to bear on different parts of the system through various management activities. For the most part, the circle is dominated by government institutions, but non-governmental and private sector organizations such as research and educational institutions, advocacy groups, and financing institutions may also be involved. The light arrows between the center circle and boxes thus represent the flow of influence. The arrows also flow in two directions, showing that the relationship is a two-way street between the policy makers and those who are affected.

There are three types of arrows flowing from the center circle. The first are the two arrows between the center circle and the box labeled "Polluting Activities." The arrow labeled "Pollution Prevention and Control Policies" represents those policies and actions which are intended to change the polluting activities to alter the kind or quantity of residuals before they enter the environment. Examples would include establishing standards or economic incentives for industries to change their production processes to reduce the pollution into the environment. The light arrow labeled "Lobbying Efforts" shows that polluters, however, will put pressure on the government to formulate policies which will not hurt their industries or cost jobs.

The second arrow, "Resource and Environmental Management Policies," represents policies and actions intended to control the ways in which people are exposed to residuals after they have entered the environment. An example would be a policy restricting fishing or recreational activities in a polluted water body.

The third are the two arrows between the circle and the box labeled "Impacted Activities." The light arrow "Public Health and Economic Policies" represents those policies and actions intended to help people cope with the effects of pollution from wastewater or solid wastes, and thus diminish its adverse impact. Examples include the provision of public health services and information campaigns. The arrow labeled "Policy Demands" shows the pressure that impacted people and organizations can put on governments. For example, citizens' groups may call on the government to stop industry from using a specific process because of the high incidence of disease in a certain area.

Figure 1 is, therefore, a general model of the system. Each of the elements will be discussed in detail in this document.

2.4 Wastewater and Solid Waste Impacts

The harmful effects of residuals are the simple reason for attempts to control the complications arising from wastewater or solid waste generation. The impacts upon people may be immediate and direct, as when pollution-caused diseases strike or resource degradation raises production costs. They may be less immediate and direct, as when plant or animal species are driven to extinction or natural beauty is obscured or destroyed. In every case, however, residuals have changed the environment. The waste management assessment process begins with a clear identification of the impacts. An understanding of how residuals are generated by human activities and transformed in the environment then uncovers those points in the causal chain where interventions to reduce undesired impacts are most likely to be effective.

2.5 Technology

A balanced approach to waste management must not ignore technology, because it is through technology that people manipulate and control the environment. Two types of technology should be considered. The first (relating to "Polluting Activities" in Figure 1) covers measures to lessen the effects of residuals associated with the generation of wastewater or solid waste. They include not only waste treatment but recycling, byproduct recovery, and conversion to less polluting production processes.

The second type of technology is that employed to mitigate pollution from wastewater or solid waste after it has occurred. In Figure 1 this is shown by the bold arrow connecting the boxes "Environment" and "Impacted Activities" and includes treatment of potable water supplies, immunization, and habitat improvement.

Both types of technology, and variants of them, should be considered in formulating waste management policies and should be evaluated in the institutional, financial, and cultural context in which they will be used.

2.6 Targets of Improvement Efforts

If efforts to improve wastewater or solid waste management are to be effective, they must begin by clearly identifying the individuals and groups whose actions and decisions are to be modified. Changes may be sought in the behavior of any of those engaged in the activities shown in the three boxes in Figure 1. Policies may be directed at domestic or organizational polluting activities or at environmental resource managers such as water resource managers or water quality monitors, who influence the transport of residuals within the environment. They may be aimed at increasing the institutional capacity of waste managers like utility managers or solid waste collection and landfill operators. They may also be directed at impact mitigators such as public health workers. Chapter 4 discusses these targets in greater detail.

2.7 Policy Instruments

Institutions with a role in waste management have a range of policy instruments that they might use (the circle in the center of Figure 1). There are four principal types:

- Institutions may provide **information** to induce people and organizations to do things differently.
- Institutions may provide economic **incentives** to encourage desirable behaviors or disincentives to discourage undesirable behaviors. These rewards and penalties, like information, are not coercive and depend upon voluntary compliance.
- Institutions may employ **regulations** that mandate or proscribe certain behaviors, using the coercive power of the state to ensure compliance. They may act directly to provide services or to effect change, as when environmental resource management measures are taken.
- Institutions may **assign rights and responsibilities** so as to increase the ability of public agencies to carry out their waste management tasks, or they may involve private individuals or companies in handling part of the job, for instance by contracting. Even changing the way responsibilities are assigned can affect the degree of problem solving that takes place.

2.8 Institutions

Institutions are the organizational forms through which actions are coordinated to attain objectives. These include government agencies, private sector organizations, community groups, and religious organizations. As societies become more complex and functionally differentiated, they develop special-purpose institutions. In relation to pollution control, these would be environmental ministries, commercial waste management firms, nongovernment organizations, and municipal waste management services, in addition to the informal contributions of scavengers, water suppliers, and traditional health service providers typical of less developed countries.

This document is concerned primarily with government institutions that provide a service, such as wastewater utilities, as well as those in the policy area, such as regulatory and financing agencies. The intention is not to minimize the importance of community organizations, particularly in the informal sector, which play a vital role in putting pressure on formal government structures, in providing input to planning processes, and often in implementing changes. Ultimately, however, improved solid waste and wastewater management is unlikely without the full attention of formal government institutions.

2.9 The Assessment Process

Figure 2 graphically depicts the assessment methodology discussed in this document. The first step is to determine the impacts of solid waste and wastewater residuals. The second step is to identify those groups and individuals whose actions and behavior are crucial to effective waste management. The third step is to examine potential options in three areas: policy instruments, institutions, and technology. The fourth step is to combine these options into an integrated strategy. Guidelines on how to assess each of these components are provided in the chapters that follow.

The fourth step mentioned here, developing an integrated strategy, is a topic of particular importance and is explained in detail in Chapter 8. Those seeking to make improvements in wastewater or solid waste management need to do more than assess current conditions and identify possible alternatives. Any decisions made must give precedence to the most pressing problems and be guided by a judgement about what is feasible. The choices should also be consistent with fundamental principles of wastewater and solid waste management. Developing a strategy, then, requires combining the results of steps one through three systematically to produce a set of options arrayed in order of priority to address the most important impacts in a particular setting. A method for integrating these steps to produce an overall strategy and an explanation of the principles to be applied are included in the final chapter.

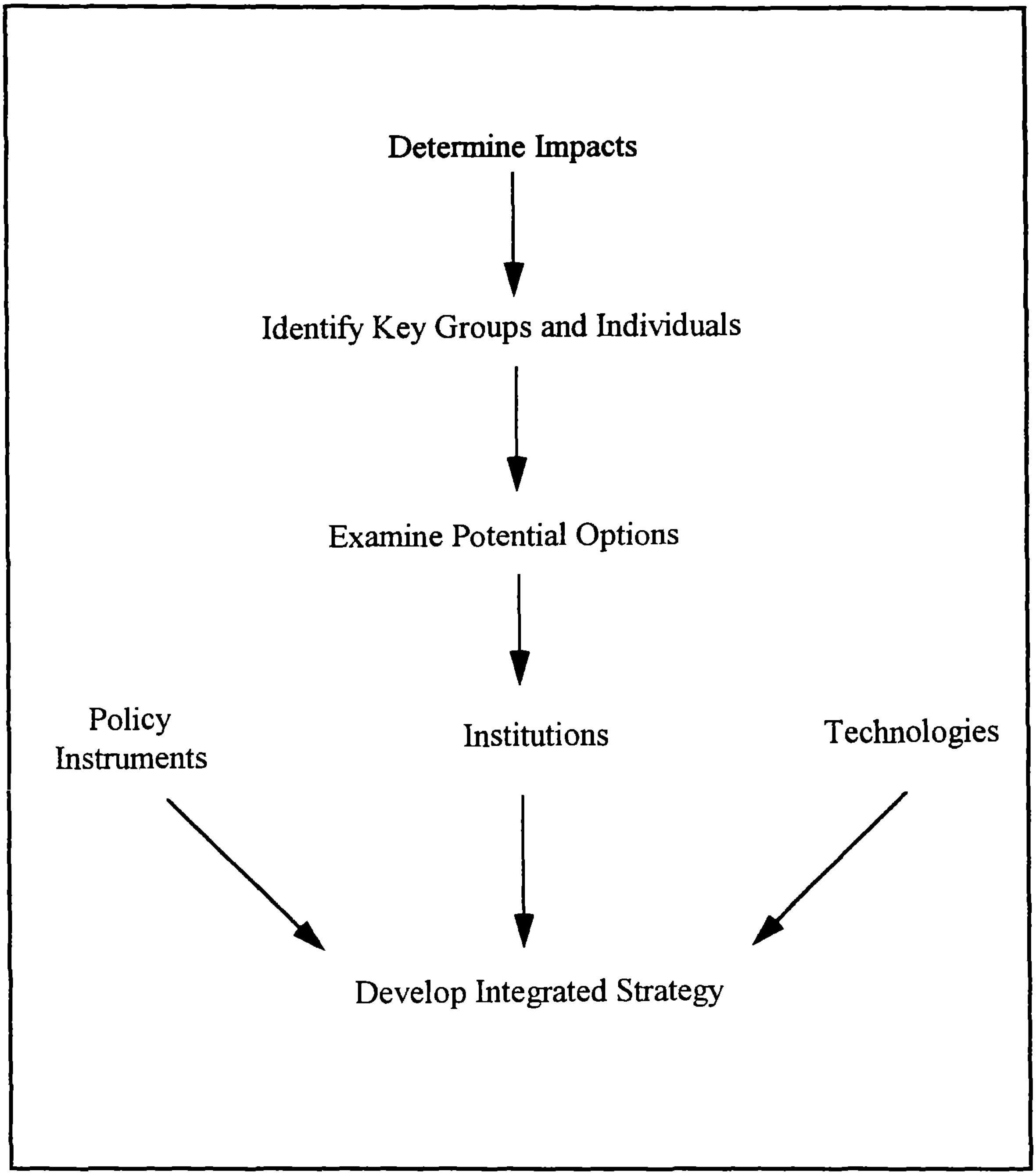

Figure 2

Assessment Process

GLOSSARY

Assessment. The process of examining a wastewater or solid waste management system and determining the possibilities for improvement.

Policy and Management Activities. Activities that are undertaken, not to produce material outputs, but to influence or control the behavior of the broader system.

Pollution. Residuals that cause environmental damage affecting human life.

Pollution Prevention and Control Policies. Policies intended to forestall the polluting activities that generate wastewater or solid waste residuals *before* they enter the environment.

Public Health and Economic Policies. Policies intended to help people cope with pollution from wastewater or solid waste, and thus diminish its adverse impacts.

Residuals. Unintended outputs of human production processes. These include solid waste and wastewater.

Resource Management Policies. Policies intended to affect the ways in which residuals are transformed.

3

DETERMINING IMPACTS

3.1 Introduction

Improper or inadequate management of wastewater and solid waste can endanger environmental quality, public health, ecological systems, economic growth, and ultimately, the social fabric of a community. Thus, one of the first steps an assessment team should take in evaluating waste management systems is to identify such negative impacts and examine their causes, extent, and severity, and their relative importance to the affected communities. Interventions to improve waste management should be designed to alleviate the main negative impacts.

3.2 Terminology

In this document, "negative impacts" are the detrimental effects of pollution in wastewater and solid waste that begin when wastes are generated and continue along the following "exposure pathway":

- Wastes from a "source" (e.g., a surface drainage outfall or a landfill) are discharged into the environment.
- Contaminants (e.g., chemicals and pathogens) from the waste travel via physical, chemical, and biological processes (referred to as "transport and fate mechanisms") and appear in water, soil, and air to reduce "environmental quality."
- People, animals, plants, and manufactured materials are "exposed" to the contaminants through contact with infected water, soil, and air.
- This exposure causes detrimental effects, both "direct" and "indirect" negative impacts. Indirect impacts are the secondary effects that direct impacts have on economic growth, personal welfare, and social cohesion.

3.3 Types of Impacts

The negative impacts to be considered in an assessment are briefly discussed below and in greater detail in Appendix B, supplement to this chapter.

Health and Environmental Impacts

via Water Pollution:

- Pathogens (bacteria, viruses, protozoa) may cause life-threatening infections in humans.
- Toxic compounds and elements (organic compounds from pesticides and industrial processes, heavy metals from metal finishing, tanning, etc.) may cause cancers, birth defects, miscarriages, and damage to various organs.
- Suspended solids may increase the cost of water treatment, reduce the attractiveness of water bodies, and inhibit the growth of aquatic plant and animal life.
- Nitrogen at high concentrations may cause methemoglobinemia.
- Nitrogen, phosphorus, and high BOD wastes may cause oxygen depletion in water bodies and consequent damage to aquatic life.

via Soil and Land Pollution:

- Pathogens and heavy metals may cause illness in humans, affect crop productivity, and harm animals, plants, and ecosystems.

via Air Pollution:

- Harmful pathogens and toxic chemicals from wastewater can enter the air.
- Open burning of solid waste can release dangerous particulates and toxic compounds.

Economic Impacts

- Reduced productivity of fisheries and agriculture due to water and soil pollution.
- Impediments to navigation, hydropower production, irrigation, and recreation from solid waste in water bodies.
- Reduced income from tourism.
- Declining or depressed land values.
- Increased costs of health care and loss of productivity.

Social Impacts

- Disharmony and conflict among segments of the population.
- Dislocation of populations.

- Reduced amenity value of the environment from objectionable odors and visual degradation.

3.4 Assessment of Impacts

One of the difficulties in the assessment of negative impacts is that they may be attributable to more than one source. To understand the full causal chain that relates a particular source to a particular impact would take more than the four weeks that assessment teams, particularly those that are donor-funded, are typically given to complete their assignments. Fortunately specialists can usually make inferences about likely impacts from knowledge of sources and production processes.

Sometimes, indeed, assessments may be conducted under circumstances in which no pressing negative impacts are currently observable. Such might be the case, for instance, if an assessment team were asked to make policy recommendations to forestall serious problems in the future. Here the assessment of impacts would not focus merely or primarily on prevailing conditions. Extrapolations of known or suspected trends must be made. For this purpose, such issues as the expected accumulation of impacts over longer periods, the results of anticipated economic development and population growth, and the repercussion of changes in production processes must be taken into account. Here the impact assessment would rely on a combination of careful forecasting plus knowledge of the likely impact of sources and causal processes that have yet to be fully felt.

For purposes of assessments using this document, it will be sufficient for an assessment team to identify sources, determine whether the negative impacts usually ascribed to them are in fact present or could be expected to occur in the future, and confirm that there is a plausible link, by establishing the existence of one or more of the pathways by which a population generally is exposed.

The assessment team should follow these four steps:

- Identify the sources of concern, the impacts that could be causally related, and the information needed to conduct the assessment.
- Gather this information from existing data, interviews, and observations.
- Determine which impacts are present or likely to occur, given a plausible link, and estimate their extent and severity.
- Determine the priority in which they should be addressed according to their importance.

3.5 Considerations in Assessing Impacts

3.5.1 Types of Information

The three types of information needed are quantitative data, qualitative data, and direct observations.

Quantitative data will cover

- sources (types and volumes of waste generated, types and concentrations of pollutants in the waste, and condition of the waste management system)
- environmental quality (concentrations of pollutants in water, soil, and air)
- exposure pathways (proximity of communities and resources likely to be affected to the water, soil, and air contaminated by the source)
- impacts (morbidity and mortality rates for environmentally related diseases, condition of affected ecosystems, and trends in economic activities such as fisheries, forests, agriculture, and tourism).

These data can be found in the records and planning documents of agencies responsible for public works, environmental quality, and health, and of their operations offices (utilities, field stations, clinics, etc.), and in university studies and the reports of previous consultancies.

Qualitative data are often the most valuable type of information. Perhaps the primary example of qualitative data are interviews with public officials, utility managers, community leaders, and other key informants, who help in identifying direct impacts and determining their importance. Some direct impacts are best known to officials and residents. Those interviewed may have knowledge of past events and conditions that will not appear elsewhere. Their judgments about the relative importance of various impacts—provided they are aware of the full range—are shaped by economic conditions and cultural norms more relevant to their circumstances than are the judgments of the assessment team. Interviews can be conducted one-on-one or in focus groups which, with adequate preparation, can yield very satisfactory results. Qualitative data may also come from reports and other written sources of information, which record people's perceptions.

Direct observations help team members to place all other information in perspective and to identify the behaviors and practices that might create exposure pathways. On-site inspections of major sources, waste management operations, and points of potential exposure should be conducted as early as possible. Occasionally, an experienced consultant will spot indications of particular impacts not apparent otherwise.

3.5.2 Evaluating the Extent and Severity of Impacts

Gauging the extent and severity of impacts is not easy in the brief time available during a typical assessment. Different types of impacts are necessarily measured in different units and the amount of information available differs considerably among impacts. Nonetheless, there are ways of arriving at a judgment about the relative significance of different impacts and setting priorities. There are two measures of impacts on health. The preferred measure is the number of people who have or will develop a disease related to exposure to a specified pollutant.[2] Given sufficient information on the rate of exposure, this measure can be estimated for many carcinogens, using standard cancer risk assessment models, and can be applied to either past or future cases.

For non-carcinogens, the estimate must be derived from mortality and morbidity data, which rarely specify the cause of a disease. For example, without detailed epidemiological studies, it is impossible to determine how much of the incidence of diarrhea is attributable to improper wastewater management, unsanitary personal habits, consumption of contaminated food, or several other possible causes. Frequently, the best that can be done is to compare the incidence rate (e.g., number of people affected per 100,000 residents) with rates from other locations and judge whether it is low, moderate, or high.

The second measure of health impacts is based on exposure to a pollutant, rather than to a disease, and uses both the number of people exposed and the level of exposure. It makes a gross estimate of the number of people residing in an area served by a water supply system contaminated by the pollutant, unless more detailed information is available. The level of exposure is the concentration of the pollutant to which the population is exposed, divided by an accepted "safe" concentration. The U.S. Environmental Protection Agency has established "reference doses" for some non-carcinogenic pollutants based on estimated safe concentrations. For other pollutants, primary standards (e.g., for pollutant concentrations in drinking water) serve as a useful but imperfect substitute.[3] Selected standards issued by the EPA and the World Health Organization are shown in Appendix C. If information is not available on both the number of people exposed and the level of exposure, then information on one or the other alone may be helpful.

Many developing countries have adopted United States, WHO, or European standards in their environmental protection programs. Uncritical adoption of western environmental standards is usually not a good practice. Environmental standards reflect a tradeoff among various factors: avoiding health and ecological impacts, with technically feasible means, at a social and

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[2] An equivalent measure is the *probability* of developing the disease due to the specified exposure, calculated as the number of people affected divided by the total subject population The probability estimate is the *risk* that an individual has of developing the disease if exposed to the pollutant, and is the most common form in which the results of a risk assessment are expressed

[3] They are imperfect because standards vary tremendously—among media (air, drinking water, surface water) and sources (USEPA, WHO, EC)—in the degree to which they are based on human health concerns, and incorporate arbitrary "safety factors" or limits based on technological feasibility and cost.

economic cost that is deemed acceptable. Thus, a particular standard reflects a particular society's "comfort level" with all aspects of this tradeoff. While citizens of developing countries generally want as much protection for their health and environment as do the citizens of industrialized countries, they may not have the technological capacity to achieve western standards or they may not be willing or able to pay the costs of a high level of protection. Adopting standards that are unrealistically stringent often leads to total disregard for the law because it cannot be enforced. Thus, developing countries would be well-served by establishing standards that reflect a tradeoff that is appropriate for their particular circumstances. It is a good strategy to start with less stringent standards that are enforceable, even if more stringent standards are environmentally or politically desirable. Less stringent standards can be adopted with a realistic schedule for making the standards more stringent over time.

The extent of impacts on environmental quality and ecological integrity is generally related to the size of the area affected. The severity is gauged in terms of ambient concentrations of pollutants, reductions in the population of a particular species or in a biodiversity index, reduced productivity of fisheries and forests, or other measures applicable to the particular resource affected. Economic impacts are generally measured as reductions in regional or national income or as costs to mitigate or remedy the damage caused. Impacts on social cohesion and personal welfare are generally measured in qualitative terms, unless contingent valuation studies have been used to estimate the economic value people place on the amenities or societal qualities they feel have been lost.

3.5.3 Comparing Impacts with Established Priorities

Comparing impacts is a subjective process. In considering the respective risks from exposure to two carcinogens, which is worse—breast, lung, liver, or bowel cancer? And comparing effects on health—cancer, diarrhea, miscarriages? The need to use societal values to set priorities becomes more important when considering health effects among different populations. Who should get attention—children, working adults, or the elderly, women or men, the poor or the affluent, one ethnic group or another? Which is more important—health or ecological integrity, economic growth, or the social fabric?

Setting priorities involves value judgments and requires the involvement of the appropriate public officials and community leaders. It would be helpful to have some sense of the priorities from the counterpart agencies before beginning the assessment, but the team can proceed without this. It should make its own preliminary judgments, proceed with its analysis, and make clear that the recommendations in its report ultimately must be accepted by the local counterparts.

3.6 Conclusion

Impacts are important in the assessment of wastewater and solid waste management, but they are not easily measured because data frequently are lacking and there is no time to go in search of them. If previous studies have been carried out, the task will be that much easier.

However, the assessment team should make the best determination of present impacts and those likely to occur and their relative importance. With this information and some guidance, the host country officials must then decide which impacts to address as a matter of public policy. Determining the main impacts leads to the next step in the assessment, the identification of key targets whose actions are critical to improving the situation.

3.7 Hints and Guidelines for Assessing Impacts

Data and information from interviews and direct observations should be gathered for environmental, health, economic, and social impacts. Quantitative data on health, water and air quality, soil contamination, economic activities, and social conditions are important. Water pollution should receive special attention because it is the primary route of exposure for pollutants from wastewater and solid waste. Water should be considered for evidence of suspended solids, pathogens, toxins, nutrients, and oxygen-demanding compounds, and for the sources of pollution, such as local industries. Where data are not available, the types of industries and industrial processes in operation may be sufficient to predict the pollutants being discharged.

Previous analyses, if available and deemed to be reliable, should be used to supplement data on losses in economic productivity or growth, declining property values, and increased health care costs stemming from wastewater or solid waste impacts. Data on social impacts should consider community tensions or harmony, population displacement, and quality of life, especially for those living near large waste disposal sites or in marginal circumstances. In every case, it is important to judge how accurately the data characterize the impacts.

Interviews can be conducted one-on-one or in focus groups. Public officials, utility managers, scientists and other technical experts, and community representatives should be asked the following questions:

- What problems are you aware of that are related to wastewater and solid waste? Are you aware of them from your own experience or because others have told you?
- Who or what do you believe causes the problems? Actions of people in general? Actions of a particular group?
- Are the problems experienced only in certain circumstances? What activities are you involved in when you are exposed to the pollutants?

- Who is affected by the problems? Who is concerned about them? Who has brought attention to them?
- What are the most important reasons for addressing these problems? Concern for human health? Economic considerations? Environmental concerns? Social justice?
- In your opinion, what are the most important problems that need to be solved to improve wastewater and solid waste management in this jurisdiction?
  - ☐ Inadequate treatment or disposal facilities (running out of capacity)?
  - ☐ Need to expand service to new areas?
  - ☐ Need to increase utility revenues?
  - ☐ High cost of service?
  - ☐ Inefficient service (bureaucracy, waste, corruption, irregular or poor performance)?
  - ☐ Inequitable service (some areas underserved or bearing unfair cost burdens), especially to peri-urban areas?
  - ☐ Lack of enforcement authority?
  - ☐ Inadequate level of staffing, or inadequately qualified staff?

Glossary

BOD (Biochemical Oxygen Demand). Indicator of water contamination that analyzes the rate at which oxygen is consumed. The higher the number, the more contamination there is in the water. Expressed in milligrams per liter.

Exposure pathways. Route by which a pathogen or toxic material travels through the environment and comes into contact with humans via inhalation, ingestion, or dermal contact.

Particulate. Particles that are suspended in the air.

Pathogens. An agent that causes disease, e.g. virus and bacteria.

Reference dose. The amount of a non-carcinogenic compound which the USEPA has determined will not cause an observable, negative physiological effect on humans, i.e. a safe dose.

Suspended solids. Particles that are suspended in water.

Toxic materials. Chemical elements and/or compounds that may cause disease in humans or damage to the environment, whether in their usable form or as waste.

4

IDENTIFYING KEY TARGETS

4.1 Targets Defined

Policies and programs designed to reduce the adverse impacts of wastewater and solid waste must target those individuals and organizations whose actions and decisions are crucial. It is not enough to come up with a good solution for improving waste management. It is as important to clarify whose behavior is to be changed and how. Without the support of these key people and organizations, no effort is likely to succeed. They can transform the characteristics of residuals before they enter the environment, can influence their movement after they have entered the environment, and can mitigate their effects on people. Table 1 summarizes the different types of targets and provides examples of each type.

4.2 Types of Targets

4.2.1 Direct Generators of Residuals

The principal direct generators of residuals are households, industrial and commercial establishments, and public facilities.

i. Households

Households generate human waste, garbage, and materials discarded in domestic activities. Of these, human waste is generally the most troublesome because it carries pathogens harmful to human health. On the other hand, in many parts of the world human waste is a major resource in maintaining soil productivity.

For some cases of wastewater or waste management, it is useful to distinguish between single households and multiple-unit dwellings. Certain policies, such as charges for treating wastewater, require individual meters, which are ineffective at reducing flows when attached to multiple-unit dwellings (see Chapter 6).

ii. Industrial and Commercial Establishments

Industrial and commercial establishments are major sources of residuals, producing the same waste streams as households in addition to chemical and biological wastes. Removal of heavy

Table 1
Summary of Types of Targets

Types	Examples
Direct generators of residuals:	
households	*individual homes, apartments*
industrial and commercial establishments	*factories, restaurants*
public facilities	*hospitals, military bases, government offices*
Indirect generators of residuals:	
suppliers of materials	*manufacturers*
consumers	*individual consumers*
Residuals managers:	
waste managers	*landfill operators, engineers, sewage treatment plant operators*
environmental resource managers	*water treatment plant operators, water quality monitors*
natural resource managers	*foresters, fish & game managers*
impact mitigators	*health workers, sanitarians*
impacted parties	*communities*
policy implementors	*officials from regulatory and financing agencies*

metals and toxic organic compounds can require costly and sophisticated waste treatment technologies. Changing packaging or production processes can reduce the need for cleanup efforts or stringent monitoring. The presence of toxic organic compounds from the waste stream will usually be less widespread in developing countries because the industrial sector is much less advanced, but they are found there as well and can be locally quite severe.

iii. Public Facilities

Public facilities such as military bases, hospitals, government offices, schools, and parks also generate residuals. Waste from hospitals and military bases can pose especially serious problems.

4.2.2 Indirect Generators of Residuals

Indirect generators are those who supply the direct generators with materials and those who consume their finished products.

i. Suppliers

Direct generators, whether they market their products or not, are sensitive to the cost of the inputs upon which they depend. Policies that encourage their suppliers to offer competitively priced and environmentally benign alternatives can effectively reduce waste streams. For example, financial incentives to beverage manufacturers to use recycled glass bottles will encourage recycling. Another example is when industries face high disposal fees for hazardous waste.

ii. Consumers

Consumers can exert great pressure upon product manufacturers. Consumer boycotts and similar dramatic protests are the most obvious ways in which this pressure is exerted. More subtle, but as successful, is the refusal to buy environmentally harmful products. Public policies that alter consumer preferences can induce generators of residuals to consider less polluting product lines. One instance would be a policy to develop markets for recycled materials and reconditioned products. A recent recycling project in Indonesia was geared to the production of compost, but consumers showed limited interest in buying the product. Short-term price subsidies might have helped to create a market. In general, consumers are less well organized in developing countries, but in those that are advancing, such as Brazil and Malaysia, consumer groups are becoming increasingly influential.

4.2.3 Residuals Managers

Residuals managers are those who influence the ways in which residuals have environmental impacts. They include waste managers, environmental resource managers, and natural resource managers. Waste managers handle residuals after they are generated but before they enter the environment. Environmental resource managers influence the movement of residuals through the environment. Natural resource managers protect forests, fish, and wildlife from the effects of residuals.

i. Waste Managers

Waste managers oversee waste collection and disposal arrangements. For wastewater these are sewage treatment plant operators; for solid waste they are collection and landfill operators. Both are usually municipal employees. Larger industries and businesses also often employ their own waste managers. Waste managers are generally considered to be the mainstay of pollution management and are pivotal actors in changing waste management policies. They can be placed on the bold line coming out of "Polluting Activities" (Figure 1) or before residuals enter the environment.

ii. Environmental Resource Managers

Environmental resource managers influence the movement of residuals through the environment. They include managers of river basins, water treatment plant managers, and water quality monitors (such as a ministry of health). All have a stake in maintaining acceptable levels of residuals in water bodies. Water treatment plant operators and watershed managers are included in this category since they manage the collection of water that meets consumption standards. Environmental resource managers can be placed on the bold lines connecting "Polluting Activities" and "Environment" as well as "Environment" and "Impacted Activities" (Figure 1). Individuals and organizations in this category control the fate of residuals before they have an impact on people.

iii. Natural Resource Managers

Natural resource managers protect fish and wildlife, vegetation, and the ecosystems in which they live. Foresters, range managers, and fish and game wardens are in this category. Natural resource managers can control the ways in which residuals affect human activities. A simple example is to restrict swimming in a polluted river that is used primarily for commercial purposes rather than for recreational activities. Natural resource managers can be placed along with environmental resource managers in Figure 1.

4.2.4 Impact Mitigators

Impact mitigators influence the ways in which wastewater or solid waste residuals, by this point acknowledged pollutants, affect human well-being. They may reduce the severity of the impact (health workers), help those affected to mitigate the impact themselves (educators), or provide resources that facilitate such mitigation (social services). Many developing countries have sanitarians and health inspectors who are responsible for monitoring the effects of environmental pollution.

4.2.5 Impacted Parties

Those exposed to hazards from wastewater or solid waste often can take steps to reduce the severity of those impacts. At the simplest level, people can boil their water supplies and kill the microbiological pathogens, reducing the most common negative impact of residuals on water supplies. In many countries in the developing world, people draw their drinking water from polluted irrigation ditches, even though they have been provided with wells. Such people are key targets for health protection measures and key constituencies for better management initiatives and impact mitigation policies. Communities can organize themselves to pressure government to change the behavior of polluters.

4.2.6 Policy Implementors

Those who implement wastewater or solid waste management policies, such as regulators, enforcers, monitors, and financing agencies, are also important policy targets because they can be made more effective in carrying out their assigned roles. They often lack the strong management skills and analytical support needed to formulate sound policy. Education and training can help them when they have been offered the incentives to improve.

4.3 Inducing Change Among Targets

Target organizations may be eager to improve their efficiency in reducing the adverse effects of wastewater or solid waste but may be hampered by insufficient institutional capacity, a lack of analytical support, or an inability to change public behaviors. They can be encouraged by efforts to improve their performance.

One of the most successful ways to induce change among targets is to bring together people with an important stake in the outcome, enabling them to air different points of view and eventually achieve a consensus for action. Targets that need to be involved in such discussions include government agencies, NGOs, private industry, financing institutions, and consumers. They could assemble in a workshop, a formal conference, a task force, or working group sessions. Facilitating communication and planning among these groups is important in identifying the critical issues and developing potential solutions. All of these actors have an influence on the current situation and all can be instrumental in changing it. Involving as many actors as possible and taking into account their interests is more likely to achieve an acceptable solution.

Another way to induce change is by providing technical material or equipment—a new information system for monitoring point system discharges of wastewater, or a refined financial system for a regulatory unit to manage expenditures, or durable parts for solid waste collection vehicles. It is useful to keep in mind that many kinds of technologies, and not simply waste-specific ones, may help improve efficiency or effectiveness and contribute to a more informed decision-making process.

4.3.1 Cultural Norms

Waste management strategies must be consistent with cultural norms to be effective. If they run counter to prevailing religious beliefs or other deeply embedded cultural norms, they are likely to fail like many past attempts to adapt Western technologies and policy approaches to non-Western societies.

Cultural influences determine what people eat, how they dress, with whom they associate, how they think about the world around them—and how they deal with wastewater and waste materials. Individuals make most of their decisions in conformity with group norms, whether the group be the family, the church, the corporation, the bureau, or the community. Behavior consistent with group norms is rewarded, and deviations are punished.

Laws and codes of conduct established by formal institutions within a society also create social norms. Islamic law, for example, provides detailed stipulations about hygiene and sanitation that were formalized centuries ago and are not subject to individual discretion. All such norms, whether formal or informal, affect behavior and must be respected by policy and program designers. A careful inventory of cultural norms most relevant to wastewater and solid waste management programs may seem a needless exercise, but experience too often has shown that they are easily forgotten in the enthusiasm for imported technologies or policy instruments.

4.3.2 Habits

One means of improving management of wastes is to change inappropriate hygiene and sanitation habits. Habits, as distinguished from cultural norms, are patterns of behavior susceptible to modification. An example of an inappropriate habit is dumping garbage outside the home or in a public place. If a regular collection service was provided, people would have to learn to put out their trash in a container. Another example is defecating near a river bank instead of in a latrine. The design of culturally appropriate latrines accompanied by hygiene education can change this habit.

Habitual behavior can be more easily changed than behavior determined by cultural norms. Rewards can reinforce desirable behaviors and penalties discourage undesirable ones. Because the habits within a group or community tend to be similar, it is recommended that, as with cultural norms, a list of prevailing habits be compiled as a prerequisite for policy and program design in waste management.

4.3.3 Rules

Social customs are informal, undocumented, and implicitly understood, whereas rules are formal, explicit, and recorded guidelines for conduct. Targets like industrial firms, residuals managers, and many implementors are organizational and both utilize and respond to explicit directives. They too operate within a culture, and it may be useful to consider how rules can shape their actions.

Rules can be supported by cultural norms and reinforced through habit. But they do not necessarily depend for their enforcement on these forms of leverage. Some rules—like driving on a designated side of the road—are virtually self-enforcing. Either side would do and there is no principled commitment to one or the other. But once a choice has been made, people stick with it to protect themselves and others.

Regulations on emission controls or plans for groundwater management contain sanctions for violations and some monitoring and enforcement mechanism. Without such features, many rules would be ineffective; with them, it is possible to exert considerable influence over the actions of targets. The effectiveness of rules derives largely from self-interest. If violations are costly in economic terms or bring negative publicity for industrial firms subject to regulatory standards, infractions are likely to decline. Again, cultural norms and habits can also help in reinforcing rules, which offer great potential for improving wastewater or solid waste management.

Rules do not come out of nowhere. Some are generated by government. Others—including environmental laws and regulations—are adopted by lawmakers and regulatory authorities and enforced by regulators. Some are the product of agreements among nongovernmental actors; for instance, the provisions of a contract. (These rules carry weight because they are built upon principles governing the nature of contracts.) Rules often also govern conduct within organizations, as when standard operating procedures in a firm determine the details of packaging or industrial pretreatment. An apparent absence of rules can be misleading, for ostensibly unregulated activities may actually develop within settings that are themselves shaped by rules. An example is the operation of markets, which are reliant on explicit rules about property rights, pricing, contract law, and adjudication. Rules are adopted by choice and can be changed in the same way. Rules become the tools or instruments of policy and will be discussed in detail in Chapter 6.

4.4 Concluding Comments

It is important to identify the impacts of solid waste or wastewater in a given setting, but knowing about them is not much help without also recognizing whose actions contribute to them and whose behavior, if altered, could improve them. Finding solutions that address the interests of key actors is essential for long-term success. Intervention in improving wastewater and solid waste management at the points shown in Figure 1 requires these individuals or organizations to change their behavior.

It is essential not to focus too narrowly on those who manage wastes while ignoring the power of many other individuals and groups. Direct and indirect generators of residuals, residuals managers, impact mitigators, impacted parties, and policy implementors should all be considered as targets of change, since all have the potential to contribute to the effectiveness and efficiency of waste management.

It is important to determine how the actions of these targets might be swayed for the better. Some influences are indirect or even unconscious, others direct and explicit. Some offer the promise of improvement immediately, others only over the long haul. The impact of a culture and its norms on the prospects for change should not be overlooked. Nor should decision makers ignore the force of habit, which can obstruct efforts to modify entrenched behavior.

It is equally important not to be trapped by the status quo. Technology can be introduced to advantage, provided it is adapted to the local context and can be supported and maintained there. Rules derived from public policies can also be of consequence, especially when they are consistent with cultural expectations.

4.5 Hints and Guidelines for Assessing Targets

Targets are selected with an eye to their current or potential influence on wastewater or solid waste management and on their susceptibility to change. It is necessary to understand the cultural norms and the habits that determine their behavior and to identify what each has to gain, so that whatever actions are taken are seen as acceptable by them.

Here are some questions that should be asked in an assessment of the targets and their potential.

Direct Generators of Residuals

- Which of the direct generators are significant sources of waste? What proportion of waste does each group account for (households, industrial/commercial establishments, and public facilities)?

HOUSEHOLDS:

- Is their residuals-generating behavior likely to be much influenced by informational campaigns? By individual metering and billing?

INDUSTRIAL AND COMMERCIAL ESTABLISHMENTS:

- How concentrated are they by physical area?
- Do they account for the production of chemical and biological wastes beyond household types (like heavy metals, toxic organics)?
- Are current production or packaging processes a factor?
- Are alternatives available? Without costly technological change?

PUBLIC FACILITIES:

- Degree of concentration?
- Do serious problems stem from any—for instance, hospital wastes?
- Possibilities for governmental control over them?

Indirect Generators of Residuals

- Do any firms currently offer recycled or biodegradable products?
- Does public policy support markets for these materials? Does government itself use them?
- Does the consuming public know about these alternatives? How supportive are they? Any evidence on willingness to pay?
- Do any consumer groups focus specifically on these issues?
- Are firms that generate residuals sensitive to the pressure from their suppliers and markets?

WASTE MANAGERS:

- Who are they?
- Do any besides the municipality have any local impact?
- Any important private sector waste managers?
- How well trained are those currently in place and how supportive of improvements?

ENVIRONMENTAL RESOURCE MANAGERS:

- What are the key resources through which the residuals travel? River basins? Groundwater aquifers? Agricultural systems?
- Who are their managers? What about water treatment plant operators and watershed managers?
- How central is each environmental resource manager in terms of current impacts?
- How likely is each to be influenced for improvements?

NATURAL RESOURCE MANAGERS (foresters, range managers, fish and game managers):

- Which are important in the context?
- Which manage resources that are affected in significant ways by residuals?
- Can they be influenced to make improvements?

IMPACT MITIGATORS (health workers, educators, and social service providers):

- How important are these parties now in mitigation efforts?
- How amenable are they to influence improvements?

IMPACTED PARTIES:

- Which are the key ones?
- Are they concentrated or dispersed?
- How large is their stake in potential improvements?
- Can they be reached by specifically directed approaches? (By area, or medium of communication, or institution, or other form of concentrated effort?)
- How aware are they of current impacts?
- What estimate can be made of their willingness to consider improvements?

POLICY IMPLEMENTORS:

- Who and where are they?
- Which implement policies that most heavily influence impacts?
- What is their capacity? Their degree of support?

Inducing Change

TARGETS CURRENTLY COMMITTED TO IMPROVEMENTS:

- Are their efforts impeded by insufficient institutional capacity or a lack of analytical support?
- Are there mechanisms that provide a forum for discussion among the key actors?
- Can information, training, or other resources make an important difference for their effectiveness or efficiency? Can the introduction of new technologies make a difference?
- Are these forms of assistance likely to be enough?
- How costly would an effort to change their habits and routines be?

CULTURAL NORMS:

- Do cultural norms support practices or beliefs that aggravate waste management difficulties?
- Are there ways of changing these practices without violating cultural norms?

- Can cultural norms be used to support a change in some current practices that are causing a problem?

HABITS:

- Are there widespread habits that contribute to the problem?
- Are there any organizational routines that pose difficulties?
- Estimated ease of altering? Costs of change?

SIGNIFICANT TARGETS:

- What rules help to influence current practices? Which ones pose impediments?
- How easily could they be changed?
- Is there a clear forum for changing them (regulatory body, legislature, etc.)?
- What would be needed to promulgate amendments?
- Degree of controversy to be expected?
- Do the changes fit with cultural norms?
- What are the costs of changing rule-bound behavior?

GLOSSARY

Cultural Norms. Views of approved or disapproved behavior that are imbedded in and supported by a culture.

Direct Generators of Residuals. Households, businesses, industries, and other entities that produce residuals.

Environmental Managers. Individuals, groups, or organizations who influence the movement of residuals through the environment.

Impact Mitigators. Those who influence the ways in which wastewater or solid waste residuals, by this point acknowledged pollutants, affect human well-being.

Impacted Parties. Those who bear the effects of improperly managed wastewater or solid waste.

Indirect Generators of Residuals. Those who supply materials to direct generators of residuals and those who buy their finished products, if any.

Habits. Learned, patterned behavior. Habits in organizational settings are routines or standard operating procedures.

Natural Resource Managers. Those who manage forests, fish, and wildlife and protect them from the effects of residuals.

Policy Implementors. Those who implement wastewater or solid waste management policies, such as regulators, enforcers, monitors, and financing agencies.

Residuals Managers. Those who influence the ways in which residuals have environmental impacts. They include waste managers, environmental resource managers, and natural resource managers.

Rules. Formal, explicit, and recorded guidelines for conduct.

Targets. The persons and groups at whom wastewater or solid waste programs and policies are directed to build institutional capacity, provide analytical support, or change behavior.

Waste Managers. Individuals, groups, or organizations that manage residuals after they are generated but before they enter the environment.

5

ASSESSING TECHNOLOGY OPTIONS

5.1 Definition

Technology in this document is defined as the engineering methods encompassing structural and chemical processes for reducing pollution from wastewater and solid waste. The intent in this chapter is to focus on physical and structural facilities, leaving other management options such as regulatory and institutional approaches to be discussed later. Several appropriate technologies are described and some guidance is offered on selecting from among them. But there is no intent to provide an in-depth review. Readers who want more detail on individual technologies should consult the bibliography at the end of the document.

5.2 Waste Management Approaches

Technologies are used to separate or reduce the toxic elements in the waste stream. For optimal effectiveness and efficiency, they must be part of a strategy that is mindful of such scarce resources as energy, capital, time, and effort.

Returning to Figure 1, technologies are applied as end-of-pipe treatments to bring residuals to an acceptable level of concentration as they enter the environment. Before this point, however, there are pollution prevention measures that begin with waste reduction, recycling, and reuse of materials, and end with the treatment and disposal of wastes.

5.2.1 Waste Reduction, Recycling, and Reuse

Waste reduction should be considered the first step in waste management, preceding the more expensive option of treatment and disposal that necessitates the use of water and other materials. Solid waste can be reduced by limiting single-use packaging, making products more durable, and educating the public in using resources efficiently. Industrial waste producers can be encouraged to change to production methods that use less water and alternative raw materials to reduce the toxicity of their effluents and the volume of their wastes. Many industries, especially in developing countries, are unaware of the availability of new technologies that produce less waste or are given insufficient incentives to be concerned.

Waste recycling and reuse of materials can contribute significantly to the reduction of waste discharges and the volume of waste that needs to be treated and disposed of. The reuse and recycling of the organic matter in wastewater sludge, newspapers, plastics, metals, glass, and wastewater itself conserve resources and energy.

5.2.2 Waste Treatment and Disposal

The waste that remains must be disposed of carefully, generally after treatment. In many cases, however, safe disposal is possible in properly designed disposal areas such as sanitary landfills for solid wastes. Treatment and disposal should not be considered as the first line of approach but only after reduction, reuse, and recycling have been tried.

5.3 Wastewater

Wastewater is produced by households, by commercial operations such as restaurants and retail stores, by institutions such as hospitals and schools, and by industrial operations.

The volume of domestic wastewater, discharged from washing, food preparation, toilets, and baths, is generally related to the amount of water available to the household and to the location of the dwelling. Affluent households generate the most wastewater. Low-income households have fewer taps, but the number of users per household is usually larger and the volume of wastewater per unit can be high. However, in fast-growing urban areas where water shortages are frequent, erratic flows can forcibly reduce consumption and consequently wastewater discharges.

Commercial and institutional wastewater is usually of the same quality as domestic wastewater but is produced in larger volumes.

Industrial wastewater varies in quality and can preclude or permit reuse. Steel mills, for example, may discharge water with a heavy concentration of toxic metals unsuitable for crop application. Conversely, breweries produce a wastestream high in organics beneficial to some agricultural land.

Appropriate technologies for wastewater management fall into four categories: collection, treatment, disposal, and sludge management.

5.3.1 Collection

Collection systems include:

- individual on-lot treatment
- individual holding tanks and truck collection
- community systems
- regional sewerage
- small-diameter gravity, vacuum, and pressure sewers
- shallow sewers
- flat sewers

- simplified sewerage systems
- solid-free sewerage
- conventional sewerage

The first consideration is whether to treat wastes on-site or to convey them elsewhere for treatment. The choice is influenced by lot size, population density, topography, groundwater elevation, and soil characteristics. On-site disposal is appropriate for low-density areas with nearly flat topography, good percolating soils, and a water table at least three feet below the surface. For households, the on-site choices are latrines or septic tanks that combine collection with treatment.

Off-site treatment is appropriate in high-density areas with gently sloping topography, high water tables, clay soils, or rock with poor percolation, and where space for off-site treatment and disposal is available. The choice among the various sewerage systems mentioned is determined primarily by cost; conventional sewerage is expensive and suitable only for the more affluent neighborhoods in most developing countries.

It should be noted that the collection systems listed above are not mutually exclusive and are often used in various combinations. (See USEPA 1980 and 1991 for further information.)

5.3.2 Treatment

Treatment systems include:

- community on-lot systems
- oxidation ditches
- stabilization ponds
- aerated lagoons
- facultative lagoons
- wetlands
- land treatment
- aquaculture
- conventional systems (activated sludge, trickling filters, biodisks, etc.)
- physical-chemical processes
- preliminary or primary treatment and ocean disposal

Conventional systems generally are not employed in low-income communities in developing countries because of the delicate and expensive operation and maintenance requirements.

However, they may be necessary in dense metropolitan zones where land is at a premium. Generally, the simpler the system of treatment, the more reliable and economical it will be to construct and operate. Physical-chemical processes are applicable primarily to industrial wastewater. Ponds, lagoons, wetlands, aquaculture, land treatment, and ditches are land-intensive and thus suitable for medium and small communities, not for large metropolitan areas. (See USEPA 1974, 1977, 1981 and Water Environment Federation 1992 for further information.)

In coastal areas, preliminary or primary treatment and ocean disposal are acceptable with favorable currents and sufficient ocean depths at a reasonable distance from the shore. Ocean disposal after treatment, however, should be considered very carefully as coastal areas are sensitive to extreme changes.

5.3.3 Disposal

Disposal methods include:

- reuse in agriculture
- industrial and urban reuse
- groundwater recharge
- rapid infiltration
- underground injection
- surface water discharge
- nightsoil treatment plants
- ocean disposal

WASH has developed guidelines for water reuse for the U.S. Environmental Protection Agency that set acceptable limits for various applications (Crook et al. 1992). These include fire fighting in urban areas and cooling water, boiler feed, and other industrial uses. Water reuse is the most common in agriculture, but there are many health risks that must be considered. Water reuse in habitat restoration for wildlife and recreation purposes is not unusual. Groundwater recharge and augmentation of potable water supplies are also possible but require careful attention to health concerns.

Most of the disposal methods listed are likely to require some degree of treatment, depending on the nature and concentration of pollutants. Groundwater recharge and augmentation of potable water supplies are considered special applications because of the sophisticated treatment necessary.

Surface water discharge has many potential impacts on wildlife, recreation, and aesthetic interests (see water quality standards for receiving streams in Appendix C). Nightsoil treatment plants are an option where holding tanks and truck collection are used instead of sewerage.

5.3.4 Sludge Management

Sludge management includes:

- reuse in agriculture or silviculture
- land reclamation
- composting
- co-composting with municipal refuse
- landfill
- ocean disposal
- incineration
- energy production

Generally, sludge from domestic wastewater is suitable for application in agriculture, land reclamation, or composting. Sludge in metropolitan areas where there are large numbers of industries is usually contaminated with toxic metals that render it hazardous for agricultural use. Pretreatment to remove these contaminants from industrial discharges can correct this problem.

Landfilling is a common and acceptable option if the landfill is properly located, operated, and monitored. Composted sludge can be used as a cover in landfills.

Ocean disposal is a very sensitive option because of concerns for ocean and beach pollution. The cost of transporting sludge long distances to deep ocean waters is also prohibitive.

Incineration has several undesirable features such as high capital and fuel cost, air pollution, and ash disposal.

Energy production, through anaerobic digestion to create methane, is suitable in large and medium-sized communities, using conventional treatment technologies. However, its initial cost is high. (See USEPA 1979 for further information.)

5.4 Solid Waste

Solid waste comes from the same three sources as wastewater: households, institutional/commercial establishments, and industrial operations. In general, it contains putrescible organic matter such as kitchen wastes, combustible matter such as paper, textiles, oil and grease, and plastics, and inert materials such as metals, soil, and ash. It can also contain pathogenic organisms such as bacteria and parasites, especially in neighborhoods without adequate sanitation where infant feces are thrown into the garbage. Toxic and hazardous materials such as pesticides, heavy metals, volatile organics, and solvents are also common in the solid waste stream.

The per capita weight of solid waste produced in less developed countries is about 25 percent, and the per capita volume only about 6 percent, of that produced in industrialized countries. It also is higher in organic content, moisture, and density, making certain alternatives for disposal less desirable. For example, stabilization in landfills will occur faster in the tropics because of the high temperatures and humidity. Incineration is not self-sustaining because of the high moisture content. Mechanical separation for recovery of materials is usually not economical because of the small volume of recoverables and the lack of a market for them. Compaction trucks produce small reductions in volume, which make them impractical for solid waste transport.

The technology appropriate to a specific community will depend on the location and characteristics of the community. In peri-urban areas with large low-income populations, small dwellings, and narrow streets, smaller collection vehicles, night collection, and labor-intensive methods are most suitable. Hot climates require more frequent pickups because waste decomposes more rapidly.

The same management strategies of reduction, recycling and reuse, treatment, and final disposal used for wastewater apply to solid waste. (USEPA 1989 and Seuss 1985.)

5.4.1 Reduction

Reduction should be a basic goal of solid waste management. Minimizing waste generation will reduce the requirements for collection and disposal and their associated costs, will save on energy and materials used in production, and will lessen the environmental impacts of the entire cycle of resource use, from the extraction of raw materials to the disposal of wastes.

Waste can be reduced by products requiring less material per unit (smaller cars, thinner containers); products with longer lives (more durable tires and appliances); reusable products (refillable containers) that replace single-use disposable products; limiting the number of units per household (fewer cars per family); and adopting standards to reduce the amount of packaging (selling dry goods from bulk storage rather than by package). Waste reduction can be promoted by education campaigns and by rewarding those who do cooperate with lower collection fees.

Although these examples taken from more affluent countries would not generally apply in developing countries, where conserving materials, reusing products, and minimizing waste are imposed by economic necessity for much of the population, they could be tried in neighborhoods with wealthier residents.

5.4.2 Collection

Some methods for collection and transportation of solid waste are:

- self-reliant on-site management
- use of pushcarts, animal carts, tractors, and trucks
- communal stationary and portable containers
- curbside collection from liftable containers
- block collection systems
- separate collection of hazardous wastes

Reducing waste can have significant financial implications, since some municipalities spend as much as half their budget on solid waste collection and transport. On-site management can eliminate the need for collection and transportation but is feasible only in rural areas with low-density population. Backyard compost piles are one solution in other areas.

Pushcarts and animal carts may be the only vehicles that can negotiate very narrow or steep urban streets. Carts and wagons can be constructed locally to meet neighborhood needs. Communal containers and block collection systems that require residents to deliver wastes to a pickup point can reduce collection costs by reducing truck trips and collection time.

Separate collection of hazardous wastes from producers such as hospitals or gas stations can diminish the toxicity of the waste stream and protect workers and scavengers.

5.4.3 Treatment and Disposal

The methods for treatment and disposal of solid waste range from processes for final disposal to processes for volume reduction and materials recovery. Among them are:

- volume reduction
- recycling
- composting
- landfilling
- incineration and energy recovery

Solid waste requiring disposal can be reduced by compaction, source reduction, recycling, incineration, and composting. Compaction is impractical in less developed countries, except in the most affluent neighborhoods, as explained earlier.

Recycling mostly relies on the separation of reusable materials at the curb or at a recycling plant either manually or mechanically. In less developed countries, materials are separated by scavengers or by municipal workers, who pick reusable material from the waste stream, either at the curb or at the landfill. Scavenging often strips the waste stream of all items of value. In Egypt, a well-organized ethnic group has taken over the recycling operation and made it a profitable enterprise. Municipal workers in Thailand reportedly earn more than their salaries from the sale of recyclable items.

Solid waste can be composted with sludge from wastewater to produce a material useful for agriculture or land reclamation, as previously discussed. Composting operations in some developed countries have become quite complicated and expensive because of odor control requirements, land requirements, and market requirements. Developing countries with poor or badly eroded soils, such as in Haiti, could profit from using compost as a soil conditioner.

Incineration can be used to recover energy from waste, to treat medical waste, and to reduce the volume of the waste stream. It is capital intensive and requires sophisticated operation and air pollution control equipment, and produces ash that must be properly disposed of, usually in a secure landfill.

Landfilling is the most common method of solid waste disposal but is becoming more complicated and expensive in developed countries because of strict groundwater protection laws. Landfills must also be located away from population centers, which is an incentive to reduce, recycle, and reuse to minimize transportation costs.

5.5 Selecting Technologies

Selecting an appropriate technology from the available array of choices requires three considerations. The chosen technology should effectively solve the problem without creating new ones. It should be sustainable so that the benefit it confers can last for a long period. There should be a competent institution to oversee its application. To facilitate the selection process, the following steps should be considered in the order presented:

- consider how the wastes affect health and the environment
- ensure that the volume of wastes has been reduced by nontechnological means
- verify whether similar technologies are already in use
- confirm that the skills required to operate the technology are available
- confirm that there is an established O&M system
- confirm that there is an effective management system

- confirm that there is a cost recovery system
- verify that the technology meets the perceived needs of the beneficiaries
- remember that small and simple is still a good operating principle

5.5.1 Effects on Health and the Environment

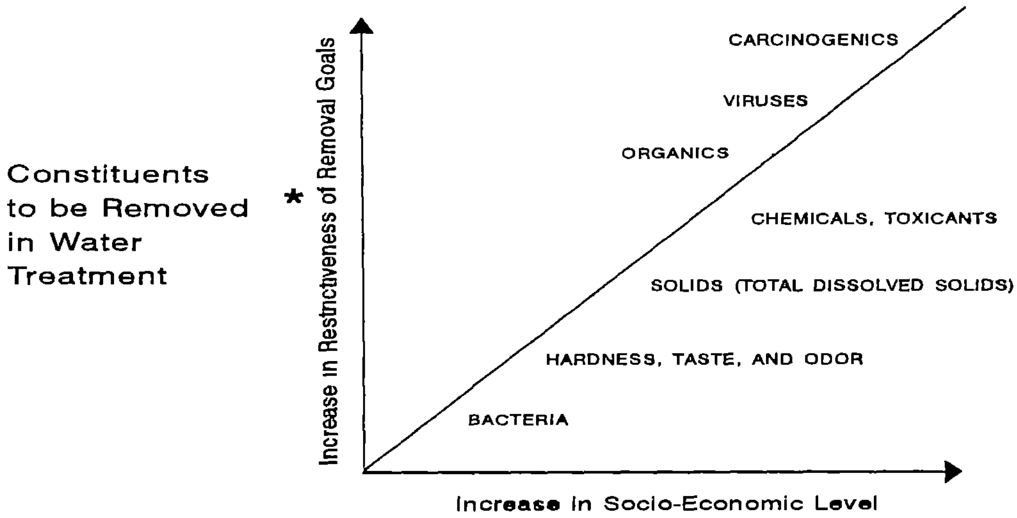
Protecting the health of the population and of the surrounding ecosystems should be the paramount concern in selecting the type and location of a waste management technology. Water-related diseases and those from bacteria in human feces are the greatest threats to the populations of developing countries.

As a first priority, wastewater and solid wastes that contain feces must be isolated from humans to prevent such diseases. Avoiding contamination of drinking water supplies is a top priority. Insect vectors, such as flies and roaches, and animal vectors, such as rats, thrive in most wastes and are responsible for spreading diseases beyond the immediate vicinity of the wastes. Untreated wastes applied as fertilizers are a health hazard both to field workers and to consumers of contaminated agricultural products. Solid wastes containing feces should be transported by trucks and handled with care. A technology as simple as shovels and trucks with covered bins may suffice in poor communities. For more affluent communities, closed containers and automated compactor trucks may be the solution.

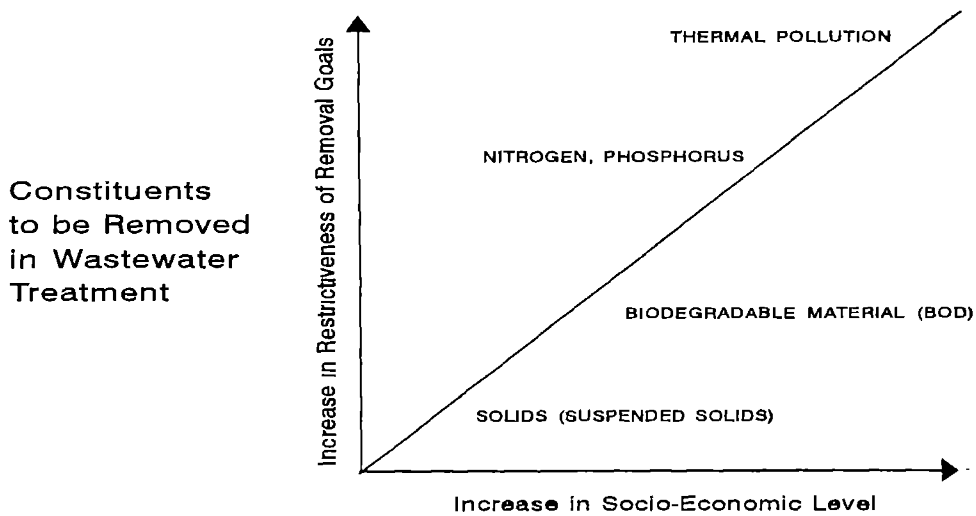
Latrines, which are the most effective means of containing and treating human wastes at low cost, must be properly designed so that they do not become a source of pollution. It is also important to emphasize the need for blanket coverage in a neighborhood. Individual households with improved sanitation will not be protected if others in the neighborhood do not have it.

Industrial wastes are another major health hazard with their long-term effects as carcinogens. Tradeoffs will be necessary in selecting the most appropriate technology as not all risks can be avoided, especially when financial resources are limited. Figure 3 shows the tradeoffs between available finances (level of economic development) and the risks (constituents) to be avoided by water supply and wastewater treatment processes. Treating bacteria in water supplies, for example, is relatively cheap but treating viruses and carcinogens is expensive. Similarly, treatment to filter solids for disposal in surface streams is not as complex and does not cost as much as removing nitrogen and phosphorus.

Human health is not the only impact, of course, to be considered in waste management. Impacts on plant and animal life and their interrelated ecosystems must also be considered. For example, a wastewater technology that is growing in popularity is the construction of artificial wetlands. These are chosen specifically to create or preserve habitats for fish and water fowl. Preserving natural habitats will often be a consideration in choosing technology as there may be important economic and quality of life benefits involved.



* "Restrictiveness" refers primarily to the complexity of treatment processes required to achieve a specific water quality outcome. Treatment processes are designed to bring raw water or wastewater to a potable or acceptable level. As a country develops, more attention will be paid to tackling increasingly complex solutions to achieve higher standards.



Source: "Appropriate Methods of Treating Water and Wastewater in Developing Countries," edited by George Reid and Kay Coffey. Bureau of Water and Environmental Resources Research, The University of Oklahoma, 1978.

Figure 3

Conceptual Representation of Socio-Economic Development
Bringing Additional Treatment Parameters and More Restrictive Levels of Control

5.5.2 Reduction and Recycling of Waste

There is an inverse relationship between the level of economic development and the quantity of wastes generated. The waste stream from the poorest communities has little value to the recycling industry and there are fewer opportunities for waste reduction. However, every country has some recyclables, such as paper from the commercial and government sectors, that must be identified. Of course, countries that are more consumer oriented or are industrialized have a higher potential for waste reduction. The countries of eastern Europe and the new Central Asia republics offer good opportunities for waste reduction.

5.5.3 Introduction of New Technologies

Technology transfer from the richer to the poorer countries has long been a perplexing problem in development circles. An axiom of development, not always followed, is that it is best to build on available expertise rather than introduce technological changes that would require highly specialized skills or radically new institutions. For example, it would be unwise to recommend a sophisticated technology such as activated sludge treatment where there had been no previous experience with a conventional sludge process. But constructed wetlands might be a suitable recommendation as a wastewater treatment technology, even in a country that had no previous experience with it, if there were farmers who knew how to grow rice with waste effluent.

5.5.4 Availability of Trained Personnel

A technology is only as good as the operator using it. A wastewater treatment facility to handle heavy concentrations of chemicals needs a plant operator who thoroughly understands chemical reactions. Garbage collectors who pick up medical wastes should understand the necessity to avoid undue contact with infectious materials. Training can upgrade operator skills but operators must have minimal skills to begin with. To rely on low-paid operators who are illiterate, for instance, would be unwise. Operator skills should not be overlooked in the selection of an appropriate technology.

5.5.5 Effective O&M System

Every technology will eventually break down and require repairs or new parts, making an adequate O&M system an important prerequisite. Donors often provide capital for the construction of a facility and expect local institutions to carry it from there on. Each technology has a particular set of maintenance requirements that must be matched with the skills and resources available. The introduction of a technology and the establishment of an O&M system should go hand in hand.

5.5.6 Capability of the Management System

Closely related to an O&M system is the need for an individual or institution with the experience and skill to make day-to-day decisions in operating the technology and to plan for the long term. It could be the home owner in the case of latrines, or a municipal sewerage authority for a centralized treatment system. In other cases, such as communal septic tanks, management responsibility may be less clearly defined and will require institution building. Again, the introduction of a technology should be fitted to an institution with the capability to sustain it.

5.5.7 Cost Recovery and Affordability

An assurance of adequate financial resources is essential. Operation, maintenance and repairs, fuel, spare parts, and staff salaries are but a few of the costs that must be met. Many waste technologies are funded directly by water and sewerage or garbage collection fees. Others are subsidized from general tax revenues. The chosen technology should be compatible with available revenues to operate and maintain it over the long term.

5.5.8 Acceptability by Users

A technology is only effective if it is used correctly. Garbage containers on street corners will not improve sanitation unless citizens believe that a clean neighborhood is worth the effort of depositing garbage in them rather than dumping it in a nearby drainage canal. Cultural norms and behavior patterns were discussed earlier. Here it is sufficient to emphasize that each technology has a degree of user acceptance that must be clearly understood.

5.5.9 Keep It Small and Simple

It is good to remember that small and simple technologies should be tried first. Sophisticated and complicated technologies transferred from advanced countries have often failed in developing countries, but this should not rule them out entirely. The objective is to isolate wastes from contact with humans and their ecosystems, and to treat them so as to render them less toxic. For both wastewater and solid wastes there are certainly economies of scale associated with bigger operations. A single wastewater treatment facility or a regional sanitary landfill is generally more appropriate for an entire metropolitan area than several smaller facilities. The technologies outlined in this chapter are listed in increasing order of complexity. In choosing one, it is better to err on the side of simplicity.

5.6 Concluding Comments

Although technology is certain to be part of any strategy, reliance on technology alone will not be sufficient for improving waste management. Resource constraints make reliance on conventional technologies simply unaffordable. This chapter has outlined a range of technologies beyond end-of-pipe treatment. In selecting a technology, it is preferable in the long run to consider one that reduces waste rather than to construct facilities to treat and dispose of an ever-expanding waste stream. The technology should fit the socioeconomic setting and be consistent with the institutional capability and financial resources available to sustain its use. It should also be designed to serve as many people as possible, especially the poor and underserved.

5.7 Hints and Guidelines for Assessing Technologies

The assessment of new technologies should be mindful of technologies currently in use and of the feasibility of introducing change. It should also consider the present institutional capacity for operation and maintenance. Care should be taken to gather data at the national, municipal, and community levels. The perspective of national agencies must be complemented by the views at the municipal level, where waste is actually managed, and by the opinions of the community, which must ultimately accept and pay for the service.

The following are questions that should be asked in assessing wastewater and solid waste technologies.

Current Technologies in Use

WASTEWATER

- Are there any attempts to reduce or reuse wastewater?
- How is wastewater currently collected?
- What percentage of wastewater is treated? What technologies are employed?
- How is wastewater currently disposed of? If wastewater is treated, how is the sludge disposed of?

SOLID WASTE

- Are there any attempts to reduce the rate and volume of solid waste?
- How is solid waste collected?
- How is solid waste treated and disposed of? Is there any recycling? Does landfilling remain a viable option?

Assessing Potential for Solutions

- What quantity of wastes is involved? Is it small enough to be handled on site or will it have to be conveyed to a reduction, recycling, or treatment center?
- Is there a technology to reduce the quantity of wastes produced? Will it save valuable natural resources?
- How hazardous or toxic are the wastes?
- Can the wastes be recycled or reused? Are there recycling facilities already in operation or will they have to be introduced?
- What barriers are needed to shield humans and their associated ecosystem from the wastes? Can wastes be rerouted to avoid sensitive areas? Can a landfill be relocated away from an aquifer? Can it be lined?
- After exhausting the possibilities of reduction, reuse, or recycling, which technologies might be appropriate for treatment and disposal? Are there any new approaches that deserve investigation such as reclaiming old landfills for park and recreation lands?
- Will current policies support the introduction of lower-cost technologies?
- What is the likely attitude of users to new technologies?
- What role can public education play in the acceptance of new technologies? Will mass media campaigns on radio or by other means be effective?
- What is the local experience with trying new technologies?
- How capable are existing institutions in operating and maintaining new technologies?
- Which new technologies are users willing to pay for?

GLOSSARY

Technology. The engineering methods encompassing structural and chemical processes for reducing pollution from wastewater and solid waste.

Wastewater. Spent water from residences, commercial buildings, institutions, and industrial plants and any groundwater, surface water, and stormwater combined with it.

Sludge. The accumulated solids separated from wastewater during processing.

Solid Waste. Waste composed of solid matter from household, commercial, institutional, and industrial sources.

6

ASSESSING POLICY INSTRUMENTS

6.1 Definition of Instruments

Wastewater and solid waste management can be provided by governments, public agencies, private entrepreneurs, cooperatives, or private contractors. However, governments—whether or not they are directly involved in management—have a unique function in determining how wastes are managed. Through explicit policies, they establish the playing field and the rules of the game by which wastewater and solid waste will be managed. They also influence the use of materials and the generation of wastes, as well as the physical and socioeconomic context in which wastes must be managed. Many of these influences are inadvertent and sometimes perverse. Effective wastewater and solid waste management requires that they be conscious and helpful.

Policies are implemented through policy instruments, which are all the actions that can be taken by governments to achieve a public purpose. The most obvious are direct government investments in purchasing waste management sites, constructing sewers and treatment facilities, and acquiring and operating waste collection vehicles. These investments are not always the most effective or economical instruments. Other policy instruments include measures to reduce the volumes and hazards of wastes generated; to encourage recycling and reuse to diminish the need for waste disposal facilities; and to increase the efficiency of wastewater and waste management services.

These instruments fall into four groups: regulations, economic incentives, information and education programs, and assignment of rights and responsibilities (see Table 2). An effective waste management strategy will combine these instruments, both within and across the four groups, with the appropriate technology. Although many of them have been used only in industrialized countries, they may be relevant in developing countries and are presented to make the reader aware of the options available.

TABLE 2

Public Policy Instruments for Waste Management

Regulations	*Economic Incentives*	*Information and Education Programs*	*Assignment of Rights and Responsibilities*
Ambient environmental quality standards Land-use restrictions and designations, building codes Facility siting, design, operation and performance standards Water and effluent contaminant concentration standards Product content and performance standards Permits, licenses, charters for service providers and users Prohibited practices (bans) Required practices (mandates) Enforcement and compliance measures	User charges (unit- and marginal-cost pricing, flat fees) Taxes, advance disposal fees Deposit-refund systems, refundable sales taxes Differential taxes, tax benefits, product surcharges Performance bonds (contingent charges) Government procurement preferences Public investments Other subsidies Marketable permits Collection systems Fines Linkages (revenue/expenditure, tax/subsidy, deposit/refund)	Labeling requirements (content, hazards, unit costs, impact, recyclability, disposal instructions) Reporting requirements (e.g., annual emissions reports) Itemization of pollution-based charges Public awareness campaigns Training programs	Enforcement programs Public enterprises, enterprise funds Publicly operated or contracted collection services Publicly operated or contracted processing and disposal facilities Metering, monitoring, and billing of service usage Waste management financing programs, revenue bonds Waste management in government operations (e.g., military bases, hospitals, offices, schools) Industrial waste exchange programs Settlement planning Liability assignment

6.2 Regulations

Regulations cover both the basic standards of environmental quality and the measures by which these standards are maintained. (See Bernstein 1991.)

6.2.1 Ambient and Exposure Standards

Waste management must begin with ambient standards for water and air quality and exposure standards for workers and others exposed to environmental hazards. Both must at least be based on accepted international norms and can be expanded to address hazards of local significance. Appendix C gives examples of water quality standards based on U.S. EPA and WHO guidelines. Governments should not assume that standards should be universal. For example, there is no reason why water bodies not used as a source of drinking water should meet drinking water quality standards. In addition, standards may have to be phased in because of resource constraints. Many different combinations of policy tools can be used to achieve these standards, including both regulatory and nonregulatory instruments. However, there is no substitute for the responsibility of government to establish minimum standards of acceptable ambient environmental quality and human exposure to environmental hazards.

6.2.2 Technology-based and Performance Standards

The minimum standards for water and air quality are often implemented by regulations that cover

- design and operating standards for waste management facilities
- effluent standards for pollutant discharges
- land-use controls and facility-siting criteria
- pretreatment requirements for industrial wastewater

Such standards can be codified, applied consistently, and easily enforced, and thus provide clear directions for engineers designing facilities and for local governments investing in them. However, they also have disadvantages. They may be uniform across diverse locations where they may not always be necessary or appropriate; they may require installation of particular technologies that preempt more innovative solutions; and they may be more costly and rigid than other policy incentives that could achieve the same purpose more effectively. Standards therefore must be carefully considered along with alternative policy tools such as economic incentives, labeling, and reporting requirements. Even when they do appear to be the best measures, they must be designed for flexibility and avoid creating unintended incentives for evasion or for unsafe disposal. One way of achieving this is to write the regulations so that they require fulfillment of specific performance criteria rather than the use of particular technologies.

6.2.3 Disposal Restrictions

Restrictions are widely used to prevent dumping and littering, improper disposal of hazardous liquids, poisons, and tires in municipal landfills, and combustion of materials containing toxic metals. However, such restrictions will be evaded unless people find that it is not inconvenient to abide by them. Any disposal restrictions must be combined with acceptable disposal options and effective information and enforcement strategies to ensure appropriate responses to the restrictions.

6.2.4 Product Standards

Product standards, which establish quality levels for particular goods such as paper bags, permit more flexible use of recycled materials. In some countries, virgin-materials content requirements create unnecessary barriers to recycled and recovered materials. Product standards can also be used to restrict toxic ingredients. The European Community, for instance, prohibits non-biodegradable detergents, and many countries restrict the contents of insecticides, herbicides, and fertilizers. Product standards can also be used to ensure the homogeneous content of large-volume products (containers, for instance) so that they can be recycled, and to limit trace contaminant levels that might be hazardous to consumers or waste handlers. Many product standards are developed by voluntary cooperation among producers and distributors; others may be imposed by government mandates; still others may be encouraged by government procurement specifications that create markets for desirable product characteristics.

6.2.5 Mandatory Take-back Requirements

Germany has pioneered the use of take-back requirements that compel manufacturers and retailers of specified products to take them back for recycling or disposal when they are discarded. Some countries require pesticide containers to be recycled. This could be extended to batteries and tires, consumer electronics, and even containers and packaging materials, thus transferring the disposal responsibility and costs back to the producers and distributors and giving them the incentive to plan these costs into product design. Some governments, including U.S. state governments, have introduced more limited take-back requirements for products such as lead-acid automobile batteries (Sinha 1990).

6.2.6 Flow-control Laws

Flow-control laws stipulate that certain wastes must be managed only in specially designated facilities. Denmark and several German states require that all hazardous industrial wastes be treated and disposed of in state-operated facilities where high levels of safety and environmental protection can be maintained. Where such facilities exist, can be afforded, and are effectively regulated and monitored, they offer potential for high levels of environmental protection. In many developing countries, however, they could create monopolies that breed inefficiency or corruption, without providing commensurate benefits in greater safety and environmental protection.

6.2.7 Procedural Requirements

Regulatory policies may also be used to introduce a systematic administrative process for wastewater and waste management. Regulations such as planning requirements can be used by national and regional governments to encourage professionalization of municipal waste management systems, and mandatory waste reduction and recycling standards can serve as incentives for design of such plans.

Malaysia, for example, has adopted a national policy intended to establish a solid waste management system that covers all local authorities by 2010. This policy includes

- strengthening the capabilities of local authorities to provide efficient and effective solid waste management services
- adopting regional approaches wherever applicable
- preparing long-term municipal solid waste management plans, with periodic revisions for all urban centers
- ensuring that all municipal systems protect public health, the health of workers, and environmental conditions, and provide technically and financially viable management systems
- holding generators in rural areas responsible for disposal that meets national standards of sanitation
- reducing waste generation, especially of packaging and household chemicals, in cooperation with producers, distributors and consumers
- treating municipal solid wastes as resources to be recovered and recycled where most of them now are burned or buried
- operating municipal solid waste services on a self-financing basis, supported by user charges or other methods
- encouraging private sector involvement in solid waste management, especially as contractors and management consultants
- promoting cleanliness and resource recovery through both public awareness campaigns and strict anti-litter enforcement
- identifying and reserving land for future waste disposal sites by local authorities with the assistance of state and regional governments
- strengthening research and development on waste management.

6.3 Economic Incentives[5]

The second group of policy instruments are economic incentives, actions by which governments can alter the attractiveness of choices for wastewater and waste management by individuals and businesses. Incentives can be designed to finance services, support enforcement programs, and increase waste reduction and recycling by the creation and maintenance of markets for recycled materials. At the same time, they can create undesirable effects. An increase in the cost of legal disposal, for example, may encourage unsafe disposal unless there are strict littering restrictions or other countermeasures to prevent this. Also, since the impacts of waste streams are interconnected, solving one disposal problem may unintentionally worsen others, and reducing wastes at one point in a material's life cycle may only increase them at another. A number of widely used incentives are discussed below.

6.3.1 Fines and Financial Penalties

Fines and financial penalties are the usual incentives to stop unsafe disposal, littering, and other violations of waste management standards and regulations. But in many countries they are frequently ineffective, either because they are too small to matter or because the government is powerless to enforce them efficiently. The ability of governments to enforce regulations is discussed more thoroughly in Chapter 7.

6.3.2 Emission and Disposal Charges

Emission charges, based on the characteristics and quantities of wastewater effluent or discarded materials,[6] can be levied either at a flat rate or a per unit basis, with higher rates for discharges that are toxic. They have been implemented in many countries, including most OECD countries, China, and some eastern European countries.

In principle, emission charges are a source of revenue and an incentive to minimize waste generation. To be effective as an incentive, they must be based on metered flows, not simply flat rates; they must be billed to individual households or waste generating units, not simply to the owner of an apartment complex or to the general overhead account of a business; and they must be set higher than the marginal cost of pollution abatement. If they lack this last feature, as often happens, the fees serve merely as a modest source of revenue.[7]

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[5] Material in this section draws extensively on OECD 1991 and Bernstein 1991.

[6] For more detailed discussion of existing charge systems and their strengths and weaknesses see OECD (1989), pp. 33-74.

[7] In China, for instance, 80 percent of the proceeds are allocated to an earmarked environmental improvement account to finance wastewater treatment facilities (Robert Bohm, *UTN Waste Management Research and Education Institute*, Winter 91 4/4 newsletter), similar special-purpose funds exist in the Czech Republic. Proper allocation criteria must also be used for investments from such funds, which also does not always occur.

Disposal charges are also an economic incentive. Simple charges, called tipping fees, based on weight or volume are now widely used for solid waste in most OECD countries. More sophisticated systems, adjusted for toxicity or other characteristics, are less suitable for solid waste than for wastewater management because of the greater variety of both generators and composition in solid waste. Such charges work best when they are targeted to dischargers who cannot easily evade them, such as small numbers of polluters whose hazardous waste streams are large but relatively homogeneous. The charges can be based on the special handling costs of these specialized waste streams and the imputed costs of their environmental damage.

6.3.3 User Charges

User charges, a broadly applicable form of disposal charges, differ from effluent charges in that they are more closely associated with actual costs and provision of treatment services. They can be assessed as a flat periodic charge (for instance, weekly or monthly), as a variable charge based on amounts collected, as an *ad hoc* fee paid directly to the collector, or as a tipping fee paid at the point of disposal. Product charges, as for standardized waste collection bags or required tags, can also be used as a proxy for user charges (see discussion below).

In developing countries, where municipal governments often spend up to 50 percent of their total budget on solid waste management, user fees can improve their revenue base and increase the sustainability of their systems. Where desired, user fees permit cross subsidization, by which high-income neighborhoods (which usually enjoy a higher level of service) pay more than the marginal cost of service to offset the cost of service in low-income areas.

User charges are an effective mechanism both for paying the costs of solid waste management and, to the extent that acceptable options are available, for encouraging waste reduction and least-cost management. Most effective are per-unit charges based on volume or weight for wastes with reasonably similar characteristics such as household wastes; higher charges can be set for materials that cause problems.[8] It is essential, however, that any system of charges be backed by effective enforcement measures against unsanitary dumping and littering.

There are four questions that must be addressed in setting user charges. The first is their purpose and level. If they are intended not merely to pay for the cost of service or to generate revenues but as an incentive for waste reduction or recycling, it is necessary to determine how high they should be set to be effective. The costs of acceptable alternatives and the costs and effectiveness of enforcement programs must be estimated to ensure that waste generators do not simply turn to cheaper but unacceptable methods of disposal.

The second question is the balance between what is desirable and what is administratively practical. In theory, the charges should reflect the costs of treatment and damage from each

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[8] See *e.g.* U.S. Environmental Protection Agency (1991), a useful review of economic incentives for environmental protection Pp. 2-7 through 2-12 describe unit-pricing initiatives; pp. 2-13 through 2-17 describe higher-fee programs for management of scrap tires.

of several types of pollutants, but in practice such a system would be too complex and costly to implement and enforce.

The third question is the purpose for which the revenues are intended. If they are intended to meet the cost of service, they should be earmarked for wastewater or waste management (treatment, composting, recycling, and enforcement). There is always the possibility, however, that they may be diverted to other purposes or jurisdictions for political reasons. Consideration must also be given to the extent to which charges paid by some users (the more affluent or businesses) should be used to subsidize others (low-income users or households generally), either as a matter of redistributive equity or as a practical necessity for the protection of public health and sanitation.

The fourth question with user charges is their enforceability. The normal penalty for nonpayment is a cutoff of service, which is easy if the user fee for wastewater or waste management is charged on the electricity or water bill. But if electricity and water are provided by national or regional utilities and solid waste collection is charged on its own, a cutoff of service would simply defeat the purpose of controlling sanitation and possibly violate the government's responsibility in that regard.

6.3.4 Product Charges

Product charges are imposed on products responsible for increasing the costs of waste management or environmental damages. Some countries have levied charges on identifiable high-impact water pollutants such as detergents, fertilizers, and pesticides. Others have levied them on products that cause special management problems or environmental hazards in landfills, such as tires, fuels and oils, fertilizers, and pesticides.

Product charges can be levied as sales taxes at the point of manufacture or sale. They can also be differentiated by concentrations, and in some cases they can be used as a proxy for emission charges. One use of product charges is as a surrogate for disposal fees, for example, by requiring that all wastes be disposed of in specified bags, or bags with official charge stickers, sold at a price reflecting the average or marginal cost of waste disposal.

A second use is as a surcharge or advance disposal fee levied on products that present particular problems or hazards in disposal. Revenues from these charges (like other product charges) can then be redistributed proportionally to the organizations that provide waste management services for these products.[9] This charge is particularly suitable for high-volume products with short-term use (for instance, packaging materials and nonreturnable containers) and problematic or toxic products with a long life (for instance, tires and automobile batteries). Examples of product charges are those on nonreturnable beverage containers in Finland, on plastic bags in Italy, and on lubricating oils in France and Germany. Product charges are

[9] An example is special sales tax surcharges on tires by some U.S. states, which use the revenue for scrap tire management programs.

especially useful as a source of revenues to finance extra services for problem wastes; their value as an incentive, however, depends on the availability and relative prices of substitutes. In general, product charges have moderate potential for improving waste management and high usefulness for waste management of a few key problem products. For example, Norway and Sweden impose them on fertilizers and pesticides to reflect the adverse impacts of these products on water quality. Here, too, the issues of revenue versus incentive and of revenue uses are important. Product charges will reduce consumption only of products whose price elasticity is high relative to the availability of cleaner substitutes; otherwise the charges will simply be a new source of revenue. Such charges also should be allocated specifically for wastewater or waste management, and imposed only on a few products with relatively uniform characteristics and severe environmental impacts. It would be administratively impractical to impose them on a large number of products or on products whose contents differed widely.

6.3.5 Deposit-refund Systems

Deposit-refund systems, under which the consumer pays a product charge that is refunded upon return of the used product, are most widely applied to recyclable beverage containers. They are also applied to pesticide containers, automotive and appliance batteries, tires, and even car hulks. Sweden, for example, levies a refundable deposit equivalent to about US $50 on each new car; Norway has a similar program (see OECD 1989: 82-88). Maine and Rhode Island operate deposit-refund systems for lead-acid automobile batteries, charging $10 and $5, respectively; deposit-refund or recycling credit systems have also been proposed for used oil (see USEPA 1991). Deposit-refund systems are very effective for a few large-quantity, relatively homogeneous products that are easy to collect and have a recyclable value (such as beverage containers).

6.3.6 Tax Differentiation

Differential tax rates can be charged on products that have different environmental impacts. For instance, government can assess a higher tax on a polluting product and provide a tax benefit for a less-polluting alternative. The Netherlands, Norway, and Sweden, for instance, charge differential tax rates on automobiles depending on their air pollution characteristics and on whether they use leaded or unleaded gasoline (see OECD 1989: 69-72). Tax differentiation systems, like many other economic incentives, can also be designed to function purely as incentive systems (that is, as revenue-neutral instruments). Their main limitation, as with many of the other instruments described here, is the complexity of applying them on an item-by-item basis to more than a few high-priority products.

6.3.7 Marketable Permits

Marketable permits enable dischargers of wastewater or wastes that are costly to control to pay instead to clean up discharges from other sources that could achieve the same degree of environmental protection. Marketable permits have been most widely used to reduce air pollution, but can be used to reduce water pollution as well. An example is trading cleanup investments among point sources of water pollution, such as industries and municipal treatment plants, or between point and nonpoint sources, such as treatment plants and agriculture (see OECD 1989:88-100; Hahn and Hester 1989). Marketable permits are less useful for solid waste management because of the complexity and variability of solid waste discards.

6.3.8 Subsidies

Subsidies are often used to promote investments in wastewater treatment or waste management facilities, either through public investments or through private tax concessions such as tax credits, accelerated depreciation, and special tax relief. However, they tend to distort incentives for proper waste management and therefore should be used only to reduce important risks whose correction would otherwise impose severe financial hardship. Capital investment subsidies may also be wasted if they are not linked to financially viable systems for paying operating, maintenance, and replacement costs (see OECD 1989: 74-82).

Two types of subsidies related to the creation and maintenance of markets for recycled and recovered materials are appropriate for solid waste management. One is procurement price preferences for recycled materials, which help to create and stabilize markets for these materials and thus to promote private investment in reprocessing facilities at appropriate economies of scale. The other is direct or tax subsidies for the development of such facilities. In both cases, the subsidies are justified so long as recycling costs less than using new materials and disposing of the waste materials in other ways (such as landfilling, composting, or incineration).

Withdrawing subsidies is another policy option. When water is priced at market rates, conservation reduces the volume of waste flows and increases the volume of higher quality, natural stream flows.

6.4 Information and Education Programs

The third group of policy instruments are information and education programs, which meet two types of needs: horizontal information needs, and vertical information and aid needs.

Horizontal information needs are those for information exchanges among developing countries. Traditionally, most technology transfers to developing countries have been from developed countries and often have been inappropriate to local conditions. Because there are significant social, cultural, economic, and religious similarities shared by many developing countries, such as those in South America, a more appropriate exchange would be among these countries themselves (Sakurai 1986). This would apply in exploring solutions to waste management problems.

Information and education cover campaigns to increase public awareness and technical training programs for those who must manage wastewater and solid wastes. They also include the use of labeling and reporting requirements as incentives for safer and more effective management practices.

Vertical information and aid needs are those for information and aid from industrialized countries, an essential component of any successful effort to assess, establish, or implement pollution management policies and programs. There is a profusion of available information. The challenge is to seek out what is useful and provide it in usable form to the right people.

6.4.1 Awareness and Training

Water users, wastewater dischargers, and waste generators can all benefit from adequate information and awareness in the management of solid waste and wastewater. Economic incentives provide important information in the form of price signals, especially when user charges are assessed on a per-unit basis and are clearly itemized, so that individuals can alter them by changing their own behavior. But campaigns are also needed to publicize and market low-cost technologies for water conservation, leakage reduction, and wastewater improvement.

Public awareness programs can also be used to promote recycling, waste reduction, and sanitary disposal practices, and to organize cooperative waste separation, collection-transfer stations, and neighborhood clean-up activities.[10] Many informed observers agree that a shared public commitment to improved waste management at the neighborhood level is a crucial factor in its success. In developing countries, groups that typically have weak or nonexistent ties to local officials but are important to effective waste management and thus are suitable targets for public awareness programs are:

- residents of peri-urban fringe areas, where sanitation is often most problematic and services most lacking
- women, who are the real generators and managers of wastes and are also responsible for their families' health

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[10]Several experiments in community participation have been documented for improving collection of wastes in peri-urban areas where motorized collection services cannot be provided (Sakurai, 1986). In Tijuana (Mexico) and Valparaiso (Chile), for example, residents bring their refuse down to communal containers at the foot of the hills; in Rio de Janeiro (Brazil), open ducts and in some places aerial cableways are provided on the slopes for this purpose. In Nigeria, every month there is an "Environmental Sanitation Day" during which all garbage on streets is removed and empty lots are cleaned; no cars or trucks are allowed unless they are involved in sanitation activities, no commercial activities are open, and all people visible in public are supposed to be busy cleaning up or they may be fined; all owners of trucks are expected to offer their vehicles, with drivers, for sanitation activities. This project is reportedly quite successful.

- scavengers or waste pickers, who in many countries operate informal businesses for waste reuse and recycling but under highly unsanitary conditions.[11]

Another important target is local public officials themselves, who often perceive sanitation as a problem mainly for illegitimate squatter settlements in peri-urban fringe areas, and accordingly as a matter of low priority. But the residents of peri-urban areas often work as maids, vendors, waiters, and in other employment in the city, and their health is important not only for them but for the whole city.

A particular informational need is technical assistance on waste minimization for small- and medium-scale industries and businesses, including informal sector operators, who do not have the requisite expertise.

6.4.2 Reporting and Labeling Requirements

Reporting and labeling laws require documentation and disclosure of information necessary for effective wastewater and waste management. Reporting requirements can be established for wastewater and waste disposal facilities, collection service providers, and revenue assessment agencies to provide information on flows of materials and costs to monitor the efficiency and effectiveness of the waste management system. A recent innovation is emissions reporting, such as that mandated under the U.S. Toxics Release Inventory, which requires every firm that discharges more than a specified amount of some 200 toxic chemicals to make an annual report. This information is used by emergency services personnel and public health officials to plan for potential hazard control; but it has also created public pressure on companies to manage their wastes more safely, and has led business executives themselves to question the amount of costly materials they are wasting each year.

Labeling requirements can be used to guide and influence consumers in their purchases. Examples are labels identifying recyclable products by content type (such as recyclable containers and different grades of plastics); labels identifying hazardous content and giving special instructions for use and disposal (such as pesticides and household chemicals); and labels identifying other factors that could influence consumer decisions (such as advance disposal fees or deposits included in the product price, and recycled-material content). Itemization of all waste management charges, especially variable ones, is essential in any incentive system to promote efficient waste management.

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[11] For examples of innovative pilot projects in formalizing scavenging and waste-picking operations, see *e.g.* Furedy (1990).

6.5 Assignment of Rights and Responsibilities

The fourth group of policy instruments pertains to the terms and conditions under which public agencies, contractors, and private organizations provide waste management services.

6.5.1 Public Sector Responsibilities

Even in predominantly free-market economies, governments frequently are responsible for providing wastewater and waste management services, either directly or through contractors. These include both collection and treatment services to businesses and households, and to military bases, hospitals, schools and universities, and other public enterprises. Governments also take actions for other purposes that can either aid or hamper wastewater and waste management. Examples include the planning of settlements and land uses, reserving or failing to reserve sites for disposal facilities and transfer stations, and promoting economic development and industrial recruitment. These policy initiatives are often more important to local officials than improving sanitation itself, and particularly in developing countries, therefore, it is essential to ensure that wastewater and waste management are integrated into these policy initiatives.

6.5.2 Private Sector Participation

Private sector participation in waste management has become popular in recent years and has been encouraged by international agencies. Policy changes are usually unnecessary when the private sector takes over billing or meter reading, but would be required when public assets are turned over to private companies as in the current privatization of the Buenos Aires water utility. The legal protection that private companies demand is something that only governments can provide. Private sector participation is discussed more fully in Chapter 7.

6.5.3 Liability Principles

A different rearrangement of property rights occurs when the government defines the boundary between the right to discharge wastes and the right to be protected from pollution and environmental harm. Those who have a legal right to protection can then bring action against the polluters to compel them to correct the violation or to pay compensation. Government itself may exercise this right on its own behalf or on behalf of the victims. Polluters are thus held liable for damages caused by their emissions and waste disposal practices, and are deterred by the potential cost of judgments against them.

Where the law permits, damages can also be recovered for unsafe disposal by waste generators or waste management facilities, but this makes sense only against large organizations with sufficient economic assets. Law suits can also have unintended side effects. The introduction of strict joint and several liability for abandoned hazardous waste sites in the United States, for instance, has caused many industries to be far more careful in the disposal of new wastes, but it has also led to expensive lawsuits by parties seeking to avoid or reduce financial penalties or to force others to share the cost.

Performance bonds are a simple way of providing contingent liability to ensure safe waste management by private contractors. The firm deposits a specified sum that is returned if the firm fulfills its obligations. If it fails to do so, government can forfeit the funds.

6.6 Concluding Comments

Several conclusions may be drawn from studies of wastewater and solid waste management strategies in developing countries. Programs that are heavily reliant on foreign expertise and foreign exchange, that institutionalize "command-and-control" and "end-of-pipe" control strategies, and that depend on formalized judicial and administrative methods of dispute resolution are unlikely to be effective. In contrast, processes that integrate environmental and economic planning activities, selectively borrow from external sources while cultivating indigenous skills, avoid pollution to begin with, and rely on self-enforcement through a combination of outright prohibitions and market incentives will increase the likelihood of achieving environmental protection. Strategies and policy tools that limit the rate of growth of demand for waste management services, such as reducing waste generation at the source, should precede decisions about the size and cost of facilities.

This chapter has outlined four broad groups of policy instruments that can be used to develop an effective wastewater and solid waste management strategy. Developing countries for the most part have limited experience in applying these policy instruments. Yet as governments and international agencies increasingly realize the need to make the most of scarce financial resources, it is to these instruments that they will turn. With growing experience they will learn which instruments or combinations of instruments are likely to be most effective in a given situation.

The next chapter discusses the capabilities of institutions. They are presented last since technologies and policy instruments cannot be applied without them.

6.7 Hints and Guidelines for Selecting Policy Instruments

The selection of policy instruments requires not only awareness of the possibilities, but also a well-designed process for generating understanding, acceptance, and rapport for a workable combination of solutions. The selection process should be guided by two principles:

- The incentives offered by policy instruments, whether positive or negative, should be strong enough to have significant and purposeful effects on wastewater or waste management, and should avoid introducing significant new undesirable side effects.
- The benefits of these instruments will be only as great as the commitment of the key stakeholders—government, businesses, households, and service providers—to adopt and use them to solve wastewater and waste management problems.

Some questions to be asked in the selection of policy instruments follow.

Local Public Officials

Data on Wastewater and Wastes

- What factual information can be obtained about the quantities, composition, and sources of wastewater, general municipal wastes, and industrial hazardous wastes?
- How detailed is the breakdown by materials and characteristics (e.g., moisture content, contaminant concentrations)?
- Is information disaggregated by geographic areas or neighborhoods? By seasonal variation and over time?
- How recent are these data? How were they collected? Which of them are collected and monitored continually (e.g., weights of materials disposed of in official landfills)? Which only in ad hoc studies?

Standards and Regulations

- What standards (national, state, and local) exist for protection of ambient air and water quality from wastewater discharges and waste disposal? For sanitation? For human exposure to waste-related toxins, pathogens, or vectors?
- Are programs prescribed at the national or state/provincial level?
- What standards, regulations, permit requirements, or other policy mandates exist for wastewater collection and treatment services? For waste collection and treatment, storage, and disposal facilities? Are there separate restrictions for hazardous industrial discharges and wastes? What regulations if any deal with the siting of facilities? With their design? With their ongoing operations, monitoring, and management practices? With their continued economic viability?
- What requirements are there for record-keeping and reporting by wastewater and waste management facilities?
- Who implements and enforces these requirements, and how effectively are they enforced *(to be asked of all stakeholders)*?
- Is legal authority adequate for enforcement, or is the lack of it a hindrance to implementation and enforcement?
- Who (if anyone) is liable for any public health hazards or environmental damage resulting from wastewater or waste management activities? Are these liability provisions actually enforced? Why or why not? What actions can victims take to invoke this liability? Are there examples of recent successful demands for compensation?

- Are wastewater and waste management considerations factored into any other policy sectors? Land use and transportation planning? Tax policies? Economic development strategies? Budgets for health education?
- What groups have important roles and stakes in wastewater and waste management decisions, and how can they be persuaded to participate constructively in defining the issues, developing possible solutions, and putting them into practice? *(Probe for and involve functionally important but marginalized groups; for instance, indigenous networks and leaders in peri-urban settlements, women, waste picker and scavenger networks.)*
- Is privatization of some services an option? Which are these?

All Stakeholders, as Appropriate

Economic Incentives

- Who pays whom for wastewater and waste management services? How does this vary by sector (commercial, industrial, institutional, residential)?
- In what forms are these payments made? General taxes? Earmarked or special-purpose taxes such as levies on particular products? User fees or charges by private haulers? At what rates? How are these rates determined?
- Do existing pricing mechanisms create any incentives or disincentives for proper waste management?
- Are costs differentiated by weight or volume of wastes, by waste characteristics, or any other factor? On what basis are they billed or assessed?
- What are the approximate costs per household for wastewater and waste management? Per business? What are the costs and revenues to the municipality itself, and to the organizations responsible for wastewater and waste management?
- What is the approximate cost per ton of household waste to the responsible management organization? Of commercial waste? Of industrial hazardous waste?
- What fraction of this management cost is for collection, for treatment, for disposal, and for administration? For labor, for capital equipment, for operation, maintenance and replacement, for treatment facilities and disposal sites? For compliance with environmental quality standards?

Information and Education Programs

- What information or education programs now exist for wastewater and waste management? What are their goals, target audiences, and levels of effort? What are they achieving?

- Are there any public awareness programs? At what groups are they targeted? Communities? Public officials? Large waste generators?
- Are there any reporting and labeling laws? Are they effective?

Consultant/Analytical Team and Other Outside Sources

- What policy actions by higher levels of government, beyond the authority of the municipality in question, could significantly help in improving local wastewater and waste management?
- Standardization of product labeling, container content, or other characteristics? Wastewater or waste planning, record-keeping and reporting requirements for local governments?
- Will the policy instruments under consideration serve the most vulnerable populations, or merely those that are easiest or cheapest to serve or have the greatest ability to pay for services?
- How much and how reliably will they reduce the most serious risks, and at what cost compared with other options?
- What new risks might each option introduce? How can these be minimized? How do they compare with the risks of other options as well as existing conditions? (For instance, by collecting and moving wastes to a different site do they simply reduce risks to one population at the expense of another?)
- Which policy options will be most effective in reducing waste at the source? Minimizing leakage and wasteful use of water? Substituting less hazardous products and materials for toxic ones? Reducing excessive and single-use packaging, and making products more durable?
- Which options might help to develop markets for recycling and reuse of water and solid waste, either in their existing form (such as some containers) or after reconditioning or reprocessing?
- Which policy options appear to contribute most to the efficient operation of waste management services, such as collection and treatment and disposal? To the most efficient use of all resources, including both the materials and energy being managed and the human and capital resources involved in managing them?
- Which policy options appear to contribute most to fair sharing of the benefits, costs, and risks of wastewater and waste management services?

GLOSSARY

Flow-control laws. Laws stipulating that certain wastes must be managed only in specially designated facilities.

Horizontal Information. Information exchanged among countries with similar characteristics and at a similar stage of development.

Marketable Permits. A system under which generators of waste that is costly to control can trade to pay for cleaning up discharges that are cheaper to manage.

Policy Instruments. Measures, such as regulations, incentives, and information campaigns, by which government policies are implemented.

Product Charges. Charges imposed on products responsible for increasing the cost of waste management.

Product Standards. Quality levels for products, as developed by agreement among manufacturers and distributors or imposed by government mandate.

Tax Differentiation. The use of differential tax rates on products according to the environmental impact they have.

Vertical Information. Information transferred from the industrialized countries to the developing countries.

7

ASSESSING INSTITUTIONAL CAPABILITIES

7.1 Definition of Institutions

Institutions for purposes of this assessment mean organizations and the links among them that make up interorganizational arrangements.

Improvements in wastewater and solid waste management require action by institutions, which use policy instruments and technologies to effect change. Even the best policy instruments are of little avail without an appropriately crafted institutional arrangement to manage the process of change through careful monitoring and enforcement and the provision of channels for feedback. Technologies also require the institutional capacity to plan, construct, operate, and maintain them and the ability to finance them initially and over the long term.

Institutions are considered in this chapter as agents of change. The most obvious point of change is in reducing the impact of polluting activities. However, institutions can also be useful in the policy process. It is important to consider a broad range of institutions that may be available to assist. They may be public or quasi-public organizations at the national level, like government ministries; state, regional, or local agencies; parastatal units or public enterprises; and donor organizations. However, an institutional assessment should also consider institutions outside the public sector, organizations with nonbureaucratic structures, interorganizational patterns (Honadle and Cooper, 1989), and institutions not currently engaged in combating pollution but with the potential to make a contribution. Schools, health clinics, and the media are examples of this last category. The question is how analysts might identify the best institutions to help in the solution of wastewater and solid waste problems. The approach to assessing institutions is to identify those of interest in a particular setting and then determine which of them are likely to be useful in dealing with the most pressing problems.

7.2 Types of Institutions

The two levels of institutions to look for are the organization of the sector itself and the discrete organizations within the sector.

The term "sectoral organization" refers to the tier where policy and interorganizational arrangements affecting overall wastewater and solid waste management are developed. Dealing effectively at this level requires that the sector itself be structured to set policies, plans, define jurisdictions, and manage financing and implementation. Thus, one aspect of institutional assessment is to see whether the sector itself is well organized to deal with the range of functions that must be accounted for.

It is important to determine whether there is an effective forum for the wastewater and solid waste sector as a whole. The major sector tasks are setting policies, planning, financing, and ensuring the implementation of programs. The organization of the sector is important for its impact on policy making, and an assessment team needs to discover if there is a significant institutional presence competent to carry out the wide range of sectoral responsibilities.

Organizations within the sector, the second category that should be considered in the assessment, are regulatory, service-delivery, public health, educational and informational, advocacy, and financing institutions.

7.3 Regulatory Institutions

Regulatory institutions develop and enforce rules, regulations, and sanctions for compliance with wastewater and solid waste management policies. They can be highly effective in dealing with problems at more than one point in the pollution cycle (see Bernstein 1991). The more pressing the perceived pollution problem, the greater the temptation to intervene at the point of discharge; however, the largest long-term payoffs come from lessening the production of polluting materials in the first place.

Where controls are imposed at the point of discharge, regulation is likely to be cost effective for more concentrated waste streams. And no matter what the target, the less regulatory efforts conflict with norms and the less behavioral change they require, the more likely they are to succeed. Indeed, one of the most cost-effective regulatory options is negative regulation: removing impediments that restrict the ability of targets to deal with waste management problems.

Even under otherwise ideal circumstances, effective central regulation requires several institutional features that may not be present in sufficient strength in a developing country.

7.3.1 Government Regulators

Generally, water pollution is regulated at the national or provincial level, while solid waste is regulated at the district level. But no matter at what level, government regulatory organizations have a substantial impact only if a number of requisites are in place. One of the most important is that the regulatory institution should have sufficient authority. This is most likely to happen when it is established with a specific regulatory mandate, like an environmental ministry. However, when the institution entrusted with regulatory functions is weak, other government institutions—with an acceptable jurisdictional fit, adequate resources, and perceived authority—should be considered.

While authority is derived from formal jurisdiction, it is also influenced by the size of resources and the quality of personnel. It is difficult to say precisely what staff or budget should be considered adequate, but it should be easy to determine if existing regulatory institutions are the size and quality needed. Regulatory units in some countries, for instance, are little more than small staffs in offices in the capital city. Effective regulation is impossible without analysts, a monitoring and enforcement staff, and a field presence.

7.3.2 Nongovernment Regulators

Technically speaking, regulation is a government function. But nongovernment organizations sometimes fulfill the function by agreement among themselves, as when manufacturers or large dischargers decide to limit pollution or households take responsibility for reducing threats to the environment. Neither constitutes regulation in the narrow sense, but both illustrate the assistance that nongovernment bodies can render.

Typically, this kind of self-regulation by large dischargers is encouraged by an industry or business association. It may also be encouraged by government. Although rules adopted by associations may be prompted by self-interest, they frequently are able to reduce pollution in cost-effective ways. However, restrictions on manufacturing processes affect different firms in different ways and may constitute a more subtle form of competition.

Self-regulation by individuals or households is often accomplished through cooperatives. If they are able to influence the polluting or water-consumption behavior of their members, they can be of special importance. They are also useful in service delivery, as explained later.

7.4 Service-Delivery Institutions

Regulation is of little help without adequate institutional support for service delivery. A careful assessment should consider standard public service delivery as well as informal institutions and should not overlook interorganizational relations.

7.4.1 Standard Public Service Delivery

Wastewater treatment and the removal of solid waste are usually municipal functions, although some developing countries have national or regional authorities responsible for these or may offer technical assistance from the national government.

Services for wastewater treatment are provided by several types of public organizations or clusters of them. The institution may be a government department or a parastatal unit responsible for wastewater (or water and wastewater) services, or it may be integrated with other infrastructural functions. There is no single best way of organizing such services. Structures that are functionally integrated can sometimes take advantage of economies of scale and greater planning potential but lose a clear focus on water. The needs and priorities for service delivery must be considered in the specific context in which they occur.

There are a number of variables in determining the institutional effectiveness and efficiency of the typical structures for service delivery: institutional autonomy, leadership, management and administration, commercial orientation, consumer orientation, technical capability, ability to develop and maintain staff, organizational culture, and quality of interactions with key external institutions. Standards of measurement for these performance indicators have been established for several developing countries in which public wastewater services were examined (see Cullivan et al. 1988).

Realistic judgments must be made about institutional deficiencies, which often are related to resource shortages or politically imposed constraints. For instance, for political reasons, leaders may favor capital investment in new projects over adequate maintenance of existing facilities, despite the efficiency advantages of the latter. Another constraint often found is an attitude that declines to consider simpler technologies for wastewater treatment. Agencies staffed by technical specialists trained in advanced wastewater treatment methods will cling to these even if they are impractical or unaffordable.

Solid waste services in developing countries are conditioned by the high organic content of the waste combined with the high temperatures that generally prevail. This means that frequent collections are more important than technology for compaction, which in any case is impractical with the denser wastes. In crowded urban areas, solid waste is best handled by a service able to collect waste from many households and transport it to the disposal site efficiently. Therefore, a fleet of small vehicles is more appropriate than some sophisticated solid waste technology (see Cointreau 1987).

Many of the institutional difficulties of regulatory agencies discussed earlier apply here as well. Both solid waste service delivery agencies and wastewater treatment units may be unsuccessful in retaining a skilled and motivated workforce. In Bangkok, for instance, sanitation workers spend much of their time retrieving usable materials before disposing of waste because profits from recycling are approximately equal to their salaries (see Cointreau 1987: 548). Thus, applying efficiency standards valid in the industrialized countries would be inappropriate, and addressing such matters as wage scales would be more relevant to improvements in standard service delivery.

Other institutional difficulties also stem from a scarcity of resources. Chronic maintenance problems preclude regular, reliable collection of refuse, although these problems are often attributable to political choices rather than resource scarcity. Irregular collections in turn lead individuals to seek less sanitary, alternative methods for the disposal of wastes.

Service-delivery institutions, too, may require community support. Such tasks as collecting tariffs or stopping leaks in sewage systems are made easier with help from a population that views the service unit with favor rather than as an unresponsive bureaucracy. Also, it may be important to identify service-delivery institutions at the level of government responsible for enforcement of related regulations. An additional point is that standard institutions for solid waste disposal may have opportunities to cooperate with parts of the informal sector.

7.4.2 Informal Sector

Because solid waste disposal in the developing countries yields recoverable materials of value, it attracts well-organized informal participation by groups seeking an income. Thus, in cities like Cairo, scavengers handle a substantial portion of the solid waste operation, albeit in unsanitary ways.

Sometimes standard delivery services and the informal sector work together. In Ecatepec, Mexico, scavengers are registered with the city for the right to search for recoverables at the disposal site, and city workers organize their dumping routines to protect them from infectious or hazardous wastes. Needless to say, managing relations between the city agency and scavengers requires uncommon care and sensitivity.

7.4.3 Nongovernment Organizations

Nongovernment organizations (NGOs) do not usually feature in service delivery, but they should be considered when standard government-provided delivery systems are unsatisfactory. The most appropriate can obviously be identified only in a particular context; they should be respected and reasonably effective in what they do. With NGOs as with other institutions, it is important that organizational capacity, skills, and other resources should match the service-delivery needs to be met.

7.4.4 Private Sector Participation

Private entrepreneurs provide wastewater and solid waste services in expectation of a financial return and thus look for favorable conditions: attractive markets, regular revenue, political stability, a helpful business environment, and minimum risks. There are several methods of private sector participation (see Cullivan et al. 1992: 39-40):

- Divestiture of Assets. The government transfers its ownership of wastewater and solid waste facilities and gives the private party exclusive rights to, and responsibilities for, service delivery.
- Concessions. The government awards private concessions for all phases of new service.
- Management Contracting. Private contractors take over the operation, maintenance, and repair of publicly owned facilities, usually for a short period.
- Service Support Contracting. Private sector participation is limited to providing such services as billing.

The differences among these forms of private sector participation are important when officials are seeking the most appropriate one with which to match objectives (see Donahue 1989). Not all of them merit discussion here, but a few can be briefly reviewed.

One purpose in using the private sector is to attract capital for the development of an infrastructure. Investments will be made, provided the firms are sufficiently compensated. Bargains can be struck so that large capital projects are constructed without any drain on the public treasury. Costs usually are passed along to consumers or potential consumers. However, certain precautions are necessary because private sector involvement may result in service for those who can pay and the neglect of poorer sections of the community. Projects that appear attractive from the viewpoint of the government may impose substantial long-term costs on a population.

Another private sector role is the operation of a wastewater or solid waste system under contract with the government. Private expertise may achieve some gains in efficiency, but except in very small localities or where operations are unusually inefficient, contracting is not likely to bring dramatic results. The number and quality of private firms are important. If there is no competition, privatization may merely substitute a private monopoly for a public one, with little gain in efficiency. Competition tends to produce savings and its absence tends to mean negligible efficiency advantages.

In solid waste, there may be untapped markets for private enterprise in recycling and recovery. Helping to create such markets, or at least removing impediments to their operation, may be worthwhile. Another private sector role is management or management consulting.

Satisfactory private sector participation is contingent on competent public sector oversight. There should be careful attention to the terms of contracts and the service areas and responsibilities they cover, contract duration, ownership and maintenance of physical assets, penalties for nonfulfillment, and competitiveness in the contracting procedure itself. A competitive market for service provision is likely to need less attention than one organized on a public utility model, which may require regulation to prevent monopoly profits and service deterioration. In fact, the privatization of a water company will not necessarily lower costs but will shift the responsibility for cost recovery from government to the private sector. Public decision makers should also avoid arrangements that entail excessive long-term costs.

7.4.5 Self-Organized Arrangements

In addition to public, NGO, and for-profit arrangements for service delivery are institutions organized by the members of a community themselves. The most obvious candidates are strong, well-respected cooperatives able to perform several waste-related tasks: encouraging compliance with regulations, monitoring violations and perhaps enforcing penalties, constructing and maintaining appropriate technology and training the population in its use, and collecting solid waste. A community that perceives waste management as a matter of self-interest, is willing to give a cooperative unstinted support, and is committed to long-term participation is more likely to benefit from a self-organized arrangement.

7.5 Public Health Institutions

Public health institutions assist not by reducing or removing waste but by protecting people from its ill effects. They include ministries of health, community-based health organizations, health-related NGOs, and hospitals and clinics. They are essential in combating a crisis like a water-related epidemic and serve as agents of change in educating people to alter their polluting behaviors. They serve to insulate people from unsafe situations.

7.6 Education and Information Institutions

Education and information institutions are also worth attention in an assessment. They include schools and training centers, public health educational networks, media organizations, and sections of government ministries. These institutions can improve popular understanding of the importance of wastewater and solid waste management, encourage people to act out of self-interest as well as for the common good, explain the significance of official injunctions, and inform them of the options at their disposal.

In turn, public participation is best assured when individuals who produce waste know that their views are taken into account in decisions on sanitary disposal methods, and this makes management more effective. Education and information organizations are valuable when they convey accurate and understandable information on problems and solutions, pay heed to public concerns, tap existing action networks, instill respect for conservation and the environment, and are realistic about socioeconomic and political constraints.

7.7 Advocacy Institutions

Advocacy institutions are another type of organization that should be considered. They promote policy innovations or social changes for the welfare of certain segments of society, and use publicity, community organization, and political activism to press their agenda. They frequently exploit their connections with individuals in important positions, including public officials sympathetic to their cause.

Advocacy institutions are rarely involved in the details of service delivery or regulation and few are primarily concerned with environmental matters. Nevertheless, some of them may find that publicizing wastewater and solid waste information and proposing improvements in policy and management are ideas with considerable appeal. They may also be of assistance in pressing for legislative or administrative changes or in getting environmental issues on the agenda of policymakers.

7.8 Financing Institutions

Finance, which is essential for the successful implementation of wastewater and solid waste improvements, also requires an institutional presence. Financing issues require support for analysis and implementation of financing ideas and provision of direct financial aid. An institutional assessment must include an inquiry into the existence of suitable sources for the necessary funding, such as the ministry of finance, development banks, commercial banks, and the savings and loan industry.

7.9 Concluding Comments

Institutional assessment is an important task but should not be regarded as time-consuming or burdensome. A systematic review can be conducted without difficulty by individuals with some knowledge of the local scene and a willingness to gather a modest amount of additional information. The assessment of institutional capabilities is the last step in the process of assembling the findings needed to develop a strategy.

7.10 Hints and Guidelines for Assessing Institutions

The institutional assessment entails the identification of organizations with the capacity to improve wastewater and solid waste management. The following are the kinds of questions that should be asked.

Institutional Framework

- What organizations are responsible for wastewater and waste management services?
- What services do they provide? Which areas are fully served? Inadequately served?
- What organizations actually provide these services? Public agencies? Contractors? Private entrepreneurs? Cooperatives or community agencies? Informal sector? What benefits do they receive for providing these services?
- To what extent do public officials tolerate or encourage service providers outside the formal institutional framework? Under what conditions or restrictions?
- Which of these informal providers are effective?
- What is the capacity of current collection, treatment and disposal facilities, and when and at what rates will they require augmentation or replacement?
- What organizations are responsible for protecting public health and enforcing environmental standards?
- Which of these are local, and what roles if any are played by regional, state and national organizations?

- Does the national government provide technical or financial support for wastewater or waste management?
- What authority and autonomy are delegated to local governments for wastewater and waste management? Does the local government have authority to levy user or product charges to finance waste management services?

Hints for Gathering Data

- Political and administrative officials, leaders of community groups, social organizations, the business community, environmentalists, religious leaders, and representatives of the media should be asked to identify organizations currently involved in wastewater and solid waste management and other organizations that could help.
- Where there is disagreement, or where additional information is needed, reports or memoranda should be sought.

Assessing Effectiveness

SECTORAL INSTITUTIONS (see Edwards, Salt, and Rosensweig 1992: 82):

- How is the sector organized?
- Are roles and responsibilities divided efficiently?
- What kind of coordinating bodies exist? At what level?
- Is their functioning relevant to the operation of the sector?
- Are roles and responsibilities defined in a way that consistently supports articulated policy?

REGULATORY INSTITUTIONS:

- Do units have formal authorization? At which levels of government?
- Is this authorization compromised by jurisdictional division?
- Are regulatory standards reasonable and adapted to the local context?
- Do existing policies actually impede regulators and undercut their credibility?
- Are regulations treated seriously and implemented impartially?
- Is monitoring effective?
- Are peri-urban areas covered?
- Is the regulatory institution perceived as fair?
- Are financial and informational resources sufficient?

- Are the personnel adequate in numbers and specialties?

SERVICE-DELIVERY UNITS:

- Does the structure of service institutions match the technical and/or political demands of the setting?
- Is their effort given strong political backing?
- Do they have the features required for effective performance?
- Is the service being provided fairly and regularly?
- Are managers attuned to issues of appropriate technology?
- Do units have sufficient revenue sources? Do they collect fees regularly and fairly?
- Where appropriate, have they developed satisfactory working relationships with the informal sector?

PRIVATE SECTOR UNITS:

- Is the political regime hostile or friendly to the private sector?
- Are well-managed and competent firms available?
- Are business-government relations relatively free of corruption?
- What precise purpose(s) might be served by involving the private sector?
- What financing options are possible? Who pays? When? How much?
- Does competition exist? Is it possible to contract for a sufficiently short period to maintain the competitive stimulus on a successful contractor?
- How much efficiency gain can be expected?
- Is service quality likely to be influenced?
- Is there a tendency to serve those who are easiest to satisfy or can pay more?
- Does government possess the capacity to negotiate appropriate terms, analyze financing options, monitor performance, and ensure that the public priorities are emphasized?

COOPERATIVES:

- How well do the waste streams match the group's jurisdiction?
- Is wastewater/solid waste viewed as an important issue?

- How large is the community, and how much mutual trust and long-term perspective seem present?

MASS EDUCATION AND INFORMATION UNITS:

- Are there widely noticed channels of communication?
- How expensive is it to obtain access for a wastewater/solid waste informational campaign?
- Is there a good match between target populations and the audience served?
- How believable (authoritative) are the existing educational organizations?

ADVOCACY ORGANIZATIONS:

- Are these units sufficiently well-organized and respected to play a useful role?

FINANCIAL UNITS:

- Does the government have a unit for wastewater/solid waste finance?
- How respected is it?
- How able to select and implement appropriate financial instruments?
- Are banks able to work with government on solid waste/wastewater projects?
- Is access to capital easily arranged? Fairly effected?

Glossary

Advocacy Institutions. Organizations that promote policy innovations or social changes for the welfare of certain segments of society and use publicity, community organization, and political activism to press their agenda.

Authority. The ability to induce cooperative effort stemming from the power inherent in a principle, organization, position, or person.

Common Interest. The interest shared by different participants in an enterprise.

Cooperatives. Voluntary associations of producers or consumers.

Exchange. Inducement toward cooperation because the shared enterprise provides each with something of value.

Informal Sector. Unofficial, loosely organized providers of service.

Institutions. Organizations and the links between them that make up an interorganizational structure.

Regulatory Institutions. Organizations that utilize rules, regulations, and sanctions to direct the behavior of targets toward clean water goals.

Sectoral Institutions. Organizations involved in developing policy and interorganizational arrangements that affect overall wastewater/solid waste operations.

8

DEVELOPING STRATEGIES FOR IMPROVING WASTEWATER OR SOLID WASTE MANAGEMENT

8.1 Introduction

Earlier chapters have covered different steps in the assessment process shown in Figure 2, including a determination of wastewater and solid waste problems, a definition of the key targets, and an assessment of technology, policy instruments, and institutions. This chapter represents the final step—an analysis of the information and findings from the previous steps and the development of strategies for action. This chapter will provide guidance on how to synthesize the information gathered and develop recommendations for the next steps. This process will not result, however, in a definitive strategy, since that will require more in-depth study and discussion than is possible in an initial assessment.

8.2 Designing Strategy

A strategy for improving wastewater or solid waste management, taking into account the resource constraints that exist in most developing countries, must try approaches that do not rely primarily on conventional approaches as in the past. In most cases, the use of available options will require actions at all levels of government and often the assistance of external agencies. The strategy must make a choice of policy instruments in an institutional context that can employ them effectively with affordable technologies.

The two points to remember in designing a strategy are:

- Policy instruments and institutions should be considered in tandem.
- These instruments and the technologies, where appropriate, should be selected so as to address the most important impacts.

Policy instruments or technologies are used in and through institutions. Likewise, institutions act on targets with instruments or technologies. Not all instruments can be employed with equal ease by a given institution, and not all institutions are well adapted to a particular instrument or technology. To emphasize this point, the term **option** is used to refer to a specific combination of instrument, technology, and institution.

Decision makers should consider regulatory instruments if they are working where authoritative institutions can do some of the regulation. Economic instruments may be worth attention where there is a reasonably developed private sector, a well-defined and recognized market with associated institutions (like financing units and clear laws regarding property), the opportunity for competition, and a regime open to private involvement in traditionally public services. Furthermore, implementation of appropriate technology is more likely to be successful if the institutions are staffed with experts who have had experience with lower-cost, less advanced technologies (as well as more sophisticated ones) and do not have incentives to adopt inappropriate ones. Indeed, the importance of selecting options not driven by high tech, high cost criteria cannot be overstated.

The second point in strategic design implies a determination of priorities that address the most pressing needs that feasibly can be confronted. To do this requires a set of principles for evaluating alternative solutions to wastewater or solid waste problems.

One statement of guidance organizes the remainder of the discussion:

> **Strategy development: Select policy instruments, technologies, and institutions so that they have the greatest impact in addressing the most important problems.**

This statement is elaborated and clarified in the sections that follow.

8.3 Fundamental Principles

The choice of strategies should be guided by five fundamental principles:

- Risk reduction
- Pollution prevention by waste reduction
- Effective and efficient waste management
- Equity and cost recovery
- Selection of appropriate treatment and disposal technologies

These principles might not all apply with the same emphasis in a given case, but they offer appropriate direction and have informed the discussion in the preceding chapters as well.

- Risk reduction. The foremost concern should be to reduce the risks of waste materials to public health and the ecology. The severest can be determined from the guidance given in Chapter 3.
    - ☐ Will the options being considered protect the most vulnerable segments of the population, or merely those that are easiest or cheapest to serve or can pay for services?
    - ☐ How much and how reliably do they reduce these risks, and at what cost compared with other options?

- ☐ What new risks does each option introduce, how can these be minimized, and how do they compare with the risks of other options as well as existing conditions? For instance, by collecting and moving wastes to a different site do they simply reduce risks to one part of the population at the expense of another?

- ■ Pollution prevention by waste reduction. The least costly strategies are those that prevent pollution by reducing waste at its source, rather than merely managing it once it is generated. The most desirable option is **waste reduction at the source**, followed by the development of markets for **recycling and reuse** of waste, either in existing form (such as some containers) or after reconditioning or reprocessing. To the extent that used materials substitute for new ones, recycling and reuse contribute to waste reduction as well. In some circumstances, additional materials can then be **recovered for other uses** such as composting, land application, or energy production. The residue with no further economic value must receive **safe disposal** at a properly managed site.

  Options to reduce waste should therefore precede decisions about the size and cost of facilities for waste collection, treatment, and disposal. Waste management must also be designed to accommodate changing trends in waste generation, including both population and urban growth and changes in the mix of waste streams due to industrialization, increased use of packaging, and other expected shifts.

- ■ Effective and efficient waste management. The management of wastewater or solid waste should be as effective and efficient as possible. Effectiveness refers to the degree of achievement of goals; efficiency means maximizing output for a given level of effort or input, including both materials and energy as well as human and capital resources. Effective and efficient waste management can be achieved only if the institutions responsible have the capability to implement and sustain changes and the political support to make them.

- ■ Equity and cost recovery. Both the availability and the costs of wastewater or waste management services should be distributed fairly among beneficiaries. The costs should be borne by those who benefit both directly (households, businesses, and institutions that discard wastes) and indirectly (manufacturers and retailers), as discussed in Chapter 6. Producers and purchasers of raw materials should also be expected to pay prices reflecting the full health and environmental costs of resource extraction. Payment of the real costs for virgin materials will increase their prices relative to those for recycled or reused substitutes.

  Some might argue that this principle neglects large existing inequities in ability to pay. However, subsidies will not remedy these inequities and are likely to create serious distortions in the use of services (for example, encouraging wasteful use of water and other materials), which raise costs as well as environmental and health risks for everyone. Insofar as possible, therefore, charges for specific services should reflect true costs, and income inequities should be dealt with by other means.

Even in poor areas, highly subsidized systems do not succeed for long because users have no stake in them. Encouraging maintenance and efficient use means that residents should bear most of the costs of managing their wastes (Sakurai, 1986). These costs can be minimized through creative use of cooperatives and the informal sector (see Chapter 7).

- Selection of appropriate treatment and disposal technologies. Waste management policies must assure the selection of appropriate and affordable technologies, as explained in Chapter 5. The bias towards the use of conventional technologies must be changed as developing countries simply do not have the resources to pay for them.

The principles for the choice of strategies also are useful in the **design** of projects and programs. What now needs to be explained is the selection of options, according to the general statement about strategy development presented earlier.

8.4 Designing and Selecting Strategies

The information gathered during the assessment process can be used for matching, or "triangulation," to narrow the range of options for serious consideration. What is necessary is to *select, with the help of the guiding principles, policy instruments, technologies, and institutions so that they have the greatest impact in addressing the most important problems.* The steps are shown in Figure 4.

8.4.1 Step One: Rank Impacts or Problems

Information gathered on impacts (Chapter 3) may be positive or negative. The negative impacts are the "problems," which must be ranked in order of importance as the first step in developing a strategy for improvement. Not all problems are worth equal attention. The problems will be those perceived by the assessment team itself and those revealed in the opinions of the local population.

In all likelihood, the health impact will head both lists as the most pressing problem, and information on mortality and morbidity rates gathered in the survey can be used for further analysis. Sometimes the economic impact will emerge as important and will have to be studied in the same way. Generally, most people will agree on the biggest problems, even if they do not see their way to the same solutions.

The assessment team should take advantage of its own expertise and access to data, yet recognize that the information provided by both local officials and the local population is important and may well contribute to better problem diagnosis. In any event, without their support and cooperation any strategy for improvement will be an uphill task.

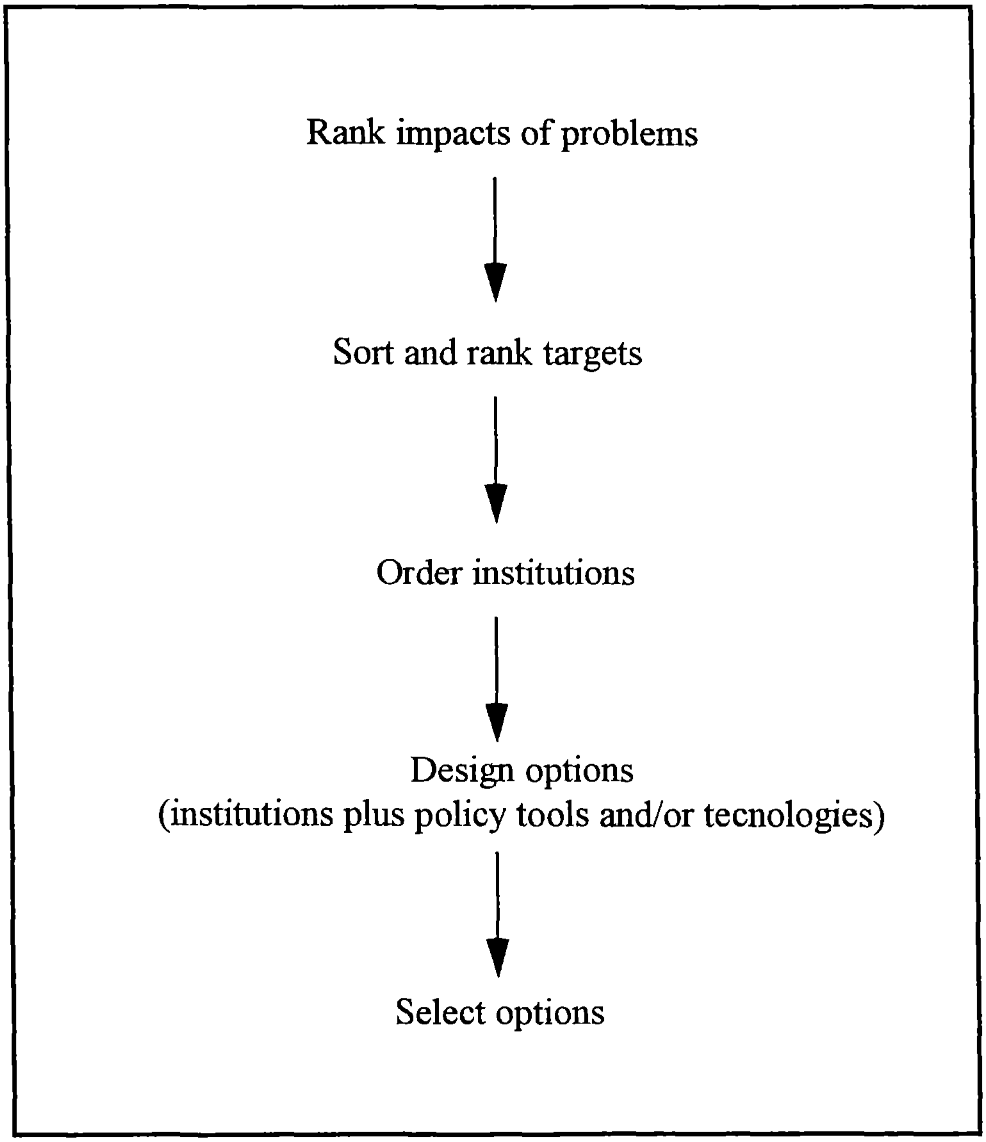

Figure 4

Designing a Strategy

Step One will produce a list of problems ranked in order of importance. The action to be taken is: **Give special attention to those problems seen as significant on both sets of measures by both analysts and the local population**.

8.4.2 Step Two: Sort and Rank Targets

Efforts to correct the negative impacts or problems of pollution must be directed at one or more of the targets discussed in Chapter 4: residuals generators, residuals managers, impact mitigators, policy implementers, and others. Some of these are sure to be more effective than others. Step Two consists of ranking them according to expectations of their contributions to solutions of the major problems and their amenability to changes in behavior.

Some questions in making this determination are:

- Which of these targets are sufficiently concentrated so that policy instruments can be directed at them, compliance readily monitored, and recalcitrance discouraged?
- Which can be influenced by information? Regulation? Economic mechanisms?
- Which can most afford, without economic loss, to alter their behavior?
- Which are unlikely to use politics as a means of resistance?
- Which can reduce negative impacts without violating cultural norms?

Changing the behavior of targets that cannot be of help is a waste of time, effort, and resources, but working on important targets that cannot be influenced is also pointless. The action to be taken is: **Concentrate on targets that are likely to contribute to solutions to priority problems and are likely to change their behavior**.

8.4.3 Step Three: Order Institutions

Institutions differ in the scope of their geographical reach. Water and wastewater generally are managed at the municipal or local level, as are the behavior of households, businesses, and organizations that purchase products and generate wastewater and wastes. Many innovations in waste management occur first at this level and are then applied elsewhere. Examples include neighborhood cooperatives for waste collection and the levy of user charges, and the privatization of collection and disposal services through competitive bids. In several Latin American countries, young unemployed people in inaccessible hillside *barrios* are paid by the neighborhoods to bring garbage down to communal containers at transfer stations at the bottom of the hill.

However, some elements of management require regional, state, or national government attention. The diversity of jurisdictions may require a state or regional government to organize services, authorize the use of land for disposal facilities, and promote markets for recycled and recovered materials to achieve regional economies of scale. The national government must set minimum standards for health and environmental quality, as well as for financial management of public enterprises. It must also determine product standards and product charges for goods sold throughout the country and allocate national revenues for wastewater and waste management. National leadership is required for promoting planning by each local and state jurisdiction, supporting research useful to many jurisdictions, disseminating information about transferable innovations, and providing training and technical assistance.

Step Three in the design process consists in grading institutions according to their likely ability to serve as effective agents of change. In some cases, institutions may be willing to support change but may need to be strengthened in a particular area before they can be of use.

Institutions should be ranked on the basis of four criteria:

- Leverage with the top-priority targets (identified in Step Two). Which institutions hold promise of dealing effectively with these targets? One aspect would be their reach or jurisdiction.
- General influence
  - ☐ Which institutions are most powerful?
  - ☐ Which have reputations for being able to get things done?
  - ☐ Which have relatively few antagonists?
- Empathy with environmental/ health objectives
  - ☐ Which institutions have leadership that knows and cares about these objectives?
  - ☐ Which could be encouraged to develop an interest?
- Willingness to strengthen overall capability

The action to be taken is: **Consider for special attention those institutions that meet at least three of the four criteria**.

8.4.4 Step Four: Design Options

This step involves the selection of tools—policy instruments and technologies—in the context of institutional capacity so as to arrive at the most attractive options for improving wastewater or solid waste management. The guiding principles should be: risk reduction, waste reduction, efficient and effective waste management, equity and cost recovery, and the use of appropriate technologies.

The main points in evaluating technologies are useful to keep in mind.

- Select a technology that is **acceptable to the community to be served**, that meets minimum environmental and health standards, and that can provide service at the lowest cost.

- Consider the **ability to implement** the technology
- Consider the **capacity to operate and maintain the system efficiently**.
- Make sure that the **capital, operating, and maintenance costs are affordable** by the beneficiaries. Usually, technologies that are cheaper are easier to operate and maintain.

Step Four ranks policy instruments and available technologies according to:

- their likely fit with the most promising institutions (from Step Three)
- their cost
- the five principles in the choice of strategies explained in Section 8.3.

The action to be taken is: **Consider those policy instruments and technologies that are compatible with promising institutions, that meet budget constraints, and that satisfy most of the five guiding principles**.

8.4.5 Step Five: Select Sets of Options

The four steps yield options (combinations of institutions, policy instruments, and technologies) that can now be ranked in priority. **Select the highest-ranked options or, more likely, groups of options for more detailed study with the goal of implementation**. Some suggestions for additional refinements are offered next.

8.5 Helpful Hints for Strategy Development

It is advisable to consider **groups** or **packages** of options rather than focus only on the top one or two. The selection of perhaps six to eight would be more prudent. There are margins of error that enter into ranking, and there are constraints like political interference that could render a single choice inappropriate. Pursuing a set of several options also makes sense because it allows decision makers to proceed on more than one choice simultaneously. In this process, one may appear more attractive or less costly.

Timing is also important and not the least of the many factors that influence success. The vagaries of sequencing, rising and falling expectations, and politics cannot be discounted. Also, the order in which high-priority wastewater or solid waste projects is undertaken is not inconsequential. Early success with one may make the success of others more likely (a bandwagon effect).

Sometimes choices must be made under unfavorable circumstances that offer no flexibility. When the ranking process produces no strong institutions that fit the preferred technology and policy instruments, or the options available do not match the most important targets, it might be necessary to lower the standards of selection or consider tapping a strong institution in new ways.

Another possibility is to repeat the process after experience with the "first cut." Going through a second round can reveal points or relationships that might have been overlooked.

It is also important to share tentative conclusions about strategies with other informed parties who can verify the accuracy of the information on which the analysis has been based. Such discussions could uncover new options and suggest how some of those being considered might provide leverage for the adoption of others. This point may be especially relevant when political considerations are important. Analysis should not simply yield to political difficulties. Yet it is necessary to recognize the political context in which analysis takes place and in which accommodations might have to be made. Assessment teams may find themselves subject to the priorities of a regime. No solutions they devise will be accepted without political support. To recognize, for instance, that private sector participation in service delivery could be viewed as a high or low priority in a particular country is to be alert to a factor of obvious relevance. Local priorities and political constraints are as important as the analysis itself.

The involvement of local decision-makers in the development of strategies is so important that it cannot be overemphasized. The assessment team must allow adequate time to interact with local decision-makers and to explain the findings so they are clearly understood. But more importantly, such interaction will allow the team to understand the concerns and issues that local officials have. The local perspective is fundamental since ultimately no action will be taken unless local decision makers are convinced that their concerns and priorities have been taken into account. The assessment team should ensure that there are structured opportunities for this interaction to take place, i.e., working meetings, short workshops, or task forces. Whatever the process selected, there should be adequate time for discussion.

8.6 An Example of Strategy Development

The example on page 94 provides an illustration of what could actually happen.

The example is somewhat oversimplified, but it does illustrate the type of analysis that could be made by using this document. The difficulties and options in a real case could be more complex, the links or rivalries between organizations more marked, the political constraints more severe, and the causes of negative impacts more problematic. Still, the illustration gives a sense of how much is possible, absent well-funded regulatory operations or major investments in advanced technology.

It also covers each element in the conceptual model: the most pressing problems, the most promising targets, and the most sensible options.

8.7 Conclusion

The process outlined here offers a way of developing options to alleviate some of the most serious wastewater or solid waste hazards. As has been emphasized throughout, the most vexing challenges often stem not from the complexity of the pollution problems, but rather from limitations on financial resources and the frequent lack of effective regulation. This document points out other controls besides waste treatment and disposal: policies to change the behavior of polluters before residuals enter the environment; policies to influence the actions of those responsible for the movement of residuals through the environment; and

Hypothetical Example

An assessment team in a large urban area in Latin America has identified several problems attributable to wastewater or solid waste: intestinal diseases and other evidence of poor health, some of this clearly stemming from the quality of water in the area; seasonally elevated mortality rates apparently due to water-borne diseases; and evidence of chemical toxicity among residents of slums near an industrial tract on the edge of the city. There are other problems as well, but the assessment team, using its own information and the views of the local population, concludes that health-related problems are the most significant.

The assessment discovers that there are several causes at work: improper placement of on-site treatment technology in 60 percent of the households where it is being used; negligence in the maintenance of individual facilities and the simplified sewerage system and stabilization ponds in a few neighborhoods; probable leeching of dangerous pollutants into groundwater from a poorly designed landfill in the industrial district; unsanitary conditions in several neighborhoods where solid waste is collected sporadically by municipal vehicles (the local agency faces shortages of capital and spare parts); and violations of emission standards by several heavy industries that had been encouraged to locate here by the previous government.

A review of available institutions suggests several possibilities. Public health clinics set up by an NGO to dispense medicines could be tapped in an information campaign. The national regulatory agency is reasonably competent, well-intentioned, and nonpolitical but lacks staff and wastewater monitoring capacity. A new association of industrial firms led by a small group intent on improving the city's image is seeking financing from abroad for further development. A community-based religious organization is trying to increase awareness of health issues among the population. The industrial development that has given rise to pollution has also spawned a small sector of service firms that profess competence in solid waste removal.

Policy instruments like deposit-refund systems and packaging regulations are obviously out of place here. New capital-intensive technology is unaffordable. But a combination of local talents and institutions may be worth pursuing. Educational and social marketing efforts by the public health clinics, in concert with the organizational capacity of the respected religious group, might succeed in rebuilding and maintaining technology at the household level. This group could be asked to organize neighborhood monitoring to reduce noncompliance with approved practices. The regulatory unit could be induced to work with the industrial association by offering to support the search for further investment (or at least not oppose it) under clearly specified conditions, like the association's willingness to set producer-enforced emission standards to reduce chemical toxicity. The regulators might also work with the association to offer technical assistance to firms and combine this with selective economic incentives like fines on large-scale dischargers.

Local political leaders might consider working with the private sector to determine if competitive contracting could replace the current arrangements for solid waste. Until this happens, budget reallocations could emphasize the maintenance of collection vehicles over less essential capital expenditures. Solid waste collection could also receive a boost through the assistance of the religious organization, which has the support of local scavengers.

policies to help people cope with the adverse impacts of pollution. This range of options greatly increases the possibilities for improved wastewater and solid waste management.

No matter how well conducted, strategy development is no substitute for the careful exploration of promising options before it is undertaken. No assessment team, for instance, can deliver a plan for private sector participation in a few weeks' time. The process can, however, suggest some of the requisites of nontraditional choices.

It can alert decision makers to the importance of assembling **sets** of options. Project designers, for instance, need to look at policy and institutional implications before yielding to the easy temptation of recommending a technological solution. However, technology can be a lever to induce government to consider options that reinforce its benefits. The options recommended must accommodate the political constraints present in every setting. An assessment that identifies innovative options, while keenly aware of the political limitations, offers the surest guarantee of success.

Glossary

Option. Any combination of policy instruments and/or technology with institutions.

Priority Ranking. Arraying items in a list in order of priority according to stated criteria.

Strategy. An approach to solving or mitigating a problem. A strategy makes a choice of policy instruments in an institutional context that can employ them effectively, with affordable technologies.

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Appendix A

ANNOTATED BIBLIOGRAPHY

The following annotated bibliography is intended to help readers find additional information in the various areas covered in this document. The citations are divided into eight categories that correspond to the eight chapters in the document to make it easy for readers to locate references they want. Several documents could have been placed in more than one category.

- **Introduction.** References that elaborate on the dimension of the problems caused by inadequate management of solid waste and wastewater.
- **Conceptual Framework.** References that make the case for an integrated approach to waste management, pollution prevention, and a sector-oriented strategy.
- **Impacts.** Sources that provide information on assessing the impacts of poor solid waste and wastewater management. This category also includes some references on environmental and social impact assessments.
- **Targets.** Documents that define the targets of actions. Very few references are available on this subject.
- **Technologies.** Documents that provide in-depth information on the range of technologies for solid waste and wastewater management: collection, recycling, reuse, treatment, and disposal.
- **Policy Instruments.** References on the different types of policy instruments including regulation, economic incentives, and assignment of rights and responsibilities.
- **Institutions.** Sources of information on broader institutional issues such as decentralization, privatization, and sectoral organization.
- **Strategy Development.** Documents that describe case studies of projects and programs. This category also includes cross-cutting references and some that could be placed in a number of the other categories as well.

Introduction

Hardoy, Jorge, and David Satterthwaite. "Third-World Cities: The Environment of Poverty." *World Resources Institute Journal.* 1985.

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Martinez, Martin Medina. "Municipal Solid Waste Management in Developing Countries." Unpublished master's thesis, University of North Carolina at Chapel Hill, Chapel Hill, NC, 1990.

Identifies issues, technologies, and needs in municipal solid waste management in developing countries with Mexico as a primary example.

Stren, Richard E. and Rodney R. White (eds.). *African Cities in Crisis, Managing Rapid Urban Growth.* African Modernization and Development Series, Westview Press, 1989.

A compilation of papers on urban growth and management in African cities.

World Health Organization. *Environmental Pollution Control in Relation to Development.* 63 pp. 1985.

An overview of urbanization, deteriorating environments, and consequences for public health. Identifies human excreta as the principal source of pathogenic organisms which spread enteric and viral diseases, the leading causes of death in areas inhabited by 2/3 of the world's people. Advocates non-conventional sewerage solutions and labor intensive approaches. Case of Manila's 10,000 street sweepers cited as good example.

Conceptual Framework

Huisingh, D., and L. Martin, H. Hilger, N. Seldman. *Proven Profits from Pollution Prevention: Case Histories in Resource Conservation and Waste Reduction.* Institute for Local Self-Reliance, 316 pp., 1986.

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High population density and scarcity of land for burial of garbage have made incineration a popular option for many European countries. Similar circumstances may force designers of programs in the developing world to consider the option. A critical look at a long-standing practice.

Kalbermatten, John M., DeAnne S. Julius, Charles G. Gunnerson. *World Bank Studies in Water Supply and Sanitation No. 1*. The Johns Hopkins University Press, 1982.

Results of two years of field studies by the World Bank in 14 countries. Very comprehensive. Provides guidelines for design and management of both solid waste and wastewater management. Makes strong case for nonconventional (nonsewerage) solutions. Outlines factors in choosing appropriate sanitary systems, such as climate, soil type, population density, and social considerations. Includes analysis of various treatment strategies, economic comparisons, and projected health benefits. Provides detailed algorithms for matching specific latrine systems with community needs.

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Recent tests show efficiency gains of up to 20 percent where water hyacinth was introduced to oxidation ponds. Technology deemed applicable in new treatment plant design as well as for upgrading old facilities. Cautionary note on dissolved oxygen levels, which were reduced by the plants. Aeration recommended before using treated water for other purposes. Potential aquaculture benefits.

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Technical considerations in solid waste collection and separation preparatory to final disposal by incineration. Reviews types of incinerators, caloric yields of various trash constituents, prospects for heat recovery, and health risks posed by incineration of hazardous substances. Specific consideration given to incinerator needs of various industrial byproducts as well as models for the public sector. Briefly examines alternatives to incineration (refuse collection, recycling, composting, and bio-gas generation).

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Rao, S.V.R. "Urban and Semiurban Planning in Developing Countries from a Water and Wastewater Treatment Point of View." *International Journal of Environmental Studies*, 31:2-3, 129-142, 1988.

Advocates down-scaling conventional water treatment facilities and replacing sewerage systems with low-cost on-site treatment.

Sanitation in Developing Countries. Proceedings of a Workshop on Training Held in Lobatse, Botswana, 172 pp, August 1980.

Thirty-nine case histories from various African nations are divided into three categories: technology (human waste), software, (education, community participation, financing schemes), and training. Articles are concise, written in nontechnical language, and highly readable. Judicious use of subject headings makes relevant information easy to locate. An excellent reference for anyone working in rural Africa or introducing human waste containment systems.

Singh, U.P. and O.J. Helweg (eds.). *Supplying Water and Saving the Environment for Six Billion People*. New York: American Society of Civil Engineers, 1990. Proceedings of selected sessions from the 1990 ASCE convention. San Francisco, California: November 5-8, 1990.

Contains several articles on sanitation alternatives and sanitation planning, especially: R.N. Middleton and J.M. Kalbermatten "Strategic Sanitation Planning"; W.J. Oswald "Advanced Integrated Pond Systems"; D.W. Elliot "Alternative Technologies for Waste Minimization."

Shuval, Hillel I. "Health Guidelines and Standards for Wastewater Reuse in Agriculture: Historical Perspectives." *Water Science & Technology* (Kyoto), 323:2073-2080, 1991.

History of developments leading to current standards governing use of treated and untreated wastewater in agriculture and aquaculture. For reasons explained, restrictions have been recently relaxed: 10,000 coliforms and one helminth egg per liter of water are now recommended limits for application to produce that will be eaten raw.

Treatment, Disposal and Management of Human Wastes. International Association on Water Pollution Research and Control, 18:7/8, 1986.

Fifty country reports and case studies with emphasis on Southeast Asia. Papers deal with social obstacles to implementation, planning and management, and application of human wastes to fish ponds, soil, chemical processes, dentrification, etc. Comprehensive and well-organized study of the water purification options suited to the developing world. Written for the nontechnical person yet includes all the details and schematics an engineer would require to design his own system. Charts included are WHO's guidelines on water-borne contaminants. Appendices include "Simplified Procedures for Water Quality Analysis."

Walker, J.M., and M.J. O'Donnell. "Comparative Assessment of Municipal Solid Waste Compost Characteristics." *Biocycle*, 32:8, 65-69, August 1991.

Uses results from nine operating and pilot projects to assess potential benefits of composting municipal refuse. Suggests that high pH levels ameliorated some of the worst effects of heavy metals contamination. Suggests more research to establish standards.

Waste Minimization: Hazardous and Non-Hazardous Solid Waste. National Technical Information Service, 1987.

An annotated bibliography compiled by EPA's Office of Solid Waste to facilitate waste reduction efforts.

"Waste Minimization." *Industry and Environment* 12:1-50, Jan./March, 1989.

Fifteen articles describing waste minimization efforts in both industrialized and developing nations.

Wastewater Treatment Systems for Rural Communities. 1973 Village Technology Handbook. VITA (Volunteers for International Technical Assistance) College Campus, Schenectady, New York, 1973.

Concise introduction to the concept of sustainable living emphasizes minimization at the source, recycling what is ultimately usable, and proper disposal of what cannot be used. Lots of examples of successful projects for waste minimization, recovery, and reuse in various settings. Comments on some of the regulatory options, institutional changes, and financial innovations that various groups have used to overcome political opposition and human inertia in instituting change.

Winblad, Uno, and Wen Kilama. *Sanitation Without Water.* McMillan, 158 pp, 1985.

Guide to latrines of the world. Styles from 17 countries evidencing varying degrees of complexity are represented and explained. Separate chapters devoted to criteria for selecting specific styles, general engineering, and directions for constructing the most popular designs: pour-flush, ventilated improved, and composting latrines.

World Health Organization. *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture.* Technical Report Series 778, 78 pp, 1989.

Review of current practices, suggestions for upgrading old systems, and guidelines for planning new ones. Consequences for health, implementing safeguards, and suggestions for research.

U.S. Environmental Protection Agency. *Innovative and Alternative Technology Assessment Manual.* Washington, DC, 1980.

Comprehensive guide to wastewater treatment unit operation, including design criteria, energy requirements, environmental impacts, and costs.

■ Policy Instruments

Bartone, Carl R. "International Perspective on Water Resources Management and Wastewater Reuse—Appropriate Technologies." *Water Science & Technology*, (Kyoto) 23:2073-2080, 1991.

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Bartone, Carl R. "Investing in Environment Improvements Through Municipal Solid Waste Management." Presented at the Regional Workshop on Municipal Solid Waste Management, Kuala Lumpur, Malaysia, February 26-March 2, 1990.

Describes World Bank involvement in improving solid waste management and the lessons learned. Addresses the need for a comprehensive solid waste management policy framework and issues to be considered therein.

Bernstein, Janis D. *Alternative Approaches to Pollution Control and Waste Management: Regulatory and Economic Instruments*. Discussion Paper. UNDP/World Bank/UNCHS Urban Management Program. 1991.

Explores how regulatory and economic instruments are used to control air and water pollution, protect groundwater, and manage solid and hazardous wastes.

Bhatia, Ramesh and Malin Falkenmark. *Water Resource Policies and the Urban Poor: Innovative Approaches and Policy Imperatives*. Background paper for the Working Group on Water and Sustainable Development, International Conference on Water and the Environment: Development Issues for the 21st Century, Dublin, Ireland, January 26-31, 1992.

Identifies symptoms of a malfunctioning sector, expected increase in urban demands for water, and policy options and key policy instruments to address water supply and demand problems; presents four case studies of increased water supply to urban poor and imperatives for a new approach to water sector issues.

Bower, Blair T. *Urbanization and Environmental Quality*. Office of Housing and Urban Programs, U.S. Agency for International Development Working Paper, November 1989.

Identifies adverse environmental effects typically resulting from urbanization in developing countries and the responses of governments to these problems. Discusses factors that restrict the ability of urban governments to manage environmental quality and the role that major donors can play in assisting them.

Cointreau, Sandra J. *Financial Arrangements for Viable Solid Waste Management Systems in Developing Countries*. Presented at the Third International Expert Group Seminar on Strategies for Developing Responsive Solid Waste Management in Asian Metropolises, Bandung, Indonesia, February 4-8, 1991.

Discusses financial resources used to pay for solid waste management services. Identifies issues of significance to developing countries, such as financing of services to low-income neighborhoods or illegal squatter settlements. Discusses privatization as a means of obtaining capital and implementing user charges, and recycling as a means of decreasing the financial burden for collection and disposal services. Outlines financial incentives to support recycling.

Cointreau, Sandra J. *Policy Options for Improving Solid Waste Management.* Presented at the Second Expert Panel to Improve Solid Waste Management in Asian Metropolises held in Kitakyushu, Japan, October 1989.

Identifies many issues that need to be addressed by policy, including citizen cooperation, adequacy of budget and reliable cash flow, procurement, accountability, and public education.

Cointreau-Levine, Sandra. *Private Sector Participation in Municipal Solid Waste Services in Developing Countries*. Presented to U.S. Agency for International Development and World Bank, December 1991.

Poses the question of when and how to privatize solid waste management services. Identifies the many, sometimes conflicting, goals of privatization and outlines some of the pitfalls.

Cross-Sectoral Issues: Utilization of Economic Instruments: Progress Report of the Secretary-General of the Conference. Report from the Preparatory Committee for the United Nations Conference on Environment and Development, Third Session, Geneva, August 12-September 4, 1991, Plenary Session, Item 2(C) of the provisional agenda.

Background paper on the role of many existing and potential economic instruments in improving the quality of the environment.

Hahn, R. W. & Hester, G. L. "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program." *Yale Journal on Regulation*, 6:106-153, 1989.

Provides a history of economic incentives, with special reference to U.S. EPA's emissions trading programs including banking, off-setting, bubbling, and netting. Includes one case of water pollutant discharge rights trading.

Montgomery, John D. "Environmental Management as a Third-World Problem." *Policy Sciences* 23:163-176, 1990.

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Organization for Economic Co-Operation and Development. *Economic Instruments for Environmental Protection*. OECD, Paris, France, 1989.

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Organization for Economic Co-Operation and Development. *Environmental Policy: How to Apply Instruments*. OECD, Paris, France, 1991.

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Roark, Philip, Menajem Bessalel, David Dalmat, and Kevin Murray. *Market Survey of Solid Waste Management, Port-au-Prince, September 10-28, 1990*. Volume 1. WASH Field Report No. 319. Arlington, Va., WASH Project. 1991.

Presents results of a solid waste management survey carried out in Port-au-Prince, Haiti, of households, industry, and business. Identifies several plausible scenarios for improvement of waste management and offers preliminary recommendations and financial projections for each.

K. Sakurai. "Basic Concepts and Procedures for the Improvement of Solid Waste Management in Urban Fringe Areas." *Water Science & Technology*, (Tokyo) 18:113-120, 1986.

Provides detailed discussion of issues in solid waste management in urban fringe areas, particularly such problems as topography and appropriate technology, roles of women, attitudes of public authorities, and cost-bearing; includes examples; emphasizes importance of community participation in implementing solutions.

"Using Economic Incentives to Maintain Our Environment." *Challenge* 332:42-46, 1990.

Discusses legal and institutional changes to bring market forces to bear on environmental problems. Some measures consider needs of developing countries explicitly.

■ Institutions

Bartone, Carl R. *Institutional and Management Approaches to Solid Waste Disposal in Large Metropolitan Areas*. Presented at World Bank Seminar on Environmental Issues in Urban Management, Washington, DC, May 30-31, 1989.

Discusses areawide versus decentralized approaches to solid waste management and compares three approaches used in large metropolitan areas.

Cullivan, Donald, Bruce Tippett, Daniel B. Edwards, Fred Rosensweig, and James McCaffery. *Guidelines for Institutional Assessment: Water and Wastewater Institutions*. WASH Technical Report No. 37. Arlington, Va., WASH Project. 1988.

This report, referred to in Chapter 7 of this document, focuses on the provision of water and wastewater service by public utilities. Presents a detailed procedure for assessing the performance of these units. Covers questions to be answered, data to be examined, and analyses to be conducted. Includes advice on setting priorities for action on the basis of the assessment findings.

Donahue, John D. *The Privatization Decision: Public Ends, Private Means*. New York: Basic Books, 1989.

Focuses neither on LDCs nor on wastewater, but provides one of the best overviews of private contracting for public services. Covers arguments, mostly based on economics, for increased efficiencies through the use of private firms; discusses the criteria that determine whether such efficiencies are likely in a given case; and provides substantial evidence from several fields of service provision. Sets aside ideologically based arguments in favor of careful reasoning and gives attention to the real considerations that affect decision-making on this issue.

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Honadle, George, and Lauren Cooper. "Beyond Coordination and Control: An Interorganizational Approach to Structural Adjustment, Service Delivery, and Natural Resource Management." *World Development* 17, 10: 1531-1541, 1989.

Although dealing broadly with natural resource management, this article sketches the implications of institutionally complex settings for development efforts. Argues that the typical context for projects has no single agency or hierarchical control mechanism to enforce the coordinated effort needed for success. Analyzes ways to involve diverse stakeholders in the program process.

Peterson, George. *Decentralization and Democratic Governance: A Review of Latin American Experience and Lessons for Sub-Saharan Africa*. Office of Housing and Urban Programs, The Urban Institute.

Reports on how recent decentralization in Latin America has led to rise of local decision-making bodies. Their experience with the provision of urban services offers lessons for Sub-Saharan Africa (and other locales) where centralized power continues to be the rule.

- **Strategy Development**

Cointreau, Sandra J. "Solid Waste Management in Developing Countries." In F.W. Montanari, Terrance P. Thompson, Terence P. Curran, and Walter Saukin, (eds.). *Resource Mobilization for Drinking Water and Sanitation in Developing Nations*. New York: American Society of Civil Engineers: 544-551, 1987.

Succinctly covers several aspects of solid waste management in urban areas of developing countries. Provides brief but practical advice regarding such issues as appropriate technologies, administrative organization, and operations and maintenance.

Cook, David B., and Jens Lorentzen. "Overview of Operations and Maintenance Issues." In F.W. Montanari, Terrance P. Thompson, Terence P. Curran, Walter Saukin, eds.., *Resource Mobilization for Drinking Water and Sanitation in Developing Nations*. New York: American Society of Civil Engineers: 561-567, 1987.

Succinct observations regarding a variety of O&M issues, including the low priority often given to maintenance by political leaders, impact on the urban poor, the effects of intergovernmental relations, the role of international development agencies, possibilities of private sector participation, and community participation.

Nicolaisen, Dieter, Ursula Plog, Eckhardt Spreen, and Sashi Bahadur Thapa. *Solid Waste Management with People's Participation, An Example in Nepal*. Deutsche Gesellschaft fuer Technische Zusammenarbeit and Solid Waste Management and Resource Mobilization Centre, 1988.

Detailed description of a long-term project undertaken by the German and Nepalese governments to improve waste management in Kathmandu, Nepal. In English and German.

Poerbo, Hasan. "Urban Solid Waste Management in Bandung: Towards an Integrated Resource Recovery System." *Environment and Urbanization* 3:1, April, pp. 60-69, 1991.

Describes organization of scavenging communities into integrated resource recovery modules (IRRMs). Objectives included composting, recycling, and marketing of recovered materials, with end goal of decentralizing waste management.

Putting People First: Sociological Variables in Rural Development. International Bank for Reconstruction and Development, 591 pp, 1991.

Emphasizes grassroots organization and community participation to protect water and land resources. Considers adverse impacts on marginal groups as result of change. Presents results of recently tested survey techniques and offers suggestions for information gathering.

Syme, G.J. and E. Eaton. "Public Involvement as a Negotiation Process." *Journal of Social Issues* 45(1): 87-107, 1989.

Discusses participatory planning in development.

U.S. Agency for International Development. *Towards a Strategy and Action Plan for Helping Developing Countries to Manage Urban and Industrial Pollution.* Working Paper. 1990.

A.I.D.'s approach to assisting developing countries in upgrading environmental conditions. Calls for effective policies and institutions to promote sound pollution management as a prerequisite to sustainable development. Emphasizes need for private sector development, improved public education, adjustment of A.I.D.'s current operations, and improved coordination with other donors, and researchers and universities.

White, Allen, and Srinivas Emani. *Environmental Regulations in Developing Countries: Case Studies of India, Thailand, and Venezuela and Priorities for a Capacity-Building Program.* Submitted to Center for Environmental Management, Tufts University, March 1991.

Contrasts environmental management approaches in Venezuela, Thailand, and India and presents priority recommendations for a capacity-building program.

Women, Water Supply and Sanitation: A National Training Seminar. Kadugli, Sudan, January 1988. United Nations International Research and Training Institute for the Advancement of Women (INSTRAW), 51 pp, 1988.

A summary of discussions and suggestions for increasing the role of women in planning, implementation, and management.

Appendix B

SUPPLEMENT TO CHAPTER 3: POTENTIAL NEGATIVE IMPACTS OF WASTEWATER AND SOLID WASTE

1 Health and Environmental Impacts

Poor management of wastewater or solid waste can cause contamination of water, soil, and air. Polluted water is usually the most significant because the contaminants in it are soluble and easily transported, it is usually discharged into waterways, and all forms of life need water to survive.

1.1 Water Pollution

The most common contaminants in polluted water are suspended solids, pathogens, toxins, nutrients, and oxygen-demanding compounds. Their presence is an indicator of detrimental impacts on aquatic life and public health.

Suspended solids. Suspended solids consist of organic and inorganic matter discharged in domestic and industrial wastewater and runoff from solid waste disposal sites. Organic solids in lakes, rivers, and estuaries may be biologically degraded, reducing the oxygen content of the water body and causing the death of aquatic life. Suspended solids by themselves do not result in adverse health impacts. They reduce the effectiveness of some disinfection techniques, increase the cost of water purification, contain toxic materials such as heavy metals, and reduce the aesthetic appeal of the water body. Suspended solids can be detected visually or by laboratory analysis. Properly treated wastewater should contain less than 30 mg/L of total suspended solids (TSS). Untreated domestic wastewater contains 100 to 500 mg/L of TSS, and industrial wastewater from food processing, textile manufacture, and leather processing contains much large concentrations. Table 6-3 in Appendix 3a is based on the California State Water Quality Control Board recommendations and shows that TSS should be less than 100 mg/L for most uses.

Pathogens. Pathogens are often present in domestic wastewater, wastes from animal production and processing, and runoff from solid waste disposal. When improperly controlled, they can infect the population through drinking water and food. Because of difficulties in detecting them, the presence of indicator organisms such as fecal and total coliform and fecal streptococcus bacteria are considered evidence of fecal contamination of water (and, therefore, the likely presence of pathogens).

The presence of coliform bacteria (measured as total or fecal coliform) is usually not acceptable in drinking water, according to the USEPA and the World Health Organization. However, occasional samples containing up to three coliform organisms (total coliform) per 100 mL in piped distribution systems and up to 10 per 100 mL in unpiped supplies are allowed to pass (see Tables 6-13 and 6-21). The State Water Quality Control Board in California recommends irrigation water containing fewer than 1,000 total coliform per 100 mL for use on fruits and vegetables likely to be eaten raw. The recommended limit for other crops is 10,000 per 100 mL. Raw water for drinking should contain fewer than 100 total coliform bacteria per 100 mL and fewer than 20 fecal coliform organisms per 100 mL if the water is to be disinfected before distribution. Raw water that will be filtered can contain up to 5,000 total coliform per 100 mL.[1] Under ideal conditions, then, assessing impacts would involve matching pathogen (and other contaminant) concentrations with water uses to isolate problems to be addressed. Frequent sampling is needed for proper monitoring of the water quality.

Toxic compounds. Toxic compounds in water include heavy metals and organic compounds such as pesticides and solvents released by industrial or agricultural activities and sometimes found in municipal wastewater. Their harmful effects on humans, plants, and animals may not become evident until many years after exposure. Industrial wastes deposited in solid waste facilities can contaminate runoff and leachate that enter surface and groundwater sources.

The laboratory analyses to detect toxic substances are complex and require sophisticated equipment and therefore are not often made. An assessment team is left to infer the presence of these substances from an inventory of industrial activities associated with them. Information on the compounds to be expected from specific industries can be obtained from USEPA documents and the literature on waste management for these industries. It is necessary to know the types of industries present and the toxins associated with these industries. Acceptable concentrations for some of the more common toxins in drinking water are given in Tables 6-16 and 6-21.

Nitrogen and phosphorus compounds. Nitrogen and phosphorus compounds discharged into lakes and streams cause eutrophication, stimulating the growth of algae that make water treatment more difficult. Excess algal growth can also cause depletion of dissolved oxygen in water bodies when algae die and are oxidized by bacteria. The main health concerns are from nitrates, which are particularly problematic in groundwater. Nitrogen, and to some extent phosphorus, are natural components of domestic wastewater. Phosphorus concentrations are elevated by the use of detergents containing phosphates. Typical domestic wastewater in the United States contains between 20 and 85 mg/L of total nitrogen and 4 to 15 mg/L of total phosphorus.[2]

Industries with the potential for high phosphorus loads are metal finishing and textiles. High nitrogen loads are found in the food processing, dairy, meat, alcohol, and leather industries.

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[1] Salvato, 1982 and Purdom, 1980

[2] Corbitt, 1990

Concentrations of nitrogen and phosphorus compounds in industrial wastewater are highly variable but much greater than in domestic wastewater.

Landfill leachate typically contains organic nitrogen compounds and ammonia (20 to 1,400 mg/L total nitrogen) and some phosphorus compounds (0 to 70 mg/L total phosphorus).[3] Agricultural nonpoint sources of nutrients also contribute to the nutrient loading in a system. The acceptable loading of nutrients into aquatic environments is determined by the characteristics of each water body. Desirable nitrate concentrations in drinking water are below 10 mg/L as nitrogen.

Oxygen-demanding compounds. Oxygen-demanding compounds consist mainly of organic materials and ammonia and are measured in terms of biochemical oxygen demand (BOD). When discharged into water bodies, these compounds are oxidized by bacteria consuming dissolved oxygen. Given the conditions of high BOD concentration and low oxygen transfer from the air, the dissolved oxygen concentration in the water body can be depleted to the detriment of aquatic life. The sources of BOD are domestic wastewater, animal feeding operations, and industries such as food processing, dairy products, meat processing, alcohol manufacture, and leather tanning. Solid waste landfills can also leach BOD-containing wastes into surface and groundwater. The five-day BOD (BOD_5) concentrations in the United States are between 100 and 400 mg/L for domestic wastewater, several thousand mg/L for industrial wastes, and from 2,000 to 30,000 mg/L for landfill leachates.[4]

The contaminants released into the environment by wastewater or solid waste have a range of impacts, of which the impact on health has especially high priority. When specific information is not available, as is often the case, health indicators are used to gauge both impact and severity. These are morbidity data of water supply and sanitation-related diseases:

- incidence of diarrheal disease (e.g., cholera)
- incidence of hepatitis A
- incidence of typhoid

Indirect indicators are

- percentage of water supply coverage
- percentage of sanitation coverage
- percentage of solid waste collected
- estimated volume of industrial wastewater generated
- estimated volume of domestic wastewater generated

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[3] Corbitt, 1990

[4] Corbitt, 1990

- estimated percentage of industrial wastewater treated
- estimated percentage of domestic wastewater treated

Some of these indicators can point to obvious impacts like high morbidity rates for cholera. However, it is important not to ignore other indicators, like hazardous wastes or large volumes of untreated wastewater, which can also pose serious threats.

1.2 Soil and Land Pollution

The major contaminants here are pathogens and heavy metals, which can reach the soil from land disposal of wastewater, irrigation with wastewater (or surface water contaminated with wastewater), land disposal of wastewater sludge, and solid wastes in landfills, posing hazards for humans and causing crop damage. U.S. standards for acceptable concentrations of metals in sewage sludge applied to agricultural land, forest land, sites where public contact is possible, and reclamation sites are shown below.

RECOMMENDED MAXIMUM METALS CONCENTRATION IN SEWAGE SLUDGES TO BE LAND APPLIED

Pollutant	Concentration (mg/kg - dry weight)
Arsenic	41
Cadmium	39
Chromium	1200
Copper	1500
Lead	300
Mercury	17
Molybdenum	18
Nickel	420
Selenium	36
Zinc	2800

Source: 40 CFR 503.13, Table 3, U.S. EPA Regulations

These concentrations showing relative toxicities can be used to determine when metals present in sewage sludge are likely to be a threat to health and the environment. Some pathogens in wastewater or solid waste can survive for extended periods in soil; on crops, they rarely survive more than 2 months.[5] Soil contamination can be gauged from health indicators similar to those recommended for water pollution.

1.3 Air Pollution

The air can be polluted by particulates, pathogens, toxins, and odors. Wastewater treated in anaerobic lagoons and transported in open channels releases odors. Spray irrigation with wastewater spreads pathogens as well as odors. Open burning of solid wastes generates particulates, odors, and toxic gases from incomplete combustion. Measuring these contaminants is difficult, so it may be necessary to infer the existence of adverse impacts from a general investigation of air polluting activities.

2 Economic Impacts

Contaminants can harm and reduce productive activity. In a water body they can kill off fish and other marine resources of economic value, or at least render them unfit for consumption. They can alter the quality of irrigation water and soil and thus decrease agricultural productivity. The accumulation of solid waste in water bodies can hinder navigation, hydropower production, irrigation, and recreation. Improper disposal of refuse affects property values and tourism. And ultimately, poor health takes an economic toll in absenteeism, low productivity, and costly medical services.

The tradeoffs between economic growth and environmental protection are often discussed. Some analysts argue that the tension between these two goals is exaggerated and that it is difficult to demonstrate any real incompatibility. There is talk of indirect costs of pollution abatement policies as they impinge on employment, sales, and profits in polluting industries, but often less is heard of the benefits they confer in reduced health care costs, more enjoyable recreational activities, and increased opportunities for leisure. Some policies also may improve prospects for the viability of better wastewater and solid waste management, as Chapter 6 explains. So it is appropriate for an assessment team to consider the economic advantages of improving present conditions.

In this context, it is worth repeating that human wastes have potential value as fertilizer in some parts of the world, and that byproduct recovery and recycling are other ways of turning an environmental liability into a gain. Approaches to wastewater and solid waste management should emphasize such possibilities where practicable, since they combine prospects for environmental and health improvements with economic profit.

A complete analysis of economic impacts would include direct and indirect effects and would extend beyond marketed goods and services. Inevitably, it would make assumptions in

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[5] McJunkin, 1982

rendering values for nonmarketed goods and services and in weighing present versus future costs and benefits. The literature on how to conduct a complete economic impact investigation is extensive. However, under most circumstances, assessments will not be conducted with the luxury of ample economic data and the time to analyze them.

Some guidelines are in order. The findings of any reliable previous studies should always be taken into account. If an assessment team conducts its own review, it must be selective. It should seek information about any loss of economic resources that reasonably can be attributed to wastewater or solid waste contaminants, such as a decline in agricultural productivity, tourism, or property values, and increased health care costs. Where estimates of losses in monetary terms prove impossible, qualitative information should be used. Losses suffered by an economic activity because of contaminants are more important when large sections of the local population rely on it for their livelihood or when they live at or close to the subsistence level.

3 Social Impacts

Social cohesion is the ability of people to live together by following mutually acceptable rules that enable them to solve problems and regulate behavior at the community level. Social cohesion can be influenced for the worse—and, occasionally, for the better—by wastewater or solid waste problems. Pollution can split a community by dividing those primarily responsible for creating it from those being affected by it. For example, a factory polluting a stream with chemical wastes endangers the health of those who live near it. Conflict can be high if managing wastes also has economic implications, as between people who do not want to lose their jobs and those concerned about health impacts. Solid waste removal services that favor wealthier over impoverished neighborhoods can create tensions and even carry political implications. Heavy contamination of a neighborhood by toxic chemicals can drive families from their homes and force them to find a safer environment. Yet sometimes a pollution problem can bring a community together and strengthen its demand for ameliorative action by institutions that can help (see Chapter 8).

An assessment team can quickly discover how wastewater or solid waste problems are affecting a community by talking with informal representatives. Sometimes the level of conflict is obvious even to the casual observer by the strikes, lawsuits, or political campaigns related to pollution. The team's findings may influence the priority in which wastewater or solid waste issues are considered or the options suggested as solutions.

Aside from the impact on social harmony, solid waste or wastewater may be seen by members of the community as a public nuisance that detracts from the quality of life. Polluted streams and uncollected garbage and litter are eyesores, and malfunctioning wastewater treatment can impose social costs through odors and visual degradation.

Some communities and cultures are more tolerant of these inconveniences than others, but where people are forced to live in a day-to-day environment that is deplorable, they may suffer long-term negative impacts because of the poor quality of life. Direct observation of living conditions and alertness to evidence of these impacts are important during the data-gathering phase of the assessment.

A team faced with limited time and resources can turn to these basic social indicators for information about local conditions:

- percentage of population below the poverty level
- percentage of population in substandard housing
- percentage of children among exposed population
- life expectancy
- population density by city or neighborhood
- urban growth rate

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Appendix C

STANDARDS

Standards have been established by various organizations for specified purposes including drinking water, industrial use, irrigation, fish and aquatic life, and recreation. Some specific standards have and will continue to be updated as better data and improved methods of assessment become available. There is also an expanding list of pollutants that are recognized as requiring research in setting criterion for standards.

The standards provided in this appendix are examples. They are fairly complete for water quality but are a partial list in other areas. Examples are provided from international organizations (WHO), national (U.S.) and state (California). For comparison purposes within the United States, California has higher standards than the United States. Although these standards are not reachable by most developing countries in the near term, they do provide a model of what to strive for.

It is important to recognize that variation in some standards exists between the U.S., EEC, Canada, and the World Health Organization. Even within the United States, standards among states may vary. In spite of some variation worldwide in standards, the tables provided in the appendix offer sentinel values which are valuable for comparison purposes.

WHO has established standards for drinking water but prefers the term "guideline values." These are defined as levels of constituents which do not "result in any significant risk to the health of the consumer." Further, WHO allows that "in developing national drinking water standards based on WHO guidelines, it will be necessary to take account of a variety of local, geographical, socioeconomic, dietary and industrial conditions. This may lead to national standards that differ appreciably from the guideline values." (WHO 1984)

WHO recognizes that individual countries may adopt standards that consider not only medical and environmental sciences but also economic and political concerns. Assessment criteria which address risks and benefits vary from country to country. More often, however, developing countries have tended to adopt the WHO guidelines but have not been vigorous in enforcing the application of the standards.

Many industrialized countries have increasingly turned to economic incentives to allow increased flexibility, efficiency, and cost-effectiveness in pollution control. These incentives have the capacity to regulate in accordance with market mechanisms and thus reduce government regulation. In practice, however, there is still a need for standards and corresponding monitoring and enforcement on the part of responsible government agencies. The adoption of practical standards and the means to enforce standards remains a priority objective for most developing countries.

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SECTION B. DRINKING WATER QUALITY STANDARDS—UNITED STATES

The U.S. Environmental Protection Agency's National Primary Drinking-Water Regulations and National Secondary Drinking-Water Regulations are summarized in the following tables. The primary regulations specify maximum contaminant levels (MCLs), and health advisories. The MCLs, which are the maximum permissible level of a contaminant in water at the tap, are health related and are legally enforceable. If these concentrations are exceeded or if required monitoring is not performed the public must be notified. The secondary drinking-water regulations specify the secondary maximum contaminant levels (SMCL). The SMCLs are for contaminants in drinking water that primarily affect the esthetic qualities related to public acceptance of drinking water; they are intended to be guidelines for the States and and are not federally enforceable. Health advisories are guidance contaminant levels that would not result in adverse health effects over specified short-time periods for most people.

As provided by the Safe Drinking Water Act of 1974, the U.S. Environmental Protection Agency has the primary responsibility for establishing and enforcing regulations. However, States may assume primacy if they adopt regulations that are at least as stringent as the Federal regulations in levels specified for protection of public health and in provision of surveillance and enforcement. The States may adopt more stringent regulations and may establish regulations for other constituents.

TABLE 6–13. NATIONAL PRIMARY DRINKING WATER STANDARDS

Constituent	MCL mg/L	Constituent	MCL mg/L
INORGANICS		Lindane	0.004
Arsenic (AS)	0.05	Methoxychlor	0.1
Barium (Ba)	1.0	Toxaphene	0.005
Cadmium (Cd)	0.01	Total trihalomethanes	0.10
Chromium (Cr)	0.05	RADIONUCLIDES	
Fluoride (F)	4.0	Beta particle and photon	
Lead (Pb)	0 05	activity, mrem	4 (annual dose equivalent)
Mercury (Hg)	0.002	Gross alpha, pCi/L	15
Nitrate (as N)	10.0	Radium-226 and 228, pCi/L	5
Selenium (Se)	0.01	VOLATILE ORGANIC CHEMICALS	
Silver (Ag)	0.05	Benzene	0.005
MICROBIOLOGICALS		Carbon tetrachloride	0.005
Coliforms	1/100 mL	1,2-Dichloroethane	0.005
PHYSICAL CHARACTERISTICS		1,1-Dichloroethylene	0.007
Turbidity, NTU	1–5	1,1,1-Trichloroethane	0.20
ORGANICS		para-Dichlorobenzene	0.075
2, 4-D	0.1	Trichloroethylene	0.005
2,4,5-TP Silvex	0.01	Vinyl chloride	0.002
Endrin	0.0002		

Source: U.S. Environmental Protection Agency

TABLE 6–14. NATIONAL SECONDARY DRINKING WATER STANDARDS

Constituent	SMCL Level (mg/L)	Constituent	SMCL Level (mg/L)
Chloride (Cl)	250	Manganese (Mn)	0.05
Color, color units	15	Odor, threshold odor number	3
Copper (Cu)	1	pH, pH units	6.5–8.5
Corrosivity	Noncorrosive	Sulfate (SO_4)	250
Fluoride	2.0	Total dissolved solids (TDS)	500
Surfactants (MBAS)	0.5	Zinc (Zn)	5.0
Iron (Fe)	0.3		

HEALTH ADVISORY

Constituent	Level (mg/L)
Sodium	20

Source: U.S. Environmental Protection Agency

TABLE 6–15. PROPOSED RMCLs FOR MICROBIOLOGICAL AND PARTICULATE CONSTITUENTS IN DRINKING WATER

[RMCL - recommended maximum contaminant level]

Constituent	Proposed RMCL	Constituent	Proposed RMCL
Total coliforms	Zero	Asbestos	7.1 million long fibers/L
Giardia lamblia	Zero	Turbidity	0.1 NTU
Viruses	Zero		

Source: USEPA, November 13, 1985

TABLE 6–16. PROPOSED NATIONAL DRINKING WATER STANDARDS FOR ORGANIC AND INORGANIC CHEMICALS

[MCL - Maximum contaminant level; SMCL - Secondary maximum contaminant Level]

Chemical	Level	Chemical	Level
Proposed MCLs for organic chemicals:		**Proposed MCLs for inorganic chemicals:**	
Acrylamide	treatment technique	Arsenic	0 03 mg/L
Alachlor	0.002 mg/L	Asbestos	7 million fibers/L
Aldicarb	0.01 mg/L		(longer than 10 μm)
Aldicarb sulfoxide	0.01 mg/L	Barium	5 mg/L
Aldicarb sulfone	0.04 mg/L	Cadmium	0.005 mg/L
Atrazine	0.003 mg/L	Chromium	0.1 mg/L
Carbofuran	0.04 mg/L	Mercury	0.002 mg/L
Chlordane	0.002 mg/L	Nitrate**	10 0 mg/L (as N)
Dibromochloropropane	0.0002 mg/L	Nitrite	1.0 mg/L (as N)
o-Dichlorobenzene	0.6 mg/L	Selenium	0.05 mg/L
cis-1,2-Dichloroethylene	0.07 mg/L		
trans-1,2-Dichloroethylene	0.1 mg/L	**Proposed SMCLs:**	
1,2-Dichloropropane	0.005 mg/L		
2,4-D	0.07 mg/L	Aluminum	0.05 mg/L
Epichlorohydrin	treatment technique	o-Dichlorobenzene	0.01 mg/L
Ethylbenzene	0.7 mg/L	p-Dichlorobenzene	0.005 mg/L
Ethylene dibromide	0.00005 mg/L	1,2-Dichloropropane	0.005 mg/L
Heptachlor	0.0004 mg/L	Ethylbenzene	0.03 mg/L
Heptachlor epoxide	0 0002 mg/L	Pentachlorophenol	0.03 mg/L
Lindane	0.0002 mg/L	Silver	0.09 mg/L
Methoxychlor	0.4 mg/L	Styrene	0.01 mg/L
Monochlorobenzene	0.1 mg/L	Toluene	0.04 mg/L
PCBs	0.0005 mg/L	Xylene	0.02 mg/L
Pentachlorophenol	0.2 mg/L		
Styrene*	0.005 mg/L/0.1 mg/L		
Tetrachloroethylene	0.005 mg/L		
Toluene	2 mg/L		
Toxaphene	0.005 mg/L		
2,4,5-TP (Silvex)	0.05 mg/L		
Xylene	10 mg/L		

* EPA proposes MCLs of 0.1 mg/L based on a Group C carcinogen classification and .005 mg/L based on a B_2 classification.
** In addition, MCL for total nitrate and nitrite = 10.0 mg/L.
Source: USEPA Office of Drinking Water, August 1988; amended based on May 22, 1989, Fed. Register Vol. 54, No. 97, pp. 22062-65

SECTION C. DRINKING WATER STANDARDS—WORLD

TABLE 6-21. WORLD HEALTH ORGANIZATION GUIDELINES FOR DRINKING WATER QUALITY

MICROBIOLOGICAL AND BIOLOGICAL QUALITY

Organism	Unit	Guideline Value	Remarks
I. Microbiological quality			
A. Piped water supplies			
A.1 Treated water entering the distribution system			
Faecal coliforms	Number/100 mL	0	Turbidity <1 NTU; for disinfection with chlorine, pH preferably <8.0; free chlorine residual 0.2–0.5 mg/litre following 30 minutes (minimum) contact
Coliform organisms	Number/100 mL	0	
A.2 Untreated water entering the distribution system			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	0	In 98% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
Coliform organisms	Number 100 mL	3	In an occasional sample, but not in consecutive samples
A.3 Water in the distribution system			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	0	In 95% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
Coliform organisms	Number/100 mL	3	In an occasional sample, but not in consecutive samples
B. Unpiped water supplies			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	10	Should not occur repeatedly; if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible
C. Bottled drinking-water			
Faecal coliforms	Number/100 mL	0	Source should be free from faecal contamination
Coliform organisms	Number/100 mL	0	
D. Emergency water supplies			
Faecal coliforms	Number/100 mL	0	Advise public to boil water in case of failure to meet guideline values
Coliform organisms	Number/100 mL	0	
Enteroviruses		No guideline value set	
II. Biological quality			
Protozoa (pathogenic)	—	No guideline value set	
Helminths (pathogenic)	—	No guideline value set	
Free-living organisms (algae, others)	—	No guideline value set	

TABLE 6-21. WORLD HEALTH ORGANIZATION GUIDELINES FOR DRINKING WATER QUALITY (continued)

INORGANIC CONSTITUENTS OF HEALTH SIGNIFICANCE

Constituent	Unit	Guideline Value	Remarks
Arsenic	mg/L	0.05	
Asbestos	—	No guideline value set	
Barium	—	No guideline value set	
Beryllium	—	No guideline value set	
Cadmium	mg/L	0.005	
Chromium	mg/L	0.05	
Cyanide	mg/L	0.1	
Fluoride	mg/L	1.5	Natural or deliberately added; local or climatic conditions may necessitate adaptation
Hardness	—	No health-related guideline value set	
Lead	mg/L	0.05	
Mercury	mg/L	0.001	
Nickel	—	No guideline value set	
Nitrate	mg/L (N)	10	
Nitrite	—	No guideline value set	
Selenium	mg/L	0 01	
Silver	—	No guideline value set	
Sodium	—	No guideline value set	

ORGANIC CONSTITUENTS OF HEALTH SIGNIFICANCE

Constituent	Unit	Guideline Value	Remarks
Aldrin and dieldrin	μg/L	0.03	
Benzene	μg/L	10[a]	
Benzo[a]pyrene	μg/L	0.01[a]	
Carbon tetrachloride	μg/L	3[a]	Tentative guideline value[b]
Chlordane	μg/L	0.3	
Chlorobenzenes	μg/L	No health-related guideline value set	Odor threshold concentration between 0.1 and 3 μg/L
Chloroform	μg/L	30[a]	Disinfection efficiency must not be compromised when controlling chloroform content
Chlorophenols	μg/L	No health-related guideline value set	Odor threshold concentration 0.1 μg/L
2,4-D	μg/L	100[c]	
DDT	μg/L	1	
1,2-Dichloroethane	μg/L	10[a]	
1,1-Dichloroethene[d]	μg/L	0 3[a]	
Heptachlor and heptachlor epoxide	μg/L	0 1	
Hexachlorobenzene	μg/L	0.01[a]	
Gamma-HCH (lindane)	μg/L	3	
Methoxychlor	μg/L	30	
Pentachlorophenol	μg/L	10	
Tetrachloroethene[d]	μg/L	10[a]	Tentative guideline value[b]
Trichloroethene[d]	μg/L	30[a]	Tentative guideline value[b]
2,4,6-Trichlorophenol	μg/L	10[a,c]	Odor threshold concentration, 0.1 μg/L
Trihalomethanes		No guideline value set	See chloroform

[a] These guideline values were computed from a conservative hypothetical mathematical model which cannot be experimentally verified and values should therefore be interpreted differently. Uncertainties involved may amount to two orders of magnitude (i.e., from 0.1 to 10 times the number).

[b] When the available carcinogenicity data did not support a guideline value, but the compounds were judged to be of importance in drinking-water and guidance was considered essential, a tentative guideline value was set on the basis of the available health-related data.

[c] May be detectable by taste and odor at lower concentrations.

[d] These compounds were previously known as 1,1-dichloroethylene, tetrachloroethylene, and trichloroethylene, respectively.

TABLE 6–23. COMPARISON OF UNITED STATES PRIMARY DRINKING WATER REGULATIONS WITH CANADIAN, EEC, AND WHO GUIDELINES

Substance	US Maximum Contaminant Level* mg/L	Canadian Maximum Acceptable Limit† mg/L	EEC Maximum Admissible Concentration† mg/L	WHO Guideline Value mg/L
Inorganics				
Arsenic	0.05	0 05	0 05	0.05
Barium	1.0	1.0	0 1	NS
Cadmium	0 01	0 005	0 005	0 005
Chromium	0 05	0 05	0 05	0 05
Fluoride	4 0	1.5	NS	1 5
Lead	0 05	0 05	0 05	0.05
Mercury	0.002	0 001	0 001	0 001
Nitrate	10 0	10.0	50	10 0
Selenium	0.01	0.01	0 01	0 01
Silver	0 05	0 05	0 01	NS
Microbials				
Coliforms—*organisms/100 mL*	<1	10	0	0
Turbidity—*ntu*	1–5	5 0	0–4	<1
Organics				
2,4-D	0 1	0 1	NS	0 001
Endrin	0 0002	0.0002	NS	NS
Lindane	0.0004	0.004	NS	NS
Methoxychlor	0 1	0 1	NS	0 001
Pesticides (total)	NS	0 1	0 005	NS
Toxaphene	0.005	0.005	NS	NS
2,4,5-TP silvex	0 01	0.01	NS	NS
Trihalomethanes	0 10	0 35	0 001	0 03 ($CHCl_3$ only)
Radionuclides				
Beta particle and photon activity	4 mrem	NS	NS	1.0 Bq/L‡
Gross alpha particle activity	15 pCi/L	NS	NS	0.1 Bq/L‡
Radium 226 + radium 228	5 pCi/L	1 Bq/L‡	NS	NS
Volatile organic chemicals				
Benzene	0.005	NS	NS	0.01
Carbon tetrachloride	0 005	NS	NS	0 003
1,1-Dichloroethylene	0.007	NS	NS	0 003
1,2 Dichloroethane	0 005	NS	NS	0 01
para-Dichlorobenzene	0.075	NS	NS	NS
1,1,1-Trichloroethane	0 2	NS	NS	NS
Trichloroethylene	0 005	NS	NS	0 03
Vinyl chloride	0 002	NS	NS	NS

* Enforceable
† Nonenforceable
NS = No standard
‡ Becquerels per liter
EEC = European Economic Community
WHO = World Health Organization
Source. Sayre, I M , 1988, International Standards for Drinking Water, J. Am. Water Works Assoc., v.80, no 1. Copyright AWWA Reprinted with permission

TABLE 6–24. COMPARISON OF UNITED STATES SECONDARY DRINKING WATER REGULATIONS WITH CANADIAN, EEC, AND WHO GUIDELINES

Substance	US Secondary Maximum Contaminant Level*	Canadian Maximum Acceptable Limit*	EEC		WHO Guideline Value
			Guide Level*	Maximum Admissible Concentration	
Chloride	250 mg/L	250 mg/L	25 mg/L	NS	250 mg/L
Color	15 cu	15 cu	1 mg Pt-Co/L	20 mg Pt Co/L	15 cu
Copper	1 mg/L	1.0 mg/L	100 µg at treatment plant, 3,000 µg after 12 hours in piping	NS	1 0 mg/L
Corrosivity	noncorrosive				
Fluoride	2 mg/L	1 5 mg/L		Water should not be aggressive Varies according to average temperature in the area	1 5 mg/L
Foaming agents	0 5 mg/L	NS	NS	NS	
Iron	0 3 mg/L	0.3 mg/L	50 µg/L	300 µg/L	0.3 mg/L
Manganese	0 05 mg/L	0 05 mg/L	20 µg/L	50 µg/L	0.1 mg/L
Odor	3 TON		0 dilution number	2 dilution number at 54°F (12°C)	
pH	6 5–8.5	6 5–8 5	6 5–8 5	NS	6 5–8.5
Sulfate	250 mg/L	500 mg/L	25 mg/L	NS	400 mg/L
Total dissolved solids	500 mg/L	500 mg/L	NS	NS	1,000 mg/L
Zinc	5 mg/L	5 mg/L	100 µg at treatment plant, 5,000 µg after 12 hours in piping	NS	5 0 mg/L

* Nonenforceable
NS = No standard

TABLE 6–3. OPTIMUM AND MAXIMUM VALUES OF WATER QUALITY CHARACTERISTICS IN RELATION TO TYPE OF BENEFICIAL USE

Characteristics	Domestic Water Supply	Recreation: Bathing and Swimming, Fresh Water	Recreation: Bathing and Swimming, Salt Water	Recreation: Boating and Fishing	Wildlife Propagation: Fish, Fresh Water	Wildlife Propagation: Fish, Salt Water	Wildlife Propagation: Fowl Refuge	Shellfish Culture	Irrigation: Truck Garden Vege-tables	Irrigation: Citrus Fruits	Irrigation: Other Crops	Industrial: Food Processing, Fresh Water	Industrial: Food Processing, Salt Water	Industrial: Cooling and Other, Fresh Water	Industrial: Cooling and Other, Salt Water	Aesthetic Enjoy-ment
1. *Bacterial—per ml.*																
Coliform (opt.)	1.0	none	1.0	10	10	10	100	1.0	1.0	10	100	0.1	1.0	1.0	10	
Coliform (max.)	50	1.0	10	100	100	100	1,000	5	10	100	100	1.0	3.0	10	100	
2. *Organic—ppm.*																
B.O.D. (opt.)	none	5	5	10	10	10	10	5				none	1	5	5	20
B.O.D. (max.)	0.5	10	10	30	30	30	50	20				5	10	10	20	100
D.O. (opt.)	5	5	5	5	5	5	5	5				5	5	3.0	3.0	5.0
D.O. (min.)	2	2	2	2	3	2	2	2				1	1	1.0	1.0	1.0
Oil (opt.)	none	none	none	none	none	none	none	none	none	none	none	none	none	5	5	none
Oil (max.)	2	2	2	5	5	5	5	2	5	5	5	2	5	10	10	10
3. *Reaction*																
pH (opt.)	6.8–7.2	6.8–7.2	6.8–7.2		6.5–8.5	6.5–8.5	6.5–8.5	6.8–7.2	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	4.0–10.0	4.0–10.0	
pH (critical)	6.6–8.0	6.5–8.6	6.5–8.6		6.5–8.5	6.5–8.5	6.5–8.5	6.6–8.0	6.0–9.0	6.0–9.0	6.0–9.0	6.0–9.0	6.0–9.0	4.0–10.0	4.0–10.0	
4. *Physical—ppm.*																
Turbid. (opt.)	5	5	5	10	5	5	10	5				5	5			50
Turbid. (max.)	20	20	30	50	10	20	100	50				20	50			
Color (opt.)	10	10	10	10	5	5	10	10				10	10			20
Color (max.)	30	30	30	50	10	20	100	50				30	50			100
Susp. solids (opt.)	10	50	50		10	10	50	10				10	10	50	50	
Susp. solids (max.)	100	100	100		20	50	250	100				50	100	150	150	
Float. solids (opt.)	none	none	none	none	none	none	slight	none				none	none	none	none	slight
Float. solids (max.)		gross	gross	gross	gross	gross	gross	gross				slight	slight	slight	slight	gross

Characteristics	Domestic Water Supply	Recreation: Bathing and Swimming		Recreation	Wildlife Propagation: Fish		Wildlife Propagation	Shellfish Culture	Irrigation			Industrial: Food Processing		Industrial: Cooling and Other		Aesthetic Enjoyment
		Fresh Water	Salt Water	Boating and Fishing	Fresh Water	Salt Water	Fowl Refuge		Truck Garden Vegetables	Citrus Fruits	Other Crops	Fresh Water	Salt Water	Fresh Water	Salt Water	
5. *Chemical—ppm.*																
Total solids (opt)	500				1,000				500	500	500	500		1,000		
Total solids (max.)	1,500				5,000				1,500	1,500	2,000	1,500		1,500		
Cl (opt.)	250				1,000				200	100	250	500				
Cl (max.)	750				2,500				750	500	750	1,000				
F (opt.)	0 5–1.0								0 5–1 0							
F (max.)	1.5								5							
Toxic metals (opt.)	none	0.1	0 5		0 5	0 5			0 1			none	none			
Toxic metals (max.)	0.05	5	10		10	10		0 1	2.5			0 1	0.5			
Phenol (opt)	1*	5*	50*	1	0 1	0 5	5	1*	5*			1*	5*			
Phenol (max.)	5*	50*	1	10	1	5	25	10*	20*			10*	50*			
Boron (opt)										0.5	1.0					
Boron (max.)										1 0	5					
Na ratio† (opt.)									35–50†	35–50†	35–50†			90†		
Na ratio† (max.)									80†	75†	80†			90†		
Hardness (opt.)	100													100		
Hardness (max.)	250													500		
6. *Temp.—°F. (max.)*	60	65	65		60	60		70								
7. *Odor ‡ (max.)*	N	N	N	M	M	M	M	N	O	O	O	M	M	O	O	O
8. *Taste‡ (max.)*	N	M	D		M	M	M	N				M	M			

*Parts per billion.
† Per cent.
‡ Key: D—disagreeable; M—marked; N—noticeable; O—obnoxious
Source Calif. State Water Pollution Control Board, 1952

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Associates in Rural Development, Inc.
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Research Triangle Institute
University Research Corporation
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THE WASH PROJECT

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (A.I.D.) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH) The funding mechanism was a multi-year, multi-million dollar contract, secured through competitive bidding. The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc. (CDM), an international consulting firm specializing in environmental engineering services. Through two other bid proceedings since then, CDM has continued as the prime contractor.

Working under the close direction of A.I.D.'s Bureau for Science and Technology, Office of Health, the WASH Project provides technical assistance to A.I.D. missions or bureaus, other U.S. agencies (such as the Peace Corps), host governments, and non-governmental organizations to provide a wide range of technical assistance that includes the design, implementation, and evaluation of water and sanitation projects, to troubleshoot on-going projects, and to assist in disaster relief operations. WASH technical assistance is multi-disciplinary, drawing on experts in public health, training, financing, epidemiology, anthropology, management, engineering, community organization, environmental protection, and other subspecialties.

The WASH Information Center serves as a clearinghouse in water and sanitation, providing networking on guinea worm disease, rainwater harvesting, and peri-urban issues as well as technical information backstopping for most WASH assignments.

The WASH Project issues about thirty or forty reports a year. WASH *Field Reports* relate to specific assignments in specific countries; they articulate the findings of the consultancy. The more widely applicable *Technical Reports* consist of guidelines or "how-to" manuals on topics such as pump selection, detailed training workshop designs, and state-of-the-art information on finance, community organization, and many other topics of vital interest to the water and sanitation sector In addition, WASH occasionally publishes special reports to synthesize the lessons it has learned from its wide field experience.

For more information about the WASH Project or to request a WASH report, contact the WASH Operations Center at the above address.