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A SUBJECT REFERENCE: BENEFIT-COST ANALYSIS OF TOXIC SUBSTANCES, HAZARDOUS MATERIALS AND SOLID WASTE CONTROL

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PREFACE

CONSAD Research Corporation prepared this Subject Reference under Contract Number 68-01-3116 for the Office of Research and Development, Environmental Protection Agency. The materials contained herein are largely based upon a workshop attended by approximately 70 participants held in Tyson's Corner, Virginia, from June 23 to June 25, 1975. The purpose of this Subject Reference is to provide the benefit-cost practitioner (and specifically those who participated in the workshop) with a single document presenting the various thoughts, concerns, solutions, etc., of those who attended the workshop.

This report consists of three chapters plus an Executive Summary.

In the introductory chapter, the problem context of benefit-cost analysis vis-a-vis toxic substances, hazardous materials, and solid waste control is presented. The seven predetermined problem areas which were utilized to focus the workshop efforts are identified, i.e.:

- Economic impacts/production net benefits;
- Environmental/ecological effects;
- Human health effects;
- Integrating non-commensurables;
- Equity/long-term impacts;
- Risk; and
- Sequential approaches/effective alternatives.

In Chapter 2.0, the regulatory context for toxic substances, hazardous materials, and solid waste control is presented, including a brief discussion of the recently passed Toxic Substances Control Act of 1976.

Chapter 3.0 of this report first contains excerpts from the opening remarks of the three-day workshop wherein various areas amenable to benefit-cost analysis are discussed. Then, the reports of each working group (corresponding to each of the seven problem areas delineated above) are presented.

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EXECUTIVE SUMMARY

1.0 Introduction

This Subject Reference for Benefit-Cost Analysis of Toxic Substances, Hazardous Materials, and Solid Waste Control presents a discussion of methodological issues for conducting benefit-cost analysis and provides guidance for selecting and applying the most appropriate and useful mechanisms in benefit-cost analysis of toxic substances, hazardous materials, and solid waste control.

Benefit-cost analysis, as used in this Subject Reference, is a broad term, having the connotation of a "scientific method." It is meant to be less restrictive than the formal definition which includes an implied emphasis on monetary measurement of all benefits and costs.

Benefit-cost analysis is presumed to be a part of the overall decision process, not a replacement for it, or a substitute for the experience and judgment of the decision-makers. The major strength of benefit-cost analysis, and its most prominent feature, is its emphasis on formal arrangement of data and repetitive calculating procedures. Those areas which are rightfully handled by experience and judgment, and for which analytical techniques are not sufficiently developed, are identified as such, and are brought into sharp relief with respect to the monetary benefit and cost structure of the analysis.

2.0 Discussion of Problem Areas

It is a characteristic of detailed benefit-cost analysis that judgments are required at many stages. This feature is certainly present in analysis involving toxic substances, hazardous materials, and solid waste control. The scope of these studies is widely varied, and the limitations of time and funding imposed by the typical regulatory context require judgments on the part of the analyst as to what to include and to what level of detail to include. Therefore, this Subject Reference emphasizes the separation of components where the analysts are making judgments and assumptions, and provides guidance to them in identifying these areas for the decision-makers.

This Subject Reference is intended to provide guidance to all levels of the decision-making process, emphasizing the working analysts as the major audience, although this group is recognized to include a wide variety of personnel, experience, and sophistication in benefit-cost techniques. Thus, some of the sections are more general in nature and provide background for those less familiar with the details of benefit-cost analysis. Other sections provide current state-of-the-art or "avant garde" approaches to obtaining solutions for monetary and non-monetary values required in the accomplishment of benefit-cost analysis.

It is the nature of the subject matter that the impacts and effects of significance and importance very quickly become specific to the particular alternative actions in question. The specificity is influenced by the nature of the transport models, i.e., the mechanisms by which the substances dispose through and influence the environment. These physical processes are partly a function of the technology in use. But both the technology and the basic physical mechanisms influence the available control schemes. In other words, time, nature, and the technology available greatly influence the alternatives available for analysis. In addition, the measurement and analytical technologies available to gain insight into the relative merits of solutions and the data to support their application are prime factors in determining the structure of the analysis itself. Techniques for measuring benefits and costs in dollars, and for connecting them to very precise physical measurements have steadily improved as scientists have developed practical methods for use by the field investigators and bioassay technicians. Thus, the state-of-the-art, from the benefit-cost practitioner's standpoint, is advancing rapidly, and impacts are traced and measured which were previously unimagined, as in the case of polychlorinated biphenyls in air and water.

The current legislative base and judicial review processes have provided ideas and approaches regarding application of benefit-cost analysis which are different among the subject areas (pesticides, nuclear materials, etc.), and thereby have provided incentives or disincentives for following standard methods depending on case-by-case interpretations. Recent efforts, however, at both the academic research and regulatory implementation levels have provided broad insight and some encouragement on the possibility of using a consistent system of benefit-cost techniques in attacking these very diverse problems.

The key issues are separated more concisely in the paragraphs below.

Economic Impacts/Production Net Benefits. Inherent in the particular issue of "fiscal" impacts and production net benefits is the determination of those elements of the many production factors that can and should be valued and aggregated in dollars, and under what circumstances inclusion of secondary and tertiary (e. g., labor force, resource depletion, transportation hazards) impacts become of marginal value to the analysis. Techniques for valuing induced impacts in a broad social sense must be determined, as well as recommendations for identification and special treatment of "growth-producing" (and possibly inflationary) alternatives. Assessment of data-related influences, a traditional problem in large-scale economic analysis, further determines the effective use of the benefit-cost techniques.

A significant subset of the economic impacts is the valuation of benefits and cost related to quality of life derived from the production, use, transportation, and disposal of the toxic and hazardous materials and solid waste. Within this broad category of impacts, there must be a definition of approaches for modeling, integrating, and aggregating benefits and costs of impacts which touch directly on "human values," a concept integral in the quality of life context.

The techniques utilized and the data required for analysis of various alternatives include "consumer surplus" measurements, measurements of impacts on population subgroups, and tracing of inter-industry resource and product flows.

Environmental/Ecological Effects. A process is required by which measurement techniques and desired variables are defined and selected for use in a given benefit-cost analysis. These measures and variables must enable the analyst to trace environmental impacts and to assess their benefit-cost significance and calculational techniques to define dose-response relationships for target and non-target species, and secondary, tertiary, etc., impacts via air, water, and soil. Screening procedures for determining the most sensitive indicators and the most important effects, and value judgment guidelines for use in aggregation of impacts, are essential requirements. The Subject Reference gives approaches to these requirements, but a broad-scale effort for each particular analysis would also be helpful.

Human Health Effects. This issue has been viewed from an epidemiological standpoint. That is, what significant effects do health data reveal? However, a second issue is that of where and when the health damages get linked to the damaging materials, i.e., what do the exposure data reveal? Of particular concern is the accuracy in evaluating the effects of any substance relative to others present in man's environment.

Integrating Non-Commensurables. Past practice suggests that not all value judgments can or should be made in a common metric, pecuniary or otherwise. The issue is the selection and definition of a reasonable set of "final" non-commensurables and development of rules for tradeoff and resolution of these "final" variables by the decision-maker. Alternate "formats" may be evaluated and used if beneficial to the decision-maker's understanding. Another helpful procedure is to identify "best" indicators for inclusion in a non-commensurables juxtaposition format. Before arriving at the final format, it is possible to select taxonomy elements to afford the greatest facility in aggregating into the final set. In other words, calculational techniques must be identified based on pre-defined judgment criteria, which assist in the elimination of multi-metrics.

Equity/Long-Term Impacts. Recommendations regarding the inclusion of equity considerations in the benefit-cost analyses technical precision of impacts measurement are a prerequisite in dealing with this issue. Guidelines must be developed for identifying the most useful and/or significant equity differences and impact measures, e.g., geographic, time, economic or demographic. Even if equity differences and impacts are discernible, then the social policy alternatives must be spelled out clearly for the decision-maker.

A specific problem is the development of ground rules for the analysis of short-term quantifiable gains/losses versus "long-range" impacts. A major area for investigating within this issue involves guidance for the treatment of irreversible and irretrievable commitments and their distinction (if any) in the benefit-cost methodology. Evaluation of the techniques for discounting and their application, with the effects of inflation, to dollarized impacts should then lead to recommendations for tradeoffs of future versus present benefits and costs.

Risk. The issue of risk must be evaluated with respect to its quantifiability first through probability analysis and second through the way it is perceived by the public. The values of risk, its ranges, and acceptable levels change with time. Considering these two measurement factors in recommending the best procedures for incorporating risk evaluations in benefit-cost analysis is essential. Evaluation of risks in delaying the start of "beneficial" (regulatory) programs in the context of irreversible exhaustion of resources such as aquifers or ocean dumping sites must lead to guidelines for "risk abating" projects or programs.

Sequential Approaches/Effective Alternatives. The issue here is whether the use of sequential approaches can help to optimize available resources in performing benefit-cost analysis and in identifying project and program choices. In other words, is it possible to know how useful the analysis will be before investing in the performance of it? Ground rules and techniques for incorporating effective judgments on scope and depth of the analysis, final presentation format, and aggregation principles must be defined. Equally important are guidelines for specification of alternatives to be included in the benefit-cost analysis, depending on the stage of the problem, the time for analysis, the significance and criticality of the problem, and regulatory options available. Some effort must be spent in defining criteria for alternative technologies, regulatory actions, monitoring technologies, and resource consumption levels to be evaluated, including the null case. Finally, the decision process into which the benefit-cost results will feed must be closely inspected. The context of the agency, including its present program structure and its legislative mandate should be compared to the probable outcomes of the benefit-cost analysis.

3.0 State-of-the-Art

It is indeed fortunate that a firm theoretical base exists in economic theory for application of the benefit-cost analytical approach. The Subject Reference provides assistance in the application of the theory to the assessment of social issues, and alternatives where the assumptions are of necessity much less restrictive. The parameters cannot always be quantified in monetary terms, and decision-making in the public domain is confounded with emotional issues not subject to clearly objective evaluation.

Among the more perplexing problems associated with benefit-cost analysis is the ever present restriction on time available for the analysis and the skilled resources for its completion. Thus, it is essential that the methodology should deal with measurement and efficiency problems in that it should provide a systematic way for the determination of the relative scope and depth of the individual analysis. The assessment of the parameters to be included thus identifies, along with the data availability, the approximate source requirements for conducting the analysis.

4.0 Benefit-Cost Methodology

Criteria. The analytical framework for the conduct of benefit-cost analysis recommended in this Subject Reference meet a number of criteria which are essential for any methodology to be of benefit in the solution of problems. Among the major criteria are the following:

- Summary Format: The methodology identifies a summary format for presentation of the results of the analysis. It makes visible the areas where the analytical methodology are straightforward and objective, and identifies those areas where subjectivity has played a major role.

- Key Issues Highlighted: The methodology provides a mechanism for identifying and illustrating the key issues involved in the analysis. It is essential that any good methodology accomplish this fact, and provide that aggregation of non-commensurables not screen or obscure the essential elements and variables.

- Explanation of Assumptions: One of the key elements of the methodology applied to this very difficult subject area requires detailed explanation of the assumptions involved in the explanation of the problem and the articulation of the solutions. Also included is an explanation of the assumptions required to implement the analytical techniques for assessment of the problem.

- Toxic Substance Circumstances Description: The Subject Reference ensures that the background and surrounding social context for the featured alternative actions are described and used as a basis for the analysis.

- Explicit Comparison of Alternatives: The methodology presented herein puts the objective of providing clear illustration of the alternatives analyzed and those significantly omitted, and the reasons why.

- Range of Impacts: The methodology provides for an evaluation of the range of impacts related to the problem and its solution and provides a clear explanation for limitation and the reasons why.

- Detail of Impacts: The methods are provided for selecting specific variables for the investigation of the impacts and for defining the level of effort to obtain evaluation in specific areas.

- Discussion of Data Sources: Any methodology in the subject areas requires a thorough evaluation of the sources of data, the data itself, i.e., its accuracy and completeness and reliability, its relationship to the overall data availability for parallel and related problems.

- Sensitivity Analysis: A methodology must clearly indicate and provide for the evaluation of the fluctuations provided and the results by application of different levels of parameter evaluations included in the analysis. The effects of final value judgment evaluations are also a key part of the methodology.

Discussion of Methodology. The methodology presented here utilizes data sources and analysis techniques for the purpose of identifying the key parameters and approaches to evaluation of alternatives. The initial step in a typical analysis is the evaluation of the transfer mechanisms of the problem under consideration. This includes an evaluation of the mass flows throughout the environment and the effects on it and mankind. Next, an evaluation of the time frame is performed. In this evaluation, which should be accomplished through utilization of a time line, the problem is viewed with the effects in chronological order. The continuing steps of the analysis should include identification of those receiving the impacts, followed by a preliminary screening, i.e., assessment of the probable magnitudes and significance of the impacts. Next, the functions or models best able to contribute to the analysis should be identified followed by evaluation of the sources of data and their availability. The analysis then proceeds with the valuation and aggregation, treatment for sensitivity to value sets, and summary presentation.

This methodology thus provides guidelines and approaches to accomplishment of a benefit-cost analysis, including recommendations for the handling of some especially difficult problems (i.e., aggregation of non-commensurables, treatment of equity considerations, and evaluation of the sensitivity analysis to the final value sets), and organization to the materail for detail backup information, along with the summary format.

5.0 Conclusions and Recommendations

The usefulness of this Subject Reference in the application of benefit-cost analysis to the areas to toxic substances, hazardous materials, and solid waste control derives from the use of an overall organization of materials, i.e., data, models, and guidelines for the use of the analysis for the evaluation of the methodology conclusions which will be applicable to the wide variety of problems encountered in the regulatory context.

Of major significance is the recommendation that the methodology presented in this Subject Reference will provide a significant input to the decision-making process. Benefit-cost analysis will not be a substitute for the decision-making process, but it can provide significant improvements by identification of alternatives and parameter significance.

Consistency in performance of benefit-cost analysis along the lines of the methodology outlined herein, including presentation of the results and the summary format proposed, would provide significant benefit to the provider of the analysis (i.e., the benefit-cost analyst) and to the user of the analysis (i.e., the decision-maker and the public who are reviewing the results of the decision-making process).

1.0 INTRODUCTION

1.1 Purpose and Scope of Effort

This Subject Reference is intended to serve as a document for benefit-cost practitioners in certain types of environmental policy. It is also intended to be useful to any analyst in the many areas of environmental policy, but it is specifically oriented toward problems of toxic substances and hazardous waste materials. Policy analysis in this field is particularly difficult since the chemical theory and engineering practices are rapidly evolving.

The effort involved in compiling this Subject Reference involved three components:

- Planning and conceptual development;
- Seminars; and
- Review and documentation.

The planning and conceptual development was the most intense and demanding of the three components, and resulted in the structure of the seminars and of this document itself. The seminars brought together many diverse researchers and policy-makers for discussions organized around the conceptual structure. Finally, the review and documentation organized all the materials and references developed previously to produce this Subject Reference.

The report did not intend to provide new theoretical developments or original research results. Furthermore, a basic premise of the study was to avoid devising a set of specific variable definitions and to reject specific calculation routines (algorithms): in other words, to avoid the mistakes of the "Green Book."* It did happen, however, that many new approaches and methods were generated throughout the project, and this new material has been compiled in Chapter 3.0 below.

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*Subcommittee on Evaluation Standards, Proposed Practices for Economic Analysis of River Basin Projects, Washington, D.C., Report to the Inter-Agency Committee on Water Resources, May, 1958.

1.2 General Problem Context

Benefit-cost has evolved as a general approach to public sector decision-making.* The types of decisions which have been approached by way of benefit-cost analysis have varied, but more recently, the field has broadened from public works investment to include health, safety and, by no means least, the environment.

The method has been surrounded by controversy from its earliest applications, which began with the concepts contained in the Rivers and Harbors Act of 1902 (U. S. Congress PL 154).** The very concept of the method has been so controversial that a review in 1965*** noted at least two alternative terms, "investment planning" and "project appraisal," and they might well have included "cost-effectiveness" and "risk-benefit," and "policy analysis."

An important step in the evaluation of benefit-cost analysis was going on even while public investment studies were being performed by the U. S. Department of Defense under the headings "cost-effectiveness" studies. This separate development was the application of benefit-cost analysis to public policy questions which did not have a single large investment associated with them. In other words, the need for better fiscal control of government, and the accompanying trend toward program budgeting, required the application of benefit-cost methods to broad-scale "policy analysi" problems.

The U. S. Department of Transportation applied benefit-cost analysis to safety problems, and other types of applications included health programs. The total bibliography of benefit-cost analysis thus

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*The reasons the approach is not widely used in private industry are complex, and are not especially crucial for this report. A comprehensive benefit-cost analysis is not particularly appropriate in a business management context where the orientation is toward maximizing a single monetary variable such as revenues, net income or dividends.

**Hammond, R. J., Benefit-Cost Analysis and Water Pollution Control, Stanford, California, Stanford University, Food Research Institute, 1960, pp. 3-5.

***Prest, A. R., and R. Turvey, "Cost-Benefit Analysis: A Survey," The Economic Journal, Vol. 75, No. 300, December, 1965, pp. 683-731.

includes examples of studies in most problems which are now associated under the heading of "environment." The application of benefit-cost methods to toxic substances and hazardous materials regulatory policy and and should draw on all of the analytical methods developed for the many other social policies.

At the same time that the use of benefit-cost analysis has been pushed to broader horizons, its traditional use in water resource projects has continued, and, in fact, has continued to reveal weaknesses in various application techniques. Thompson describes some recent difficulties:

> "Some of the environmental degradation perpetrated by the Tennessee Valley Authority and others is carried out through the sophistry of cost-benefit analysis. One example was the Corps $15.3 million Gillham Dam across the Cossatot River in Arkansas, which was halted by an Environmental Defense Fund (EDF) sponsored injunction against the Corps. Three-quarters of the benefits claimed to the Gillham, $970,000 annually, were in flood damage that the Corps said the dam would prevent. Yet on the 50 miles of flood plain below the dam, there was virtually nothing to protect - in sum, three old wooden bridges, a dozen summer homes, and about 20 miles of gravel road. There had never been a recorded flood death on the Cossatot.
>
> Another example was the proposed Tennessee-Tombigbee Waterwas Project that the U. S. Army Corps of Engineers wanted to build to join the Tennessee River to the Tombigbee River in order to open up more of middle-America to the Gulf of Mexico and to foreign markets. The Corps claimed the Tenn-Tom project would produce $641 million in various benefits between the years 1980 and 2030 at a cost of $385 million for construction and $2.7 million per year in operating and maintenance costs. The Environmental Defense Fund won an injunction against the project in July of 1971 on the grounds that the benefits were overstated, the costs minimized, and the expected return on each invested dollar less than 10 cents.

Part of the dispute arose because the claimed benefits were all nonmonetary items, like time saved by shippers and increased recreation days, whereas the costs of the materials that were to go into the canal were very real monetary items. Paul Roberts, Economics Professor of the University of Florida, carefully evaluated the $641 million in claimed benefits on the Tenn-Tom project and concluded that a more realistic projection of the benefits would be approximately $17.5 million. The Corps, of course, disputed his figures."*

The above discussion illustrates the type of attack which can be made on benefit-cost analysis if care is not taken to thoroughly rationalize and document all results and calculations. These remarks also indicate that in spite of guidelines provided in the "Green Book," the use of benefit-cost analysis techniques in water resource planning is far from a standardized procedure.

The difficulty of estimating benefits and costs over long periods of time is only one source of controversy in performing benefit-cost analysis. The present project has developed a categorization of "problem areas" wherein benefit-cost analysts <u>must</u> specify their techniques and variables before putting them together in an overall analysis.

A major difficulty of large-scale policy analysis using a benefit-cost framework is the difficulty in comprehending all of the components of the analysis as separate subanalysis which contribute to some final set of a few "bottom line" figures. The categorization of "problem areas" mentioned above provides an outline form for illuminating the many rationales and decisions which go to make up a comprehensive benefit-cost analysis. If the public decision-makers understand the issues and rationales in each of these problem areas, then they will be in a better position to evaluate and use the results of benefit-cost analyses.

If such understanding is not achieved, on the other hand, the decision-makers will be unwisely relying on the finality and incontrovertibility of the few "bottom line" figures. They would then be likely

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*Thompson, D. N., <u>The Economics of Environmental Protection</u>, Cambridge, Massachusetts, Winthrop Publishers, 1973, pp. 12-13.

to find themselves in court, and very possibly facing an injunction as illustrated in the cases cited above. The decision-maker who uses benefit-cost analysis must come to realize that its value is not in demonstrating a final decision, but in lending rigor and logic to the decision <u>process</u>. The approach to modern use of benefit-cost techniques must be one where alternative assumptions and scenarios can be conveniently and flexibly tested by a <u>process</u> which can be iterated many times to illustrate the outcome of alternative decisions.

1.3 Problem Areas in Benefit-Cost Analysis

The major product of the planning and conceptual development phase of this project is the benefit-cost analysis problem list. This list is a set of problem checkoff points which the analyst must confront and must keep in mind from beginning to end of a benefit-cost analysis. The problem categories are:

- Economic impacts/production net benefits;
- Environmental/ecological effects;
- Human health effects;
- Integrating non-commensurables;
- Equity/long-term impacts;
- Risk; and
- Sequential approaches/effective alternatives.

For each of these problem areas, the analyst must wrestle with questions concerning variable definition, data availability and accuracy, relationships among variables, available experimental and field results, and model availability and adequacy. The following paragraphs give some details of questions and issues for each of the seven problem areas.

1.3.1 Economic Impacts/Production Net Benefits

The introduction of a new chemical process into the economic system leads to an altered pattern of production and consumption. In principle, if one had a highly disaggregated model of the economy, one could evaluate the changes induced in the entire economy. No such all-embracing econometric model exists. What principles or guidelines should the analyst follow in deciding how far to attempt to trace economic impacts? What are the uses and limitations of existing input-output tables for such purposes?

Where is the concept of "consumer surplus" applicable in benefit-cost analysis and how is this to be calculated? What data sources and techniques are available? Is the notion of "producers's surplus" applicable to benefit-cost analysis and how is it to be calculated?

In addition to causing alterations in the pattern of production and consumption, the introduction of a new chemical process may generate substantial indirect benefits and/or damages. Although it is possible to develop estimates of the values of many of these indirect impacts in dollar terms, many, if not most, of these estimated dollar values are biased estimates of the desired measures of these indirect impacts. These biases arise, for example, because of non-market factors in human choice behavior. Recognizing these biases, can guidelines be developed to determine when the calculation of estimated monetary values can make a useful contribution to a benefit-cost analysis? For those values which are calculated, how should they be interpreted relative to "unbiased" impact measures when using benefit-cost methodology in the formulation of public policy?

1.3.2 Environmental/Ecological Effects

The introduction of a chemical may alter a food chain and change the composition of species in an ecosystem. What procedures exist for predicting, monitoring, and measuring these effects? How does the analyst decide which effects are benefits and which are costs? If the effect is to increase the population of some species and decrease the population of others, how can these changes in population be evaluated?

What techniques exist to aid the analyst in the valuation of different non-market features of the environment? For example, the use of pesticides may result in runoff which eventually makes its way to a stream and consequently kills the fish-life and alters the vegetation on the scenic banks. Are these two effects evaluated differently because the utility derived from fishing in the stream is a more active deliberate activity than viewing the scenic banks from a bridge across the stream while on a Sunday drive? Or are both activities "recreation" which is evaluated using a time and/or distance model?

1.3.3 Human Health Effects

The introduction of a toxic substance, pesticide or other hazardous material into the environment can result in short-term immediate human health effects and/or long-term gradual human health effects if the population is exposed to the pollutant. Below is a list of questions and issues designed to help the analyst structure his analysis of health effects:

- What dimensions should be used for delineating the likely human health effects from exposure to a particular toxic substance or hazardous material, e.g.:
  - Short-term versus long-term?
  - General public versus occupational?
  - Voluntary versus involuntary?
  - Direct exposure versus indirect exposure?
  - Types of illnesses induced?

- How can the analyst determine the size and identity of the population likely to be exposed to dosages of a given level of a particular toxic substance or hazardous material?

- How can the analyst separate the human health benefit of eliminating a particular pollutant or one source of a particular pollutant from the overlapping effects of a pollutant known to occur in the same environment?

- Given that he knows the animal toxicology data is deficient in many respects, can the analyst use existing data to predict the likely human health effects; that is, can he effectively estimate dosage-response rates in people from animal toxicology experiments?

- How much epidemiologic data must be supplied in order to assess the likely human health effects of a given pollutant, and how can epidemiologic data be made precise enough to predict effects on future populations?

- Assuming that human health damage can be quantified in non-dollar terms (e.g., number of people incurring a certain type of injury), how can the damages be then quantified in dollar terms? In addition, what is the relative importance of short-term human health effects versus long-term human health effects and how should these differences be measured?

1.3.4 Integrating Non-Commensurables

The scope of the non-commensurables problem overlaps the entire benefit-cost structure and logic. Even in the more sophisticated context of recent studies in which no single benefit-cost ratio has been required or sought, the problems of aggregating diverse measures has been pervasive, nagging, and perhaps debilitating to the analysis.

Consider the conceptual problem of what is measured. Even though the units all came out in dollars, questions of comparability of dollar values must be raised. For example, suppose the value of fish is assessed on the basis of stocking costs and the value of waterfowl is assessed on the basis of hunting licenses. These measurement techniques probably do not give a complete measure of the value of wildlife to the average person, but can they even be added to give a single value? These underlying philosophical questions extend throughout any benefit-cost analysis.

For some well-defined variables, such as number of human lives endangered and number of aesthetic views erased, it is hardly possible to achieve a meaningful scale much less decide what measurement technique can be aggregated. In other words, certain items (lives, views) have attributes which are difficult to locate on a dollar scale, and for which alternative quantitative scales are difficult to define.

A third entanglement which combines with the two preceding problems is that of similarities among items for which data are available but not disaggregated. Data on the amounts paid for hunting licenses are sometimes disaggregated by broad classes of quarries: waterfowl, deer, small mammals. But is a grebe the same value as a Canada goose? It is unlikely that a fisherman values a carp and a rainbow trout the same, and these two fish have very different ecologic roles, and respond to ecologic disruption differently.

Probably all three of the above problems are different approaches to the same enigma. In environmental impact statements, court proceedings, and public hearings, the non-commensurables are going to be compared and aggregated, for better or worse. What are the techniques for preliminary research data collection, analysis, formatting, and aggregation that exist and that should be used by the benefit-cost analyst? Thus, what aids can be given the policy decision-maker who finally makes the choice in comparing the effects of alternative toxic substances policies?

Should ranked dimensions be used in some situations, whereby x would be preferred to y as long as it is superior to y in dimension n regardless of the rankings according to other dimensions? How severe are data problems if multi-dimensional comparisons are required? How convenient are complicated techniques for use in non-technical contexts such as public hearings or courtrooms?

1.3.5 Equity/Long-Term Impacts

Traditional approaches to benefit-cost analysis have explained the need to isolate those impacts of public projects which bear only on efficiency from those which serve to redistribute wealth. While it is true that benefits and costs can be defined only with respect to a given distribution of income, direct transfer could, in concept, be used to achieve a state of distribution deemed desirable, and market prices could theoretically be determined for that distribution. Unfortunately, the benefit-cost analyst must operate with something less than perfect information.

Should the equity and efficiency be analyzed separately or should benefit-cost analysis include estimation of equity-efficiency tradeoffs? If tradeoffs are to be evaluated, how should each evaluation be made and what role should the analyst play in determining proper tradeoffs? Should, for example, the analyst's role be simply to estimate benefits and costs and to specify which socioeconomic groups gain and which lose, leaving the decision-maker to evaluate the relative importance of distribution and efficiency impacts, or should the analyst attempt to derive techniques for assessing relative importance? What techniques might be used to assess the relative value of policies producing different distributional effects? Should all alternatives be subject to an equity review? When alternatives have very long-term benefits and costs, should equity considerations be limited to current generations or should intergenerational equity be analyzed as well? How could the interest of future generations be weighted against those of current recipients of benefits and costs?

1.3.6 Risk

How is the "risk" associated with the use of a chemical compound best described for purposes of incorporating risk evaluation into a benefit-cost framework? Is there a class of events which are so horrendous that there does not exist any non-zero probability of its occurrence that would allow the assignment of a finite negative value to its possible occurrence? How can the benefit-cost analyst establish whether an event belongs to this class? How should the "probability" of an event occurring be established if there is no prior experience of such an event actually occurring? Are simulations very useful in this regard? In the absence of definite knowledge of the probability distribution of events, should "risk" be discussed and incorporated into a benefit-cost analysis?

Risk as perceived by the general public is sometimes a subjective emotional response which is possibly not accurate in a problematic sense but is a real social attitude. For example, how does one evaluate the public perception of increased risk of an accident at a nuclear power plant after the community has experienced an earthquake or another natural disaster? The type of risk perception of the public is also influenced by the media through both news, stories, and spot advertising provided by various interest groups. Should this subjectively perceived risk modify the benefit-cost analysis via adjustments to the application of probability calculations or should this analysis of public opinion by a separate and final chapter in the analysis? How then, does one assign a dollar value to the willingness to reduce risk?

1.3.7 Sequential Approaches/ Effective Alternatives

Any analysis for policy formulation may be undertaken with numerous alternatives for evaluation in mind. For example, alternatives might be restriction in the use of a material known to be toxic such as asbestos, or restriction of its manufacture. That is, restriction may take the form of complete elimination of the toxic substance or partial restriction in terms of quantity levels, the length of shift that employees may be exposed to the material or regulations concerning the air quality level in the plant.

For the purpose of analysis, how does the benefit-cost analyst establish the number and type of alternatives which are to be evaluated? Does he take into consideration a possible future level of technology which might reduce the importance of the problem?

Since the selection of alternatives is subject to time, monetary, and manpower constraints, is there a method which may be used to select alternatives which would be optimal in the sense of obtaining the most worthwhile analysis subject to administrative constraints?

Benefit-cost analysis is frequently limited by difficulty in obtaining information related to the impacts of a policy. This lack of information usually stems from an incomplete understanding of a subset of areas impacted, e.g., the ecosystem, or the industrial structure. It is difficult to ascertain the environmental effects of a policy if environmental relationships themselves are not clearly understood.

Iterations of a benefit-cost analysis can enable the analyst to test policy decisions under different assumptions about the state of the world, i.e., industry or ecology. Thus, a mix of policy alternatives can be tested against a series of state-of-the-world assumptions. But how does the analyst construct a benefit-cost model which is conveniently revised and iterated? And how does he select reasonable cases from an almost limitless number?

1.3.8 Summary of Problem Areas

The above discussion of problem areas have raised many methodological and theoretical questions which are difficult to answer, but the benefit-cost analyst must review these questions each time he embarks on a benefit-cost project. He should check through the above questions and at least make a preliminary note about how each question will be handled in his own analysis. If he does not face the questions in the planning stage of his study, he can be sure he will meet them later when his study is reviewed by policy-makers, or in the courtroom.

In the next section of this Subject Reference, some aspects of the regulatory situations which the benefit-cost analyst will encounter are reviewed. These include law-making procedures, litigation, public hearings, and intra-agency deliberations. Given his answers to the questions above, the analyst should contemplate how the resulting study will be useful in the various regulatory contexts. He should then proceed to Chapter 3.0 for some detailed thoughts on the issues he must confront.

2.0 THE REGULATORY CONTEXT FOR TOXIC SUBSTANCES, HAZARDOUS MATERIALS, AND SOLID WASTE CONTROL

2.1 The Use of Benefit-Cost Analysis in Regulatory Situations

It is possible to view the evolution of pollution regulatory action as a dichotomy of tax incentives and direct prohibitions or restrictions. This view, analogous to the carrot-and-stick view of government, oversimplifies the actual sequence and interaction of events both by minimizing the popular citizen involvement features of environmental regulation, and also by implying that significant pollution control efforts have been derived mostly from legislation, either Federal or state. The fundamental basis of progress in the past 15 years is debatable. But the facts do not support the emphasis sometimes placed on new laws. There have also been important judicial and executive branch initiatives.

A more balanced approach to understanding the current regulatory context, and its implication for benefit-cost analysis, is the examination of four institutional structures where regulatory actions occur:

- The legislative structure;
- The litigational structure;
- The public hearing structure; and
- The regulatory (Federal and local) structure.

The above four types of institutional structures comprise the elaborate system which has expanded rapidly in the past few years in response to pollution of many types. It is necessary to understand the overall regulatory system in using benefit-cost analysis, because this system produces the definitions of benefits and costs.

There are specific reasons why it is important for the user of benefit-cost analysis to keep in mind the regulatory system and the institutional structures within it. The following are included:

- The conceptual structure of benefits and costs is defined by the regulatory system, i. e., by the various agencies and organizations;

- The results of the benefit-cost analysis become part of the procedure of regulatory action, and they must be used by the components of the institutional structures; and

- Although benefit-cost analysis is traditionally applied to a single specific decision, it is possible to devise techniques for entire regulatory programs and policies.

2.2 The Legislative Context

The legislative structure includes not only the U. S. Congress but also state legislatures, and sometimes county and city councils which control zoning and public works at the local level. These legislative groups make decisions which cut across their political boundaries when they legislate air and water quality. The user of benefit-cost analysis must be prepared to calculate impacts for counties, AQCRs, and river basins. Environmental impact statements, which typically provide inputs primarily to the cost side of a benefit-cost analysis, can involve toxic substances and hazardous materials, such as, for example, in the case of nuclear power plants or sanitary landfill operations.

The U. S. Congress has enacted legislation to provide tax incentives for pollution control,* an idea which was formulated in 1965 by the President's Science Advisory Committee (Environmental Pollution Panel).**

Many -- perhaps the majority of analysts and commentators -- have recommended that careful study be given to tax-like systems in which all polluters would be subject to "effluent charges" in proportion

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*Thompson, D. N., The Economics of Environmental Protection, Cambridge, Massachusetts, Winthrop Publishers, p. 169.

**Report of the Environmental Pollution Panel, President's Science Advisory Committee, Restoring the Quality of Our Environment, Washington, D. C., 1965, pp. 16-17.

to their contribution to pollution. Federal and local efforts to reduce pollution of air, soil, and water have traditionally rested upon a mixture of prohibitory regulation and persuasion. The public interest can often be served by reducing pollution below the levels where these means are appropriate and effective. Effluent charges have enhanced effects because individual polluters are provided the prospect of financial gain from further reductions in their contribution to pollution.

Even before 1965, some states had pollution control incentive laws.* The importance of this approach to society is that is purportedly enables private sector managers to exercise some freedom in pollution control decisions.

The concept of tax incentives for pollution control has long been recommended, but opposition arises on three grounds:**

- The U. S. Treasury Department opposes such use of corporate taxes as improper on principle;
- The implementation of such policies would reduce tax revenues; and
- The idea exists at the grassroots level that tax incentives would not prompt the private sector to take rapid comprehensive pollution control action.

Regardless of whether these objections are valid, Federal legislation has emphasized direct regulatory action rather than tax incentive mechanisms.

From the benefit-cost analyst's viewpoint, tax incentive programs imply a particular orientation for analysis conducted in a tax incentive context. The following probable conditions should be expected:

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*Bureau of National Affairs, Environment Reporter, Vol. 4, State Air Laws, Parts 1 and 2; Vol. 5, State Solid Waste-Land Use; and Vol. 6, State Water Laws, Parts 1 and 2, Washington, D. C.

**Degler, Stanley E., and S. C. Bloom, Federal Pollution Control Programs: Water, Air, and Solid Wastes, Washington, D. C., The Bureau of National Affairs, Inc., 1969, pp. 14ff.

- The direct costs of pollution control will be spread over a short period of years because the tax incentive law probably specifies some specific period of credit.

- The costs of pollution control (i.e., some clean-up action) will tend to be confused with benefits, since the environmental damages of pollution will be avoided if the action is taken. But the costs of clean-up are not necessarily a precise measure of benefits. Nor are the values of possible damages a good measure of the ideal size of incentives, since the incentive must be meaningful to the industrial decision-maker.

Therefore, the benefit-cost analyst must view incentives as one component of data, which represents what an agency or legislative body judged to be a proper amount to achieve some effect on the reasoning of decision-makers.

The value of tax incentives in pollution control is a reasonable policy question which should be susceptible to benefit-cost analysis. Although there has been much discussion of such policies,* and at least one study of the concept in 1967,** policy shifts have occurred since then,*** and more data would be available for a new study.

Tax deduction incentives are a controversial method, and legislation on pollution has evolved some much more widely accepted features, of which the following are examples:

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*Thompson, D. N., op. cit., pp. 168ff; and Wilson, R. D., and D. W. Minnotte, "Government/Industry Cost Sharing of Air Pollution Control," Journal of the Air Pollution Control Administration, Vol. 19, No. 10, October, 1969, pp. 761-766, reprinted in M. Gordon and M. Gordon, eds., Environmental Management: Science and Politics, Boston, Massachusetts, Allyn and Bacon, 1972, pp. 485-497.

**ABT Associates, Inc., Incentives to Industry for Water Pollution Control: Policy Considerations, prepared for the Federal Water Pollution Control Administration, December, 1967.

***Thompson, D. N., op. cit., p. 169.

- Standards

  The Water Quality Act of 1965 (PL 89-234) required states to establish standards for all interstate and coastal waters.

  The Air Quality Act of 1967 (PL 90-148) provided for issuance of air quality criteria.

- Treatment Facilities and Other Grants

  The 1956 Federal Water Pollution Control Act (PL 84-660) authorized construction grants to public agencies, and these grants were increased by amendments.

  The Solid Waste Disposal Act of 1965 (PL 89-272) provides for grants for state and interstate planning and surveys of disposal practices and problems.

- Enforcement

  Title I of the 1967 Air Quality Act (PL 90-148) provides specific steps to enforce pollution abatement action (Section 108).

  The 1899 Refuse Act (33 USC 407) provides for fines and imprisonment for wrongful deposit of refuse (Section 411).

The above are selected examples from more well-known Federal legislation. A benefit-cost analyst should also be familiar with the state laws. These laws have been compiled and indexed by the Bureau of National Affairs in separate volumes for water, air, and solid waste.* The indexing provides references by states under categories such as air quality standards, water quality standards, and enforcement, but even so, there is no simple way for the benefit-cost analyst to assess specific policies or methods.

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*Bureau of National Affairs, Environment Reporter, op. cit.

One particular feature of the Federal Environmental Pesticide Control Act of 1972 (FEPCA) (PL 92-516) would be suitable for a detailed study of its effects: this feature is the use of the concept of benefit-cost analysis. Section 2 of this act contains a series of definitions, and the term "unreasonable adverse effects on the environment" is defined as:

> "...any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide."

The concept of "unreasonable adverse effects" is used in the FEPCA to provide a constraint on classification of pesticides for general or restricted use (Section 3) and as a basis for cancellation (Section 6). It is likely that as more pesticides are cancelled in the future, some benefit-cost analyst will be faced with the problem of analyzing the benefits and costs of requiring that cancellation decisions consider the benefits and costs of the pesticide.

2.3 The Litigational and Juridical Context

Although most legal proceedings involving the environment have no doubt arisen from and been directly based on specific Federal or state statutes, or local ordinances, rather than traditional common law, there have been some important legal proceedings which add to the definitions provided by legislation and which further develop the basis for using benefit-cost analysis in the regulatory context. In other words, these legal cases provide insight into the social concepts of environmental benefits and costs. The proceedings indicate how benefit-cost analysis could be useful in the litigational and juridical context, and what types of benefits and costs would be suitable for use as evidence.

This evidence would typically be used by a judge to determine the consequences of an environmental decision which he must make. In the same manner that a legislator and an administrator set policies, a judge sets precedent, with a single case before him to define the basis for his decision. The decision, for example, may require a judgment between alternative land uses, or between competing claims for some resource, such as water, or between the different possible effects of some action by a corporation or agency.

This juridical process in environmental cases is discussed in detail by Joseph L. Sax.* The legal basis for environmental litigation has changed some since Sax's report was written (about 1969) and today few judges would agree that legal action has been "too rarely considered" in dealing with environmental quality problems. In reporting a 1967 case involving a right-of-way across a wildlife preserve, however, Sax describes how the court viewed the case as a question of benefits and costs to society of the two alternative actions. The verdict was for the right-of-way (for a gas transmission line) but with court-directed safeguards to minimize environmental damage.

In developing his assertion that the courts are not used enough for litigating environmental disputes, Sax favors the adversary process:

> "This is what is unique about the litigation process. If you have ever seen or taken part in congressional or administrative hearings, or in the processes of planning-type commissions, you know how much hot air, unproven assertion, vague denials, and plain obfuscation usually attend the resource decision-making process. In the well-run courtroom, there is no place for such nonsense. If you have an assertion to make, you had better stand ready to prove it; if you have exaggerated, you will pay for it on cross-examination; if your perspective is limited, the court will be apprised of the fact through the adversary process.
>
> The judge in this case was not an expert on the technical questions being debated by the experts. Indeed, at one point in the trial he said, 'Before this case started I looked up the meaning of ecology in the dictionary because I noted it in the Supreme Court's opinion. I was not aware of that before.' But he is an expert in decision-making, and for this reason he was able to make sense out of the controversy. That, after all, is what was required."

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*Sax, Joseph L., "The Search for Environmental Quality: The Role of the Courts," in H. W. Helfrich, Jr., ed., The Environmental Crisis: Man's Struggle to Live with Himself, New Haven, Connecticut, Yale University, 1970, pp. 99-114.

The implication of the above comments is that if the case is brought to court without the clear juxtaposition of the issues, then such juxtaposition will be achieved by the adversary process.

The benefit-cost analyst should face this prospect and should study court cases in which actual comparisons have been made by various benefits and costs. At present, there is not a large number of such cases, but the numer will undoubtedly grow if Mr. Sax is correct.

2.4 The Public Hearing Context

Public hearings preceding government decisions have begun to appear more often in the past 15 years. The tradition has developed most rapidly in contexts where the decision-making involves transportation facilities such as expressways or rapid transit.* But in addition, more cases of public hearings in other types of environmental contexts are appearing.

Public hearings are prescribed in the Federal Water Pollution Control Act, Section 10, when the Secretary of the Interior is required to prescribe water quality standards, or when abatement action is not being taken. Similarly, public hearings are prescribed by the 1967 Air Quality Act, Section 108, under similar conditions. The 1972 Federal Environmental Pesticide Control Act also provides for public hearings in the event of cancellations of pesticide registrations, as does the recently passed Toxic Substances Control Act.

Analysis of the results of these hearings is difficult, but case study reports of grassroots action have been published and should be studied by the benefit-cost analyst.** For better or worse, grassroots

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*CONSAD Research Corporation, Analysis of Railroad-Community Conflicts, prepared for the Federal Railroad Administration, U. S. Department of Transportation, April 15, 1975.

**Greene, W., "What Happened to the Attempts to Clean Up the Majestic, The Polluted Hudson?", in M. Gordon and M. Gordon, op. cit., pp. 498-508. Other case studies are indexed by the Environment Reporter under "Citizens' Suit." See, for example, "North Carolina Freeway Project" and "Trident Impact Statement," Environment efforts in environmental controversies frequently reach the litigation stage and more formal records of the benefit-cost issues become available. A good summary of legal strategies for litigation is given by Thompson.*

2.5 The Regulatory Context

One feature of environmental legislation not discussed above is the provision for issuance of guidelines and other interpretive documents by designated Federal or other government officials. This feature defers or delegates a substantial role in environmental affairs to administrative officials, even though their actions must be consistent with the legislation. The designated agency thus has the double-edged freedom to interpret the intent of the legislative body and to exercise administrative powers as he sees them.

The Secretary of the Interior was faced with the problem of issuing guidelines for implementation of the 1965 Water Quality Act. These guidelines, issued in 1967, tried to set the tone for Federal-state cooperation, and to advise states on the setting of standards:

> "The Water Quality Act of 1965 amended the Federal Water Pollution Control Act to provide for establishment of water quality standards for interstate waters. In the absence of State action, such standards will be adopted by the Secretary of the Interior under procedures set forth in the Act.
>
> It is the position and purpose of the Federal Water Pollution Control Administration to encourage and support the States in establishing their own standards. The guidelines that follow are presented to assist the States in the development of the required water quality criteria and the plan for the implementation and enforcement thereof, and to delineate factors which

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Reporter, June 18, 1976, Vol. 7, No. 7, p. 284. Miscellaneous report: Haskins, H. J., "A Strategy for the Ghetto: The Philadelphia Story," in H. W. Helfrich, Jr., Agenda for Survival: The Environmental Crisis 2, New Haven, Connecticut, Yale University, 1971.

*Thompson, D. N., op. cit., pp. 194-223.

will be considered in the Secretary's determination of whether the criteria and plan are consistent with the purposes of the Act.

1. Water quality standards should be designed to 'enhance the quality of water.' If it is impossible to provide for prompt improvement in water quality at the time initial standards are set, the standards should be designed to prevent any increase in pollution. In no case will standards providing for less than existing water quality be acceptable.

2. No standards of water quality will be approved which provide for the use of any stream or portion thereof for the sole or principal purpose of transporting wastes.

3. Water quality criteria should be applied to the stream or other receiving water or portions thereof. The criteria should identify the water uses to be protected and establish limits on pollutants or effects of pollution necessary to provide for such uses. Numerical values should be stated for such quality characteristics where such values are available and applicable. Where appropriate, biological or bio-assay parameters may be used. In the absence of appropriate numerical values or biological parameters, criteria should consist of verbal descriptions in sufficient detail as to show clearly the quality of water intended (e.g., 'substantially free from oil')..."*

Thus, the Secretary sought to "clarify the standards requirement, and to mediate between the legislation passed by Congress and the state governments.

The requirement for a dialogue between state and Federal governments is a feature of much environmental effort (not to mention United States history). The benefit-cost analyst should be prepared to set his analysis at the local level and expand it to the multi-state or national level.

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*FWPCA Guidelines on Water Quality Standards, under the Water Quality Act of 1965, PL 89-234.

The conduct of a benefit-cost study at the national level only would be plausible because many types of pollution have very large-scale impacts. But such a study would not be realistic in the light of the actual decision-making context.

In continuing the effort to mediate between Federal legislation and state governments, the EPA Administrator in 1976 issued a new policy on enforcing water quality, although the 1965 Water Quality Act had been amended extensively in 1972. The new policy emphasized the need for sanctions of industrial firms not achieving the goal of "Best Practicable Technology" (BPT) by 1977. But exceptions permitted in the policy led to accusations by one United States Senator that EPA was acting unlawfully and was assuming judicial and legislative authority improperly.*

The benefit-cost analyst cannot overlook impacts of guidelines and other agency policies. It is possible that a policy will require careful benefit-cost analysis before provisions are made for enforcement actions, or for allowing exceptions to enforcement. If enforcement policies cause unemployment or inefficient use of capital, then society, as well as the firm involved, must bear the cost.

2.6 Recent Legislative Developments

The current debate on society's response to toxic or hazardous chemicals and other materials encompasses the social mechanism for developing and implementing the response, as well as such topics as the analytical techniques to be used in developing proper responses and the accumulation of information on hazards, benefits, and costs. The debate is occurring not only in universities and industries, but also in government as the U. S. Congress recently contemplated the various versions of a Toxic Substances Control Act.

Given the structure of the Toxic Substances Control Act of 1976, the benefit-cost analyst will be called upon to help answer many questions, raised in the course of recent debate, on assessment of hazards,

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*"Muskie Scores EPA '77 Policy: Claims Noncompliance Letters 'Unlawful'", Environment Reporter, Vol. 7, No. 9, July 2, 1976, pp. 379-389.

scope of potential damage, and possible impacts of regulatory decisions such as restriction or cancellation of licenses to produce and use certain chemicals. These regulatory questions and problems are already well-recognized because of difficulties which have arisen under presently existing Federal laws. The National Academy of Sciences report* mentions the Clean Air Act, the Federal Water Pollution Control Act, the Federal Insecticide, Fungicide and Rodenticide Act, as amended by the Federal Environmental Pesticide Control Act, the Occupational Safety and Health Act, the Marine Protection Research and Sanctuaries Act, and the Safe Drinking Water Act. Other Federal statutes which might be mentioned include the Federal Refuse Act of 1899 and the Hazardous Materials Transportation Control Act of 1970.

It is noteworthy that the existence of the nine laws named above did not deter Congress from viewing the Toxic Substances Control Act as "one too many." In fact, the National Academy of Sciences report commented:

> "The current body of environmental laws does not represent a harmonious and purposeful whole. It was developed at different times by different committees of the Congress, and it reflects the vagaries of competing pressures and regulatory schemes. There are legislative actions that we believe could make federal regulation of chemicals more effective. The passage of legislation similar to the proposed Toxic Substances Control Act would provide a systematic basis for developing and collecting needed toxicological and other information about industrial chemicals and would provide authority to regulate potentially hazardous chemicals that are not now subject to any statutory authority. It would thus fill a number of gaps in the existing regulatory structure."**

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*National Academy of Sciences, Decision-Making for Regulating Chemicals in the Environment, Washington, D.C., Committee on Principles of Decision Making for Regulating Chemicals in the Environment, Environmental Studies Board, Commission on Natural Resources, National Research Council, 1975, p. 11 (hereafter referred to as the "NAS Report").

**NAS Report, ibid., p. 15.

2.6.1 The Toxic Substances Control Act

The Toxic Substances Control Act had been debated in the U. S. Congress since 1971 and was under consideration in both the House of Representatives (HR 10318) and in the Senate in numerous versions. The hearings in the Subcommittee on Consumer Protection and Finance, prior to passage of the Act in 1976, revolved around the very same issues addressed in the NAS Report.

These issues generally are related either to the actual mechanisms of the regulatory and decision-making processes, or to the information, data, and analytical techniques. Although these two broad categories are not entirely comprehensive, they do, in fact, encompass most of the content of the debate. There is little question or argument that there must be <u>some</u> regulatory decisions, and that these decisions will at least inconvenience <u>some</u> chemical producers and users. The debate usually proceeds directly to the questions: "How will the regulatory decisions be made?" and "What will be the extent or degree of the inconveniences, costs, continuing hazards, and other benefits of such regulatory decisions?"

At least one issue in the regulatory process debate has some implications for the performance and use of benefit-cost analysis. This issue is the problem of how much involvement of non-technical public interest and consumer groups is to be expected. If such involvement is to be extensive, the benefit-cost analysis will probably be used on a much broader scale than just within the technical-regulatory community.

Even though a benefit-cost analysis might be performed and interpreted by technically trained industrial personnel, its <u>eventual</u> use might necessarily be much more general, especially is some of the NAS recommendations regarding openness and access to the decision-making process are implemented, i. e.:

- The essential elements of decision-making should be part of the public record. The agency should publish a "white paper" for each important regulatory action undertaken. The paper should include the key details of the economic, legal, scientific, and other considerations taken into account in reaching the decision. It should be issued when the agency decides to take some action but sufficiently in advance of a final decision to permit considered response. An important decision to take no regulatory action, or to defer such action, should also be accompanied by a "white paper."

- Any information available to an agency on the hazards of a chemical that is regulated by that agency should not be considered proprietary and should be available for public inspection in a timely fashion during and after the decision-making process.

- The early and open exchange of information and opinions on a proposed decision should be encouraged to reduce the current dependence on subsequent judicial challenge. The EPA Administrator should hold public hearings at the earliest feasible stages of the decision process. He also should facilitate prehearing exchange of information among parties (for example, through depositions, interrogations, and other discovery procedures).

- At appropriate points in the decision-making process, the agency should actively seek to identify the affected parties and solicit suggestions and comments from them. Ways should be explored to better represent the interests of future generations.

- The press, as well as other interested parties, should be told when a standard-setting process begins and when the proposed standard is ready for publication; further discussions during this process should occur as often as warranted.

- EPA and other agencies should initiate programs aimed at training and encouraging citizens to participate in the decision-making process.

- The Department of Commerce should develop an educational resource to help small businesses acquire the information on chemical regulatory matters that is at present routinely available to large corporations and major trade associations.

- All ex parte communications, including those from Congress, members of the Executive Branch, private corporations, and citizen groups, on any adjudicatory decision pending before a regulatory agency should be made public with sufficient time for comment before a decision is made.*

In other words, the current debate over the procedures and mechanisms of regulatory decision-making has some implications for the approach and methods used in benefit-cost analysis, in terms of technicality, complexity, and the level of training required to use it.

Thus, the use of benefit-cost analysis in the regulation of toxic substances and hazardous materials will face all of the problems mentioned by the NAS Report, and the problem of broad understanding by legal, political, and other officials, plus lay citizens, could be even more acute than the problems encountered in environmental regulation to date.

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*NAS Report, ibid., pp. 4-5.

3.0 BENEFIT-COST TECHNIQUES FOR HAZARDOUS MATERIALS, TOXIC SUBSTANCES, AND SOLID WASTE CONTROL: OPENING REMARKS AND WORKING GROUP REPORTS

In this chapter, excerpts from the opening remarks of the three-day conference, wherein various areas amenable to benefit-cost analysis were discussed, are first presented. This is then followed by the reports of each working group, corresponding to the seven problem areas delineated in Chapter 1.0.

3.1 Opening Remarks: The Applications of Benefit-Cost Analysis

Within the last three years, there have been a number of conferences dealing with benefit-cost issues, procedures, and techniques. Two of the most recent were the symposium sponsored by the National Academy of Sciences in New Orleans in February 1975, and the workshop sponsored by the EPA Office of Research and Development (ORD) in June 1975 which was part of the project that produced this Subject Reference.

In drawing on these previous efforts, this Subject Reference is focused on those areas and those techniques in benefit-cost analysis for which there appears to be no ready set of answers to provide guidance to EPA benefit-cost analysts. Assuming that much of the theoretical foundation for benefit-cost analysis is well established, there still remain a number of broad questions that must be resolved in order to provide procedural guidelines for the practitioner.

The practitioner is the benefit-cost analyst within EPA who must, given the current regulatory situation, conduct a benefit-cost analysis. The purpose of convening a group of experts, as was done in the middle phase of the project, was to develop and recommend guidelines in these difficult areas. The remainder of this introductory section will summarize the benefit-cost user's needs and difficulties as stated in a series of statements made at the EPA/ORD workshop in June 1975. Then, a series of seven problem sections will describe the methods discussed at the workshop for developing a benefit-cost study to meet the user's needs.

3.1.1 Fundamental Policy Decision Issues Which Benefit-Cost Analysts Must Face

The nature of society places severe limits on the precision of benefit-cost analysis as a policy decision tool. This section reviews the social basis for these limits and shows how these limits impact on two technical problems of benefit-cost analysis: the analysis of industrial firms' responses to regulatory actions, and the analysis of human health hazards.

> "First, there is the obvious difference in values held by different segments of society. In many kinds of policy decisions, the critical parameters tend to be value judgments about the value of life, the value of aesthetics, how much is national security worth and so on. There is no agreed-upon way, nor is it likely there ever will be, to assign dollar values to these parameters. Since they tend to be the critical variables to society and to the policy decision-maker, there is not any scientific way of reaching a final decision, because you can always argue with the method by which dollar values were assigned to those social values.
>
> Perhaps even more important than assigning dollar values is the problem of distribution among social groups, among geographic groups and over time. Clearly, for the decision-maker at least who wants to be responsive to Congress and the electorate, this is a crucial consideration. It may be fine to think on a national basis so that if you close down a chemical plant in Pennsylvania, you merely assume full employment and liquidity of capital, you then assert that nationally there will not be much effect. But the people in Pennsylvania, if the plant moves to California, will not take kindly to your views. This is a real problem for benefit-cost analysts because there is not any very good way to deal with distributional problems."

A similar set of problems involves distribution over time, particularly the effect on future generations and how to use the discount rate to deal with those kinds of problems. Discount rate is a problem in any kind of benefit-cost analysis, but in addition to the "usual" problems when dealing with regulatory issues with chemicals, there is the set of problems arising from residual chemicals in the environment leading to very long-term effects.

One of the technical problems arising from the equity and impact distribution problems is whether a specific regulatory decision will have a major impact on the supply and demand factors for a given chemical. This involves addressing the question of what kinds of substitutes will appear if the policy decision is to ban the chemical.

> "From the standpoint of economics, it is possible to assume that the benefits of chemical substitutes are reflected in the market price of the chemical banned. But, is that really true? The degree to which you can substitute is sometimes underestimated."

A second technical problem is the definition of "chance," or probability. In dealing with toxicological or hazard data on hazards to human health and hazards to the environment, "probability" is a very inexact and very often misunderstood word, in part because it has more than one meaning. In the sense in which toxicologists use it, the definition involves the distinction between general population and exposed population. Also, how accurate is the research that led up to that first set of probabilities? What is the probability that those estimates are right? These are fundamental problems of policy-making in society, stated in a generally non-technical way. One function of benefit-cost analysis is to force some rigor into the analysis of these problems, and the development of regulatory policies which are sensitive to them.

3.1.2 Discussion of Regulatory Policy As Stated in Existing Legislation: The Federal Insecticide, Fungicide and Rodenticide Act of 1972

Benefit-cost decision-making enters concretely into the Federal Insecticide, Fungicide and Rodenticide Act of 1972. Under this Act, all pesticides introduced into interstate or intrastate commerce must be registered with the Federal government. To do this, the parties seeking registration submit data to the Agency attesting to the product's efficacy and safety. The Agency reviews the data and determines whether it meets the Agency's standards of safety. Three outcomes can result from this review process.

First, EPA can register the pesticide for general use. It then means the pesticide is available to the public at large and can be used by essentially anyone.

Second, EPA can register the pesticide with restrictions. For example, it can restrict the pesticide to applicators who have demonstrated competence in the use of pesticides.

Third and most dramatic of all, EPA can preclude the pesticide's entry into commerce.

The statutory standard under the Federal Insecticide, Fungicide and Rodenticide Act is "unreasonable adverse effects." The Act defines "unreasonable adverse effects" to mean any unreasonable risk to man or the environment, taking into account the economic, social, and environmental benefits and costs of the use of that pesticide. So there is an explicit requirement for the need of balancing in the decision-making process.

> "The system involves looking at risk first and then turning the degree of intricacy of the balancing to the degree of the risk that pesticide poses. If the risk is minimal, then minimal balancing is in order. If the risk is moderate, then the degree of analysis is escalated. Finally, if the pesticide appears to pose a substantial question of safety to man or the environment, a very detailed benefit-cost balancing must be performed.
>
> Here is one example of how the legislation is applied. This is based on an actual case experience. The Administrator of the Agency issues a notice to cancel the use of a certain pesticide. Under the legislation in this case, the manufacturer and other Federal agencies have the right to ask for a full administrative hearing. The hearing did last a number of years and filled in thousands of pages of transcript.
>
> On this record, the Administrator suspended all but one or two minor uses of the pesticide. The applicant or the registrant in this case appealed his decision to the Court of Appeals. The D. C. Circuit Court upheld the Administrator's decision, and the pesticide has been removed from the marketplace.

The major issues that were argued revolved about whether the pesticide was carcinogenic to man upon ingestion and whether certain food crops would suffer if the pesticides were not available. There was no application of any sophisticated or esoteric benefit-cost methods or models. Esoteric models relying on unavailable data are of no use."

3.1.3 Discussion of Regulatory Policy as Stated in the Proposed Toxic Substances Legislation*

In July 1975, there were four bills under consideration by the U. S. Congress. The Senate Commerce Committee had held hearings on S. 776, which was a staff draft working paper dated June 6, 1975. In the House, the Ekhardt Bill was the major one, and was reasonably close to the Senate version. William Brodhead had introduced a bill favored by labor and environmentalists, and John McCollister introduced one favored by industry. This discussion treats the June 6 version of S. 776 because it is the most senior of the four. The purpose of discussing a preliminary version of a bill is to show how concepts of regulation evolve in the legislative process. The language of the proposed bill exemplifies benefit-cost thinking as it appears in legal language, and this type of language should become familiar to all benefit-cost analysts.

The Bill is concerned throughout with benefit-cost considerations. The opening policy statement, after declaring that adequate authority should reside with EPA to regulate chemical substances, then goes on to state:

> "Such authority should be exercised in such a manner as to assure that technological innovation and commerce in chemical substances and products containing chemical substances are not unduly impeded...."

Both major authorities vested in EPA by this Act -- to require risk assessment data from manufacturers of specific chemicals, and to prohibit or restrict such manufacturer -- are substantively linked

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*This Workshop was held prior to the passage of the Toxic Substances Control Act.

to the concept of "unreasonable risk" which, in turn, is explicitly defined to mean "...any risk associated with the manufacture, processing, importation, or distribution in commerce for a specific purpose if such risk outweighs the benefits."

There are four significant authorities vested in EPA by this Bill to which benefit-cost considerations are relevant. These are:

- To require risk assessment data from the producers of chemical substances;
- To screen new chemical substances prior to permitting their production;
- To regulate hazardous chemical substances; and
- To require reports from producers regarding the nature, volume of production, and use of the chemicals produced.

The authority to require risk assessment data from producers is perhaps the most important. Section 4 directs the Administrator to prescribe "criteria for data development" to assist in determining whether the production of specific chemical substances poses an "unreasonable risk." The EPA is to promulgate such criteria, within two years of enactment, for each of the 300 substances it considers potentially most hazardous. Thereafter, the producers must develop and submit whatever data is necessary to satisfy these criteria.

EPA's authority here is broad. It may specify both the adverse effects of concern, selecting any that may cause an unreasonable risk, and the particular methods and tests to be used in generating these data.

In addition to specific criteria for particular substances, EPA must prescribe comparable but generic "criteria," to be applied to all new chemical substances, and to substances for which a significant new use is proposed. It is in connection with this authority that EPA is empowered to screen chemical substances prior to their manufacture or introduction in commerce. These generic "criteria" are to be promulgated within one year of enactment, and anyone proposing to produce a new chemical substance thereafter must submit the risk assessment data in the prescribed format and meeting the criteria. These must be provided 90 days prior to commencing production. The Administrator then has three options within that 90-day period:

- He may take no action, in which case the proposed production may commence at the end of the 90-day period;

- He may promulgate a rule prohibiting or restricting the proposed production; or

- He may, if he deems more or different information desirable, issue an order temporarily continuing the prohibition on the proposed production until such time as EPA promulgates a new rule revising the relevant "criteria." The proposed activity then remains prohibited until the new rule is promulgated, new data satisfying the new criteria is submitted, and either the 90-day review period has elapsed or a restrictive order has been issued.

Section 6 of the Bill authorizes EPA to regulate hazardous chemical substances. Whenever the Administrator concludes that any chemical substance, new or existing, other than a pesticide, drug, food or tobacco product, presents an "unreasonable risk" which cannot be adequately handled under other Federal laws, he must promulgate a rule regulating that substance. Again, the options are broad. The rule may flatly prescribe production or use of the substance; limit the amount or concentration that may be produced; prohibit or limit the particular distributions or uses; or prescribe conditions, including labeling and providing instructions for use or disposal, under which the substance may be manufactured, processed, imported or distributed.

Finally, Section 8 would enable EPA to require any producer to maintain whatever records and submit whatever reports the Administrator deems necessary, including:

- The trade name, chemical identity, molecular structure, and location of manufacture of any chemical substance produced;

- The uses to which such substances are put;

- The amounts produced;

- The number of workers exposed, and levels of exposure; and

- Any health or safety data regarding the chemical substance that is being, or has been, produced by or for, or is known to the producer.

That summarizes the relevant provisions of the Act. The benefit-cost implications of both the reporting and regulatory requirements regarding existing chemicals are, indeed, challenging, but in the case of new chemicals, the problems become particularly so. In assessing the implications of regulating substances that have yet to be manufactured, we are necessarily reduced to estimating what might be with respect to both benefits and costs, rather than measuring what is. This immediately introduces levels of uncertainty into the analysis which can very quickly lend an Alice-in-Wonderland quality to the exercise.

Another problem is the relatively unspecified and open-ended nature of the proposed premarket screening process. This procedure calls for the Administrator to establish the ground rules for developing and submitting risk assessment data; receive and evaluate the submitted data; if deemed necessary, continue indefinitely the prohibition on production in order to change the ground rules to obtain more or better data; carry out a formal rule-making procedure to modify the ground rules; evaluate the new data generated and submitted in response to the new ground rules; and finally, conceivably prohibit, and probably restrict, the proposed activity on the basis of that evaluation. The inherent uncertainties in this process will certainly affect, to a largely unknown extent, industrial research and development commitments.

In this situation, the benefits of rule-making are likely to be overestimated while the costs may go unrecognized. Benefits will tend to be exaggerated because of the invariable tendency to make "worst case" assumptions in the process of assessing risks in health-related rule-making situations -- in order to err, if at all, on the side of safety. While reasonable men may differ as to the propriety of this tendency, it is an ineluctable aspect of health-related rule-making.

> "Popular opinion to the contrary notwithstanding, bureaucratic careers seldom founder on the shoals of too much solicitude for human health. Once these "worst case" assumptions have been formalized in a criteria document justifying and providing the rationale for a rule, the hyperconservative nature of the premises tend to be forgotten or ignored, and the 'benefits,' those highly theoretical 'lives saved,' are reified.

> In contrast, the significant costs may not even be recognized, much less weighed in the balance, simply because history doesn't reveal its alternatives. Benefit-cost analysis must be pressed to consider the costs of not producing those goods that are explicitly prohibited or restricted by rule."

A more serious problem, and one largely ignored, are the costs associated with not producing goods as a consequence, not of explicit prohibition, but because of the dampening effect upon industrial research and development of the increased costs and risks created by the uncertainties in the rule-making process described above. Research efforts not undertaken, and goods not produced, are not missed and are therefore not treated as costs.

In this respect, the proposed provisions for screening and regulating new chemicals under the Toxic Substances Control Act are similar to the Food, Drug and Cosmetic Act and to some provisions of the Federal Insecticide, Fungicide and Rodenticide Act, first in that the assessment of benefits and costs, because they necessarily depend upon an estimation of the consequences of prohibiting or not prohibiting an activity that has not yet occurred, is an uncertain exercise at best; and second, in that the relative ease of appreciating the benefits of regulation contrasts sharply with the difficulty of even discovering the costs.

While this is an extremely difficult problem, it is one that should concern anyone interested in the benefit-cost equity aspects of health-related rule-making, simply because it is in this area that overzealous regulation can do the most damage.

3.1.4 Some Policy Decision Needs in Radiation

The EPA has authority for overseeing the presence of radiation and radioactive materials in the general environment. This authority has been interpreted in two ways. One is to maintain an overview in the total amount of radiation and radioactive materials being deposited into the environment, and also one area that is a source of disagreement or conflict today in the Federal government, and that has to do with setting guidelines for the amount of radioactive materials in effluents from various kinds of facilities.

Setting guidelines for radioactive releases automatically brings up the question of benefit-cost (risk) analysis. It is generally agreed that even low levels of ionizing levels create the risk of cancer in the environment. There are risks large enough and inequitably distributed enough that EPA would be very reluctant to apply dollar values to them. There is also the question of intergovernmental effects from radiation, especially when it is possible to release into the environment materials that have half-lives of 25,000 years.

3.1.5 Policy Needs in the Hazardous Waste Area

Of the 280 million tons of industrial waste, 10 percent are estimated to be hazardous. Industrial waste come primarily from manufacturing plants and this includes a growing quantity of process residuals and wastes. In other words, there is a byproduct that leaves this plant. There are also service sector wastes from restaurants, offices, and repair shops.

A growing quantity of sludge and slurry is going to land disposal because it is an inexpensive option in many cases. One reason for concern about land disposal is the growing problem of public health and environmental damage resulting from the mismanagement of those particular wastes. In many cases, it is a problem of no economic or regulatory incentives to cause the type of proper disposal.

One benefit-cost aspect of this problem is the degree to which there must be a limit or more costly disposal options for these hazardous industrial wastes so those increased costs are at least balanced by the environmental benefits.

> "A major concept is waste sinks and how the benefit-cost method relates to waste sinks is a major policy problem. Byproducts of our society used to go freely into the air and the water including the oceans and the lands. Congress restricted the amount going to the air. In water pollution, emphasis has been on best practicable and best available technologies.
>
> The ocean disposal option is not freely available to all and the land has become the final waste sink. The pressure for waste disposal to landfills will become tremendous as the pollution control systems start taking effect about 1983."

Therefore, in the macroeconomic sense, two of the media variables in the benefit-cost equation for effective environmental control of hazardous wastes have been set, but not on the same basis. Thus, with respect to the regulation of residuals disposal to the land, the benefit-cost analysis must be more precise since regulatory actions influence the last parameter or medium in this equation, as well as the final variable in industry's environmental decision-making.

The cost side of industrial waste disposal is an easier problem with which to work. There are thirteen categories or SIC sectors for which data are available on costs of current and proposed environmentally sound disposal alternatives, not just those limited to land disposal.

The EPA Office of Solid Waste Management Programs (OSWMP) has two studies underway of the economic impact -- in the economist's sense of the word, primary and secondary effects, on two industries, of meeting waste disposal regulations. They are the petroleum refining and inorganic chemicals industry. There are also two related studies underway. One is studying the feasibility of waste exchange in the American setting. According to the concept of waste exchange, one man's waste is another man's feedstock. This has been very successfully used in Europe, thereby reducing the amount of waste that has to be factored into the equation. A second study relates to utilizing industrial waste as a fuel for energy production, and both obviously have the potential for offsetting revenue to an industrial firm facing ultimate regulation.

> "Benefit-related work, as you see, is a much shorter list. Based on experience in air pollution, it is possible to use negative costs to society to identify the benefits to be derived from avoiding improper hazardous waste management. So the EPA/OSWMP is currently documenting on a microeconomic scale the costs of counterpumping wells to avoid contamination from land disposal and the cost of redrilling contaminated wells. On the macro scale, the OSWMP hopes to develop a way to extrapolate these individual regulatory problems due to improper industrial waste management by the end of calender year 1975."

Comparing damages versus the benefits involve both the traditional short-term aspect -- that is, the harm to the operating personnel affected by the waste, and a bothersome long-term aspect. This long-term effect of mismanagement of residuals is complicated by the fact that land disposal, for example, usually affects other media like the soil or the groundwater or the drinking water before human receptors are exposed. Therefore, benefit-cost calculations are needed for environmental contamination, as well as human exposures after a rather complex chain of interactions.

A second unique problem the Office of Solid Waste Management Programs faces is the question of renewability of the land resource. The rain, wind, and upstream snow can flush the air and the water contaminant loading and improve the quality over time, perhaps over a time horizon of months, but natural cleaning actions which might rejuvenate poisonous soils or acquifiers, if they happen at all, may happen over the course of decades.

Finally, a third unique factor in the OSWMP context is that material and recovery aspects of the residual disposal equation are constantly changing, not only due to that ever familiar inflation which affects all pollution abatement costs, but also due to the changing availability and prices of virgin materials. Thus, there are natural resource preservation benefits that could be accrued in a benefit-cost equation that otherwise would address only the balance of pollution abatement costs versus public health and environmental benefits.

3.1.6 Criteria for Application of Benefit-Cost Techniques

The needs of program offices in EPA are for the kinds of procedures for which benefit-cost is very appropriate, but difficult to apply. There is a need to be very pragmatic, to be able to specify very concrete procedures and methods and perhaps to crystallize subjective judgments as to how to do the benefit-cost analysis. There is also a need to stay at a level that will enable a standard method to be used in various EPA program groups.

3.2 Methods of Analysis in Problem Categories: Working Group Reports

3.2.1 Problem Category One: Economic Impacts/Production Net Benefits

The contents for this section include a number of types of economic impacts and appropriate measurement techniques and considerations for each. The most productive efforts within this section were identified to be further explication of the specific techniques. These techniques appear in the following order:

- Human capital approach to estimation of health effects;
- Psychic loss to individuals from health effects;
- Bidding games;
- Property value studies;
- Travel cost method of valuing nonmarket utility;
- Quality-of-life indices; and
- Traditional economic impact studies.

Human Capital Approach to Estimation of Health Effects. The measurement technique for this subproblem should apply the principle that the cost of adverse health effects equal discounted present value of the foregone earnings of the affected individuals either during their period of illness or after their death plus costs of hospitalization, treatment, and discounted present value of differences in burial cost. This technique provides a lower bound on the value of a human life because it ignores psychic loss to the individual.

A procedure to calculate total health effects costs is to multiply the number of individuals of each type affected in each manner by the cost of that effect on that type of individual and then to sum across people. It may be desirable to document the distributional effects of health impacts as indicated by changes in transfer payments (court settlements, retirement payments, welfare payments, social security benefits, unemployment payments, etc.).

Psychic Loss to Individuals from Health Effects. Insurance premiums constitute an inappropriate measure since payment is made to guarantee support of dependence in the event of death, not to protect an individual from risk of death. Thus, a single individual would naturally buy little or no insurance regardless of the value which he places on his life. Court settlements for pain and suffering are weak measures of psychic loss since evaluation is performed by a "disinterested" party, not the individual whose valuation of the psychic loss is desired.

Bidding Games. This technique involves the interview of a sample of an impartial population. The interview technique is designed to stimulate market behaviors by collecting information on hypothetical response to hypothetical change. The situation under study is described and presented to the respondent in detail. The interview criteria include:

- Present facts;
- Use aids, e.g., photographs; and
- Situation must be realistic, credible to respondent; respondent must be placed in a role and an institutional setting with which he is familiar.

A basic question is asked: Would you be willing to pay some amount X to achieve a given improvement in the environment (or some subset thereof)? The question must also:

- Specify means and instruments of collection of money;
- Circumvent the free-loader problem, if a public good situation;
- Enable the aggregation of results over the population; and
- Use several kinds of bidding games to provide a check on reliability of answers (posted validation).

The interviewer may collect social and economic data, which may be used in interpretation of results.

Property Value Studies. The characteristics of the environment of a parcel of land are inseparable from that parcel of land. Consequently, in purchasing a parcel of land, a person unavoidably also commits himself to the consumption of these environmental characteristics. Thus, the value which the buyer of land attaches to these environmental characteristics should be reflected in the price which he pays for this parcel. Conversely, the application of any policy which impacts upon quality of the environment of some number of parcels of land should cause a change in the values of these properties. Statistical techniques (particularly regression analysis) can, in some instances, isolate the net effect of this application of policy upon the values of parcels which are impacted by these changes in environmental quality.

Problems in conducting property value studies include:

- Desirability of transactions price data, which reflects actual exchanges, relative to assessment data as a measure of property value.

- Need to control for effects of all variables whose change can affect property values.

    - Identification of relevant variables (e.g., site improvements of parcel, public facilities serving parcel, socioeconomic characteristics of the neighborhood of the parcel, etc.).

    - Obtaining data to measure each of these variables.

- Statistical problems in estimating property value functions -- especially multicollinearity problems -- may cause interpretation of results to be difficult.

- Technique is difficult, if not impossible, to apply when the properties which are likely to be affected by a particular policy cannot be readily identified.

    - Cost of assembling data set describing a geographic area which is large enough to capture these impacts may be prohibitive.

    - Estimating relationships for an area which is too small to capture enough of these impacts may provide unreliable estimates of these impacts.

The cost of assembling an acceptable data set when the available data are not in the desired form can be extremely high (especially in terms of man-hours required to manipulate the available data). Finally, observed property values constitute a lower bound of value of the property to its owner. Consequently, the measured values of environmental impacts are likely to be lower bound.

Travel Cost Method of Valuing Nonmarket Utility. Utility theory provides the basis for an evaluation procedure based on empirical demand functions of the form:

$$Q_r = f(p, I, Z_1, \ldots, Z_n)$$

where: Q_r = quantity of recreational activity;
p = travel cost as a proxy for price;
I = income; and
$Z_1, \ldots, Z_n$ = other explanatory variables.

These may include travel distance, environmental quality, other recreational activities, taste and intensity of preference among others. Consumer surplus can then be determined by either discriminating monopoly revenue method or monopoly revenue method.

Assumptions required for the travel cost method are:

- Households assume to react to fees in the same way as travel costs;
- Households maximize a utility function subject to an income constraint;
- Households have monogeneous tastes and preferences (except in Siden's generation of the demand function from individual indifference curve maps);
- Data acquisition by interview or questionnaire;
- Appropriateness of travel costs as a proxy for price; and
- Appropriateness of assumptions.

Quality-of-Life Indices. Sociologists and psychologists are working on quality-of-life indices which take a matrix of quality-of-life indicators and compress it all into a matrix number:

- Useful for comparison, i.e., is the impact beneficial or adverse for quality-of-life?
- Not for a dollar figure: cannot be incorporated in benefit-cost calculation.

Traditional Economic Impact Studies. Traditional economic impact studies require an assessment of the costs and returns of production process changes and subsequent effect on profits and consumer satisfaction. These studies are adequate for evaluating the impact of a change when the effects can be expressed in monetary terms. The study contains the following analytical components:

- Factors affected:
  - Production costs -- internal and external to the firm:
    - Quantities used;
    - Costs of production inputs.
  - Returns:
    - Quantities produced;
    - Quality of product;
    - Price of product.
- Description of techniques:
  - Linear programming;
  - Regression analysis.

Reliable coefficients are available for use in the analysis. They can be readily obtained through sample surveys, census, engineering studies, and experimental data. Reliability depends upon reliability of the coefficients used in the analysis.

The cost of the study varies with respect to level of aggregation, number of alternatives or activities considered, and availability of secondary data, e.g.:

- The need to generate cost and return data will add to the cost; and
- The larger the number of alternatives or activities considered, the greater the data costs and costs of analysis. Costly for small area implication.

The dollar magnitude of impact is the primary indicator, i.e., one should make the attempt to put dollar values on the big items even if techniques are relatively unreliable. One should also make an a priori estimate of the range of magnitudes of all relevant variables. One should measure carefully the big items (i.e., those with large expected magnitudes) and those with potential catastrophy but low probability. Then it is possible to make a priori estimate of reliability of estimation techniques and data.

There are two types of error:

- Failure to estimate in dollar terms a large item; and

- Make a wrong estimate -- if expected value of the error (due to failure to include expected value of error in estimation) exceeds cost of making estimates, make the estimate.

3.2.2 Problem Category Two: Environmental/Ecological Effects

The release of a substance into the earth's environment may affect non-human ecosystem components in various ways such as:

- Immediate damages, i.e., injury or death to present generation;

- Delayed or latent effects that may appear at some future date in present generation's life span; and

- Future effects that may recur in subsequent generations resulting in long-term population shifts, i.e., some species may decrease or disappear, others may increase or shift to dominant positions.

Substances may be released into environments in a single dosage in a chronic continuing release over a long period of time.

Dimensions of Ecologic Impacts. Effects may occur in plants, animals, i.e., both micro and macro flora and fauna. Some affected organisms (species) may be major environmental components; others may be minor or very limited components of the environment. Some may be of obvious importance to people; others, of no obvious benefit or significance. For example, compare the major primary autotrophs, i.e., photosynthetic producers with an obscure little-known vertebrate.

In some instances, the environmental component is of an obvious value that can be assessed in monetary terms, i.e., major crop plants. In others, such as song birds, monetary evaluation is essentially impossible. Some effects are quantifiable in non-monetary terms using numbers of individuals affected, etc., while others such as aesthetic effects may not be quantifiable in any sense.

Assessment of environmental effects in a benefit-cost analysis will require a maximum effort on the part of the analyst. It is an area fraught with pitfalls. Major problems begin to appear at the conceptual level even before the mechanical process is initiated. Three major problems, both from the conceptual and mechanical view are:

- Integration of apparently non-commensurable effects or values;
- Equity and long-term effects; many environmental effects occur over the long term; and
- Because of the indirect data available to some instances, the likelihood of a given environmental effect occurring can only be described in terms of risk and probability calculations.

Environmental effects may range from minimal to catastrophic. The single trauma to a few individuals in a species is rapidly obliterated in a few or even in single, new generation of a species. On the other hand, a chronic continuing effect to a major complex of primary autotrophic producers, i.e., N-cycle bacteria, photosynthesizers or heterotrophic decomposers, may result in drastic or complete overturns of life on earth as we know it. The analyst must distinguish severity levels and significance of effects to be documented or predicted.

Effects may appear in all aspects of the earth ecosystem. Techniques should be created to ensure that the analyst does not neglect or miss an important aspect of impact. Various ways are available to accomplish this: two most common are the checklist system and the impact matrix. On one side of such a matrix are listed all possible effects and, on the other side, all possible "effectors" or impaction mechanisms. The major benefit or use of such a system is the rapid scanning of a situation and the minimization of omissions.

Basic Measurement Problems of Ecologic Effects. Information on environmental effects seldom directly measure effects in an ecologic sense or even "au nature." Much environmental data consists of toxicologic studies of laboratory animals or measurement of residuals of toxic substances as they occur in the environment. Very little data exists relating or extrapolating laboratory animal toxicology to the significance of residuals. Modeling and simulating ecosystems needs further work, and the incorporation of toxicologic factors and residuals into indicator or predictive schemes has barely begun. Indicator species for extrapolation have been suggested as techniques for appraisal of larger or more complex impacts but again this has not yet been successfully demonstrated. Hence, at present, only indirect appraisals can be made based on intuitive or deductive processes from the limited available data. This places very severe constraints on the use of such data for expansion into finite ecologic effects.

Some emphasis in other aspects of environmental assessment has been devoted to energy budget techniques for the various organisms and trophic levels in an ecosystem or land or water area. This would appear to be very successful in modeling severely disturbed ecologic contents situations, i.e., highways, buildings, and surface mining. It is of limited use in the more subtle areas of effects where single species are involved and the affected groups do not produce a significant energy value. This latter condition would be true of the toxic substances area.

It is anticipated that in the near future, environmental/ecologic modeling/simulation will rapidly upgrade the quality of information available to the benefit-cost analyst. In the meantime, extreme caution should be exercised.

Toxic substances may affect both market and nonmarket areas. For example, the agricultural commodity prices of plants and animals can easily be dealt with using market data. However, the market areas are diverse and the analyst should be alert to this diversity. On the other hand, many of themore controversial and emotionally charged effects will occur in the nonmarket areas. These will involve the ecosystem in its entirety and may range from aesthetic scenic beauty concerns through endangered species to classic "pest" plants and animals, i.e., snakes or poisonous plants.

The non-market areas may be quantifiable or non-quantifiable depending on the quality of the data available. Even further, some non-market areas may not be quantifiable under any circumstance such as certain aesthetic values. Wherever possible, effects should be quantified. This step alone is a vast improvement over a mere description or a narrative statement of the problem. However, quantification must be based on sound data or predictive models. This will be especially difficult in areas of wildlife or fish populations. Percentage estimates should reflect some measure of total populations.

A major problem exists in the task of commensurating non-monetary quantifiable effects. The core of the problem is the diverse nature of the impacted organisms. The problem is to weigh or integrate impacts on fish, ospreys, rattlesnakes, starlings, azaleas, nitrogen cycle bacteria, and hundreds of other species. The variables may occur between trophic levels of the ecosystem or in geographically diverse areas. Seldom is a species eliminated; rather the effects are more subtle, often resulting in a shift in population numbers resulting in a balance change that may be expressed only in the long term.

Environmental effects may be short-term or long-term. Often short-term effects may be measurable but the probability exists that an ultimate long-term spillover or carry-through will be involved. These effects can be defined or estimated only through probability or risk techniques. In some instances, the effect may be involved in reaching an ultimate conclusion. This would be true with mutages, teratogens, radio nuclides, and food chain carry-through persistent toxicants.

Non-quantifiable effects may be extremely difficult to integrate. In most instances, the effect or impact must be judged in terms of human subjective value systems and thus are innately a part of socio-economic value systems and the individual's frame of reference. A number of techniques have been proposed for the creation of non-monetary aggregating units without successfully dealing with the issue. Two possible approaches discussed were:

- To use monetary units wherever possible through all conceivable transformation techniques such as:
  - Bidding games (willingness to pay);
  - Recreational and scenic expenditures; and
  - Aesthetic expenditures.

- The creation of non-absolute relative integrating units using various techniques to assign value to environmental components, i. e., Delphi procedures.

Numerous drawbacks were noted in both areas. Alternatively, it is possible that non-monetary effects can be aggregated into a structural priority ranking system that would allow the effects to stand alone. Such a system is explored in the following discussion.

Typology of Ecologic Effects. The following system ranks non-monetary ecological effects into three categories for purposes of aggregation. It does not attempt to aggregate monetary effects. Category 1 is an inventory of effects which should be aggregated only after Category 2 effects have been aggregated unless the decision-maker dictates otherwise. In other words, there is a greater necessity for the decision-maker to address non-monetary ecological effects which impact life support systems on an individual basis than it is for the decision-maker to address each impact on marketplace organisms or aestheric organisms.

Category 1: Life Support Organisms

- Natural biological and biochemical cycles
  - Nitrogen
  - Carbon including photosynthesis
  - Hydrogen
  - Other
- Energy transformations
  - Between trophic levels
- Chemical transformations
  - Oxidation
  - Reduction
- Physical environment
  - Atmosphere and climate
  - Geologic and hydrologic
- Subtle indicator species not appropriate to place elsewhere

Category 2: Marketplace Organisms Where Not Quantifiable in Monetary Terms

- Food
- Feed
- Fiber

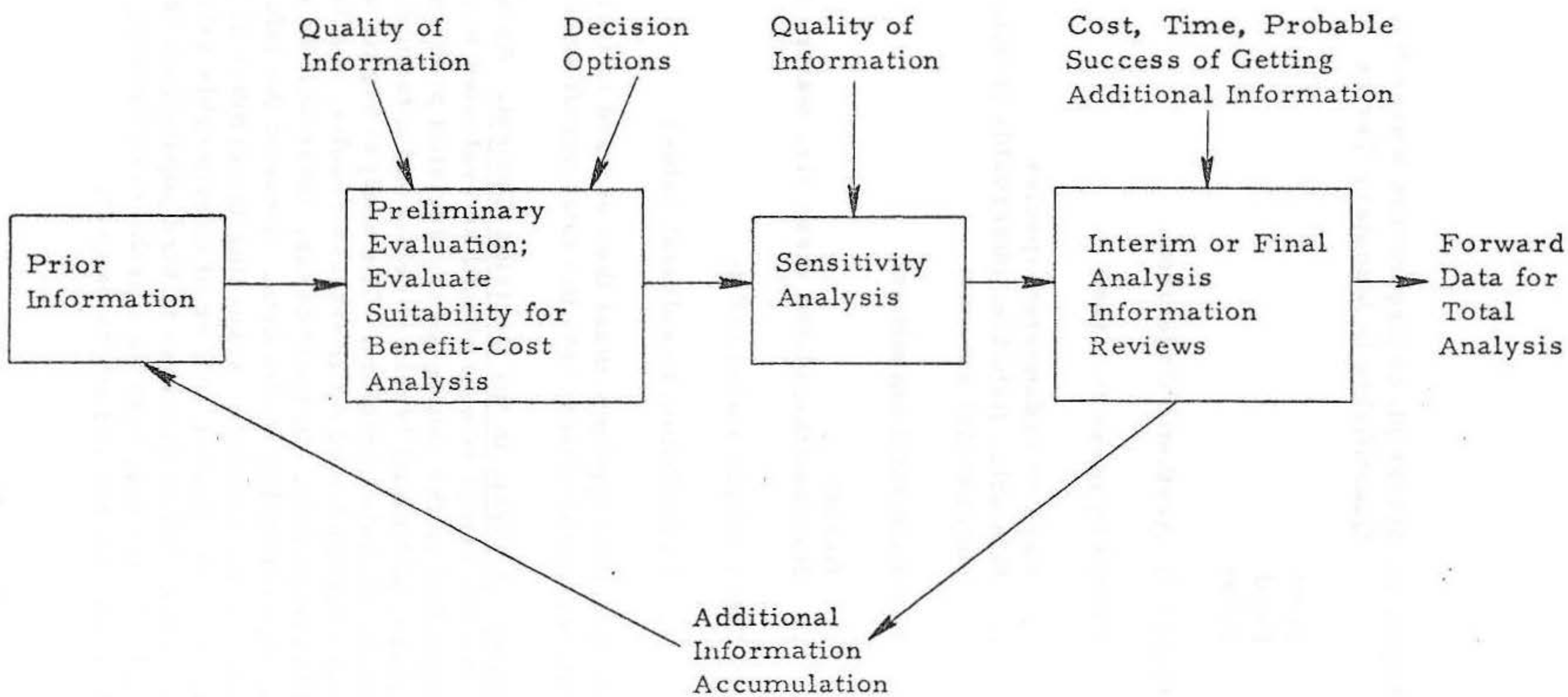
Category 3: Aesthetic Organisms

- Valued by mean for itself
  - .. Rare or endangered species
  - .. Huntable, fishable, observable in non-commercial amounts
- Environmental amenities
  - .. Beauty
  - .. Non-health-related clean air, water, and land
- Other unique social utility
  - .. Contribution to cultural values

The preceding typology must then be used to incorporate environmental and ecological effects into the total benefit-cost analysis.

Ecologic Analysis in the Decision Context. As shown in Exhibit 3.1, the environmental effects should be evaluated in a number of stages depending on the context of the decision problem. At each successive stage, additional levels of detail and information will be brought to bear on the decision problem. The analyst begins with some prior state of information based on literature results, available expert opinion, and hearings data. In most cases, there will be significant questions over the reliability of the data. Some of the information will be imprecise (as, for example, assessing the number of trout that will be lost) and other information will be of questionable relevance (as, for example, extrapolating damages to bird populations from LC_{50} data on sunfish). There may also be a problem of knowing what kinds of effects to even look for and try to project.

EXHIBIT 3.1: Evaluation of Environmental/Ecological Impact Information



Given this prior state of information, the analyst must make some judgment as to whether additional information should be gathered before integrating the environmental effects information into the benefit-cost analysis. This is best done in an iterative fashion by first evaluating the decision alternatives in the context of the best information currently available and then performing sensitivity studies to determine whether the decision would change by varying the input data or reasonable ranges. If the decision is sensitive to changes in the input data, then efforts should be directed toward improving the data. This might be done by incorporating the inputs from a wider set of experts, or, more likely, by carrying out new research.

The decision to actually undertake additional information gathering activities would also depend on a number of other factors including time, cost, and the perceived likelihood of being able to obtain the desired research results. Thus, for example, it would be infeasible to undertake a one-year data gathering effort if the decision had to be made in one week, nor should five million dollars be spent on a one million dollar decision.

A complete outline of a typical preliminary evaluation follows:

. Problem evaluation

.. Placement of problem in total context, setting, or perspective

.. Accumulation of existing data from

... Hearings

... Literature surveys

... Other sources

.. Identification of impact areas through

... Checklists

... Matrices

... Other sources

.. Precision and relevance of data

. Additional information needs estimate

.. Identification of areas requiring more or better data (possibly from checklists or matrices)

.. Development of cost and means to acquire data

After sensitivity tests indicate areas in which to proceed, comprehensive analysis should be conducted in the following manner:

- Identify and bound decision
  - .. Identify toxic substance(s)
  - .. Identify transport and transformation phenomena
  - .. Identify ecosystems, population, etc., at risk
    - ... Plants
    - ... Animals
    - ... Non-living entities
  - .. Identify spectrum of host responses (e.g., cancer, death, etc.)
  - .. Establish range of responses (perhaps as function of time)
    - ... Most likely
    - ... Extreme points
    - ... If necessary, develop probabilistic assessments
  - .. Characterize biological significance -- expand
  - .. Characterize scale and severity of problem

- Present results in units of terms that decision-maker can easily identify with
  - .. May use different units for different consequences
  - .. Point out impacts on human values, although final value assignment rests with decision-maker

Guidelines for ranking of "importance" of various effects:

<u>Geographic Scale</u>

High	Global
	National
	Regional
Low	Local

<u>Time Scale</u>

High	Irreversible
	Continuing
	Repetitive
Low	One Time

Functional Scale

High	Ecosystem -- function, structure
	Communities
	Species
	Populations
Low	Individuals

3.2.3 Problem Category Three: Human Health Effects

Listed below are recommendations and conclusions on selected topics.

Focusing the Benefit-Cost Analysis. At present, time and resource constraints prohibit an in-depth benefit-cost analysis for all toxic substances and other hazardous materials. To help focus such efforts, initially one must decide if a substance is causing concern, vis-a-vis, its human health effects. Events that lead one to believe that human health effects exist include:

- Legislation;
- Politics (Congressional pressure);
- Press;
- Epidemiological data;
- Incidents (accidental poisonings, pollution episodes, safety data, etc.);
- Exchange of information via literature reviews; and
- Foreign regulatory activity.

Quantifying Human Health Effects. The following guidelines are of note when attempting to quantify human health effects:

- The starting point of quantifying human health effects must begin with an identification of the nature of the health effect that may result to the population at risk (e.g., is it death, acute short-term illness, chronic long-term illness, future generational effects, etc.).

- In all health-related rule-making, a dollar value is implicitly placed upon human health effects. These values should always be made explicit.

- The principles used to assign these values should be consistent, and consistently applied, throughout the Federal health-related rule-making process.

- The benefit-cost analysis must be designed and conducted in such a way as to treat rationally the uncertainty regarding the relationships between the suspected chemical and the adverse effect. Specifically, care must be taken not to overemphasize the importance of a problem simply because the causal relationship is certain, on the one hand, or fail to address sufficient attention where causality is less well established on the other. One must pay close attention to the magnitude of the hazard (i. e., who and how many are affected), as well as the severity of the effect (i. e., how debilitating is the effect).

Data Requirements. The kinds of health effects data needed for a benefit-cost analysis include, but are not limited to, the following:

- Toxicity, use patterns, route and level of exposure, and disposal pattern of the substance in question.

- Population at risk to the pollutant.

- What percent of the population at risk is affected by the pollutant.

- What kinds of adverse health effects will result from different pollutant exposures.

- Age-sex distribution within adverse health effects category.

- Degree of severity within each category.

- Income distribution within disease category.

- Percent of incidences within each category resulting in:

  - Restricted activity days;
  - Work day loss;

.. Physician visits;
.. Hospital admissions;
.. Death;
.. Etc.

- Establish confidence bounds around all estimates above where applicable.

Extrapolating from Animal Toxicology Data. When extrapolating from animal toxicology data, attempts should be made to correlate positive or negative animal data with available human findings on the basis of metabolic pathway information where available. That is, when discrepancies with animal experiments appear (i.e., positive findings in one species and negative findings in another), results from that species most similar to the human being vis-a-vis metabolic pathways, should be favored. This necessitates an increased effort in metabolism studies in such instances.

Furthermore, for the purpose of informing, rather than distorting the benefit-cost analysis, toxicological experiments and extrapolations therefrom should be designed and implemented to yield the best (i.e., most likely) estimates of risk, as well as the traditional conservative estimates.

Use of Epidemiological Data. In assessing health effects, epidemiological studies should be used (if available) in conjunction with standard toxicological tests. The former deal directly with humans, but leave the causal relationships unclear, while the latter establish causality, but present problems of extrapolating to humans.

Available Data Sources. There is a spectrum of human health effects data ranging from chronic exposure to toxic substances to one-time exposures, often of a catastrophic nature, such as fires, explosions, or massive acute exposure to a toxic substance. The methods of quantifying the former are the most difficult. Data on the latter may often be determined from local, state, or Federal accident records; industrial or labor union records; industrial association records; etc.

A number of data sources are available for supplying information in various areas, e.g.:

- For epidemiological data:
  - National Center for Health Statistics (NCHS);
  - National Cancer Institute (NCI);
  - Community Health Environmental Surveillance System (CHESS)/EPA;
  - Decennial Census -- characteristics of United States population;
  - Trade associations;
  - Scientific literature;
  - Labor organizations;
  - State and local health departments;
  - National Institute for Occupational Safety and Health (NIOSH); and
  - Universities/hospitals/research centers.
- For exposure and monitoring data:
  - STORET (water quality)/EPA;
  - SARODS (air quality)/EPA;
  - National Emissions Data System (NEDS)/EPA;
  - United States Geological Survey (USGS);
  - United States Department of Agriculture (USDA);
  - Food and Drug Administration (FDA);
  - Consumer Product Safety Commission (CPSC);
  - Fish and Wildlife Service; and
  - Other Federal, state, and local regulatory agencies.
- For toxicological data:
  - Carcinogenesis Technical Report Series/NCI;
  - Carcinogenesis Abstracts/NCI;
  - TOXLINE;
  - MEDLINE;
  - Chemical Abstracts;
  - International Agency for Research on Cancer; and
  - Water quality criteria/EPA; State of California; Others.
- For occupational data:
  - County Business Patterns (by SIC codes);
  - Census of Manufactures;

.. Dunn and Bradstreet;
.. Decennial Census;
.. Trade and labor associations; and
.. Chemical Economic Handbook (Stanford Research Institute).

- For costing health effects:

.. National Center for Health Statistics (NCHS);
.. Social Security Administration (SSA);
.. U. S. Department of Labor;
.. American Hospital Association (AHA); and
.. U. S. Department of Commerce.

Additional Data Needs. For purposes of conducting a benefit-cost analysis, it is recommended that human health effects data be presented in a form amenable to economic analysis. This would include, but not necessarily be limited to, certain age-distributed socioeconomic characteristics, degree of severity of the given health effect, population at risk, and the percent of the population at risk which would be adversely affected per identified health effect. This requires that the economist work with the epidemiologist and toxicologist in the early stages of planning and implementing epidemiological-toxicological studies undertaken to gather the data.

3.2.4 Problem Category Four: Integrating Non-Commensurables

User Aggregation Issues. The need for comparison and juxtaposition of disparate kinds of data by decision-makers in the toxic substances context requires compilation and distillation of many variables. The needs of the decision-maker require the comparison of very disparate variables which must somehow be weighted or valued in making his decision. These variables measure the effects and impacts on each separate alternative action or investment available to the decision-maker.

The decision-maker is a human being with human capacities for absorbing, comprehending, and responding to detailed information. He must comprehend both qualitative and quantitative, numerical, and narrative kinds of information. Two kinds of data aggregation are involved in the decision process:

- The aggregation, or disaggregation, of variables and sets of data by numerical or statistical procedures.
- The aggregation or disaggregation of variables subjectively by interviewers, decision-makers, the general public, and technical analysts.

Each type of aggregation overlaps the other in terms of techniques and concepts, but the actual decision or choice of an alternative action is probably an aggregation of the second type. The comparison and weighing of two types of disparate variables is sometimes included in the term "aggregation."

Relevance and Comprehensiveness. The goal of benefit-cost analysis is to quantify all types of variables related to the analysis, and to describe narratively those variables which are not quantified. After such quantification is achieved, the decision-maker must decide whether he has obtained data on variables which are relevant and which are comprehensive.

Relevant variables are those which enable the decision-maker to distinguish among alternative actions or investments. These relevant variables should measure both benefits and costs. If the decision-maker is satisfied that he has obtained all variables which discriminate among alternatives, he has achieved a comprehensive analysis.

Data which measure benefits or costs should be aggregated or disaggregated to test whether they are relevant. County-level data on acres impacted by alternatives may show no difference among alternative actions when aggregated by state, but they may discriminate among alternatives when aggregated by farm size. "Acres per farm by size of farm" is thus a relevant variable, although "acres per state" is irrelevant.

The impact of the alternatives available to a decision-maker should be in terms of "crop loss per acre," as an example. "Tons of crop loss" and "acres impacted" are a simple example of non-commensurable variables. "Acres of wheat impacted" and "acres of corn impacted" are also simple non-commensurable variables, but these can be aggregated under the relevance rule if other requirements are also met.

These other requirements include:

- The variable must be in the same physical units, i.e., acres.
- The measurement must have significance to the decision-maker as determined by his decision-making scope and power.
- The measurement must have social face-validity. Measurements such as number of "exposure time" or "organic-ring cleavages" may be so technical or obscure that they are useless to decision-makers.
- Data must satisfy the decision-maker's priorities for importance as dictated by his subjective requirements. Health effects variables should be aggregated if some high priority variable, such as cases of cancer, is not obscured by the aggregation.
- The value of measures which are not aggregated should be carefully assessed. The value of swallows not returning in the Spring and of deer not using a traditional path may be aggregated into "wildlife affected" only if the <u>fact</u> of the event does not have <u>greater</u> impact than the actual numbers of birds or deer.
- Data should not be aggregated over time if the projection of a trend has individual significance. The presentation of data to a decision-maker should have codes or footnotes which will enable the decision-maker to quickly assess what details have been obscured in the aggregation.

The above rules for aggregation should be seen as user or consumer rules. Many other technical rules must be applied in making choices of aggregation. These technical rules are discussed in later sections below.

<u>Analysis Set-Up Considerations</u>. The scope of the non-commensurable problem encompasses both monetary and non-monetary value systems. There are three basic results which should be included in the benefit-cost analysis:

- The dollar value of damage versus dollar for abatement;
- The relationship between physical tangibles and monetary values such as how land is evaluated in dollars; and
- The role of non-tangible entities such as interest groups and their ability to impact cost analysis.

In defining scope, enough flexibility must be provided to either aggregate or disaggregate by categories or units. The scope of benefit-cost should be broad enough to tie the relevance of the variables together in order to establish some form of logical linkage across space and time. The scope must also be designed to deal with anticipated responses from population subgroups with some degree of translation to evaluate the effects upon interest groups.

Once this step has been achieved, the level of effort required to present results of impact analysis must be specified from an agency viewpoint. Basic ground rules for consideration in defining the level of effort are:

- The level of uncertainty of possible impacts will dictate the initial level of effort.
- The public interest entities such as government agencies and interest groups will dictate specific technical areas of investigation. The analysis should be designed so as to provide as broad as possible public understanding of the scope and context of technical data.

<u>Interest Groups the Decision-Maker Should Consider</u>. A number of different groups may be affected by EPA decisions and may, therefore, be strongly interested in an attempt to influence such decisions. The decision-maker should logically, then, be aware of the existence of such groups on any particular decision and to take into account their existence and characteristics.

The interest groups, in general, can be classified into at least three major categories, and numerous subcategories, which can vary in importance with the technology or expected investments involved in a particular decision as follows:

- Users and benefactors of the technology or proposed investment:
  - .. Users who receive direct economic benefits:
    - ... Manufacturers (including trade associations);
    - ... Users: farmers (including farmer organizations) and homeowners;
  - .. Agencies which promote or use the technology in the public interest: Public Health Service, USDA (Will there be interagency conflicts?);
  - .. Consumer of food and products produced with the help of the technology (e.g., food from pesticides);
  - .. State or regional proponents, e.g., those seeking a favorable balance of trade from export of surplus grain.

- Regulators of the technology (i.e., other than EPA):
  - .. Executive and independent agencies: HEW, USDA, DOI, NASA, ERDA, etc.;
  - .. Legislative, national, and state agencies;
  - .. Judiciary: Will the decision immediately be challenged in the courts and what precedents exist?
  - .. Foreign: Do other countries regulate the technology differently?

- Receptors of the perceived adverse consequences involved in the decision:
  - .. Nature of population directly threatened:
    - ... Occupational: Is a special labor category a union involved?
    - ... Local or regional public;
    - ... National or global public;
  - .. "Public interest" groups:
    - ... Environmentalists;
    - ... Consumer advocates;
  - .. Professional and scientific associations;
  - .. Other special interest groups, e.g., ethnic or religious.

There are several other factors related to these groups as follows:

- Special characteristics of the interest groups:

  - .. Abilities to assemble and integrate information which might be helpful in the decision process;
  - .. Abilities to gain news media and political attention;
  - .. Socioeconomic classes represented;
  - .. Membership totals and national reputations;
  - .. Previous "track records" as to mode of action, e.g., constructive, effective, responsible, far-sighted, political.

- Other indicators of general public concern about the problem being considered:

  - .. Public opinion polls;
  - .. News media coverage:
    - ... Printed media, e.g., number of entries in New York Times Index, Readers Guide, Business Periodicals Index, Wall Street Journal Index;
    - ... Electronic media, e.g., network television specials.

- Integrate the input potentials of the interest groups for this particular decision.

Measurement Issues. Operationalization of desired measures is an important and sometimes difficult task. Sometimes it is very straightforward, e.g., income. This is usually measured in dollars (in the United States) and is easily and readily understood. A less straightforward example is health. This can be, and is variously measured, e.g., a subjective self-perception -- excellent, good, fair, or poor. A past medical treatment record on a diagnosis or examination could be used. An even more subjective measure of benefits and costs is attitude toward a given phenomenon, such as pollution.

One probably essential aspect of operationalization is validity of the measure. That is, does the measure really reflect the concept it is supposed to reflect? In the above examples, income presents little problem since it is measured directly. Income is simply dollars per unit time per individual or group. Health presents more difficulties since the individual's perception may not adequately reflect the "true" state of his health. Similarly, blood pressure or EKG results do not reflect "health" in all its aspects. Even the physician's overall examination and report may or may not completely reflect the "true" state of health.

A second absolutely essential aspect of operationalization is reliability of measures. Reliability simply means obtaining (nearly) the same reading in successive observations of a given subject. Going back to the above examples, income may be very reliably measured from certain records but much less reliable when determined by asking people since many people are reluctant to reveal their incomes, particularly if they are self-employed. Similarly, health measures are differentially reliable, blood pressures may change from day-to-day and doctors' diagnoses may or may not agree.

The point is to be aware of validity and reliability and to take care to keep both as high as possible.

The definition of units (scales) should be, whenever possible, in familiar units and/or in units which lend themselves to or suggest amelioration. For example, loss of employment leads to loss of dollar income and also to a certain amount of social and psychological stress. However, measuring social and psychological stress to dollars would not suggest the kinds of compensation and help such people would most need. Although it may be very tempting to reduce everything to one common denominator -- dollars -- such a simplified measure can in no way adequately reflect all aspects of the problem.

Rules for Aggregation. In general, non-commensurables means data sets which should not be aggregated (added, multiplied, etc.). For a decision-maker to ask that technical personnel do so most often simply conceals socio-political judgments of value and the technical manipulation prevents adequate public understanding and review of social decisions. Wherever possible, the technical person should express results in as disaggregated form as can possibly be made intelligible to the decision-maker and those who might review the decision. For example, one dollar of cost to a person making $20 per hour does not necessarily have the same social value as one dollar of cost to a person making two dollars per hour.

Aggregating techniques should be viewed as tools for making a judgment about the relative value of different states of the world. The clarity and completeness of the world view created by the aggregates determines the usefulness of the aggregates. The goal of creating such aggregates to express data must be parallel to the general goal of the particular analysis; that is, to make the differences between the impacts of alternative administrative actions as clear as possible. Several different kinds of choices need to be made in attaining this goal.

There is always a choice between creating many fine groupings with little average data per grouping -- and creating only a few major groupings. With larger groupings, larger "sample sizes" will lend greater statistical accuracy to the results quantified in each group. With smaller subgroups, there will be some sacrifice of statistical reliability for the sake of determining which subgroups reveal substantially greater or less impact than others. The choice of level of aggregation for each study must be made on the basis of how useful it is to detect the small subgroups with impact substantially different from the average impact in the larger groups. In general, the smallest groupings which can provide reasonably reliable distinction among impacts are to be preferred.

There are generally many conflicting and alternative ways of cutting up a universe to understand the differential impact of regulatory alternatives, e.g., the economic impact on farmers. A given pesticide might be expressed:

- For each state of the universe;
- For different income levels of farmers;
- For farmers growing different croups; and
- For farmers using different growing techniques.

It might be ideally desirable to express differential impacts for as many different types of aggregational units as possible, but where data and energy are limited, those types of categorization should be selected which lead to the greatest mohogeneity of impact within groups, and the greatest differences of impact between groups.

If the regulation will not have very much differential effect between different political units, but will have substantially different impacts on large versus small farmers, the larger farmer -- small farmer categories, in general, are to be preferred because the contemplated regulation may be considered more or less desirable because of that differential impact.

Policy in Favor of Giving the Analyst Substantial Freedom of Choice and Incentive to Innovation (User Choice). Regulatory agencies should address the extent to which benefit-cost policies tend to be prescriptive (or dictatorial) rather than suggesting the design and content of the analysis. Types of data and units of measurement to be collected and used and means and extent of aggregation of data and format and forum for presentation of results to decision-makers should not be predetermined by standardization.

The regulatory agency should develop representative types of analytical design, types of data and units of measurement that may be available and/or useful to collect demonstrated ways to aggregate data stated in both similar and disparate units, and useful formats and procedures for presentation.

The agency should ensure that benefit-cost directives explain why and in what circumstances the variables are useful together with their limitations, and to provide elimination criteria. Examples of application should be set out in handbook with relevant comment. Each research analytical task is unique or close to unique, and therefore the regulatory agency should ensure flexibility as to the analysis and the format of its results, which should be the responsibility of the analyst in appropriate consultation with the decision-makers. In other words, there should be choices of tools and a basis for choosing intelligently among them -- and the analyst should decide which tools his particular situation warrants. The analyst must make explicit the rationale for his choice in design, units of measurement, aggregation, and so forth.

Development of Units and Measures. As the benefit-cost analysis proceeds along the chain of command -- the total summation of all relevant and essential units of measurement -- it is going to happen that aggregation of a final report will occur. This aggregation should be made systematically. Invariably in a chain of command, each staff level will condense the input for a briefing to his supervisor. The following remarks will present some guidance on such aggregation procedures and are intended to prevent arbitrary omissions of fact from successive condensed versions.

First, the benefit-cost analysis paper will contain facts on alternatives to the substance (pesticides, nuclear materials, etc.) under review. In developing units and measures (each staff level will be involved in this for his supervisor), some rules or procedures should be followed. These units should remain in the measurement system of the discipline that developed them for as many condensations of the report as possible. Keeping the measurement structure intact, some aggregation is possible under the umbrella of major categories such as environmental effects, health effects, food, and fiber production effects. These subcategory aggregations should be done following the general guidelines. Each addition or transformation should be done so as to:

- Clearly illustrate the differential impacts among groups;
- Not use a third measurement unit for aggregation unless absolutely necessary and then include an explanation for clarity;
- Explicitly state the basis for aggregation such as "we added together all the expected illnesses of a minor nature that were short in duration and require neither medical attention nor hospitalization";
- Help the next level of decision-makers to capture the essence of the problem at hand by presenting summary information on the variance within the aggregated variable; and
- Anticipate major issues and aggregate "around" them so a clear picture of issues and alternatives is presented.

The categories of units should be under the following headings which are presumably of main concern to EPA:

- Effects on man;
- Effects on the ecologic interactions;
- Effects on economic systems; and
- Effects on aesthetic features of the environment.

Under these main headings, data should be aggregated only if the trade-offs among alternatives are still meaningful and possible. Each of the above major headings should be aggregated to the fewest variables possible and their non-commensurability should be explained to give a sense of significance to the decision-maker. The output of each step of the analysis should be set against a background statement that would show the connection of the analysis to interested groups so that judgments of impact severity can be made.

Presentation of Data. Format is defined as the presentation of non-commensurables data -- tabular, graphic, etc. -- and narrative interpretations -- to facilitate good decisions. How does the analyst and/or manager assemble the results of a benefit-cost analysis to insure against loss of comprehension? The following rules or guidelines should be considered:

- The presentation should clearly present the favorable and unfavorable consequences of alternative choices or actions.
- All tables, graphs, and narratives should be independently complete and understandable. For example, the narrative may refer to a table or graph for additional information but the narrative should be understandable without the table.
- All summary and text graphs and tables should be simple -- present relatively few ideas or set of data in any one table or graph.
- Use numbered highlights to present narrative.
- Provide a convenient reference from the aggregated highlights to the detailed or disaggregated data displays by regions, year, etc.
- When comparing alternatives, present common variables of each alternative rather than presenting all the information about each alternative separately. For example, present the risks regarding human health, etc., for chemicals A, B, and C. Then, present the benefits of each chemical.
- Limitation of the analysis, as well as critical assumptions, should be presented as part of the executive summary.
- Avoid the use of technical terms, if possible.
- Display results, data, interpretations -- not procedures, models, formulas.

Organizational Processes for Presentation of Benefit-Cost Analysis. How can the results of a benefit-cost analysis be critically reviewed so that all information presented to the decision-maker is correct and relevant? Some suggestions follow:

- Review by representative groups within the agency for technical accuracy and correct interpretations of data, reasonableness of aggregation of sets of data.
- Steering committee on how groups, etc., may be established at the time the study is instituted to insure coordination and communication among interested units within the agency and to provide guidance in the conduct of the study and presentation of results.
- A quasi-judicial procedure may be used to subject the issue and final results to opposing users and portions (the adversary process).
- Outside agencies and special interest groups may be asked for review and comments on draft report. This approach is especially applicable if a strong public reaction is expected from the probable decisions.

Topics for Further Investigation. At the point of design and integration for presentation, it is especially imperative:

- To have a clear-cut definition of what benefit-cost analysis is and what it does not comprise -- to define its role in the context of the larger EPA effort and process.
- For the benefit-cost analyst to emphasize the analytical approach, and not to drift far into the policy or evaluative role, benefit-cost analysis cannot serve as a policy by itself. The analyst should stay within his bounds. But it is easier to tell the analyst to do that than to tell him how. Numerous criterion procedures are needed which are not now available. Other procedures are needed for obtaining decision-maker inputs into the analysis. In other words, roles should be clearly delineated and then in the course of the study they should be allowed to interact and blur. How to organize such a process is the problem.

Agency policy on benefit-cost methods must be understandable to intermediate-level non-expert bureaucrats who have much to do with specifying project scope and design, and approving presentation to decision-makers. Much work is needed on how to develop methods which will be used. Only if methods are "practical" and can be used will they be attractive to users and decision-makers and worth going further. There is not much hope for the benefit-cost analysis if the agencies are uninterested or hostile.

Should representing popular choice (or social consensus) be one objective of analysis? The appointed EPA decision-maker, who is accountable to a (usually) elected policy-maker, the President, and who must at least explain himself to an elected Congress, should join and balance the possibly quite different conclusions from "objective" analysis, expression of popular will, and constitutionally sound political leadership. What analytical techniques should be ethically used to aid him?

Most of the discussion has been directed to the situation where benefit-cost analysis will be a tool for determining what type of control/abatement/regulatory/action to take. It can also be applied to other types of choices: regulatory versus assistance versus knowledge creating among problem areas for "investment." How should techniques be adapted to do these other analyses?

The English language should be used well in the narrative material and discussion of the analysis. Jargon and bureaucratese should be eliminated, but how can this be accomplished? Some rules for grammar and vocabulary might be a good idea. Maybe the same ideas will have to be expressed twice in a juxtaposed fashion: one in technically correct form and one in the best approximation of plain English.

Background Comments on the Use of Subjective Ratings and Other Judgment Measures. The sociology of benefit-cost involves a substantial gap of outlook or philosophy between the user and the provider, i.e., the decision-maker and the technical analyst. In reality, there is probably a continuum, and people can be both. In approaching the question of juxtaposing disparate variables for comparison and, for better or worse, in attempting this kind of decision synthesis, this decision-making sociology shows some crucial things about the state of society.

Specifically, there is very little inclination and willingness among anyone, technicians and decision-makers alike, to systematically develop, apply, and use the results of the behavioral-analytic techniques which have been brought to an imminently applicable stage in academic circles by researchers such as S. S. Stevens and Anatole Rapoport. A recent study by Alan Randall and Clyde Eastman of attitudes toward air pollution in the southwest is a rare example of the application of such methods.

On a more general scale, it has been nearly ten years since S. S. Stevens published his milestone paper in the journal of the AAAS, "A Metric for the Social Consensus" -- yet this paper has generally fallen into obscurity. Meanwhile, occasional uses appear of such techniques as the Delphi technique, a technique which is supposed to achieve consensus without excessive memoranda or other documentation. Regardless of the availability of consensus among such diverse groups as the Izaak Walton League, the National Rifle Association, and the corporate members of the pesticide industry, the history of our society is one of strength from diversity. The lack of immediately obvious grounds for coalescence and consensus is all the more argument that the most precise and penetrating tools of analysis that we have should be developed and used. Benefit-cost analysis illuminates the divergence of many impacts of alternative actions, but additional effort must be made to find the places in the thoughts and emotions of society where the divergent impacts are mutually found to balance each other. The EPA should be in the business of systematically and scientifically making these efforts.

In other words, no amount of statistical trickery, scale transformation, or index construction will serve to integrate non-commensurables in the mind of society. The final aggregations should illuminate for the decision-maker all of the differences among the actions available to him, including the differences in impacts on human values.

We have begun to define rules for when to aggregate some of the many measures of impacts on wildlife, aesthetic scenes, or human health, but the purpose of such manipulations must be to make clearer the h man value differences among possible alternatives. If such differences are adequately shown by one or more "final" numbers for each alternative, there could be no objection to such an aggregation. But it is doubtful whether such an aggregation has ever been performed.

3.2.5 Problem Category Five: Equity/Long-Term Impacts

Equity and Efficiency. Analyzing equity (distributional) effects for purposes of conducting benefit-cost analysis involves documenting and perhaps evaluating the market and non-market effects accruing to specific target groups.

The concept of equity has been treated extensively in the economic literature -- specifically in the public choice-property rights (PC-PR) materials disseminated by the so-called Virginia school (Buchanan, et al.), the Chicago school, and the "neo-institutional" school. Whenever a decision is made (including the decision not to act), an equity assumption or action has in fact been made. If the existing structure of rights and wealth is perceived to be "acceptable," the status quo has in fact been decreed equitable -- as in the case with "Pareto efficiency" criteria. If a policy decision results in deviation from the existing structure of rights, a new equity position has been defined.

It is difficult to treat equity and efficiency separately. For example, in the minds of many observers, equity cannot be examined solely at the individual level -- that is, if it resulted in a loss of efficiency at the system level, it would feed back at the individual level.

Perhaps this can be explicated best by way of example. To take the classic case, suppose that a decision at the political level is made to equalize income flows by a direct money transfer from high income classes to low ones -- a "more equitable" distribution. Yet one might argue convincingly that such a policy would stifle net social investment and result in a reduction in aggregate flow incomes in subsequent periods. This argument illustrates vividly both the tradeoff between equity and efficiency and, perhaps more importantly, the importance of taking a holistic or systems level approach to these types of problems. Seldom is the sum of the parts analogous to the whole. Synergistic effects often bastardize the complete analysis.

Role of the Analyst and Decision-Maker. The analyst is usually perceived as a technician doing the bidding of a decision-maker. This is sometimes the case but is not necessarily comprehensive or a useful interpretation. Where the variables which have been identified as the impact parameters are composed of direct or indirect monetized market-valued impacts of the analyst is well defined and under these circumstances the analyst can proceed to formulate benefits and costs with little or no input from the decision-maker. However, when the project impacts include non-monetary variables (e.g., equity), the analyst is dependent upon input from the decision-maker at the onset. The choice of methodology for collecting, displaying, and analyzing such impacts often requires value judgments. When such problems arise, it is important for the analyst to seek guidance from decision-makers in making these judgments. This is particularly important in considering distributional effects.

Short-Term Periods Versus Long-Term Periods. An important issue in projects which have intertemporal effects is that of comparing benefits and costs which accrue at different points in time. Where time periods are short, market rates of interest may be used in discounting to allow such comparisons, but for longer periods, problems arise in using interest rates. Project impacts which occur fifteen to twenty years in the future have very little weight in benefit-cost analysis when discount rates are used, thus, discounting may be inappropriate.

Unfortunately, determining the length of periods over which discounting is appropriate requires a value judgment. Some possible value judgments including the following:

- Twenty years should form the upper bound for discounting.
- For periods shorter than twenty years, the time horizon of impacted groups should be considered in determining the desirability of discounting.
- Where uncertainty about irreversible impacts arises, discounting should be questioned. In such situations, it may be appropriate to either (1) display impacts without discounting, (2) estimate an upper bound to future costs and discounts, or (3) discount the mode of possible costs.

Any structure -- either ecological or man-made -- can be viewed from two different perspectives. We can look at the overall structure of the system or we can look at the functional relationships between substructures within the system. In effect, functional relationships which are altered or manipulated usually represent short-term judgments design to reduce perturbation in an overall system or maintain a predetermined trajectory. In contrast to this, the alteration of structural parameters must be undertaken in the context of long-term decision-making -- a change in the design of the system. The manipulation of either of these two aspects of the system can be accomplished in two separate but interrelated manners. Regulation of functional relationships relies primarily on a feedback system. In order for the system to work, several assumptions must be granted:

- The system must be observable on a real-time basis;
- It must be possible to provide integration (weights) in order that the relationships may be quantified;
- It must be possible to estimate the time lags of signal and response relationships within a system; and
- Perhaps most important, all of the observable parameters must be both variable and controllable.

Such a feedback system is empirical in nature and is a trial and error process. In order for the system to work adequately, the controller must be "willing" to pay the price of being wrong on occasion. By "willing to pay the price," we mean essentially that the system is robust enough to return to an acceptable equilibrium after a perturbation has occurred. We shall refer to this type of system as one in which the basic objective is to control the system.

The second type of manipulation which requires knowledge of the overall design of the system is essentially a feedforward one (ex ante) where it is explicitly recognized that one or more of the assumptions listed above are not met. For example, time lags are too long or unrecognizable or some parameters (institutional ones, for example) are not variable and/or controllable.

The control and design of a system are not mutually exclusive actions. In some cases, it may be possible to salvage an uncontrollable system by redesigning it. The basic point of this dialogue is to illustrate the difference between control and design and to show how critical the recognitition of these concepts is in terms of present and future policies promulgated by EPA. If the Agency is to perform only a control function, the available policy options are both restricted and quite different from those which would be available under a philosophy of both control and design. The following example will illustrate.

An acid waste spill from a mine in West Virginia occurred at the headwaters of a semi-closed ecological system (stream). The ecological balance in the headwater area where the mine was located was completely disrupted. The loading effect on the stream system was evident for some distance downstream. However, the natural absorbtive capacity of the system to assimilate the toxic wastes allowed the ancillary ecological subsystems downstream to maintain their basic characteristics. After a surprisingly short period of time, the entire stream, including the headwater region where the mine was located, returned to its previous ecological structure. Ecologists would describe this system as being both resilient and elastic. The diverse nature and patchiness of this ecological system provided the overall robustness which allowed it to return to its previous state.

If the mine had been located in the downstream area rather than at the headwaters of the stream, the system may have been permanently altered. The point is that by designing a system (rather than just controlling existing functional relationships on the surface of a system), we can reduce and perhaps eliminate high probabilities of irreversible events taking place and at the same time reduce the (present and future) control costs which must be absorbed by the controlling agency.

Ecologists would say that good ecology is, in fact, good economics. At a conceptual level, this is true. However, the institutional problems and the transitional linkages which inevitably accompany decisions at the regulatory agency level do not necessarily conform to those necessary for the "right" ecological decision in terms of the most durable values of society. It may be possible to map one to the other. Conceptually, this would certainly be true -- operationally, it will be more difficult.

Obviously, control policies are much more easily introduced and, in the short run, appear to be much less expensive to implement. Design policies often provoke opponents (who have shorter horizons) and require considerable (futuristic) extension of the planning horizon on the part of the controlling (designing) agency. However, it is appropriate to place greater emphasis on the potential for the design and redesign of systems in order to avoid irreversibilities and provide for a low cost method of control of toxic and hazardous emissions.

The role of cost-effectiveness studies and benefit-cost analyses in the context of this discussion is even more complicated than is usually the case. Ecologists and conservationists would probably place an infinite price (cost) on a high probability of an irreversible occurrence. Economists, on the other hand, would be quick to point out that infinity is not a workable parameter and a real number must be provided if the analyses are to be of any benefit to the control agency in making decisions. Perhaps the best way to approach the problem is in a two-step fashion. The careful selection of alternatives for evaluation can be used to bound the problems which must be analyzed. This is a necessary step and will allow the EPA to determine ex ante whether or not any given system or subsystem is able to "handle" (absorb and recover) the environmental loading which is implicit in the actions being contemplated.

Once the design of the system is determined to be ecologically workable and economically tractable (on a year-by-year indefinite basis), the choice of alternatives within the system can at last be assessed by benefit-cost techniques.

If the mandate of EPA is to be consistent with the implied meaning in the title, irreversible actions are, in fact, anathematics unless the irreversibility is completely understood and accepted as an objective in itself. This assertion should not be interpreted as a plea for the maintenance of, or return to, in specific cases, "pristine areas." Such a policy would be undesirable socially socially and unacceptable. However, to focus only on the control problem and to omit consideration of design potential is to allow the tail to wag the dog. There is no reason why any system should be viewed as "unalterable" for either technical or ideological reasons. If an institution or a group of institutions collectively are promoting accelerated environmental loading, the environmental system should be reevaluated and, if necessary, altered. A poorly designed system may be uncontrollable. It can, however, in many cases, be redesigned and altered in such a way that conventional controls can operate successfully.

When dealing with intergenerational impacts, it is more useful to think in terms of design rather than control (the traditional function of most decision agencies). Accordingly, most market-oriented tools (e.g., discounting) do not provide an adequate framework for approaching the decision problem. Benefit-cost studies reflect measured properties of the social system -- e.g., externalities or distributional effects. Implicit in the undertaking itself is a recognitition that the system is deficient. Yet benefit-cost analyses are typically a product of this very system structure, structured in the conservative context of fiscal management. Long-term intergenerational problems might be better understood -- and decisions better made -- by employing a bit of common sense and looking more closely at alternative futures from a historical perspective on the demise of previous civilizations. In other words, the approach outlined above represents a challenge to society as represented by an evolving regulatory agency. The EPA would not be expected to actually design the ecologic future, but someone ought to be thinking in those terms even while control policies for the present are emerging.

Calculation of Impacts on Equity. In isolating those factors relevant to an analysis of equity, three general types of factors might be considered:

- Market;
- Non-market; and
- Degree of aggregation.

(For market and non-market factors, sufficient published materials are available to provide checklists for analysts and decision-makers, e.g., Water Resources Council, "Principles and Standards"; and ABT publications.)

As mentioned earlier, market impacts are more easily distinguished and quantified. In some cases, the cost (or value) associated with an impact can be readily discerned according to the market valuation. However, even if this information is available, the "market price" should be examined carefully. If, for example, in the case of fossil fuels, the price can be shown to be artificially (and/or temporarily) low, this information should be included in the report -- perhaps in the context of a sensitivity analysis. Examples are as follows:

- Changes in property values;

- Changes in the value of human capital, e.g., a project may increase or decrease demands for certain skills, therefore, changing the expected income of some groups; and

- Short-term changes in income and/or property values due to market imperfections, rigidities, and time lags in market adjustments.

Impacts which occur as non-marketized events, and are perceived to be important, must be evaluated. Indeed, the category of events (often fading into the category of externalities) is usually the prime concern and the most difficult to resolve. If all impacts were reflected through market interaction, in all probability the determination of value of a project undertaking would be relegated to the market system. Examples of non-marketized impacts are as follows:

- Changes in the quantity, quality, availability or cost of publically produced goods, e.g., landfill regulations may influence the cost of collection and disposal of solid waste.
- Changes in the quantity and/or incidence of involuntary risks.
- Changes in the incidence of non-pecuniary externalities.
- Psychic costs associated with limiting opportunities, e.g., employment, educational, locational.
- Impacts on the quality or availability of recreational opportunities, e.g., control of fire ants on park land.
- Impacts on social interaction, e.g., interactions within families, ethnic groups, communities, interest groups.

Guidelines for determining the appropriate level of aggregation may not be so readily available.

Aggregation may be carried out in one or more of the following ways:

- Spatial -- geographic;
- Temporal; and
- Social/economic.

The systematic evaluation of impacts logically proceeds from the specific (spatially "close") to the general (global limit). The decision-maker or the client, for whom the benefit-cost analysis is being prepared, will often have preconceived notions about temporal or spatial boundaries. In most cases, these boundaries, landscapes or time-frames must be disaggregated into subcategories. For example, a decision-maker (pesticide regulatory agency) might be faced with a recurring or cyclical decision -- e.g., review every five years the impact of a specific restriction of a pesticide or its use. In this case, we might conclude that the bounded temporal unit of this client is five years. Yet, most environmental problems which must be resolved and the associated impacts (positive and negative) transpire over a considerably longer time period. Thus, we would say that the problem time is eleven years -- if we are dealing with toxic substances which are expressed in half-life notation, the problem time must be weighted probabilistically.

If the environmental problem and policy boundaries coincide, the task is greatly simplified. If, on the other hand, the narrower or smaller (in this case -- and most cases) policy consideration restricts or bounds the time horizon of the decision-maker, he (or she) may be forced to adopt a restrictive "tunnel vision" approach to problems. For example, if, as is sometimes argued, the time horizon of a political office holder is four years (or less), her will be inclined (but not forced) to seek solutions which have short-term (four years) payoffs. For this reason, design aspects of systems are often ignored or poorly researched. Not only are the payoffs "too far" in the future, but the initial costs may be overwhelming. For example:

- Solid waste disposal -- problem location is where the material is placed and where the major impacts of such disposal do or may take place, e.g., air pollution from transport to site activities, noise from residing within the area (both wage and quality of life). Policy boundaries include the area from which the solid waste is collected (which originally could have been a "problem area"), i.e., where the benefits will appear.

- Pesticide -- limit use of insecticide used on crops in two regions. One region needs pesticides to achieve economic production; the other does not. Production in high need area then transfers to low need area. High need area has a localized equity problem (negative); low need area has positive equity. Outside of both areas, prices of product changes due to new economies of production. In many cases, all areas benefit from smaller quantities of pesticides in the environment.

As noted in the preceding paragraphs, some of the aspects of policy restrictions have been reviewed. One question which must be addressed when analyzing the impacts of a course of action over time is the number of "rounds" of impacts which are charged (positively or negatively) to a single project. In the traditional approach, there will be discernible primary, secondary, and tertiary effects or impacts. The analyst, in consultation with the decision-maker, must determine which of these are to be assigned to the project at hand, and which should be, at least in part charged to partly independent actions undertaken at a later time -- perhaps in response to positive inducements generated by the project presently under study. For example, consider the case in which an unused or partially used resource such as a lake, stream or aquifer is polluting existing water supply wells. If the land over the aquifer is not fully developed, the developer who ten or twenty years from now wants to build on this land will incur a cost to pipe-in water to the development beyond what it would have cost to tap the aquifer beneath. Thus, the pollution damage (inequity) impacts not only on those currently exposed to the pollution, but also the aquifer and those on future residents who eventually bear the cost of the piped water.

The incidence (impact) of a project on various segments (subgroups) of society must be identified. Even if the effects are traced through many social groups, the process of evaluation must be truncated at some point. This break point can be determined by either the analyst or the decision-maker (or both).

The impact is greater on the poor and the aged to the extent the latter fit into the category of a special subgroup of the poor/aged who have respiratory diseases. The poor live in the areas where land values would allow siting of a large polluting plant. Their impact on political representation is low and they depend on raw air quality to a greater extent than the more wealthy who possess the resources to condition their air. If the source of pollution is a source of energy, the wealthy benefit more on a per capita basis since they use more energy. If the source of pollution is some minimum distance away, their position may be better if they have low cost energy and use it to condition their air than to pay a premium for energy to reduce pollution at the source. The analyst should provide the raw data on impacts, numbers of people involved, relative distribution of degree of impacts on the various groups including special effects like respiratory programs and the cost to each of these types of groups. The decision-maker then takes the raw data, etc., and provides the necessary balancing to achieve the required, indicated or mandated equity.

Methodology. Once the identification and careful articulation of impacts has been completed, the choice of methodology or combination of methodological techniques must be confronted. To a considerable degree, the characteristics of the impacts identified will influence and restrict the range of techniques which are applicable or feasible to obtain.

Two general classes of techniques can be delineated. The more common of these can be termed value measurements -- real numbers are assigned to an impact which are derived from measuring the potential impacts. If the market provides an explicit or implicit price for the impact, such a number can normally be obtained. A second method, used in cases where discrete numbers or value measures cannot be ascertained, is called the classification method. In this approach, the decision-maker must attach "importance weights" to various events.* These weights do not have common units such as money. Once ranking is done or relative values are assigned, the analyst can proceed to evaluate benefits and costs. A. Allan Schmid has outlined this process in a step-by-step example. He also demonstrates the feasibility of coverting these "explicit value" weights to monetary prices.**

There are several methods of applying weights to impact variables. One method was outlined above -- i.e., the decision-maker provides value weights which can be manipulated into proper form by the analyst. In addition, when the discount rate method is utilized to establish (net) present values of flows of benefits and costs which occur in future years, this constitutes the assignment of a weight to time.

The conventional analysis of benefit-cost discounting is inconsistent when used for the evaluation of long-term intergenerational impacts. Most projects or control programs are characterized by high cost in the initial periods with benefits lagging behind and increasing in the latter periods. Thus, the discounting technique results in a high present value of aggregate costs and a low present value of aggregate benefits -- if, for example, using conventional analytical techniques we were to evaluate benefits which might occur 50 to 100 years hence. The value of these benefits discounted to the present is extremely low.

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*Cf., Schmid, A. Allan, Systematic Choice Among Multiple Outputs of Public Projects without Prices, Michigan State University Department of Agricultural Economics, Staff Paper No. 75-14.

**Ibid.

For example, benefits which occur in year 50 at the level of ten million dollars will have a net present value of less than nine thousand dollars if discounted at a rate of ten percent interest. If time horizons extend to 100 years, ten million dollars will have a net present value of less than four thousand dollars. Thus, on the basis of conventional techniques, any attempt to provide a quantified justification for expenditures today in order to insure benefits in the long-term future will fail.

The problem is not simply one of analytical techniques. Rather, the philosophy behind the technique is what we must question. Benefit-cost analyses are geared primarily to market interaction and, as a result, take the time horizons usually found in the private enterprise. In the private or market sector, projects which have benefits extending beyond the life of, say ten or fifteen years, will seldom find justification for initial capital expenditures. It is imperative that this distinction be explicitly recognized and that a completely new "mind set" be developed in order to deal with these long-term intergenerational problems. This is especially critical when in design strategies, since these are inherently longer-term policies which may reap benefits only after many years. An additional problem of determining the social costs of the complete removal of a service because of ecological degradation must be analyzed at least in a qualitative manner.

Another problem which enters into the analysis of long-term impacts is the whole area of uncertainty and risk. Most of the analytical treatments provided in these categories have been developed in a context of individuals or in terms of actuarial, scientific data. No one really knows how much cost should be imputed to the loss of either an environmental service or a human life. However, many highway safety programs could not be justified solely on some imputed figure to the value of human lives saved. In many instances, a higher, qualitative set of values sets boundaries within which decisions (or subdecisions) can be made.

If EPA (or any other agency) must justify all actions on the basis of quantitative, benefit-cost or cost-effectiveness methodologies, they will be hard pressed to have much positive impact upon public environmental goals. If the problem is presented in the framework of simply choosing between two or more projects, this illusion of rationality can be achieved by conventional analysis -- assuming, of course, that the time horizons implicit in all of the projects being compared are relatively the same length. When the time horizons differ dramatically between projects, it is simply an exercise in self-deception at the highest level. We "justify" one project vis-a-vis competing alternatives on the basis of discounted present values of benefits. But the discount techniques are, as noted above, inappropriate. Cost-effectiveness studies and benefit-cost analyses do play an important role in the decision-making process. The limitations of these techniques require bounding the problem set in such a way as to permit the inclusion of conventional benefit-cost methodologies only when appropriate.

3.2.6 Problem Category Six: Risk

Definition of Risk. In its broadest terms, risk is defined as the potential realization of unwanted consequences as a result of a specified action or inaction. In the case of risks associated with an action, the analyst is concerned with incremental risk, i.e., the difference between the risk that exists as the result of the action and the risk that would prevail if no action were taken. Risk is always specific to particular consequences and a finite universe, such as the risk of death to the United States population, or the risk of annihilation of a specific species of birds in a particular habitat.

In addressing the problem of risk, the analyst must address three major tasks. He must identify the risks associated with the proposed action or inaction, he must attempt to measure the risk, and he must attempt to evaluate the risk. The operational problems involved in the performance of these tasks involve the identification and measurement of potential consequences, the estimation of the probabilities that the particular consequences will occur based on the universe of people, biota, or things that will potentially suffer the consequences, and finally, the assignment of some measure or value to the combination of the probability and the consequences.

The undesirable consequences of an action or inaction can be expressed in economic, health, or environmental terms. These consequences can be jobs lost, plants closed, crops lost, deaths, injuries, elimination of a species, or destruction of a unique physical resource. So long as the occurrence of the consequence is only a possibility, then there is only a risk of that undesirable consequence happening.

In defining an undesirable consequence, the analyst should adopt a Pareto optimal approach. If the proposed action will result in a consequence that is assessed as undesirable by any subset of the population having a recognized interest in the results of the action, then the consequence should be determined as a risk and dealt with accordingly. If either the interest of the group of the consequences are judged frivolous, they should be so labeled and dismissed.

Absolute Acceptability or Absolute Rejection. The analyst should be very wary of attempting to classify a level of risk as acceptable simply because the level of that risk appears low relative to the same type of risk from other actions. The willingness to accept a risk is very much a function of the benefits or perceived benefits of the action that incurs the risk. A safer approach is to exceed the marginal benefits of the other actions that create the comparable risk.

A corollary to the above is the recommendation that no proposed action be perfunctorily dismissed simply because it may create the potential occurrence of a very adverse consequence. We have many systems that have already created the existence of low probability/high consequence events. Actions which introduce the possibility of low probability/high consequence events should be dealt with on their merits to the extent that quantification of benefits to balance the risk is possible.

Risks of Inaction.

Statement: The benefit-cost analysis should include an examination of not acting, as well as of acting.

Example: A decision is to be made by elected public officials to establish and/or allow the construction of a hazardous and toxic waste land disposal facility. Included within the benefit-cost courses of action which will cite the risks of advantages and disadvantages of each course including non-action alternatives.

Risk Considerations (Examples):

Action	vs.	Non-Action
1. Values of groundwaters (Assume raw well water supplies)		
a. Costs of facility will result in control of hazardous waste; protection of groundwaters for future uses		a. Present practice allows dispersements to land without controls -- Risk that substantial groundwater will be contaminated in 20 years. Added costs in future will be incurred for treatment or importation (costs)

2. Public Health

a. Cost of industrial disposal and projected lower public health risks and costs	a. Problems of and costs of indiscriminant handling dispersement of hazardous waste in environment, land, air, water (PCB fish residues)

3. Economic

a. Added costs to industrial products, risk to place local industries in an uncompetitive situation	a. Continue present practices; however, assess costs of environmental degradation....

4. Political

a. Risks associated with views/opinions/education levels in electorate of jurisdiction	a. Same

General Comments. The decision-maker is placed between the environmentalists, governmental technocrats, and the electorate. He will need information presented in a form he can assess and also relate to those constituents which he normally "leans on" for personal advice. He would be interested in these aspects which clearly influence his constituents and the needs for the project.

Dollar Value of Risk. Dollar values may only be meaningfully assigned to risks when the risk consequences are directly convertible to dollars. Risk may often be better analyzed in other parameters than dollars. For example, the risk of life-shortening from a diagnostic X-ray is evaluated against the life extension of an early diagnosis from the X-ray, resulting in successful therapy.

Population at Risk. In most cases, risk estimates could be refined by increased information about the process being observed. Existing data may allow us to estimate the risk of a certain concentration of a toxic substance to the survival of a particular species of fish. Additional studies might allow us to discriminate the risk as to sex, age, or size of fish. Additional studies might uncover significant risk differences among populations of fish in waters of varying pH concentrations.

In the case of people, differences in risk can arise because of age, sex, health status, economic status, and a host of other characteristics. Before accepting a risk estimate, the analyst should check to make sure that important variations in risk are not being submerged by aggregations.

Risk associated by an action can be concentrated spatially by land uses, and where significant, these differences should be identified. Imprecise treatment of the population at risk is a pitfall that the risk analyst must avoid with utmost care.

Objective Versus Perceived Risk. Assessment of the risks inherent to an action of omission or commission can be done objectively to yield objective risk using rigorous processes and complete sets of experimental data. It can be done subjectively to yield subjective risk, using emotion and perceptions to supplement more objective data. Rarely, if ever, is it done entirely objectively or entirely subjectively. The common assessment is of mixed mode.

It should be the analyst's goal to delineate clearly the objective from the subjective elements of his assessment and to label them accordingly.

The objective part is circumstance-invariant and is his domain. The subjective part varies with circumstances (political milieu, socio-economic conditions, etc.). The analyst can make no greater claim to a personal insight into subjective risks than can any other member of the population subject to the risk. But the analyst can apply the social consensus techniques described above. After application of these techniques, the results must be considered by the decision-makers. Politicians and their appointed policy-makers are the typical assessors of subjective risks.

Sources of Risk Data.

- Kinds of regulatory actions which influence risk
  - Stricter (or new controls on an ongoing operation)
    - Non-action by regulator constitutes one extreme (possibly represents a social disbenefit)
    - Intuitive (non-rational) action constitutes opposite extreme

.. Licensing or approval of a new product or process
    ... Non-action by regulator is again an extreme but of the opposite impact (may represent preclosure of a potential social benefit)
    ... Intuitive action is also possible, but unlikely because bureaucrat is at risk

. Kinds of data

.. Experience on prior or current large-scale operations
.. Projection or analogy from similar large-scale operations
.. Extrapolation from past laboratory or small-scale tests

. Procedures where data available or inadequate

.. Simulation studies
    ... Transport and dose models
    ... Fault tree (event tree)
    ... Mathematical models
    ... Delphi technique

.. Propose or require new studies to obtain data
    ... Time or cost of experiments may preclude experimental approach and necessitate reliance on simulation
    ... Burden of proof on applicant (may foreclose social benefit)

. Degree of confidence of the data

An attempt should be made to assign confidence indices of greater or lesser rigor to risk estimates based on actual data, modeling considerations or expert opinion. Usually, such indices provide powerful points in support of one action or another. However, they are, in many instances, laden with subtle expressions of individual values and perceptions. That in itself is not undesirable until facts, the province of the analyst, are confused and mixed with value judgments, the province of the decision-maker. To guard against this common eventuality, indices of confidence and a measure of their rigor should always be explicitly stated by the analyst, regardless of the source. If, for example, one has used a transport model to estimate the distribution of a particular substance in the environment, the analyst should attempt to provide some idea of the possible range of error of such a predictive tool and should try to indicate the effects the error could have on the magnitude of the risk estimates.

Significant confidence intervals for risk estimates can provide valuable inputs to sensitivity analysis. For example, if it can be shown that the rankings of alternatives is invariant to the range of risk estimates that fall within the confidence interval, then the element of possible disagreement over the risk estimate can be eliminated.

Extreme Value Problems. Different actions are characterized by different sets of potential consequences. The potential consequences of certain actions fall within a fairly narrow range. For example, it may be estimated that the 95 percent confidence range of adverse health effects associated with a proposed action falls within the limits of five to twenty cancers per year. The probability distribution of possible consequences may be estimated that the 95 percent confidence range of adverse health effects associated with a proposed action falls within the limits of five to twenty cancers per year. The probability distribution of possible consequences may be estimated to be normal with a mean of 12.5 cancers per year. In that case, the use of the expected value of 12.5 cancers per year as the base number representing risk is defensible. If the population at risk were one million persons, then the risk of cancer would reasonably be stated as 1.25×10^{-5} without elaborating that the range of risk is from 0.5×10^{-5} to 2.0×10^{-5}. As the range of possible consequences associated with an action expands, however, the need to make explicit the nature of the distribution of risk becomes paramount. For example, suppose it is estimated that the risk of a death could be anywhere from 10×10^{-6} to $10,000 \times 10^{-6}$ depending upon the validity or invalidity of assumptions about exposure and the response of certain organs to the insult. Although the data may indicate that the expected value of the risk is 50×10^{-6} per year, the possibility that the risk could be $10,000 \times 10^{-6}$ is an important extreme point value that should be made explicit in the analysis.

Given the risk-averse nature of most of society, it is sometimes more desirable to reduce the variance of risk than the expected value or risk. An expected value of 100×10^{-5} with a variance of 25×10^{-5} may be more acceptable than an expected value of risk equal to 25×10^{-5} with a variance of 2000×10^{-5}.

Voluntary and Non-Voluntary Risk. In the assessment of risk as an input to policy decision-making, the associated risk can fall into three categories:

a. Risk is voluntary, e.g., seat belts, legalizing marijuana;

b. Risk is non-voluntary, e.g., Presidential declaration of war;

c. Risk is both voluntary and non-voluntary.

Some general statements follow:

- Although all assessment of risk is under (c), as a practical matter the three distinctions are meaningful when viewed in terms of the numbers of people involved.

- Importance of risk (or the level of risk, however it is chosen by the analyst) may differ between:

  - Voluntary cases where the voluntary action of an individual imply a non-voluntary risk to a given number of other individuals, the environment, etc.

    In (a), the level of risk reflects the value of freedom of choice. In (b), a lower-level of risk may be justified as the involuntary risk may be important, e.g., a certified pest control operator can expose a large group of individuals, the environment, etc., to high levels of risk. The level of risk in analysis can reflect the need for training programs, licensing of applicators, and the resource devoted to enforcement of regulations.

- In cases involving important amounts of voluntary and non-voluntary risk, it may be desirable from the point of view of society for the voluntary group to make decisions compatible with the values of the non-voluntary group. The levels of risk in the analysis could consider this (i.e., caused by one group to another).

Delphi Technique for Evaluating Risk. In certain cases, the analyst may wish to supplement his risk study with a Delphi study. This approach could be particularly useful where there is a good deal of recent literature with respect to the risks of a substance but the work has not been effectively integrated. This approach ends up soliciting only expert opinion, and so should not be the object of exaggerated expectations. Further, the approach is costly. Probably the lowest cost one could expect to incur for a Delphi analysis would be $25,000.

Additivity of Risk Data. Assume a cost function:

Cost = A + B + ...

where: A = explicit discrete numerical, certain addable commensurable consumption of definable resources:

1 = measurable in dollars;
2 = measurable in other units.

B = statistically treatable costs that are distributed across a population at risk; can be quantified in the aggregate by some mathematical product of Σ (p * 1) where:

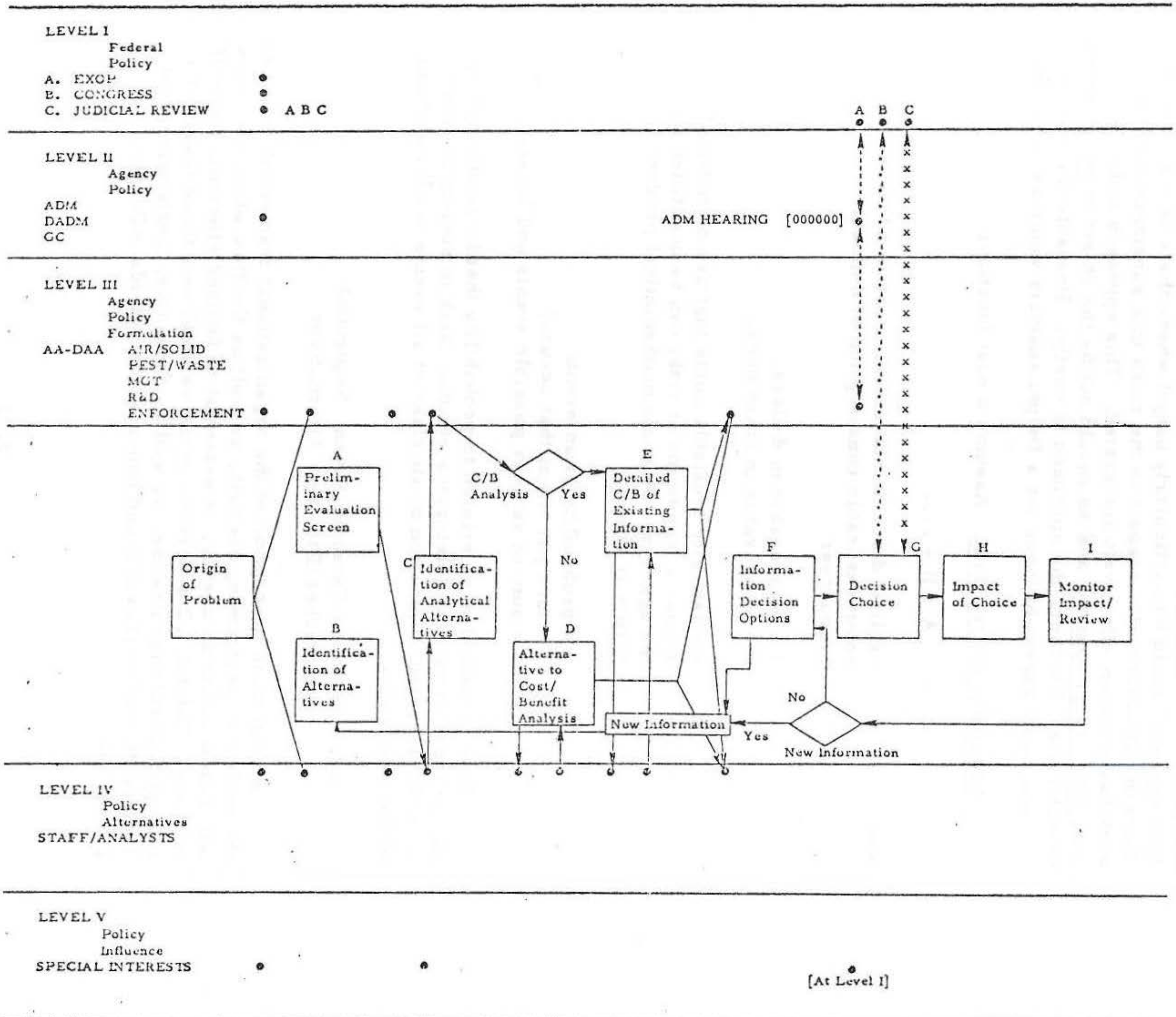
p = probability of an event;
1 = loss per event that occurs;
Σ = sum of various possible events and losses.

Risk to individual is related to probability that he is affected by one or more of various deleterious events. Risk to society is some sort of integrated summation of all risks of all events to all members of the population.

3.2.7 Problem Category Seven: Sequential Approaches/Effective Alternatives

An informed perception of the organizational framework in which the analyst is performing his task, as well as the flow which decisions will follow within an agency, is essential to focused efficient, tradeoff analysis. Exhibit 3.2 describes on the vertical axis three levels of a typical Federal organization, as well as Executive, Legislative, and Judicial Branches (Level I) and non-specific outside influences (Level V).

EXHIBIT 3.2: Organizational/Flow of Decisions



Purpose of the Decision Flow Chart. The chart tells the analyst the context into which his work must fit. The context has an organizational aspect to it, i. e., the analyst must know his role vis-a-vis the decision-makers and outside parties, what kinds of actions fall into his realm, and what information flows between levels are involved. The context also has a time or sequential aspect to it, i. e., what stage in the analytical process the analyst is working at a given time.

The intention was not to be didactic or to presume to dictate EPA-reporting relationships between elements of the Agency, but rather to indicate the concept of a hierarchy of decision-makers, and how the work of one level can, at times, call for, be initiated by, or receive guidance from another level. At present, the placement of these sequential decision steps at different hierarchical levels fairly reflects some of the decision processes current in EPA. This chart is not intended to be an infallible model of all decision sequences in any agency. Moreover, an understanding of the structure and relationships involved is necessary if benefit-cost analysis is to make the optimal contribution to the decision process.

Layout of the Chart. Five levels of organization form the rows of this chart, and are listed on the left hand side. Level I refers to Executive, Legislative, and Judicial forums which provide resolution, instruction, and guidance as to Federal policy vis-a-vis the Agency's/ Department's mission. With specific reference to EPA, Level II refers to the Office of the Administrator where environmental policy implementation decisions are made and where recommendations are received from Level III. Level III encompasses both the Assistant and Deputy Assistant Administrators who develop environmental policy recommendations based on mandated/expected media-oriented missions developed by specific tradeoff analyses from Level IV staff. In addition, Level III personnel routinely make media-oriented decisions based upon past experience in implementing well-understood statutory instructions (e. g., cancel/suspend pesticide).

Level IV analysts are the major audience for whom the decision chart is targeted as it describes on the horizontal axis the flow of decision information and decisions to which they are the major contribution in their tradeoff analysis work.

The layout of the chart reflects the reporting relationships and information flows among the levels, but it is not precise, especially regarding Level V -- Outsiders.

Arrayed across the chart are the steps which, as a package, represent the decisions to undertake a benefit-cost analysis and the actual conduct of the analysis. These are linked together in sequence and reside at one level or another.

What should be noted is both the actual steps in the sequence and the movement from level to level. The chart is intended to be applicable to both decision flow addressing broad programmatic benefit-cost decisions (e.g., should EPA regulate all mobile sources of noise, should EPA use clean air authorities to regulate certain waste disposal techniques), as well as specific actions taken under law (e.g., should pesticide X be cancelled, which substances should be labeled toxic in terms of water effluent discharges). In some cases, the programmatic analysis can be made before the enactment of new legislation to provide data for Agency/Department decision-making. More often, statutes are passed with specific mandates and time frames, and, as a result, the specific action tradeoff analyses are more common.

As will be discussed below, these different kinds of issues and the legislative-regulative climate may require benefit-cost analysis with significantly different scope, depth, and analytical approach. In the case of analysis relating to pesticide actions, for example, consideration of both economic benefits and costs and environmental effects is required by statute. For other programs, perhaps only the preparation of the minimally required Inflationary Impact Statement would be developed as a mode to assess costs without the systematic approach suggested here.

The Decision Sequence -- An Overview. Information about potential problems requiring further review and analysis comes from several of the levels outlined in the chart. The first step in the sequence is a preliminary screening process (A) that seeks to deal with the regulatory "fact of life" that there are vastly more potential environmental problems than can be considered thoroughly (or at all) by the regulatory agency, given its time and resource constraints. Therefore, it is essential for the Agency to institute some kind of "early warning system" by which it can select those problems which appear most pressing and then subject them to a more detailed analysis concerning regulatory alternatives and their benefits and costs.

As an example, one might cite the Consumer Product Safety Commission. This is a relatively new agency whose enabling legislation gave it an extremely broad jurisdiction, sufficient in theory to allow it to regulate most consumer products in common use. As one means of choosing those problems which seem greatest, the Commission has instituted a computerized accident reporting system (NEISS) which gets, from hospital emergency rooms, statistics on those consumer products which are related to the most frequent and most severe accidents. This system allows it to single out for more consideration the most dangerous products, those most in need for regulation.*

The preliminary screening process may be institutionalized or ad hoc; preferably it should be both. Development of the pesticide Hazard Evaluation System (HES) is an attempt to institutionalize preliminary screening, but the Agency also gets the impetus to assess problems in more depth from other sources. Such pressure may come from Congress, the public (e.g., environmental groups) agency personnel who uncover an unsuspected problem, academia, or the need to confront an environmental disaster. It should be emphasized, however, that the screening system should be an attempt on the part of the Agency to move beyond the reactive posture, to search out the most pressing problems rather than to act only in the face of a crisis.

Given these functions, the screening process within the Agency should be a continuous activity. It should be supplemented from outside the Agency by durable liaisons to the business and university communities (particularly their research personnel) and to public interest groups.

Approach to Preliminary Screening. Screening is not a mini benefit-cost analysis, even though it uses many of the concepts of benefit and cost. Rather, it is a quick look at problems in terms of a few criteria, and a method of selecting those few areas which merit an eventual full benefit-cost analysis.

One criterion which can be used fruitfully in the environmental area is "hazard." This is generally phrased in terms of the "population at risk," i.e., how many people are exposed to what sort of hazard. The gravity of the hazard and the numbers exposed must then somehow be translated into an index of priorities. For example, chlorine in drinking water may pose only a slight, and uncertain, risk to millions, whereas the pesticide parathion may be highly toxic to

*For a good description of this system, see "Regulation by the Numbers" in The Public Interest, Vol. 36, No. 82, Summer, 1974.

relatively few who use it regularly. The decision on which of these areas to pursue is a policy choice, but it can be articulated by the screening process.

Other criteria which might be used, either in combination with or as a substitute for hazard, are "gross benefits," "gross costs," "irreversibility of damage," "probability of harm," etc. In many instances, the screening is performed by experienced analysts who somewhat intuitively sense an "important" problem. Thus, in large part, the subjectivity perceived "magnitude" of the problem may be the overriding screening criterion.

As indicated previously, outside sources may perform the screening function for the Agency, and in this case any number of persons could perform it. When the screening is done in-house, however, it is generally performed at the staff level. Once this analytical process has been completed, it should be referred to the higher level decision-makers for review and choice of those areas which should be investigated further.

The screening process is, therefore, carried out by staff analysts but largely utilized by decision-makers as a means to prioritize and recommend for full benefit-cost analysis certain regulatory problems facing the Agency. On the other hand, screening often results in a decision not to undertake further action, and so helps to focus available benefit-cost resources on the most important issues.

Identification of Alternatives Scope and Depth. The scope and depth of analysis will be limited by available resources. Resources may be available in varying degrees depending on other Agency internal and external commitments. The resources usually available consist of time, manpower, and dollars. The dollars may be used to extend the agencies' capabilities through the use of consultants or other contractual arrangements. Depending on the agencies' role or charge, these resources may be difficult to generalize. For example, an enforcement-oriented agency may not have the technical depth or expertise to engage in a full-scale benefit-cost study and therefore the time-manpower aspect becomes submerged and the existence of dollar resources assumes prime importance in that the dollars can purchase the capability needed. With input from the analysts and others, the decision-maker should specify those categories and impacts he considers important and the precision and comprehensiveness of the analysis he feels is necessary.

Alternatives. The selection of the technical and policy alternatives to be evaluated and compared in the benefit-cost analysis should be selected by the decision-maker from a full range of options. He should consider information from the analysts and other sources, but the selection should be done by him.

Technical. From the standpoint of technical alternatives, all avenues should be explored followed by focusing on one or more viable approach. These alternatives could consist of chemical substitutions, method modification or unique applications of existing contron technologies.

Policy. Policy alternatives should be considered after the various parameters of the technical alternatives have been assessed. Such policy decisions come into play when the selected technical alternatives are deemed to be restrictive or costly. One example of a policy alternative could be a deferral of a compliance date to allow sufficient lead time for implementation by the affected parties.

As noted above, the selection of alternatives to be analyzed in more detail and the scope and depth of the analysis are important parts of the decision process. The choice of alternatives for more intensive study should not be made solely by the analyst, but rather by the decision-maker using information from a broad range of multidisciplinary sources, and covering a full range of alternatives.

Selection of Analytical Techniques. Once the technical alternatives, the range of policies to be analyzed, and the scope and depth of analysis have been determined, it is up to the analyst to decide which tools best provide information upon which an optimal choice can be made. It should be understood that each technical alternative and its policy vehicle may have different analytical requirements in terms of benefit-cost analysis. It may not, in fact, be necessary to use a complete benefit-cost analysis to evaluate each alternative (Step D instead of Step E in the chart).

The decision as to the type of analysis to be conducted should be sed on the resources available and the information necessary to solve problem adequately. The appropriate analysis may range from a ɖle benefit-risk or cost-effectiveness analysis to a full treatment the kinds of economic and environmental benefits and costs.

This step in the sequence represents the detailed evaluation of benefits and costs using existent information treated by the other panels. The purpose of the preliminary screening and consideration of analytical alternatives before proceeding to this step is because of what can be considerable resource cost of detailed benefit-cost analysis.

Information/Decision Options. Decision-maker reviews analyst's benefit-cost results and evaluation of the quality of information and determines whether or not the information base is sufficient to form a decision.

Sufficient Information. If the information is judged sufficient, the decision-maker can either: (1) choose an alternative or outcome (i.e., make the decision), or (2) make no decision and refer the question with the analysis to a higher level of decision-making in the Agency (see Decision Choice).

Insufficient Information. If the information is judged not sufficient to allow the decision-maker to make a final decision, he can: (1) postpone the decision and await additional information that is then fed back into the identification of alternatives and benefit-cost steps, or (2) make an interim decision to be reviewed when more information is available (e.g., interim standard). It should be noted that there may be significant risk and economic costs and impacts from either postponement of the decision or making an incorrect interim decision.

Assessment of available information is a key factor, and identifying gaps and weaknesses is an important part of the analyst's role. The decision as to whether or not the existing information is sufficient is the decision-maker's, but the analyst's recommendations and evaluation should be important considerations. If information is considered insufficient, a further decision must be made as to whether or not additional information should be generated. Factors influencing this decision include: (1) seriousness/importance of the problem, (2) cost of generating more data, and (3) expectation of success and benefits of obtaining more information.

It is recommended that to the extent possible, efforts should be made to ensure the timely generation of data that will be needed in future benefit-cost analysis. This would help avoid the need for postponement or interim decisions, and would probably be a less expensive means of generating data. When possible, decision-making can also draw on information derived from previous decisions of the same or similar type (e.g., pesticides).

Decision Choice. In the event that the selected decision requires analysis out of the range of the mission of the Agency, it becomes necessary to seek the wisdom of other responsible decision-makers. In this instance, there would be issues where technical requirements of the analysis are met, but the social impacts and tradeoffs involved are of a broader nature.

The agency seeking advice has three alternatives:

- To seek the advice of the Executive Office of the President. The Level II decision-maker recognizes the broad gauged socioeconomic impact of environmentally-based decision options (e.g., cleaner air and better gas mileage versus energy shortages and auto industry health).

- To request that the Congress detail further specifications. Taking into account external variables affecting (in the case of EPA) the environmental mission, this decision option is to seek Congressional resolution of irreconcilable problems (e.g., improving air quality versus banning higher sulfur coal).

- To force judicial review either administratively or through the courts. The decision-maker at Level II may also decide for a variety of reasons (insufficient resources, environmental policy inconsistencies, etc.) not to take affirmative action realizing the likelihood that outside parties would seek court mandated remedies for inaction.

Impact of Choice. The impact and effects of Agency decisions should be monitored and this information and other relevant information should be made available for subsequent review and reconsideration of past decisions. The option of reviewing decisions if new information is obtained and/or of instituting a periodic review system should be included in the decision process, but in-depth review should only occur if significant new data on costs, risks, and benefits becomes available. The resource cost of comprehensive monitoring and continuous review process of past decisions would probably not be justified except in selected importantant cases.

Whether or not provision is made for in-house review, it has become almost inevitable since virtually every important environmental decision today faces a court challenge by affected parties.