Environmental Management: A System Approach

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ABSTRACT / This paper presents a system framework whose purpose is to improve understanding of environmental management. By analyzing the links between elements of the environmental management system, it is possible to construct a model that aids thinking systematically about the decision-making subsystem, and other subsystems, of the entire environmental management system.

Through a multidisciplinary environmental approach, each of the individual subsystems is able to adapt to threats and opportunities. The fields of government, market economics, social responsibility and ecology, for example, are so complex that it is extremely difficult to develop a framework that gives full consideration to all aspects. This paper, through the application of a highly idealized system framework, attempts to show the general relationships that exist between complex system elements.

Environmental management consists of managing human affairs so as to achieve an acceptable balance between the quality of the human environment and the quality of the natural environment. This complex process requires the environmental manager to recognize the key factors by which he or she is constrained. These factors are social, technical-scientific, administrative, political, legal, and economic, represented by the acronym STAPLE.

The purpose of this paper is to describe a system framework that can be used to aid in conceptualizing environmental management. The system framework as proposed is recognized as an idealized system and is provided to aid in understanding this complex field of study. The linkage between elements of the environmental management system will be described, and a model will be presented that conveys an approach to thinking systematically about the interrelationships between the decision-making subsystem and other subsystems of the larger environmental management system.

An understanding of these interrelationships is essential to develop a full comprehension of the environmental management process. Further, understanding this process is critical to developing public policy measures that aid in achieving a desired quality of life.

In order to facilitate understanding environmental management as a system, it is necessary to identify the key subsystems involved; that is, those subsystems whose relationships and interactions define and give special character to the overall system. This is a complex matter and can be accomplished at various levels of detail. The discussion presented in this paper is intended to provide only a framework and thus will not engage in a highly detailed analysis, which would be the subject for a major treatise in the field of environmental management.

For our purposes and as a starting point, a system framework for environmental management must include consideration of the elements represented by STAPLE. These basic system elements are incorporated in the following diagram (Fig. 1), which identifies six major subsystems within the total environmental management system. Each element within this system will be discussed in terms of its interaction with the decision-making function, with emphasis on development of an overview through use of a systems approach.

Environmental Management System

A systems approach to environmental management requires a holistic view of the environmental arena in order that the many impacts or constraints conditioning the decision-making process be fully understood. This approach to framing the environmental management system suggests a substantially different role for management than does traditional management theory. In traditional theory, the emphasis is on economic rationality through the application of technology. Our current environmental dilemma, manifested by our difficulties in dealing with such problems as reducing air pollution and preventing release of carcinogens to the

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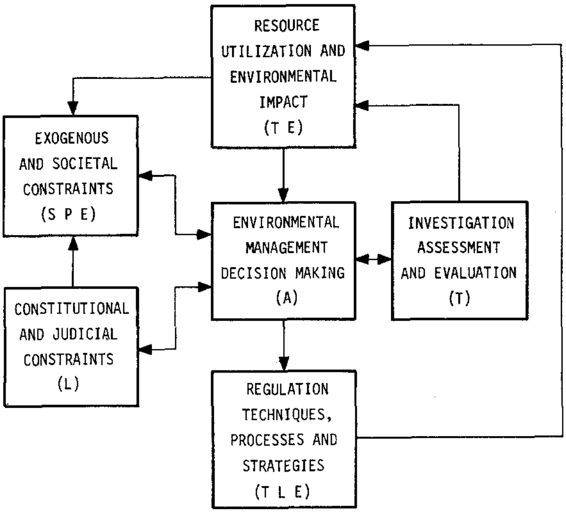

Figure 1. Environmental management system.

environment, can be attributed to this limited, narrow approach.

The view of environmental management as an interrelationship of complex subsystems presents the difficulty of the decision maker's role. Management must deal with a larger range of uncertainties and ambiguities not considered under a more narrow economic rationality model, and be continuously concerned with adapting to new and changing requirements beyond merely economic or technical changes. In this context, management must work to reduce uncertainty, while searching for the flexibility necessary to respond to changing social and political values and demands; management must integrate the activities and balance the demands of these various subsystems.

An effort will be made here to demonstrate the need for a multidisciplinary environmental management approach. Under this approach, the disciplines involved will have to accept unfamiliar input and feedback; a premium must be put on outcomes that are "useful" rather than merely "right." The decision maker will have to be cognizant of the unique values of each of the various disciplines and be able to integrate each individual contribution into the total system.

Environmental Management Decision Making: A Focus for Analysis

Decision making involves choosing among alternatives and is a critical factor in managerial performance, system effectiveness, and ultimate environmental quality. The focus of the total system framework is on the decision-making subsystem and its interaction with the other subsystems in the total environmental management system.

The environmental manager, as a decision maker, is responsible for maintaining a balanced system by giving full consideration to the social, technical-scientific, administrative, political, legal, and economic (STAPLE) elements of the system. These STAPLE elements represent inputs and expectations, as well as constraints on the environmental management system. Understanding the network relationships between these elements and how they influence the outcomes of the system, individually and collectively, is a major step toward the goal of improving communication among the representatives of participating disciplines.

The manager/decision maker is responsible for keeping the overall system in balance by giving appropriate consideration to the individual elements affecting environmental policy and decisions. The environmental manager must be able to identify the roles of the various actors in the overall system. These roles can be generally classified as policy analysts and policy advocates.

Policy analysts are the assessors of consequences, whose major focus is objectivity (i.e., a technologist, scientist, or economist); they must keep personal opinions subjugated while forming questions, assessing the reliability of information, classifying opinions, and finally, presenting the probable consequences of decisions. Policy advocates, however, tend to champion particular courses of action (i.e., a representative of a social or political interest group); they are less rigorous about keeping personal and subjective opinions under control. In general, each of the elements of STAPLE is represented by role players who are either analysts or advocates.

The manager/decision maker is required to operate from a broad base of knowledge; he or she must listen to both the assessors and advocates, weigh their input, and make policy-relevant decisions that cause action to be taken that is both effective and optimally acceptable to the total system. Fully understanding the complexity and interrelationships of the various subsystems enhances the ability to make balanced decisions that give consideration to all aspects of the problem.

Many of our environmental difficulties are the direct result of alternative decision selections based on narrow decision criteria without regard to ecological system impacts and ultimate social costs. This has resulted in environmental decision makers being required to reevaluate their roles. At least three trends in the United States indicate this need for a system perspective (Appleyard 1973).

First, the increasing emphasis on citizen participation in the planning and evaluation process has in the past few years moved the decision-making process from professional dominance to the point where people of all classes are entering the process. Citizens have been dispensing with their passive roles and are claiming full participation in environmental decision making. The professional manager will, of necessity, have to become more adept at being a facilitator-broker.

Second, the national and state environmental policy acts, which require impact assessments of all significant new programs or projects, have caused the decision maker to engage in comprehensive environmental assessment prior to project acceptance. Most of these assessments are attempts to gain an understanding of future socioenvironmental impacts, which will require that the environmental manager become more experienced in performing and assessing empirical research carried out in the field.

Finally, a shift from emphasis on new designs for the environment to a broader interest in existing environments, their conservation, rehabilitation, and management is taking place. Environmental management, which emphasizes nondegradation and monitoring of environments over time, is seen as a way of developing a better environment than that produced by single-purpose, one-time interventions.

Responsible decision making has always depended on the availability of reliable information, and the trends as noted above serve to reinforce this need. In the area of environment, where emotions run high and facts are hard to establish, decisions are made under a great deal of uncertainty. This has generally resulted in decisions based on a narrow incrementalism focusing on short-term utility maximization. As long as basic elements of the environment appeared to be ample relative to the population, the short-term, minimum-cost approach to providing maximum satisfaction of human needs was considered acceptable. Considering environmental management in the context of a system of scarce resources requires that different kinds of choices be made about allocating available resources among competing uses. These uses can no longer be left to decisions of a free, unregulated market. Institutions and mechanisms created by public action are required for the management of resources and environmental services (Freeman et al. 1973).

Environmental management and decision making as a subsystem will be constrained or conditioned by many conflicting inputs from other elements of the system (i.e., other subsystems). These subsystems are represented as the constitutional and judicial; societal; resource utilization and impact; investigation and evaluation; and regulation and enforcement subsystems. In order for the decision maker to function in a policy-relevant manner that allows for the full integration of both assessor and advocate positions, the decision-making subsystem must effectively process inputs on perceptions of environmental amenities and pollution, ecological criteria and standards, materials balance assessments, environmental and social indicators, environmental monitoring results, cost/risk/benefit assessment, and institutional/behavioral change.

This approach will require the decision-making subsystem to develop and maintain comprehensive data bases and a management information system. Optimally, these data should flow from the subsystems, be organized in terms of indices that permit the aggregation of the relevant data, and be stored as part of the decision maker's management information system.

Decision-Making Subsystem

The quality of environmental management decision making is critical to achieving an acceptable and tolerable environment. The decision-making subsystem must not only process the inputs from the other subsystems, but also assume major responsibility in achieving an overall environmental system balance by giving careful attention to the STAPLE elements. A system approach to environmental management is a unifying concept, stressing that a total system is more than merely a set of independent parts. Figure 2 presents the diagrammatic framework for an overall environmental management system with the decision-making subsystem in the central integrative position.

Problem analysis and strategic planning are critical aspects of the decision maker's function. These processes

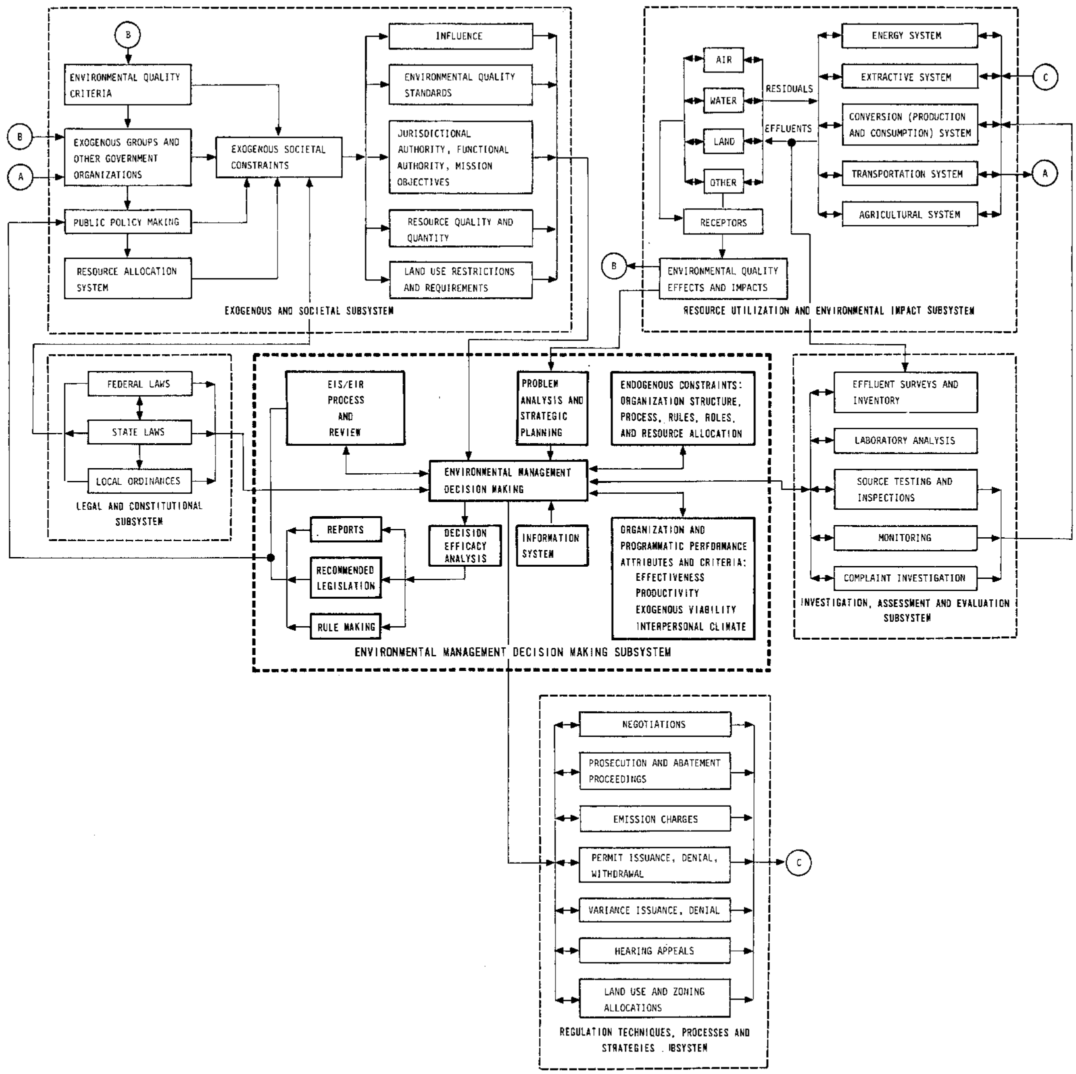

Figure 2. Environmental management interactive system and subsystems.

are necessary in order to provide insight and understanding, with regard to defining real problems and drafting strategic plans for intervention, thus precluding system responses to purely emotional issues or issues not substantiated by analysis. At this point, environmental assessment through ecological and social impact analysis, risk assessment and evaluation budget analysis, benefit-cost analysis, marginal-cost studies, and trade-off analysis becomes significant to the decision-making process.

The environmental impact statement and reporting

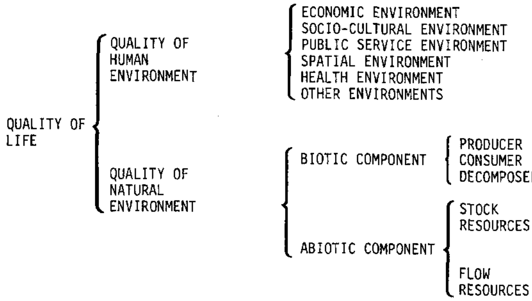

Figure 3. Quality of life classification system (Joun 1973).

process is an important input to the decision maker and provides the basis necessary for decision efficacy analysis. In standard cost-benefit analysis of system activities, intangible impacts on the environment are not generally taken into account, whereas environmental impact assessment requires the recognition of all identifiable impacts early in the planning process and provides information pertaining to the overall environmental effects of human activities. The process provides for the establishment of an inventory of the attributes of the environmental system. Environmental impacts flowing from the resource utilization subsystem may be assessed on the basis of a review of impacted attributes and compliance with established environmental quality criteria or standards. Another valuable use of the impact inventory is to provide a means to assess cumulative effects of a group or series of activities that may result in serious and unforeseen changes to the environmental system.

Decision alternatives resulting from these analyses must be assessed for their efficacy in order to minimize the probability of inadvertently making a segmented or suboptimal decision. This efficacy assessment should provide the rationale for any decision and show how the decision purports to contribute to the quality of the total system. Further, the assessment must be consistent with the concern of the societal subsystems for quality of life and provide information on progress toward overall system effectiveness.

Environmental indices are important to performance of any assessment of alternative decisions. However, despite the many positive statements by both government and the scientific community, real progress in developing a set of appropriate indices has not occurred. This is best characterized by the number of competing indices in the area of air quality (e.g., MITRE Air Quality Index, Extreme Value Index, and Oak Ridge Air Quality Index), while issues involved in land use remain unclarified (Thomas 1972). One approach to aid the environmental manager/decision maker in improving understanding of land use as well as other environmental areas is the measurement of people's perceptions of environmental quality (NAS-NAE 1975).

Thus, Perceived Environmental Quality Indices (PEQI) can provide the decision maker important input. As noted by Craik and Zube (1976), PEQIs can serve four principal uses: (1) assess the environmental quality that intrinsically involve the interplay between the human observer and the environment, (2) serve as criteria for establishing physically based environmental quality indices, (3) gauge the extent of congruence between perceptions of environmental quality and physical environmental quality, and (4) conduct person-centered environmental quality assessments, as well as traditional place-centered appraisals.

It must be understood that, even though the environmental manager has given full consideration to the PEQIs, environmental impact assessments, and environmental criteria and standards, the ultimate decision-making subsystem output of reports, rules, or recommended legislation, as well as regulation and enforcement, will be conditioned by various internal organizational constraints and performance criteria. To this extent, environmental managers must consider their organization's administrative structure, processes, rules, roles, and available resources, as well as its criteria regarding effectiveness, productivity, and interorganizational relationships. Specific attention must be paid to discovering and working through the many intraorganizational and interorganizational administrative constraints. This may result in a need for fundamental organizational change, re-allocation of resources, improvement of current technology and manpower, and most important, development of a complete understanding of current laws and ordinances and their effect on proposed decisions.

Further, the environmental decision-making subsystem should have a developed capability to apply various systems analysis and decision-aiding tools and methods. When the direct involvement of the subsystems with the policy-making process and the regulation and enforcement subsystem is being considered, this capability is particularly important. It is in these two areas that major interests surface and that significant conflicts arise.

Distinguishing facts from values and openly identifying and respecting them is a particularly important responsibility for environmental decision makers; they are continuously confronted with the problem of sorting out the conflicting inputs from the various subsystems, while working to maintain an overall system balance consistent with changing system values. As noted by Petak (1980), only when the environmental manager effectively integrates the positions of the opposing elements (i.e., technologist and ecologist) will it be possible to define states of nature more accurately and assess the alternatives in terms of secondary and higher order consequences.

Societal Subsystem

The environmental manager's decisions should ultimately serve the major goal set forth in the United States National Environmental Policy Act, which mandates the federal government to take action "in protecting and enhancing the quality of the nation's environment to sustain and enrich human life." The act declares a policy "to foster and promote general welfare to create and maintain conditions under which man and nature can exist in harmony, and fulfill the social, economic and other requirements of present and future generations." This policy means different things to different people. It can be stated that no consensus exists as to what it means in objective terms. Thus, understanding the varying attitudes, values, and perceptions of those in the societal subsystem is critical if the environmental manager is to be effective in developing and enforcing public policy acceptable to the total system. The outputs of this subsystem establish the basis for environmental management decision making, thus making this subsystem an important factor in the analysis.

Specifically, the outputs of the societal subsystem are generally recognized as being influenced by social, economic, and political factors. In this discussion, all of these influences may be considered as represented under the more general concept of quality of life (QOL). The community's environmental values are the expressed criteria by which people experience satisfaction or dissatisfaction with their economic, social, and physical environment, that is, those which can be expected to account in large measure for the quality of life experienced. These feelings, when combined as PEQIs, yield a net level of environmental satisfaction/dissatisfaction within the community.

In this context, quality of life encompasses the entire environment surrounding the human being. This environment can be divided into two broad categories: human and natural. The human environment is the man-made environment, and includes economic, sociocultural, spatial, and health components. The natural environment can also be divided into standard classifications. The following illustration (Fig. 3) developed by Joun (1973) provides a general picture of one quality of life classification system.

These quality of life components are defined as environmental system attributes and are generally contained in statements of environmental quality criteria or standards. In general, criteria are descriptive factors considered in setting standards, whereas standards are prescriptive norms established by the decision-making subsystem. The significance of the attributes as reflected in the criteria and standards is based largely on the environmental values held by society, as well as the political-economic climate. That is, the criteria or standards will be reflected in the interaction between the perceived levels of influence, jurisdiction, authority, stated objectives, resource quality, and land use requirements, as well as other various exogenous and societal constraints. Figure 4 presents a general perspective on the linkages between various elements of the societal subsystem.

The exogenous societal constraints that condition the expression of the quality of life are influenced by the complex interaction between the inputs from other elements of the larger environmental management systems, the values held by interest groups and other government jurisdictions, and the resource allocation system. Input to the policy-making element of the societal subsystem in the form of reports, recommended legislation, and rulemaking must be based on a balanced and full consideration of the societal subsystem quality of life demands as reflected by the PEQIs.

These indicators provide a basis for criteria and standards, which are based on the anticipated consequences of actions as identified through the various assessment and review processes.

Resource Utilization and Impact Subsystem

In addition to using the quality fo life, as expressed by the PEQIs, as a basis for environmental policy and decision making, it is necessary that specific impacts on various receptors (people, animals, plants, and inanimate

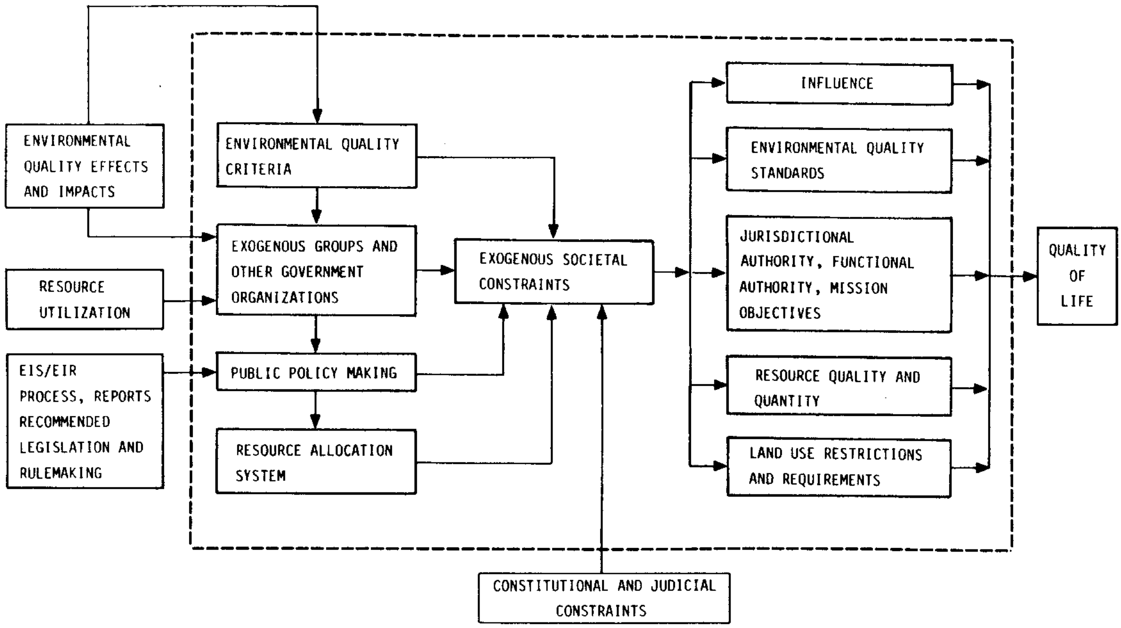

Figure 4. Societal subsystem.

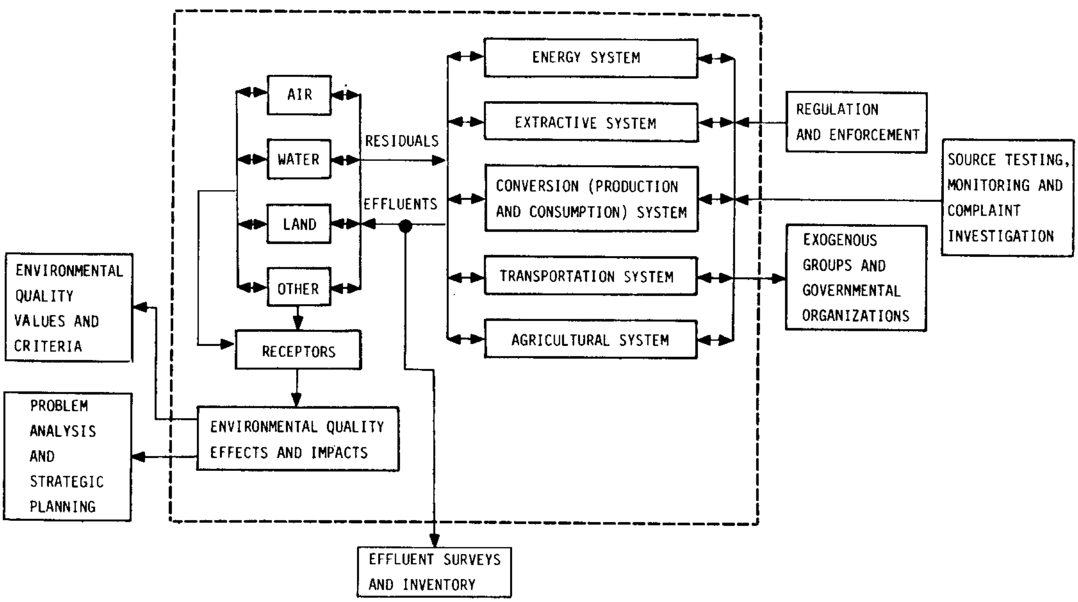

Figure 5. Resource utilization and environmental impact subsystem.

objects) caused by the resource utilization subsystem be analyzed. This requires (1) an integrating process that provides for the evaluation and screening of activities or processes of human or organizational response, and (2) special studies to ascertain the significance of the impact on the quality of the human and natural environment and to determine how the impacts may be modified or mitigated.

It is clear that the environment is important to human survival, both as a basic life support system and as a source of materials for production and consumption. The environment has, however, an enormous capacity to absorb and assimilate many types of materials, which are returned to the natural system after human intervention and use. When the assimilative capacity of the natural system is exceeded, environmental degradation results. The common usage of systems terms *input* and *output* and economic terms *production*, *consumption*, and *resource use* can be misleading to the environmental decision maker. These concepts are better described as processes of materials and energy "throughput" and balanced materials flows, which are intimately tied to the problem of residuals disposal. The consequences of residuals disposal are air, water, and land pollution; and the burden imposed on the natural processes in the ecosystem through impacts on the nutrient cycle, which is basic to the subsistance of all species of life.

Understanding the principle of materials balance and the impacts of disposal on the ecosystem is necessary to the establishment of environmental management criteria or standards, appropriate investigation and assessment programs, and the application of effective regulations and enforcement.

The following subsystem diagram (Fig. 5) is illustrative of the resource utilization system and its links with the overall environmental system. The major negative environmental consequences flowing from this subsystem are effluents or unwanted residuals.

Through the regulation and enforcement subsystem (pollution control and residuals management), the environmental manager attempts to regulate environmental pollution. Since the public policy definition of environmental quality is dependent on a determination of the public's attitudes and preferences regarding acceptable risks and tolerable pollution, scientific knowledge must be linked with the public interest to arrive at a working definition for the decision maker (Davies 1970). Acceptable environmental regulation and enforcement decisions hinge upon value determinations and political decisions; science is a critical input to the

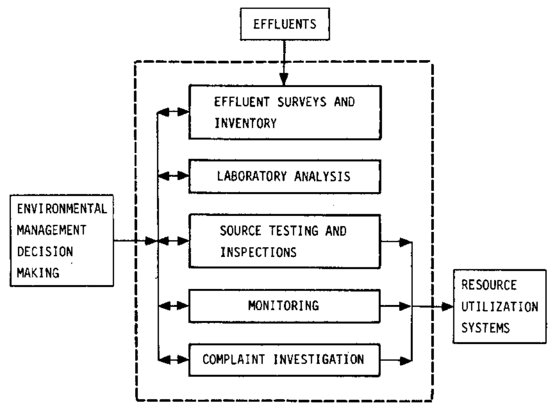

Figure 6. Investigation and evaluation subsystem.

process. The outputs of this subsystem, in the form of environmental quality, risk, effects, and impacts become the basis for analysis and assessment by the environmental manager. Action occurs in the societal subsystem when the impacts are considered to be inconsistent with environmental values and criteria. This process ultimately is reflected in demand for action on the part of the decision-making subsystem and is expressed in the form of quality of life concerns.

Investigation and Evaluation Subsystem

Responsible decision making (specifically, with regard to actions resulting in rulemaking, the enforcement of regulations, and legislative activity) depends on the availability of reliable information and a comprehensive understanding of the resource utilization and environmental impact subsystem. In an area as complex as the environment where knowledge is limited, emotions run high, and outcomes are uncertain, reliable, high-quality data are of critical importance. Thus, if the environmental manager is to make proper and effective decisions, comprehensive information on the status of changes in air, water, and land pollution and the resultant impacts on the environmental system (receptor impacts) is critical.

The environmental manager must employ an investigative and evaluative approach (Fig. 6) in order to develop physical environmental quality indicators. This approach should include:

1. The extent and types of pollutants, sources of pollution, and the population at risk (i.e., number and percent of persons experiencing pollution at levels hazardous to health);
2. A comparison of different geographic areas in terms of quality and types of pollutants;
3. The number of polluted areas (i.e., number of bodies of water and percent of rivers and streams in terms of specified pollution levels hazardous to health) and the sources of their pollution; and
4. Risk assessment and evaluation associated with the various types of pollutant releases in specific areas.

The process and resultant output of the investigation and evaluation subsystem is vitally necessary if the effects of dumping residuals are to be accurately assessed in terms of their environmental impact. Environmental quality indicators based on data from effluent surveys and laboratory analysis become integral with the environmental manager's information support system; these indicators are used as a basis for alerting the decision maker when an environmental hazard has exceeded the level of risk considered to be acceptable as evidenced by changes in the perceived and physical environmental quality indices. Notably, U.S. Supreme Court Justice Marshall in a dissenting opinion pertaining to standards for risks in the workplace stated that "when the question involves determination of the acceptable level of risk, the ultimate decision must necessarily be based on considerations of policy as well as empirically verifiable facts. Factual determinations can at most define risk in some statistical way; the judgment whether that risk is tolerable cannot be based solely on a resolution of the facts" (Industrial Union Department, AFL-CIO vs. American Petroleum Institute 1980). In this regard, standards can be considered a de facto expression of the level of risk society is willing to accept.

Consequently, complaint investigation, monitoring and source testing, and inspections are critical to this subsystem. They provide the communication network necessary to supply continuous measurement of resource utilization system effluents, residuals management, and physical environmental quality. Changes in the physical environmental quality indicators can then be assessed in relation to the environmental values of the societal subsystems as expressed in the form of PEQIs and environmental quality criteria. As the manager gains an increased understanding of the environment as a network of complex subsystems, all of which interact and influence one another, and as he or she develops tools to analyze the subsystems, monitoring and source inspection become increasingly important. Although competition for resources, concern for privacy, and frequent over-abundance of data make decisions about monitoring and data collection critical, statutes often place legal limits on the emission of pollutants, thus requiring continuous monitoring in specific areas. A high degree of involvement, by the decision maker, at the policy setting and planning stage is required to define the information/data needs or requirements of the various subsystems. This is critical if source inspection and monitoring systems are to facilitate the setting of priorities, allocating of resources, and the making of rules that are both cost-efficient and cost-effective.

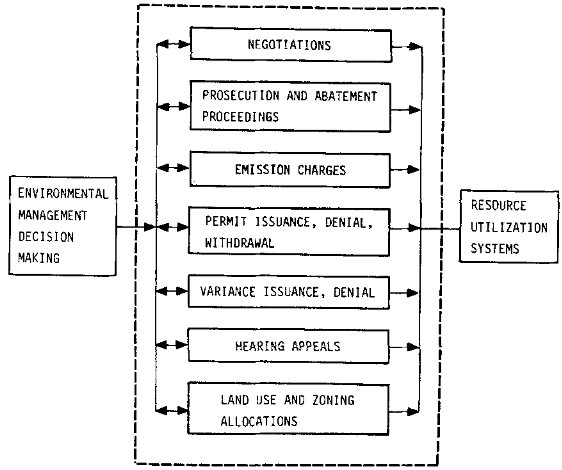

Figure 7. Regulation and enforcement subsystem.

Regulation and Enforcement Subsystem

Regulations are public policies (employing environmental standards) that are specific and systemized. The process of establishing the regulations involves the interaction of environmental managers in federal, state, and local governments and the public, especially as represented by corporate groups and environmental groups, such as the Sierra Club, Friends of the Earth, and others. This complexity makes optimum, or even adequate, standards difficult to establish and enforce. In addition to the political and intergovernmental concerns, it is frequently difficult to demonstrate clearly that a given pollution can be hazardous to health. While it is true that police power of the government under reg-

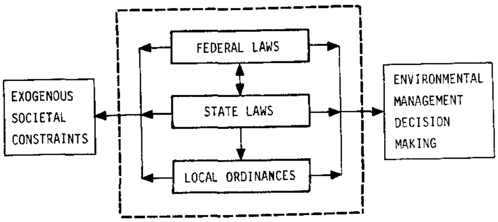

Figure 8. Constitutional and judicial subsystem.

ulations does not require absolute knowledge, action based on only judgment or intuition is extremely vulnerable if a legal protest is organized. This has been amplified in a recent benzene regulation case where the U.S. Supreme Court stated that the Occupational Safety and Health Administration did not have the unbridled discretion to adopt standards designed to create absolutely safe work places without regard for cost and sufficient evidence to demonstrate risks (Industrial Union Department, AFL-CIO vs. American Petroleum Institute 1980).

Responsibility for enforcement actions of the regulatory subsystem rests with the government sectors. Thus, some government organizations have quasi-legislative or rule-making functions, whereas others have quasi-judicial or adjudicative functions; still others have both. If an organization engages in promulgating rules or regulations that apply to all persons or industries that come under its jurisdiction (e.g., establishing emissions standards), the organization is involved in rulemaking. If the organization's responsibility is to decide whether a particular license should be granted or revoked, the organization is involved in adjudication. Although this may be stated simply, it is not always easy to determine whether an organization is rulemaking or adjudicating or whether the distinctions between the two are meaningful.

Rules, regulations, and general orders promulgated by an environmental manager in accordance with powers appropriately delegated by the legal system have the force and effect of law and are binding on all persons or organizations subject to them. Thus, outputs of the regulation and enforcement subsystem (Fig. 7) are important factors in the overall environmental management system. It is through this subsystem that the government attempts to achieve acceptable levels of environmental quality or quality of life.

A decision to withdraw an operating permit from a mining operation (extractive system) will undoubtedly result in negotiations, but is more likely to result in prosecutions and abatement proceedings, hearing appeals, or changes in zoning and land use allocations. The regulation and enforcement subsystem is powerful, and one that must be used judiciously. It is in this arena that environmental managers of all sectors (i.e., planners, regulators, and corporate managers) must work to resolve collectively the issues, using the best-developed knowledge and information available.

Constitutional and Judicial Subsystem

In order for a regulation to be the basis of a legal action, it is necessary that sufficient statutory authority exist for declaring any specific act or omission an offense. Specifically, noncompliance with an environmental regulation is not a crime unless it is made so by the legislature. Regulations that provide for penalties or criminal liability may not be developed unless they are provided by a specific output from the legal subsystem, usually in the form of a statute. Thus, jurisdiction for regulation and enforcement is limited entirely by statute; a manager may not exercise decisions in areas over which he or she has no legal jurisdiction

The legal, constitutional, and judicial subsystem (Fig. 8) provides the basis for regulation and enforcement decisions. Specifically, the Ninth Amendment of the U.S. Constitution states: "The enumeration in the Constitution of certain rights shall not be construed to deny or disparage others retained by the people." The theory promoted is that included among the Constitutional rights is the protection of natural resources and an environment free of pollution (Arbuckle et al. 1974). It has been stated that since the market does not impose true social costs associated with environmental degradation on the pollutors, the slack must be taken up by the legal system (Brecher and Nestle 1975). In this context: "A court of equity is the only place to take effective action against polluters. Only in a court room can a scientist present his evidence free from harassment by politicians. And only in a court room can bureaucratic hogwash be tested in the crucible of cross-examination." (Yannacone 1971, p. 94).

Due process, another legal principle basic to our system of laws, has become a favorite phrase of lawyers, judges, and environmental groups in environmental matters. This principle is specifically set forth in the Fifth and Fourteenth Amendments to the Constitution.

The Fifth Amendment applies to the federal government and the Fourteenth Amendment applies to the states. These amendments basically guarantee to a person the right not to be deprived of life, liberty, or property without due process of law and the right to claim redress through the judicial process. Thus, environmental managers from all sides interact with the legal subsystem through compliance with environmental statutes and through the judicial process.

When negotiations fail, when due process is not followed in hearings and appeals, or when charges, permits, variances, and land use allocations are considered unacceptable to either the group being regulated or general members of the societal subsystem, the environmental manager is likely to become directly involved in the judicial process. As such, the manager's knowledge of the statutes and regulations governing the organization's activities, as well as careful attention to due process in regulation and enforcement, are critical to the quality of interaction between the decision-making subsystem and the constitutional and judicial subsystem.

Conclusions

While it was the intent of this paper to demonstrate how the system approach can be used to conceptualize and model the complex environmental management system, it is also necessary to recognize the existence of a hierarchy of systems. In this context, the environmental management (global) system is supported by a second tier of systems (subsystem). The systems-within-a-system concept is an important principle in the development of a total framework. The decision-making system (subsystem) was conceptualized as the central element in the overall framework responsible for maintaining a proper balance among the many conflicting demands. Thus, the decision-making system is required to remain an open system within the global framework. Likewise, each of the other system elements (subsystems) are to be open systems, which respond to input and feedback.

Through this cybernetic approach, each of the individual systems (subsystems) is able to adapt to threats and opportunities, as well as to learn from its behavior. A complete analysis of the environmental management system requires a thorough examination of the interactions of all system elements, the sensitivity of changes to the elements, and the processes needed to respond to the larger environment. It is recognized that the fields of government, market economics, social responsibility, and ecology are so complex that it is extremely difficult to develop a framework that gives full consideration to all aspects. The foregoing discussion attempts, however, to show the general relationships that exist between the various complex system elements.

It is important at this point to re-emphasize that the environmental management system framework, as presented, requires individual systems to be adaptive in response to the needs of the overall environmental system. This is critical to overall system performance. Subsystem changes alone are not sufficient to achieve an acceptable quality of life. It is only when all of the individual subsystems are adaptive that the general environment can be expected to improve. Thus, the environmental manager must fully understand the complexity of interrelationships and the need for balance among the social, technical-scientific, administrative, political, legal, and economic elements of the environmental management system. It is through the application of the system approach that this complexity becomes visible.

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