77-12,760

SAFARIK, Nancy L., 1943-
A COARSE SORT SYSTEM FOR PRELIMINARY WATER RESOURCES MANAGEMENT ALTERNATIVES.

The University of Oklahoma, Ph.D., 1976
Environmental Science

Xerox University Microfilms, Ann Arbor, Michigan 48106

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A COARSE SORT SYSTEM FOR PRELIMINARY WATER RESOURCES MANAGEMENT ALTERNATIVES

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

NANCY SAFARIK

Norman, Oklahoma

1976

A COARSE SORT SYSTEM FOR
PRELIMINARY WATER RESOURCES
MANAGEMENT ALTERNATIVES

APPROVED BY

____

____

____

____

____

DISSERTATION COMMITTEE

Mechanized man, having rebuilt the landscape, is now rebuilding the waters. The sober citizen who would never submit his watch or his motor to amateur tamperings freely submits his lakes to drainings, fillings, dredgings, pollutions, stabilizations, mosquito control, algae control, swimmer's itch control, and the planting of any fish able to swim. So also with rivers. We constrict them with levees and dams, and then flush them with dredgings, channelizations and floods and silt of bad farming.

The willingness of the public to accept and pay for these contradictory tamperings with the natural order arises, I think, from at least three fallacies in thought. First each of these temperings is regarded as a separate project because it is carried out by a separate bureau or profession, and as expertly executed because its proponents are trained, each in his own narrow field. The public does not know that bureaus and professions may cancel one another, and that expertness may cancel understanding. Second, any constructed mechanism is assumed to be superior to a natural one. Steel and concrete have wrought much good, therefore anything built with them must be good. Third, we perceive organic behavior only in those organisms which we have built. We know that engines and governments are organisms; that tampering with a part may affect the whole. We do not yet know that this is true of soils and water.

Thus men too wise to tolerate hasty tinkering with our political constitution accept without a qualm the most radical amendment to our biotic constitution.

Aldo Leopold

ACKNOWLEDGEMENTS

A great deal of appreciation is owed to Professor George W. Reid for his support and guidance during my time as a student in the Department of Civil Engineering and Environmental Science, without him there would have been no dissertation. Among the many other people who encouraged me during this study were Drs. Leale E. Streebin and James M. Robertson, and Professor Robert L. Lehr. Their moral support was extremely helpful.

One's friends, including fellow graduate students, are always invaluable. Those I wish to especially thank for their help are Dr. Silas Law, Tom Harrison, Don Fitzgerald, Dr. Joseph Lawrence, Dr. Michael Muiga, Gary Miller, Kay Coffee, Jenny Yang, and Robert Jackson. I also recieved invaluable assistance from the many people in government agencies who took the time to explain how they develop water resources projects.

I owe an especial debt of gratitude to Professor Ralph C. Martin, not only for editing the dissertation, but for introducing me to the people in Environmental Science.

No one deserves more praise than the two people who struggled with my scrawl to type the drafts and the final copy, Cynthia Reed and Yvonne Stearns.

There are always many more people than can be named who contribute to one's knowledge and who keep one's spirits up when things get rough. To all of you, too, I extend my gratitude.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF ILLUSTRATIONS

A COARSE SORT SYSTEM FOR PRELIMINARY WATER RESOURCES MANAGEMENT ALTERNATIVES

CHAPTER ONE

INTRODUCTION

Water resources planning assumed new dimensions in the last decade. It used to be possible to plan a project with just a relatively straightforward, quantitative benefit-cost analysis. Now, in addition to the traditional quantitative analysis, it is necessary to evaluate an enormous amount of complex information most of which is qualitative. There are also requirements that alternative plans be developed, rather than only one plan, and that public input be solicited throughout the process of plan development and selection. These changes in the approach to plan formulation require models which can deal with both quantitative and non-quantitative information. At the same time, the models must be capable of assimilating a plethora of data into a fairly simple format in order to facilitate the decision-making process.

The purpose of this study was to develop a non-mathematical model that could cope with the preliminary aspects of the plan formulation procedure mentioned above. This includes assimilating all of the data relevant to a project, evaluating it, developing project alternatives, ranking the alternatives and eliminating infeasible alternatives so that the most feasible plans can be studied further. The process of eliminating alternatives at this level actually involves coarsely sorting through the proposed plans, so it is called a Coarse Sort System.

The method created for the Coarse Sort procedure has not been previously utilized in water resources planning. It is a model capable of handling any amount of quantitative and descriptive data. With the use of a device called a sort chart, the ranked plans can be displayed in a simple manner indicating how well each alternative fulfills the stated goals of a project. It is then easy for the water resource planners to go through the coarse sort procedure using these charts. Separate sort charts are used for quantitative and qualitative information. They provide a clear, visual picture of the coarse sort process as it is performed. The sort charts developed for this project were designed for the preliminary coarse sort procedure but they can be adapted to the final plan selection process. A reservoir project is used to illustrate the Coarse Sort process.

The basis for the change from quantitative decision-making to a combination of quantitative and qualitative procedures was the inclusion of environmental and social factors in the planning process. Both of these entities require descriptive rather than mathematical definitions. The fact that they receive equal consideration with the traditional benefit-cost analysis in the development of a plan has led to the increased complexity of plan formulation and selection.

The increasing complexity of plan development has resulted in a concomitant increase in the manpower, time and money it takes to develop a number of alternative plans. In terms of manpower, a team of planners, not just one planner, is required. The team members need to be experts in many fields with either technical, economic, social or environmental orientations. The increase in plan development time stems from the necessity to acquire more varied data than was required for a benefit-cost analysis and from the need to obtain the public's thoughts on the project during the entire planning process. The increase in the cost of developing alternatives is due partly to the manpower and time requirements, and partly to the use of sophisticated equipment, such as computers, to help analyze the data.

An Overview of Present Water Resources Planning Requirements

The changes that have occurred in water resources planning in the last ten years grew out of the battles fought by environmentalists and conservationists in the 1960's against planners of all types who had never seriously considered the effects their plans had on the environment. By the last decade, however, it was becoming all too apparent that we had encouraged economic development at the expense of our natural resources. If we wanted to preserve or conserve what remained of them, we, as a nation, would have to stop taking them for granted.

The admonition was taken seriously and several measures were adopted to increase awareness of the problem among the general public and planners. An educational campaign was started in the 1960's and is still in progress to make people aware that this country does not have an infinite resource capability. Laws were enacted, particularly the National Environmental Protection Act of 1969, to help protect these resources. Controlled growth with respect to urban sprawl was advocated along with zero population growth in an effort to limit the increasing depletion, degradation and destruction of the remaining resources. These steps have by no means resolved the problem but they have made many people more aware of the situation.

In the field of water resources planning this broader outlook was incorporated into a document written by the United States Water Resources Council the Estahlishedment of Principles and Standards for Planning Water and Related Land Resources, or the Principles and Standards. The Water Resources Council is a government agency composed of the Secretaries of Interior, Agriculture, Army, Health, Education and Welfare, and Transportation and the Chairman of the Federal Power Commission, which realized the necessity for a new approach to water resources planning in the late 1960's. Several years of effort on their part produced a set of guidelines. They solicited agency comment and public input on the guidelines, and published them as the Principles and Standards in September, 1973. These are the procedures now in effect. They incorporate the traditional method of water resources planning, the benefit-cost analysis, with the newer considerations, environmental quality and social well-being.

In the Principles and Standards, the traditional benefit-cost analysis is referred to as the national economic development (NED) objective. This is a quantitative entity. The other major objective is environmental quality (EQ) which is a non-quantitative entity. In other words, it cannot be measured in commensurate, or monetary, terms. The Water Resources Council assumes that in the planning of a water resources project, maximizing the two objectives puts them in a virtually exclusive situation. The plan which best fulfills the interests of national economic development will be the most detrimental in terms of environmental quality and vice-versa. Therefore, although the Principles and Standards stipulates that alternative plans should be developed which emphasize one objective or the other, they also imply that much trade-off, compromising and negotiating will have to occur among the planners and the public before a final alternative is chosen. The final plan will be a compromise between the environmental quality and national economic development objectives.

When a plan is developed, both the beneficial and adverse effects related to the two objectives, NED and EQ, must be detailed while keeping in mind that the purpose of planning for water and land resources is to improve the quality of life. The net changes, beneficial and adverse, related to the two objectives that will occur if the project is built are to be detailed in four accounts: national economic development, environmental quality, regional development and social well-being. National economic development is measured in monetary terms, the environmental quality and social well-being accounts are descriptive, and the regional development account is a combination of quantitative and qualitative terms. They are detailed further in Chapter Two. For the Coarse Sort System sort charts were developed only for the two objectives and their accounts, that is national economic development and environmental quality. Sort charts could easily be designed for the other two accounts if necessary.

When the accounts are being delineated, the planners must be wary of their own subjective judgements and must also be aware of attitudes of various interest groups toward the plan. These include environmentalists, conservationists, developers, farmers, ranchers, labor unions, and others who should have input into the decision-making process. If this is done effectively, it will be easier to decide on a final plan.

In the title of the Principles and Standards is a direct reference to the fact that the planning of water resources also involves the use of the land in the vicinity of the water resource. This relates to the emphasis on environmental quality. Since water is one of the natural resources which is taken for granted, particularly good quality water, consideration of land uses which will help mitigate the degradation of a water source is important. In other words, water and related land resources are mutually dependent. Water resource projects often effect land use and land use effects water resources.

A reservoir project is an example of this interaction. Constructing a reservoir means inundating many acres of land, but water from the reservoir may be used to irrigate cropland and increase its production. On the other hand, if fertilizer is also used on the cropland, runoff from it which flows into the reservoir will cause the quality of the water to be degraded by the nutrients in the fertilizer. Runoff can also contribute sediment, pesticides and minerals to a water source. Construction projects and poor land management can increase erosion in a watershed and add to the degradation of the water. The more polluted the water is, the more costly treatment it requires before it can be used for water supply and irrigation. Thus, land use related to water quality is an important aspect of current water resources planning directives.

Another reason for the change in the water resources planning process is that water resource projects do a lot of environmental damage. Reservoirs inundate agricultural land, wildlife habitats, and graveyards, alter the fishing characteristics of streams, and result in the loss of homes, other structures, and archeological sites. In an attempt to mitigate environmental damage, consideration must be given to alternative methods of flood control and water supply, and other measures related to water resource projects. Non-structural methods for achieving stated goals might possibly alleviate the impact on the environment, just as developing already established water sources further is another less destructive possibility.

In the Principles and Standards it is implied that planners should consider various methods to achieve an objective. Open-minded and enlightened thinking among the planners should be encouraged and pervade the decision-making process. At the same time, the wishes of the public for whom they are doing the planning must be taken into account. Not only will this help eliminate some of the proposed alternatives, it will also give the planners some idea of what the public is willing to pay for and what tradeoffs and compromises the public will accept.

Although there are stipulations in the Principles and Standards about what is to be included in the various accounts and suggestions as to a format for displaying the accounts, there is no methodology for sorting through the various alternatives and eliminating infeasible plans. The Coarse Sort System was developed to help fill this void. It also provides a model that can be utilized by those who are not mathematically inclined.

CHAPTER TWO

WATER RESOURCES PLANNING METHODS

The Principles and Standards incorporates the new methods for water resources planning with the traditional benefit-cost analysis method. Emphasis is placed on the development of at least two alternative plans, one related to national economic development, the other to environmental quality. The benefit-cost analysis is retained in the national economic development objective. Most of the environmental quality objective is non-quantifiable and requires a qualitative evaluation of the results of an in-depth environmental inventory.

Two other aspects of water resources planning that receive specific emphasis are land use and public participation. Land use is included in both of the objectives, public participation is to be encouraged and utilized as direct input throughout the planning process. This chapter explains the past and present elements of the planning process.

The Traditional Method

Both in writing (Linsley and Frazini, National Water Commission) and in answer to direct questions by the author, those who have been involved in the planning of water resources projects for many years admit that the environmental effects of a project were not a serious consideration. Instead, the major concern was to obtain Congressional authorization and funding for a project. This required calculating the benefits and costs of a project such that the benefit to cost ratio was at least one, preferably greater than one. Since environmental effects are generally not quantifiable they were not measured. The underlying philosophy for the benefit-cost calculations was based on welfare economics and "incremental" planning.

Welfare Economics

The theory underlying welfare economics seeks to determine "how available resources may be best used to promote human welfare." With respect to the previous remarks about our resources being finite, welfare economics is also a method "for allocating the total resources base among potential uses and users to meet indirect real and group needs" (James and Lee). The aspect of welfare economics which is applied to water resources planning is the benefit-cost analysis.

Benefit-cost analysis is a measure of the goods and services involved in a project. Those that result from a project are benefits, those required to develop a project are costs. They are measured in dollar values because this method is easily understood and puts all of the components into similar or commensurate units of measure which facilitates addition, substraction and comparison. Dollar values are also a convenient indicator of the worth of something.

The use of dollar values to represent goodness, value, utility, or welfare is basic to welfare economics. The central concept is that

> . . . under certain conditions, considered not too unreasonable, an economy operating with highly competitive markets and with consumers and producers who are rationally attempting to achieve the largest possible benefit for themselves, will tend to produce maximum welfare for its citizens within the context of a given distribution of income (Kneese).

Kneese's theory is related to the operation of a private competitive economy. Inherent in the concept are three mechanisms:

1. Competition will tend to force prices down to the lowest possible level which will still permit the full costs of production to be covered, including a high enough return on the investment of firms to make them willing to keep their investment in the industry in the long run.

2. Each productive resource will be used up to the point where the cost of an additional unit is just equal to its contribution to the value of production.

3. Consumers attempting to achieve maximum satisfaction from a given amount of income will tend to allocate their expenditure in such a way that the last dollar spent for any particular item will yield an amount of satisfaction equal to the last dollar spent on any other item (Kneese).

These mechanisms in turn are based on three corollaries:

1. A firm will produce a good by combining factors which will provide the least-cost alternative.

2. A firm will only "increase its output until the cost of producing the last unit or marginal cost is just equal to the price it brings in a market" (Eckstein).

3. Consumers are willing to substitute one good for another if at the same time they are able to maximize the satisfaction which can be achieved with a given limited income and a given set of market prices. This should result in an efficient allocation of resources.

These three corollaries are similar to the three mechanisms, however, they are in the language that planners use. The behavior of the people for whom they are planning, or what the planner perceives the consumer seems willing to pay for, should be a major consideration in developing a plan.

Direct Benefits and Costs

"Benefit is a measure of value and reflects a consumer's willingness to allocate income to the purchase of a commodity." I the term benefit is substituted for the word price, then a "firm produces up to the point where marginal cost equals benefit" (Eckstein). The benefits referred to below are all measured with this concept in mind.

In a water resources project, the primary benefits are "the value of the products or services which result directly from the project." These benefits might include "farm crops, electricity, flood control, and navigation services . . . the market value of these goods and services attributable to the project usually is taken to represent the contribution to the social benefit of the project" (Kneese). These are tangible benefits.

Secondary benefits are those "stemming from" activities influenced by the project economically rather than technologically. They accrue to producers who are not directly involved in the water-resources project but who benefit from it in terms of a greater income.

Intangible benefits cannot be measured monetarily but are factors in the decision-making process. Traditionally, these included improved health, the saving of lives, and the environmental aspects of a project: aesthetics, and "the preservation of areas of unique natural beauty, and scenic, historical, or scientific interest" (James and Lee).

Other benefits are measured which accrue from a project. Land enhancement is the result of increased production income from crops. Employment benefits can be measured if employment opportunities are increased for unemployed persons who are actually able to work on the project or wages are increased for those persons considered underemployed (James and Lee). There are difficulties in measuring this item, one of them being that in a purely competitive market system, such as that assumed previously, one of the assumptions is that "all resources and labor are employed" (Eckstein). This is known to be a poor assumption when the country as a whole is considered, which it is in the national economic development account required by the Principles and Standards. If employment benefits are included, it follows that redistribution of income will occur. This is another benefit.

The direct costs of a project are related to its installation and to the operation, maintenance and replacement aspects. Included in the installation of a project are the costs of construction, engineering and administration, right-of-way, and relocation facilities. Operation and maintenance costs include "opening and closing of gates, overseeing hydroelectric plants, purchasing power for pumping, . . . preventive maintenance," repairs, weed and erosion control. There are other cost categories which must be considered. Associated costs are those requiring "private investment to produce or utilize project output" such as preparing farm land for irrigation. Induced costs are those created by the adverse effects of a project such as downstream flooding resulting from upstream drainage. The commitment of resources to a project in order to achieve a goal "has the opportunity cost of other uses sacrificed" (James and Lee).

Other Considerations

There are several other elements of engineering economics which are considered in the process of evaluating a project with the benefit-cost method.

The incremental method involves calculating the benefits and costs for each segment of a project. If the benefits exceed the costs, the segment can be justifiably added to the project.

If a benefit or cost cannot be measured directly, then the price of the most plausible alternative is used. For instance, if the value of transporting goods by boat cannot be measured, then the cost to transport by truck or train is used.

The lifetime or expected useful duration of a project is important for the calculation of total benefits and costs using the discount rate method. The discount rate is "the expression of the time value of capital used in equivalence calculations comparing alternatives." The time periods can be 20, 50 or 100 years. Some projects include structures that have a different lifetime than the benefits that will accrue to the project, however, when the present worth method (described below) is used to determine total benefits and costs, the same time frame must be used for the entire project.

The present worth factor is derived from single payment factors. The latter are used to compare alternatives and their purpose is "to convert a value at one date to an equivalent value at another date." The single payment present-worth factor "indicates the number of dollars one must initially invest at i percent to have $1 after N years." The other factor, the single payment compound-amount factor, "indicates the number of dollars which will have to be accumulated after N years for every dollar initially invested at a rate of return of i percent" (James & Lee).

The benefit-cost analyses are calculated for the economic development of the proposed plan area both with and without the project. In this way, the specific effects of a particular project on an area can be compared to the future of the area without a project.

Predicting the future involves an intangible item not yet encountered, uncertainty. Many aspects of water resources projects contain this element including the population projections, public reaction, changes in technology, and flood prediction. Methods for dealing with this problem have been to (1) apply "preselected percentages to increase costs or reduce benefits," (2) limit the period of analysis, or (3) add a "risk increment to the discount rate" (James and Lee).

The Flood Control Act of 1936 directed that the benefits and costs of a project were to be calculated and formed into a ratio where "costs" was the denominator and set equal to one and benefits the numerator. Since the chances of having a project authorized by Congress were much better with a good benefit/cost ratio, projects without net benefits were seldom considered. The benefit/cost ratio is determined by calculating the present worth of the benefits and dividing this by the calculated value of the present worth of the costs. If initial calculations resulted in a benefit/cost ratio less than unity, then the incremental method was used to increase the benefit cost ratio until a ratio of one or greater was achieved. The benefit-cost method was specifically used for projects requiring Federal participation and Congress has used the benefit/cost ratio to determine whether or not a project should be authorized and funded. Locally funded projects have also adopted the method.

It is important to mention, with respect to the above, that Congress does not often fund a project at the same time it authorizes it. There is usually a delay of five to ten years or more. It is not unusual for a project to be completed twenty years after it is authorized, nor is it unusual to have authorization and no funding. All of the Federal water planning agencies have a large backlog of authorized but unfunded projects.

Some Terminology

Before the current water resources planning methods are discussed there are several terms which should be defined in order to avoid confusion.

The title of this study contains the word "management," yet the study discusses "planning." These terms, "planning" and "management," although seemingly different are used interchangeably here. If "managing the nation's water resources" means wisely planning for their development and use, then, indeed, the two are similar in meaning.

"Multiobjective" and "multipurpose" are two other terms found frequently in recent publications but they do not have the same meaning. Multipurpose planning refers to a water resources project having several beneficial components, or the "increments" of benefit-cost analysis. For instance, a reservoir project might have several components or purposes: flood control, water supply, recreation, low flow augmentation and irrigation.

Multiobjective planning is the essence of the Principles and Standards. In the discussion which follows there will be many references to the national economic development and environmental quality objectives to which multi-objective planning refers. These are the two basic classifications which currently take precedence in water resources planning. A benefit-cost analysis converts the national economic development objective into an account. Part of the environmental quality objective can be quantified, but most of it is qualitative. The environmental quality account is actually a verbal description of what exists and brief statements about what the environmental effects of the project will be.

There are two other accounts subordinate to the two above, regional development and social well-being. Regional development can be evaluated, for the most part, with a benefit-cost analysis, except for "environmental conditions of special regional concern." Social well-being is measured both in "dollars, other quantitative units, and qualitative terms" (Principles and Standards). There are, therefore, two objectives, national economic development and environmental quality, and four accounts, national economic development, environmental quality, regional development, and social well-being, inherent in multiobjective planning. The Coarse Sort System deals only with the two objectives and first two accounts.

Two other expressions have been introduced in the Principles and Standards to replace terms used in traditional benefit-cost analyses. These two are "external economies" and "external diseconomies." External economies are "favorable consequences or benefits which consumption or production by one party has on others." External diseconomies are "harmful consequences or costs which occur in the same way" (James and Lee). External economies are related to secondary or indirect benefits in conventional benefit-cost methods. External diseconomies are uncompensated induced costs (Bureau of Reclamation Guidelines, review draft).

In order to avoid any confusion about the environmental quality objective (EQO) in the Principles and Standards, a distinction should be made between this objective and an environmental impact statement (EIS). The

EIS is the result of the National Environmental Policy Act of 1969 (NEPA). Since the Principles and Standards includes a lot of verbiage from various Federal laws and enactments, there are phrases in both the EQO and the EIS which are similar. Both of them recognize that the results of economic and technological development are often detrimental to the quality of the environment. They are both dedicated to the enhancement of the environment.

The EIS is a detailed statement required "on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment." This statement is to include:

1. The environmental impact of the proposed action,

2. Any adverse environmental effects which cannot be avoided should the proposal be implemented,

3. Alternatives to the proposed action,

4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

5. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented (NEPA).

The EQO's purpose is to "enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems." For every alternative plan developed there is to be a "complete display or accounting of relevant beneficial and adverse effects" (Principles and Standards) on the EQO. A detailed statement of all of the components of the EQO can be found in Appendix D. Essentially, it requires a complete environmental inventory and an evaluation (accounting) of the positive (beneficial) and negative (adverse) effects a proposed project would have on the environment. In the Coarse Sort process, the EQO accounts would be completed for each alternative. After the elimination of all but the most feasible alternatives (perhaps two or three would remain), a formal EIS would be prepared for each remaining alternative. This would be necessary because NEPA requires it, not because of the Principles and Standards.

The Present Method

The Principles and Standards are based on a variety of Federal laws and directives. A review of those the Water Resources Council considered when developing the present guidelines can be found in Appendix B. Included in the review are the forerunners of both the national economic development (benefit-cost) and the environmental quality objectives.

As a guideline for water resources planning, the Principles and Standards supercedes another Federal directive, Senate Document No. 97, 1962, which was a barebones, procedural guide for developing water resources projects. In S.D. 97, the Senate required a benefit-cost ratio for all projects but did not stress environmental quality, or the development of alternative plans. The Principles and Standards is much more detailed as to what steps should be taken in the development of a plan or plans, and what specific items must be considered before alternatives are proposed.

The Planning Process

One of the innovations in the Principles and Standards is a delineation of exactly what steps should be followed in the process of plan formulation.

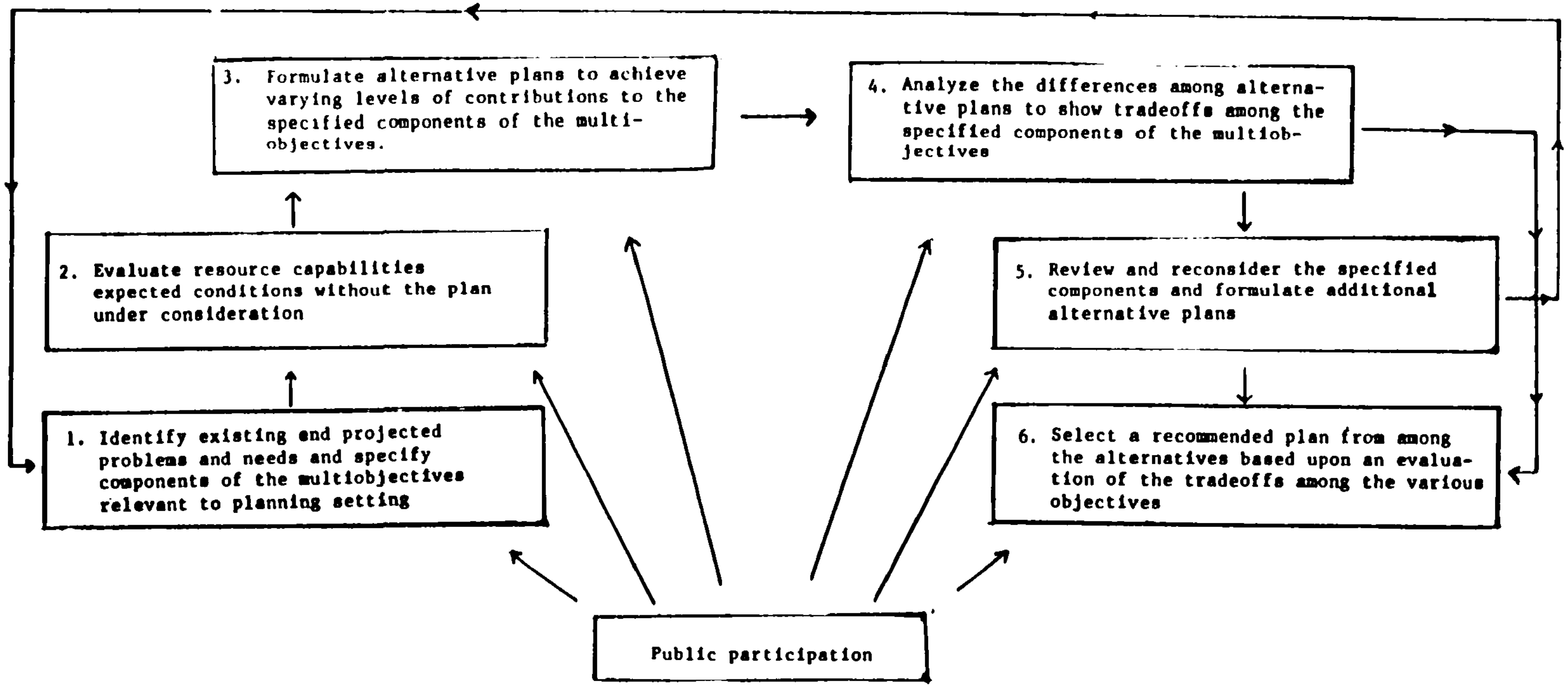


Figure 1. Steps in the Planning Process

Source: Schaefer, 1975

Figure 1 is a flow chart of these steps. Since these steps are important in the overall development of a plan, they will be discussed in more detail here and later on.

In the process of complying with the first step, "appropriate Federal, regional, state, and local groups" are to be consulted to define the needs and problems. It is anticipated that both the objectives and the components of the objectives will change "over time and between areas of the Nation as preferences and possibilities change and differ."* The Principles and Standards will be revised to reflect these changes.

The second step in the planning process requires a "sufficient inventory and appraisal of the water and land resource base of the planning area." Step three, the formulation of alternative plans, should include both structural and non-structural solutions. It is also stipulated that

> One alternative plan will be formulated in which optimum contributions are made to the national economic development objective. Additionally. . . at least one alternative plan will be formulated which emphasizes the contributions to the environmental quality objective.

In the process of formulating the alternatives the incremental method of the traditional benefit-cost analysis still applies. In other words, the beneficial effects of the component being considered must outweigh the adverse effects before it can be included in the plan. The exception to this rule is stated as follows:

> A recommended plan must have net national economic development benefits unless the deficiency in net benefits for the national economic development objective is the result of benefits foregone or additional costs incurred to serve the environmental quality objective. In such cases, a plan with a less than unity benefit-cost balance may be recommended as long as the net deficit does not exceed the benefits foregone and the additional costs incurred for the environmental quality objective.

---

*All of the quotations in this section unless otherwise stated are from the Principles and Standards.

This exception must be recommended by a Departmental Secretary or the head of an independent agency.

The other significant aspect of plan formulation is that the planning agency must report "other significant alternative plans. . ." and an "analysis of the trade-offs among them." The trade-offs and the reason for choosing the recommended plan must be explained.

The Planning Team

Although it is not specifically stated in the Principles and Standards, the enlarged scope of water resources planning demands that an adequate staff of experts be available to conduct the base line studies, evaluate the data, and help formulate an adequate number of plans, perhaps 20 or 50 different plans at the outset. For a major project, this entails hiring or contracting a large number of people and taking the time and effort to do a thorough job. This will considerably increase the cost of planning a project. As things now stand, if the money is not spent at the beginning it may be multiplied many fold in court costs and damages later.

There should be two planning teams who are highly competent in their respective fields. The national economic development team might include the following experts:

a water resources engineer for both engineering and planning functions

an environmental engineer for water quality

a hydrologist

an economist for labor, wages, benefit-cost analysis

a demographer for population projections

a geographer for land use

a geologist

a water chemist, and

a meteorologist or climatologist.

The environmental quality team might consist of:

a biologist or zoologist for terrestrial and aquatic ecosystems

a botanist

a sociologist

an anthropologist

an historian, and

a philosopher for aesthetic aspects.

Referring back to Figure 1, the two teams would work together on step 1, but should work separately when the data is being collected and evaluated. One team should work entirely on the national economic development objective, the other entirely on the environmental quality objective. This would include steps three and four. Although they are likely to develop overly biased and probably some infeasible and incompatible plans, the purpose of this approach is to make certain both teams collect as much background material as they can without interference from the other team suggesting that some of it is irrelevant. Since there is no limit to the number of plans which can be proposed at the beginning there should be no limit to the amount and kinds of data obtained.

The two teams will bring their data, evaluations and plans together in step four, eliminate the totally biased and/or infeasible ones and decide which merit further study. It is then up to the combined forces of the two teams to manipulate, compromise, and trade-off until they can present at least the two plans required in the Principles and Standards, one emphasizing each objective.

Water Resource Planning Objectives

When they are formulating plans for a water resources project, the planning teams have the following philosophy of the Water Resources Council as part of their guidelines:

> Formulating courses of action that effectively contribute to the attainment of the national economic development and environmental quality objectives is the paramount task of water and land resources planning. These actions are the only means by which objectives can be obtained.

The Water Resources Council reiterates, in defining these two major objectives, that the "overall purpose of water and land resource planning is to promote the quality of life." The two objectives are defined as follows:

> . . . to enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency, and
>
> to enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

It is also stated in the Principles and Standards that "for ea.. alternative plan there will be a complete display or accounting of relevant beneficial and adverse effects on these two objectives . . . measured in monetary or non-monetary terms."

The group of experts who wrote the Principles and Standards anticipated that there would be disagreements among the planners about what was adverse or beneficial and what trade-offs should be made. They suggested that there should be an expression of the "affected group's priorities and preferences" to help in the decision-making process. In order to facilitate this aspect of the process, they emphasized that public participation be used much more extensively than has been done previously throughout the entire planning procedure.

As was mentioned earlier, the beneficial and adverse effects of a project which relate to the two major objectives, national economic development (NED)and environmental quality (EQ), are to be displayed in four accounts: national economic development, environmental quality, regional development and social well-being. The verbatim texts from the Principles and Standards for the NED and EQ objectives and accounts are in Appendices C and D, respectively. The regional development and social well-being accounts are not pertinent to the Coarse Sort study.

In essence, the NED effects are similar to those encountered in traditional benefit-cost methodology except for the addition of the value of output resulting from external economies, and the losses in output resulting from external diseconomies which were defined in the Terminology section. The EQ effects are considered for a variety of items listed in Appendix D. They are described mostly in qualitative rather than monetary terms. Some of the categories are open and green space, lakes, archeological resources and geological resources. An account might include the number of acres of green space which would be inundated by a reservoir, or the number of archeological sites that would be lost if a project were constructed.

The regional development account is similar to the NED account except that it is confined to the benefical and adverse effects of a project on a certain defined area. It includes the effects on jobs, population distribution, the economic base and stability of the region, and on the environment. This is both a quantitative and qualitative account. The social well-being account deals with real income distribution, life, health and safety, education, culture and recreation, and emergency preparedness.

With respect to the objectives and accounts, there are several stipulations made regarding approaches to the development of a plan including:

1. Full employment is assumed unless there is knowledge that conditions are otherwise, i.e., chronic unemployment or underemployment;
2. There must be projections of national and regional employment output, of population, and of demands for goods and services;
3. The need for water and land resources will be related to the above;
4. Standards and goals for environmental quality and other factors must be kept in mind;
5. The beneficial and adverse effects which would occur without a plan must be determined, as well as those for the alternative plans;
6. If prices are used they should reflect the real exchange values expected to prevail over the period of analysis;
7. The discount rate used will be that related to the cost of Federal borrowing; and

8. . . . and plans, or increments, thereto, will not be recommended for Federal development that, although they have beneficial effects on the objectives, would physically or economically preclude alternative non-Federal plans which would likely be undertaken in the absence of the Federal plan and which would more effectively contribute to the objectives when comparably evaluated according to these principles.

The Principles and the Standards

The Principles referred to in the title, Principles and Standards, are the beneficial and adverse effects of the two objectives, national economic development and environmental quality. The section on Principles in the document includes a subheading called "general evaluation principles." This segement contains brief statements about what principles should be considered when evaluating the two objectives. These include: the general setting, beneficial and adverse effects, price relationships, and risk and uncertainty, among others. The steps in plan formulation are mentioned in another section which also contains a statement about evaluating the project area without a plan, and a segment about formulating alternative plans. The Principles are to be implemented by the establishment of "Standards for planning water and land resources in accordance with the Water Resources Planning Act."

The Standards are definitions of the components that should be evaluated when implementing the Principles. Although these Standards are only binding on projects which include Federal participation, they are also intended as a useful guide for state and local planning. It should be noted, however, that although Federal participation is an integral part of a project, sections of a project may be implemented by state or other non-Federal entities. The programs which come under the jurisdiction of these standards are

- -- Corps of Engineers civil functions
- -- Bureau of Reclamation projects
- -- Federally constructed watershed and water and land programs
- -- National parks and recreation areas
- -- Wild, scenic, recreational rivers and wilderness areas
- -- Wetland and estuary projects and coastal zones
- -- Federal waterfowl refuges
- -- Tennessee Valley Authority
- -- Federal assistance to State and local government sponsored watershed and water and land resource programs (Watershed Protection and Flood Prevention Projects and Resource Conservation and Development Projects).

The Standards apply to all levels of planning: framework studies and assessments, regional and river basin planning, and implementation studies. For those projects already authorized but unfunded, the head of the agency will determine which of them must be restudied with the inclusion of these Standards. Those that are "substantially reformulated" to include the environmental quality objective must be reauthorized. "Separable and independent elements of a project or a system also would be subject to review prior to funding for construction."

The components defined in the Standards are the same ones mentioned before in relation to the two objectives. More detail is given as to what should be considered when measuring or calculating the beneficial and adverse effects of a water resources project. Included are expanded descriptions of the NED and EQ objectives and measurement guidelines for the components of the two objectives. The following is an example from the EQ Standards:

> Open and green space: These are essentially undeveloped, visually attractive natural areas strategically located where most needed to ameliorate intensifying urbanization patterns.
>
> a. Size and measure
>   1) Total acreage (woods, fields, meadows, etc.)
>   2) Pattern and distribution
>   3) Juxtaposition to community and urban areas (effect on urban sprawl)
>
> b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected open and green space
>
> c. Improvements
>   1) Accessibility (mileage of public roads or trails provided; easements)
>   2) Public amenities (provision for limited facilities, if any)
>   3) Other (specify and describe)
>
> d. Protection and preservation
>   1) Physical (fire, bioenvironmental, etc.)
>   2) Legal (dedication, easements, institutional, etc.)
>   3) Special

The full texts are in Appendices C and D.

Public Participation

Although a project could be initiated by either the public or an agency, inclusion of the public in the planning process was never really practiced. Public hearings were formalities as far as the agency developing the project was concerned. This has been an unfortunate attitude because in the final analysis it is the public who pays for the project. To alleviate the situation new methods of public participation have been introduced.

In the Principles and Standards public participation is included in the section on plan formulation and stipulates that

> Direct input from the public involved at the local and regional level is important and will be accomplished by:

> a. Soliciting public opinion early in the planning process,
> b. Encouraging periodic expression of the public's views orally, and recording their opinions, and considering them,
> c. Holding public meetings early in the course of planning to advise the public of the nature and scope of the study, opening lines of communication, listening to the needs and views of the public and identifying interested individuals and agencies, and
> d. Making available all plans, reports, data analysis, interpretations, and other information for public inspection.
>
> Efforts to secure public participation should be pursued vigorously through appropriate means of public hearings, public meetings, information programs, citizens committees, etc.

It is also suggested that the planning agency be certain to consult environmental interest groups in the process of formulating the environmental quality objective. When components are being identified a "broad spectrum of public groups and interests must be considered and consulted" (Principles and Standards).

The public participation aspect of planning is very important if the planning agency hopes to develop and implement a water resources project. There is a growing public awareness of planning issues which must be tapped, but getting that "broad spectrum" to attend public hearings is another matter.

The general citizen does not frequent public hearings unless he has been informed that the issue in question directly affects him. It is the information process that is important, but even what seem like logical methods of communication fail to achieve their purpose. Many planning organizations have tried meetings at the neighborhood level to inform and arouse interest and had very poor attendence. However, if the opinion leaders are informed, it is possible that word will spread by one to one contact among residents in the neighborhood. The same is true of workshops and community organizations such as the Lions Club, Rotary Club, League of Women Voters, other women's clubs and service organizations. Information spreads by word of mouth so that reaching a few people leads to many more being informed. It is important to have good media coverage so that facts, rather than rumors, are spread, and to have an information officer easily accessible to answer questions and clear up ambiguities during the entire planning process.

Communicating information pertaining to the plan to the public in a comprehensible format is very important, especially with the current necessity for the presentation of several plans. The elements of each plan must be clearly defined and explained. The requirement for the development of objectives and accounts for each plan and a method for displaying these, like the sort charts in the Coarse Sort System, facilitates the communication of plan elements to the public.

The purpose of a good public participation program is to allow the citizenry to have direct input into the planning process. The methods mentioned above which involve the planners attending public meetings is only one way of accomplishing this input. The other method is to have permanent citizens advisory groups or boards appointed to review and have input into each step of the planning process. These steps include "the establishment of goals, design of alternatives, impact assessment, acceptance of a final plan and plan revisions" (a communique from the Environmental Protection Agency on 208 Planning). This may slow down the planning process somewhat, but it does give the planners a better idea of public sentiment.

Land Use and Water Quality

Included in the full title of the Principles and Standards is the phrase "for Planning Water and Related Land Resources." This terminology refers to the fact that water quality and land use are mutually dependent on each other. The water we use, whether it comes from ground or surface water sources, runs over or through land at some point unless it precipitates directly into a reservoir. As it runs over or through the land, it can be affected or degraded by the various constituents on that land. Pesticides, manure, fertilizer, and decaying organic matter are a few of the many contaminants which effect water quality. Some water is so degraded it cannot be used, other supplies must go through a costly treatment process before they are usable.

The process also works in reverse. Water can damage land. Floods destroy homes, wash away crops and topsoil, kill grazing animals, and inundate roads and bridges. Periodic flooding disturbs ecological communities. There is, therefore, much interaction between water and land.

Land use considerations are included in the water resource planning process in order to mitigate both the effects of land use on water quality and the effects of water on land use. It makes little sense to build a reservoir if it will be filled with silt in a relatively short time, or if it will be too eutrophic to obtain good quality water from it, or too high in fecal coliforms to be used for recreational purposes. On the other hand, building homes and other structures in flood prone areas is not a good practice. Proper use of flood plains would result in greatly reduced flood damages.

Water that is degraded is referred to as "polluted." There are two general sources of water pollution, point source and non-point source. Point source pollution is that which can be pin-pointed, like a sewer pipe. That which cannot be pinpointed, like urban runoff or runoff from a pasture, is called a non-point source.

There are many parameters which must be taken into account when an area is assessed for a water resources project. A description of several of them follows.

Sediment is the most significant polluter of streams. Deposition of sediment causes physical damage such as the reduction of storage capacity in a reservoir, the filling of channels, increased turbidity, increase flood frequency and damage to aquatic and terrestrial organisms.

When assessing the characteristics of a watershed for development of a surface water project, the expected erosion of soil is an important determinant since some soils erode more easily than others. If both the expected erosion and the actual amount of erosion are measured, it is possible to assess whether good land use practices are being used. If the soil is not subject to severe erosion yet there is a large amount of sediment in the stream, then poor land management is in practice. This may have to be corrected before a project is constructed.

Minerals pollute streams in three ways, as mine drainage, salinity, and heavy metals. The most serious pollutant arising from mining activities is the mine drainage generated by oxidation of pyritic materials with air in the presence of water. This drainage is an acidic mixture of iron salts, other salts and sulfuric acid. Mine drainage arises from both underground and surface mining sources, and from coal and many metal mining operations. Coal deposits and hard rock mineral deposits are commonly associated with pyrite and marcasite, which are disulfides of iron. Acid mine drainage can find its way into surface waters, where the acid and sulfate may result in severe deterioration in stream quality. The acid can react with clays to yield aluminum concentrations sufficient for fish kills and with limestone to yield very hard waters expensive to soften. The acid can also selectively extract heavy metals present in trace quantities in mineral and soil formations resulting in toxic conditions in lakes and streams.

Mining refuse, waste materials left near the mining site after raw minerals have been cleaned or concentrated, is another source of pollution. Much of this refuse contains pyritic material which can be oxidized to acidic substances. The resultant acid water may remain in the pile until a rainstorm at which time it is flushed into nearby watercourses. Mine drainage "slugs" during storms are detrimental to aquatic life in surface waters.

Mining operations also generate wastes, commonly called spoil, in the form of disturbed rock and soil. If this spoil is left in piles, erosion and runoff will carry sediment into streams. This sediment is capable of destroying life in streams, results in decreased capacity of streams and reservoirs, and destroys fish and wildlife habitats.

The evaluation of the mine drainage in the watershed should include water quality data as well as identification of areas of mining activities. The parameter estimate is determined from the present and future uses of the mines. Abandoned mines can contribute as many pollutants as operating mines and therefore need to be identified. Watersheds which contain geologic formations where future mining is likely should be identified and considered in the planning process as well.

Salinity is a measure of the salt content of water. Salts and minerals are dissolved in water when precipitation reaches the earth and flows over the land. Every body of water flows over rocks and through soil. The water dissolves certain minerals and salts out of the soil and carries them into streams. The composition of each stream's salts corresponds to the type of geologic formation in the watershed.

Plants and animals are adapted to the normal salinity in the waters of their region. Since the ecological systems of water resources are closely linked to aquatic biota, a change in the concentrations of salts can have serious consequences. An increase or decrease in the total salinity can upset normal cell functions. Increases in salinity concentrations have been directly correlated to decreases in the plant and animal species in the ecological system involved (McCaull and Crossland, 1974).

High chloride concentrations have several sources. Urban runoff containing salts used in highway de-icing has been found to contain as much as 1300 mg/l of chloride (EPA,1971). Poor land conservation practices contribute chlorides from the soil that are transported in the process of erosion. The impounding of streams often results in a higher concentration of salts than was present prior to constructing the impoundment. When water evaporates from the surface of a body of water, the salts and minerals present in the liquid remain. This increases the salinity of the remaining water. In semi-arid and arid climates the rate of evaporation is rapid enough that salt concentrations in lakes of over 1,000 mg/l are not uncommon (Bureau of Reclamation, 1971).

Irrigation return flows are another major source of chlorides in water. Irrigation water runoff contains a high concentration of salts and minerals picked up from the soil. If the irrigation water is stored in an impoundment, the salinity concentrations that may previously have been high due to evaporation will be greater after the water is applied to the crops.

The heavy metals also are a significant source of pollution. Heavy metals, including mercury, lead, zinc, silver, cadmium, arsenic, copper, iron and aluminum, are not uncommon in water supplies.

Heavy metals occur naturally in the environment as part of the earth's crust. The concentration of heavy metals from the earth usually does not reach a level in water that would be toxic. Many industrial processes produce pollutants containing heavy metals in various forms which, in large enough concentrations, can be toxic to wildlife, micro-organisms, vegetation and humans. These metals can become concentrated in the food chain and pose hazards to higher life forms.

Information about the transport of heavy metals in runoff is limited at present and measurements of them were not usually taken. They are important because they cause toxicity and attempts should be made to determine their concentrations especially if there is urban runoff and industrial pollution involved.

The over-enrichment of streams and lakes is a result of high concentrations of nutrients which enter the hydrologic cycle of a watershed. These nutrients accelerate the rate of natural aging of lakes creating eutrophic conditions. Lakes are considered to be eutrophic when biological growth is high, algal blooms appear frequently, and the water contains large amounts of organic matter and becomes turbid. Watersheds which contain high concentrations of nutrients in the runoff are not suitable for water resource developments which impound a stream because the life of the development will be shortened by eutrophication. Eutrophication is indicated by increases in nitrogen and phosphorus and decreases in dissolved oxygen. Nutrients can come from the natural release of minerals from soil and rocks, and from other sources. Both urban and non-urban runoff contain high levels of nutrients under certain conditions. Urban sources of nutrients include street litter, petroleum products, chemicals from industrial runoff, fertilizers, and domestic sewerage systems. Agricultural and forested land can contribute large amounts of nutrients from fertilizers and poor soil conservation practices which allow excessive nutrients to be leached from the soil. Animal wastes from feedlots and rangeland are significant contributors of nutrients (EPA, 1973a).

Pesticides are another source of pollution. Since pesticides are designed to be lethal to certain organisms, great concern is aroused when high concentrations are found in water. Almost one billion pounds of pesticides were applied to land in the United States during 1970. Of these, seventy percent were used in agriculture (EPA, 1973a).

The danger from pesticides is primarily due to their ability to persist in the aquatic environment where fish and other food sources accumulate them. The ban by the United States government on persistent chemicals such as DDT emphasizes the concern about the accumulation of pesticides in the environment. The transportation of pesticides from land into waterways is a complex process involving factors such as the physical and chemical properties of toxicants, the rate and type of application, topography of the receiving land, climate, and the distance between the application site and the water resource.

Analyses of the potential pollution from pesticides is essential for determining the suitability of a watershed for development of a water resources project. Any structure designed to retard or impound a stream can cause concentrations of pesticides to form in toxic quantities. An assessment of the environmental quality of a water resources project requires a thorough evaluation of present and potential sources of pesticides.

Thermal pollution of water can result from two types of actions, point source discharges of water at temperatures different from the receiving water, and modification of the environment which alters the temperature of a body of water. Regardless of the source, the impact of thermal pollutants can be devastating.

Point source discharges of water at a significantly different temperature from the receiving body of water cause changes in ecological systems. The severity of the change in temperature combined with the volume, frequency, and rate of the discharge determine the impact upon each individual ecosystem. Recent laws concerning water quality have required that polluting point sources be controlled which will lessen the impact considerably.

The second type of thermal pollution presents a more difficult problem. The temperature of a given body of water may fluctuate greatly during the year with no harm to the ecological system. Each component of the ecological community is adapted to the normal seasonal variation in temperature. Man can modify this natural temperature cycle in numerous ways. Removal of vegetation which shades the water, impounding streams, diversion of snowmelt, and alterations of the stream channel all modify the temperature of a body of water enough to cause widespread change in the ecological systems.

Measurement of thermal pollution for the water quality evaluation should include the effects of presently existing sources as well as potential sources. Components of the alternative projects should be closely evaluated to determine the effect they might have on the temperature of the water resource. Additionally, the tolerance ranges of the biotic community should be identified and compared to the predicted thermal levels to assess the impact of the proposed action on the watershed's ecological system.

The Beneficial and Adverse Environmental Effects of a Reservoir

Although there are several different kinds of water resource projects, a thorough description of the environmental effects of all of them is beyond the scope of this study. The general discussion on a reservoir, which follows, is included because the Coarse Sort System is tested on a reservoir project in Chapter Three. This is useful background information for the test.

When a reservoir is the major element of a water resources project, there are several environmental consequences. Some of them are beneficial, some adverse. There are effects on both the ecology and the water quality of the area included in the project.

Among the ecological factors are the loss of terrestrial habitats due to inundation, the creation of aquatic habitats as a result of inundation, an increase in the land-water interface area upstream from the dam, the creation of a drawdown zone (Warner, et. al., 1974) and a change in the ecosystem downstream.

When water is impounded in a reservoir, its quality is affected. Impoundment causes: thermal stratification; a loss of sediment; reduction in turbidity; the oxidation of organic material but slower reaeration due to a lesser mixing effect; the concentration of inorganics; algal bloom; and lack of bottom scour in the impoundment, but a possible increase downstream.

Land use is associated with both the ecological and water quality factors. It determines the types of flora and fauna affected by the reservoirs and the water quality problems which can be anticipated from the runoff. If the land around the project is still wild, then the number of habitats destroyed will be much greater than if it were urbanized. The destruction of terrestrial habitats puts pressure on the carrying capacity of other terrestrial habitats to incorporate the displaced species. It is possible for animals to attempt to find another place to live, but very difficult for established flora.

The reservoir destroys terrestrial habitat by inundating it, and simultaneously creates a large aquatic environment. As the quantity of water in the reservoir fluctuates, a drawdown zone is created. This is the term for terrestrial habitat that is periodically inundated. Some species of flora can tolerate intermittent inundation unless there is heavy siltation which smothers the roots. Therefore, it is possible to have some vegetation in the drawdown zone and thus some use of the area by animals for food. The rest of the terrestrial habitat cannot be described by generalizations. It has to be evaluated and monitored for each separate reservoir project.

The aquatic environment is created by the lake or reservoir which forms on the upstream side of the dam. The stream ecosystem which preceded the lake is different from the lake's ecosystem. There is more species diversity in a stream per unit area due to the many micro-habitats available. Streams have a more heterotrophic type of community metabolism and a more open food web, depending on a continual input of organic material from outside the stream itself. The change in environment will cause some species to be lost and others gained.

Damming a stream causes changes in the flow regimen downstream from the dam. These changes also cannot be generalized but must be evaluated for each individual case. Theoretically, it should be possible to assure a steady minimum flow downstream to relieve low or no flow conditions by discharging water from the dam. However, it is possible that extreme drought conditions may cause a drop in the level of the conservation pool in the reservoir which might preclude any releases downstream. Even if minimum conditions could be maintained, changes would be found in the downstream ecosystem. If the area is used for migration or spawning or is utilized by rare or endangered species, the dam will have a definite environmental effect on the stream.

Another downstream effect created by impoundment is a loss of sediments and nutrients. Water which flows overland before it reaches a stream picks up soil particles, plant residues, manure, and nutrients which it transports from the terrestrial to the aquatic environment. As these enter into the stream flow they provide a portion of the "input energy" needed by the stream's ecosystem and the stream also delivers them to downstream terrestrial habitats. The reservoir acts as a "sink" for the sediments and nutritive material and lessens the stream's contributions of these necessary items to the downstream habitats (Warner, et. al., 1974). Impoundments, then, have a definite affect on water quality. Not only do they lower the content of sediment and nutritive materials, but they also cause other alterations in the normal conditions of a stream.

A large, fairly deep reservoir tends to stratify thermally during the summer, with warm water on top and cold water on the bottom. If this condition has not been taken into account in the design of the dam, only very warm or very cold water may be released. This affects certain species of fish, some of which have an intolerance to temperature extremes. Large reservoirs also cause a concentration of pollutants as a result of surface evaporation.

The upper layer of a reservoir, although warmer, remains subject to reaeration and mixing giving it an opportunity to assimilate organic wastes. The bottom layer, being cold and stagnant, loses this property. The result is a lower concentration of dissolved oxygen and a habitat only for those species which can tolorate low oxygen levels. There is also an affect on the chemistry of the sediment and consequently on the cycling of inorganic materials, biological growth and nutrient releases. This may lead to eutrophication.

Eutrophication is the enrichment of a body of water by nutrients. This results in algal blooms which affect taste and odor and the transparency of the water. Reservoirs are more likely to produce their own organic materials than to have them flow in from elsewhere. The production of algae can be kept under control by limiting the quantities of nitrogen and phosphorus which enter the system from streamflow and runoff. This is one reason for having land use regulations. Fertilizer is an excellent source of these two nutrients so that limiting its use on land adjacent to a reservoir is highly recommended. If eutrophication does occur there is usually a decrease in species diversity since only those species tolerant of the altered environment will survive, and these few will proliferate.

It was mentioned earlier that an impoundment has an effect on the sedimentation characteristics of a stream. The amount of sediment or suspended particles that flowing water can carry is directly related to the magnitude of its turbulent flow. Streams have an ecosystem dependent on a certain amount of sediment being picked up or what is called bottom scouring, and also on the deposition of some of the sediment that enters the stream in runoff and carries nutrients. When this regimen is altered so is the composition of benthic (bottom dwelling) organisms.

When an impoundment is created, there are effects both in the reservoir area and upstream from it. The change in the depth of the water causes a change in the benthic composition of the stream and the reservoir. When the stream water upstream flows more slowly, more sediment drops than would precipitate in a swifter flowing stream.

In the larger areas of the impoundment, where there were large sized particles which served as attachment surfaces for certain species, algae, stoneflies and mayflies, there will instead be small-sized particles over the old substratum and a consequent change in benthic species. This will, in turn, lead to a difference in the larger species which used to feed on the previous benthic organisms and so on through the food chain.

Sediment build-up, or deposition, effects the life of the reservoir area. Impoundments are designed with a sediment basin included which, if the expected rate of sedimentation were closely approximated, should be able to handle the deposits and allow the reservoir to continue functioning. The consequence of sediment deposition is that the water flowing out of a reservoir will contain less sediment than it did when it flowed in from upstream. This could cause greater than usual erosion and bottom scouring in the stream below the dam and decreased deposition of sediment to the aquatic and terrestrial environments downstream. This will cause an alteration of the characteristics of these two environments.

The water source downstream from an impoundment can be effected beneficially by having been detained in a reservoir. Turbidity is reduced, organic materials are oxidized and fecal coliforms, which are indicators of pollution, have time to die off. If eutrophication in the reservoir can be controlled, the results of detaining the water are also useful to those who are using it for municipal and industrial supply.

One other aspect of impoundment that should be mentioned is that there are often homes, graveyards, oil and water wells, pipelines, roads, and other physical structures that will be inundated by the reservoir. These must be given consideration with respect to relocation, capping of wells, or compensation.

Two Water Resource Projects

The Coarse Sort System ties in with the requirement in the Principles and Standards for the development of alternative plans. It provides a means for displaying a comparison of the different plans by use of the sort charts.

This makes it easier to communicate the planning process to the public. If the six planning steps are carried out and the planning teams do a thorough and competent job of evaluating the beneficial and adverse effects of a proposed project, these teams should be accountable for the results of the final plan. This Coarse Sort System has not been used by a planning agency yet, but two different water resources projects are briefly described below which might have benefitted from using the Coarse Sort method.

The recent Teton Dam disaster in Idaho, June 5, 1976, now under investigation, is a case in point. The project was originally authorized in 1964, was held up by a court case in 1973 involving conservation groups, and was only now in the process of being completed, twelve years after authorization. Environmentalists opposed the earth-fill dam because it would destroy 17 miles of the Teton River where trout fishing was popular, and would inundate 2,700 acres of habitat for deer, elk, and other wildlife. The Bureau of Reclamation, which is the Federal agency responsible for designing and building the dam, countered that "the benefits of flood control and irrigation water that the dam would provide would far outweigh any damage to the environment" (Time, 6/21/76, p.56). There was also information available on a different matter, however, which may shed some light on the cause for the collapse. The United States Geological Survey informed the Bureau of Reclamation in 1972 that the dam site was in a "seismically active area and might be endangered by earthquakes" (Time). The Sierra Club's National News Report (NNR) states that the dam is actually built over a fault. Both the NNR and Time report that the seismic study revealed that the earth on one side of the dam was more porous and soft and that filling the reservoir would cause the softer earth to compact more than the earth on the other side of the dam.

> "This would cause a small rupture at the base of the dam, and when the bottom began to leak, the water would tear loose the basic earth structure, open a hole into which the rock covering would collapse and the whole dam would go, and that is apparently what happened" (Time).

During the 1973 court hearings, a former geologist with the Bureau of Reclamation stated that tests indicated that the soil was too porous for a dam. The project was continued, however.

So far this study has overlooked what can be an overwhelming influence in the process of obtaining authorization for a water resources project, politics. National television news coverage right after the dam collapse stated that Idaho Senator Frank Church (who was still a candidate for President on June 5) had been instrumental in pushing the dam project through Congress. Now he and his Congressional colleagues are calling for a thorough investigation.

Whatever the cause of the dam's collapse, it has become an instance where the adverse effects of the collapse will certainly outweigh any beneficial effects there might have been. The dam cost $60 million. The disasterous flooding from the rupture inundated 400,000 acres and did over $1 billion in damage. Ten people lost their lives in the flood and 4000 homes and businesses were washed away. Obviously, this kind of irreversible damage would not have been accounted for or even been considered during the planning stages. It should also be noted that environmental impact statements were not required in 1964.

The Teton Dam was planned using the traditional benefit-cost ratio method. There was a court case for enviornmental reasons, but the Bureau of Reclamation was only accountable for the design of the project and the benefit-cost analysis. It is possible that some fluke in the geological structure of the area adjacent to the dam caused the collapse. Hopefully, under the new system, the enlarged planning team will properly assess such a situation and prevent future occurrences of this type.

Another controversial project is the Lukfata Dam proposed for southeastern Oklahoma by the Corps of Engineers. The dam was originally proposed for the Glover River and authorized in 1958 as part of a flood control project for Oklahoma and Arkansas. Two other structures authorized for Oklahoma have been completed. The proposed site created so much controversy that a compromise site was suggested by an environmentalist in 1973 and an environmental impact statement prepared for it, but not for the first site.

A hearing on the draft environmental impact statement was held in July, 1975. Again, all sorts of shortcomings in the planning process were criticized during the hearing. Some of the residents of the affected area were very much in favor of a dam to control flooding and favored either site. The Choctaw Indians who lived there opposed any dam as did another group of residents. One State senator was for it, a State representative opposed the second site. Other comments see-sawed between pro and con all day.

Some of the specific reasons for criticism included the environmentalists contention that the Glover River was the last free flowing mountain stream in Oklahoma, and was also the only habitat in the world for a proposed endangered species of fish, the leopard darter. The plan failed to include recommendations from the State and Federal Wildlife agencies on reduction or mitigation of destruction of wildlife or wildlife habitat. The dam would put a large dent in small-mouth bass fishing in the State because cool-water small-mouth bass streams are scarce in Oklahoma. Also questioned was the calculation of the cost of losing this resource. The unadulterated setting and free flowing river were called unique among recreational opportunities in the State.

Another interesting and controversial point mentioned was the interest rate used to calculate the benefit/cost ratio. Using 3½ percent, which was the rate when the project was planned originally, resulted in a benefit/cost ratio of 1.4:1. The interest rate in 1975 was 5 7/8 percent which would have given a benefit/cost ratio less than one, according to the environmentalists. They also noted that the Corps of Engineers had a history of at least 100 percent cost overruns making the benefit/cost ratio even more questionable.

Among the incremental benefits of Lukfata Lake were recreation and water supply. Both drew criticism. The Governor's office stated that lake recreation needs in the area had been met for the next 25 years and refused to make a financial commitment. The environmentalists pointed out that the Corps had greatly overstated the need for the water supply benefits of Lukfata Lake. Existing supplies were sufficient for forecasted needs.

The non-structural alternative, which was to purchase or lease the flood plain area, was deemed to have net costs rather than benefits by the Corps of Engineers. Thus, they did not consider it as a feasible plan.

The two projects mentioned above are indicators of some of the problems in water resources planning. It should be possible to mitigate them if the Principles and Standards are followed. For the Idaho project the present approach is too late, but for the Oklahoma dam, there is still an opportunity to insist that alternative plans be formulated and considered with a serious consideration for the unique environmental aspects of the area.

CHAPTER THREE

METHODOLOGY FOR THE COARSE SORT SYSTEM

The Coarse Sort System is a method for dealing with the national economic development (NED) and the environmental quality (EQ) objectives and accounts required by the Establishment of Principles and Standards for Planning Water and Related Land Resources (1973). This particular system has been developed for the preliminary aspects of the planning of a water resources project.

Since the purpose of this Coarse Sort was to devise a non-mathematical, fairly simple-to-use model for the preliminary selection of project alternatives, a verbal, visual method was created. The major element of this model is called a sort chart which will be explained later.

The Coarse Sort System accomplishes several of the objectives in the six planning steps. First of all, it requires that the planning teams broaden their horizons and examine many different alternatives for achieving the needs of a community or region. Secondly, it provides a method via the sort charts for looking at all of the alternatives together on the same basis. Thirdly, if the procedures used to devise the various alternatives are made available to the public, it will give them an appreciation of how difficult it is to select a plan and how much work is involved in the process. It will also afford them an opportunity to examine the alternatives. Fourthly, the Coarse Sort System can be used even if methods other than net benefits are created, as long as the alternatives are ranked. Fifthly, in the Principles and Standards there is also a requirement that two other accounts for measuring the impacts of a proposed project be presented, a regional development account and a social well-being account. It is quite possible to adapt the sort chart method to both of these if a system of ranking each of these accounts is used.

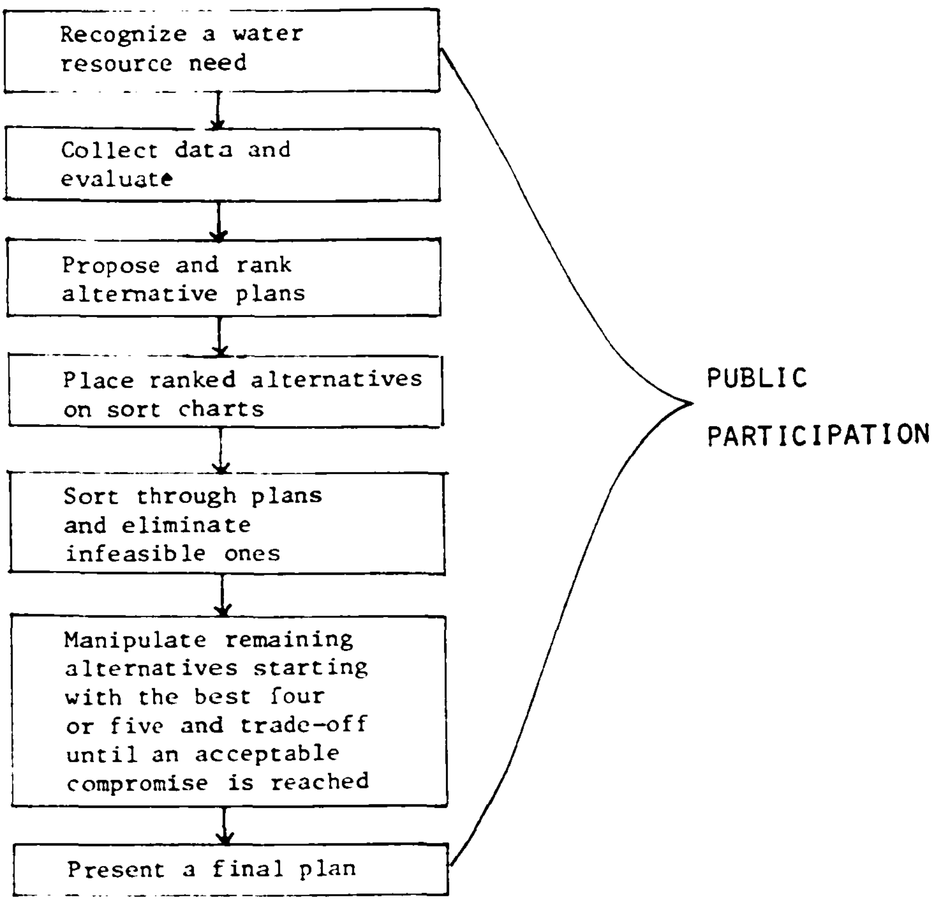
The Coarse Sort System is used after the initial data gathering and evaluation has occurred and the accounts have been developed. The EQ team has to know approximately which alternatives the NED team is looking at so that the EQ team can evaluate EQ plans for those situations. The kinds of information the two planning teams must obtain are detailed in Chapter Two and Appendices C and D. The information is evaluated and the future of the area without a plan is determined. Then alternative plans are developed. These procedures coincide with Steps One and Two of the formalized planning process. Then each team must rank the segments within the plans with respect to how close they actually come to fulfilling the stated needs. The overall rank is obtained from the total sum of the segment rankings. The lowest sum is the best overall plan and is ranked number one. Even the plans that are so biased toward one objective that they will probably be rejected should be ranked.

It is possible that the plan with the best overall ranking has segments that do not meet a goal as well as segments from another plan or plans with a lower ranking. Having this knowledge available and displayed on the sort chart is helpful in the trade-off procedure. It would probably facilitate the process if the planners followed the suggestion of a planning engineer with the Bureau of Reclamation (Schaefer 1975). He suggested that although it may be necessary to evaluate extreme cases for both the NED and EQ objectives, it is wise to develop alternative plans which emphasize one or the other but are, at the same time, viable.

After the plans are ranked, they are placed on each of the sort charts, NED and EQ. The NED plans are listed in order of rank, one, two, three and so on. To make the sorting process easier, the EQ plans should be placed on the EQ chart in the same order as the corresponding NED plan. In other words, if the NED plans are listed with Plan B first, Plan A second, and Plan D third, the EQ plans should be in the same order (B, A and D) even though the rankings for EQ plans B, A, and D may be 9, 11, 6 respectively instead of 1, 2, and 3. Then the plans can be preliminarily sorted through to eliminate those which are not feasible. This would probably mean either the net benefits criterion was not achieved, or the plan was too biased toward one objective to be able to effect a compromise. If many alternatives are presented, the most feasible ten should be selected in this first elimination process.

The next step involves a procedure similar to feedback. Of the remaining alternatives, the most likely five or six should be chosen for further study with both teams present. Having ranked the plans and the segments, it should be possible to look at both objectives for one of the overall plans, decide which segments or components of each might be altered, choose a segment with a higher ranking if possible from one of the other five alternatives, and test it in the plan. It may reduce the net benefits figure a little, but the overall plan may be more feasible. This procedure is continued, like an iteration, until an acceptable plan for both objectives is achieved. Figure 2 is a flow chart of the procedure.

Figure 2. Details of the Coarse Sort Procedure



In performing this operation it is possible that a segment with a higher ranking is not among the alternatives. In that case choose the segment that has the next highest ranking to the one that is being altered. It is also possible that manipulation of the five best alternative plans will not produce an acceptable compromise. If this happens, one of the four rejected plans, or a segment from it, might result in a better overall plan.

Later in this chapter there is an example of the use of the Coarse Sort System. For this particular case, there were two alternatives which had similar ranks for both the NED and EQ objectives. If this occurs, it indicates a fairly high degree of compatibility between the two objectives and makes the selection of a final plan much easier. Iterations are not really necessary because the few differences there are can be discussed among the planners and with the public. This should result in an acceptable plan with only a little compromising and a few trade-offs.

The Sort Chart

The sort chart is essentially a verbal matrix, but the term "sort chart" is used to distinguish it from the normally confronted mathematical matrix. Table 1 is an example of a sort chart. The numbers on the sort chart are those which designate how a particular plan ranks with respect to meeting the stated needs or goals of a specified water resources project, both on an overall basis, and for each individual segment of each plan.

The sort chart consists of three major elements. On the left side is the name of the plan or plans being considered. Across the top are the various components for which a project is being developed, such as water

Table 1: An Example of a National Economic Development (NED) Sort Chart

GOALS

Plan Name	Domestic Water Supply	Industrial Water Supply	Irrigation, Number of Acres	Recreation	Flood Control Number of Acres	Low Flow Augmentation	Power	Commercial Fishing	Fish and Wildlife	Unemployed Labor	Total Score	Overall Plan Rank
Alternative D	1	2	2	1	1	1	-	-	4.5	2	14.5	1
Alternative B	2	1	3.5	3	2	2	-	1	2	1	17.5	2
Alternative A	3	4	3.5	2	3.5	4.5	-	-	6	3.5	27	3.5
Alternative F	4	3	1	5	3.5	3	1	-	4.5	5	30	3.5
Alternative I	5	6	5	4	5	4.5	-	-	1	3.5	34	5
Alternative M	6	5	6	6	6	6	2	2	3	6	36	6
Alternative x no action												y
Alternative n												m
etc.												etc.

supply, flood control, terrestrial habitat, or fish and wildlife. On the right side and in the interior squares are the ranking numbers for the overall plan and its segments, respectively. The plans are listed as previously explained.

There may be instances when two or more segments or two or more plans tie for a rank number. In this case, an average is calculated for the rank numbers which would have been given each separately. For instance, three segments tie for third, but would have been third, fourth and fifth otherwise. The average of 3 + 4 + 5 = 12 ÷ 3 = 4 is given to all three of them. If it were just 3 + 4, then the average number, 3.5, would be given to both of them. If there is a tie for last place, the same method is used. If there are 50 different alternative plans and two tie for last place, each is given the number 49.5.

The National Economic Development Sort Chart

There are several different components that could be found across the top of a national economic development (NED) sort chart. They are similar to those used to plan projects when the benefit-cost analysis was the only objective and are generally referred to as the beneficial purposes. The list of components includes:

1. water supply
    a. community and residential
    b. agricultural
    c. industrial and commercial
2. power
    a. community and residential

b. agricultural

c. industrial and commercial

3. recreation

4. flood damage alleviation

a. agricultural

b. urban

5. land stabilization

6. drainage

7. transportation, and

8. commercial fishing

as they relate to "increases of the value of the output of goods and services and improvements in national economic efficiency" (Principles and Standards). Other beneficial elements, such as employment and external economies, might also be included.

There are adverse effects which must be measured, too:

1. resources required or displaced

a. sum of the market values of the goods and services used for installations

b. interest during construction

c. costs of operation, maintenance and replacement

d. induced costs

2. decreases in output resulting from external diseconomies.

The list of beneficial purposes is directly related to the goals of the project. These goals might be to supply a certain amount of water, prevent flooding, provide power, and/or increase recreational opportunities. They are based on known or recognized needs or, theoretically, there would not be a reason to develop a plan in the first place. Increasing population, the desire to bring in industry, and excessive flood damages every year are all reasons that might require a project. Now, however, instead of developing just one plan to meet these needs, there must be several alternatives presented for consideration.

Prior to the recent turn of events in water resources planning, a project could fulfill more than one need by using the incremental method. The incremental method of benefit-cost analysis allows additional benefits to be calculated which result from the original purpose of the plan. For instance, if the amount of water supply needed requires construction of a reservoir, recreational benefits from that reservoir can be included. If it can be proved that additional storage provides recreational benefits greater than the added cost to construct the additional storage, that, too, can be added on. This method is still in use, but is now only part of the water resources planning method.

The other part concerns the environmental damage which occurs where a project is built. If a reservoir is built, whatever was there, terrestrial habitat, homes, graves, other buildings, or archeological sites, will be inundated and destroyed. This is irreversible damage. In the new planning framework, a serious effort must be made to mitigate this damage. Thus, before a project is approved, a thorough environmental inventory is made of the area, and with the stated needs in mind, plans are made to fulfill them with the best interests of the environment taken into account. This is the environmental quality objective.

To implement the sort chart method, when the NED and EQ plans are developed, they are ranked according to how close they come to fulfilling the stated needs of the particular objective. This information appears on the charts. The NED plan which ranks number one will probably use increment after increment to realize the needs. The number one EQ plan will most likely meet a need by doing the opposite. For example, if water supply is needed than a reservoir would be built to meet only that need, provide recreation through enhancing existing facilities, use land purchase or zoning to control flood damages, and so forth. A suggestion might even be made to limit growth or urban sprawl.

In short, the needs are expressed, the plans are formulated, they and their segments are ranked according to how close they come to fulfilling both the need and the objective, NED or EQ, the information is placed on the sort charts, and the process of compromise and trade-offs is used to come up with a final acceptable plan.

The Environmental Quality Sort Chart

The use of the EQ chart was explained earlier in this chapter. Table 2 is an example of an EQ sort chart. The essence of the EQ objective is contained in the following statements from the Principles and Standards:

> Beneficial effects on the environmental quality account are contributions resulting from the management, preservation, or restoration of one or more of the environmental characteristics . . . under study.
>
> Adverse environmental effects - generally the obverse of beneficial environmental effects - are consequences of the proposed plan that result in the deterioration of relevant environment characteristics of an area under study . . . .

The environmental elements that are to be considered include the following.

TABLE 2
ENVIRONMENTAL QUALITY SORT CHART

Goals	Plan Q	Plan V	Plan H	Plan M	. . .	Plan C
Rank	9	11	6	12	. . .	20
Total Points						
Cultural Resources						
Ecosystems						
Geological Resources						
Water Quality						
Historical Resources						
Archeological Resources						
Aesthetic Views						
Acres of Wilderness						
Miles of Beaches						
Acre-feet of Lake(s)						
Miles of Scenic River						
Acres of Open and Green Space						
Plan Name	Plan Q	Plan V	Plan H	Plan M	. . .	Plan C

1. open and green space
2. wild and scenic rivers
3. lakes
4. beaches and shores
5. mountains and wilderness areas
6. estuaries
7. other areas of natural beauty
8. archeological resources
9. historical resources
10. biological resources
11. geological resources
12. ecological systems
13. control of pollution
    a. water quality
    b. air quality
    c. land quality
14. minimizing or avoiding irreversible or irretrievable effects on the environment.

The goals inherent in the environment quality objective are to preserve or enhance the environment. As a result of this directive, the best plan from this standpoint would probably not meet the goals of the best national economic development objective. In other words, the reservoir project which supplies the most water probably does the most environmental damage. However, for the sake of having as much information available as possible, the environmental quality team should consider all possible alternatives at first and make compromises later.

The approach to the environmental quality sort chart is to rank the plans and their segments by the amount of preservation enhancement they provide to the environment while at the same time keeping in mind the project goals. Although a large reservoir may do a lot of damage, alternative methods of water supply may be helpful to the environment and perhaps increase the carrying capacity of an area and/or the number and kinds of habitats available for wildlife. The NED project goals related to the particular EQ plan will be related by the plan name. In other words, although the NED plan for achieving a goal is not specifically stated on the EQ sort chart, the planning team preparing the EQ objective knows which alternative solutions are being considered by the NED team, and can prepare an EQ plan for each NED plan. If NED Plan A is using a multipurpose reservoir to fulfill the need for flood control, water supply and recreation, then EQ Plan A will evaluate the EQ objective for this reservoir project. If NED Plan B uses two smaller lakes to solve the problems, then EQ Plan B will evaluate the EQ objective for NED Plan B and so on.

It was stated earlier that this Coarse Sort System was developed for use with the NED and EQ objectives and accounts. The excerpts from the Principles and Standards in Tables 3 and 4 are guidelines for developing and displaying these two accounts. The accounts are a delineation of the benefits and costs in dollars for each of the NED components, and a verbal description of each applicable EQ component. In developing alternatives for a real project it would be helpful to include the relevant dimensions for each NED component, for instance, the number of acres covered by the flood control component, the amount of power which can be supplied , the size of the reservoir or whatever will be built for water supply, and

TABLE 3: BENEFICIAL AND ADVERSE EFFECTS FOR A PLAN
(USE ADDITIONAL TABLES FOR EACH ALTERNATIVE PLAN)

National Economic Development

Components	Measures of effects
Beneficial effects:	
A. The value of increased outputs of goods and services. Examples include:	
(1) Flood control	$1,000,000
(2) Power	1,000,000
(3) Water Supply	1,000,000
(4) Irrigation	1,000,000
(5) Recreation	1,000,000
(6) Use of labor resources otherwise unemployed or underemployed in construction or installation of the plan	1,000,000
B. The value of output resulting from external economies. Examples include:	
(1) Economies of scale in subsequent processing	1,000,000
(2) Reduced transportation costs as result of road relocation	1,000,000
Total beneficial effects	3,000,000
Adverse effects:	
A. The value of resources required for a plan. Examples include:	
(1) Project construction and OM&R	3,000,000
(2) Project pumping power	1,000,000
(3) Labor resources displayed and subsequently unemployed	500,000
B. Losses in output resulting from external diseconomies. Examples include:	
(1) Diseconomies of scale in subsequent processing for displaced activities	500,000
(2) Increased transportation costs as result of road relocation	1,000,000
Total adverse effects	6,000,000
Net beneficial effects	2,000,000

Source: Principles and Standards, 1973

TABLE 4: BENEFICIAL AND ADVERSE EFFECTS FOR A PLAN
(USE ADDITIONAL TABLES FOR EACH ALTERNATIVE PLAN)

Environmental Quality

Components	Measures of effects
Beneficial and adverse effects:	
A. Open and green space, wild and scenic rivers, lakes beaches, shores, mountains and wilderness areas, estuaries, and other areas of natural beauty.	Example include: 1. Create lake with 3,500 surface acres, 70 miles of shoreline, and depth of 80 feet, with high quality water and excellent access. 2. Create 600 acres of open and green space along creek, 1,000 to 1,500 feet wide, with good access and located 4 miles from city. 3. Inundate 3,500 acres of open and green green space, 10 miles long and 1/2-mile wide, located along stream and near city.
B. Archeological, historical biological, and geological resources and selected ecological systems.	Example include: 1. Preserve recognized historical archeological feature and enhance access to feature. 2. Enhance wildlife habitat by acquisition of 500 acres mixed forest, pastureland; construction of three small ponds with 50 surface acres expected to maintain duck and pheasant population of 5,000 and 10,000 birds respectively. 3. Disrupt 3,000 acres of wildlife habitat due to interior access roads and adjacent picnicking and camping sites, with possible decrease in deer, pheasant, and duck population.
C. The quality of water, land, and air resources.	Example include: 1. Meet State water quality standards over 200 miles of stream below reservoir. 2. Enhance esthetic appeal of land adjacent to reservoir by selected clearing and enhance visual enjoyment by unique design and location of access roads. 3. Prevent erosion by provision of 500 acres of grassed waterways and implementation of crop rotation practices on 5,000 acres of land. 4. Increase salt concentration over 50 miles of stream from X p.p.m. to Y p.p.m. due to salt load in return flows.

TABLE 4: BENEFICIAL AND ADVERSE EFFECTS FOR A PLAN (USE ADDITIONAL TABLES FOR EACH ALTERNATIVE PLAN) (Continued)

	5. Increase erosion over 2,000 acres due to access road borrow pits and denuded recreation sites as a result of expected concentrated use; silt downstream of reservoir estimated to increase X tons per year.
D. Irreversible commitments of resources to future uses.	Example include: 1. Preserve low cost reservoir site by recommending development of well field for municipal water supply at slightly greater cost to the national economic development objective. 2. Reservoir is to be located at site with some unique species of plants and wilderness qualities due to limited access but which is a very efficient reservoir site.

Source: Principles and Standards 1973.

so forth. The actual display of accounts in government agency planning documents tends to be much more complex than the oversimplified version in Tables 3 and 4.

After these accounts are completed the process of using the sort charts can occur and the eliminations and iterations performed until a viable plan is selected. At this point, it is indicated in the Principles and Standards that the planners should display the differences between the selected plan and the rejected alternatives. Table 5 is the example given in the Principles and Standards to illustrate this procedure. Since this Coarse Sort System deals with the sort charts rather than the accounts, this last aspect of the procedure, i.e., displaying the differences between the plans in an account, is not illustrated in the example which follows. The tables which define each alternative do contain the differences, however.

Application of the Coarse Sort System

In order to illustrate the Coarse Sort System and use of the sort charts, a hypothetical reservoir project will be studied. The project is based on one proposed for Arcadia Lake, Deep Fork River, Oklahoma by the Tulsa District of the Corps of Engineers. Only the elements of the project directly related to the Coarse Sort procedure will be described such as the amount of water stored and the total cost of the project. In other words, the specific design specifications of a dam will not be considered.

The project originally called for one multipurpose reservoir but other alternatives were examined. The data available for the project is not sufficient to illustrate the Coarse Sort System so some of it has been

TABLE 5: SUMMARY COMPARISON OF TWO ALTERNATIVE PLANS
(USE ADDITIONAL TABLE FOR EACH RELEVANT COMPARISON)

Account	Plan B	Recommended plan	Difference (recommended plan minus Plan B)
National Economic Development:			
Beneficial effects-------	$5,000,000	$8,000,000	+$3,000,000
Adverse effects----------	5,000,000	6,000,000	+ 1,000,000
Net beneficial effects---	0	2,000,000	+ 2,000,000
Environmental Quality: (Use same component stubs for beneficial and adverse effects as illustrated in Table 4. Examples follow.)			
Beneficial and adverse effects:			
A. Open and green space, lakes	A. Create lake with 3,000 surface acres, 60 miles of shoreline and depth of 70 feet with high quality water and excellent access	A. Create lake with 3,500 surface acres, 70 miles of shoreline and depth of 80 feet with high quality water and excellent access.	A. Create larger lake by 500 surface acres, 10 miles of shoreline and 10 feet of depth. Either plan would have high quality water and excellent access.
		Inundate 3,500 acres of open and green space, 10 miles long and 1/2 mile wide, located along stream and near city.	Inundate 3,500 acres of open and green spece, 10 miles long and 1/2 mile wide, located along stream and near city.
B. Archeological resources:	B. Inundate recognized historical archeological feature.	--------------	B. Do not inundate recognized historical archeological feature.

Source: <u>Principles and Standards</u>, 1973.

fabricated*. The components which are used for this study for purposes of comparison are the acre-feet of water stored for various purposes, the water supply yield, surface acres for recreation, acres of flood plain protected, total project costs, total average annual benefits, net annual benefit, the size of the dams and spillways, and a delineation of the beneficial and adverse effects related to environmental quality. Tables 7 through 14 briefly list the components of the various alternatives considered for the Arcadia project and the beneficial and adverse effects associated with them. The results are displayed on sort charts and a discussion of how to use them for this project accompanies the charts.

The Arcadia Lake Project

A water resources project was planned for the Arcadia area of the Deep Fork River in northeast Oklahoma County. Its purposes are to provide water supply, flood control, and recreational opportunities. The reasons given for developing the project are traditional. The nearby city of Edmond had experienced a 95 percent growth in population between 1960 and 1970, annual flood damages for the Deep Fork River area are $1,186,190, and 66,800 acres of flood plain are subject to periodic inundation. Edmond's present water supply comes from 22 wells, which can provide five million gallons a day (mgd). Many of these wells are old and inefficient. The rate of population growth in the area, and the need for replacement

---

* Fabricated data is denoted by an asterisk.

water supplies, necessitates some method for supplying water from a surface water facility. The additional benefits from flood control and recreation included in some of the alternatives are a bonus for the area.

Eight alternatives are listed including the no action plan. They are

Alternative A - Mainstem Lake on the Deep Fork River

Alternative B - Downstream Mainstem Lake on the Deep Fork River

Alternative C - Tributary Water Supply and Recreational Lakes on Coffee and Captain Creeks

Alternative D - Dry Lake in Conjunction with Tributary Water Supply and Recreation Lakes

Alternative E - Tributary Multipurpose Lakes on Coffee and Captain Creeks

Alternative F - Levees in Conjunction with the Two Tributary Water Supply and Recreation Lakes

Alternative G - Flood Plain Acquisition in Conjunction with the Two Tributary Water Supply and Recreation Lakes

Alternative H - No action.

Table 6 contains comparison information for all of the plans. Of the eight plans suggested, one, the no action alternative, has no water supply function, four have no flood control storage. The methods used by the Corps of Engineers to calculate benefits and costs resulted in positive net benefits for only one of the alternatives. This problem can be overcome, as far as decision-making is concerned, by the paragraph in the <u>Principles and Standards</u> which states:

> A recommended plan must have net national economic development benefits unless the deficiency in net benefits for the national economic development objective is the result of benefits foregone or additional costs incurred to serve the environmental quality objective. In such cases, a plan with a less than unity benefit-cost balance may be recommended as long as the net deficit does not exceed the benefits foregone and the additional costs incurred for the environmental quality objective. A Departmental Secretary or head of an independent agency may make an exception to the net

TABLE 6: A COMPARISON OF THE EIGHT ALTERNATIVES

Plan Name	Total Storage acre-ft	Flood Storage acre-ft	Conservation Storage acre-ft	Recreation surface acres	Water Supply Yield mgd	Flood Plain Protection acres	Net Annual Benefit	Total Costs x 1000	Dam Size(s) in feet
Alternative A	96,340	27,100	63,040	3157	10.8	23,470	93,200	41,987	6000
Alternative B	126,730	32,760	85,290	4214	14.8	20,170	-128,800	56,253	7600
Alternative C	57,480	N/A	52,350	3115	8.0	N/A	-763,800	41,990	3700 4600
Alternative D	90,780	27,100	52,350	3115	8.0	23,470	-2,076,100	67,911	4700 3700 4600
Alternative E	78,360	20,800	52,350	3115	8.0	41,490	-777,900	45,550	4700 4000
Alternative F	57,480	N/A	52,350	3115	8.0	8,400	-944,400	53,115	3700 4600
Alternative G	57,480	N/A	52,350	3114	8.0	10,280	-1,494,100	57,788	3700 4600
Alternative H	-	-	-	-	-	-	-	-	-

Source: U.S. Dept. of the Army. 1975b. Draft ... environmental impact statement, Arcadia Lake....

benefits rule if he determines that circumstances unique to the plan formulation process warrant such exception.

There are many areas of agricultural land in the drainage area of the project and runoff from this land will cause a eutrophication problem in any reservoir on the Deep Fork River. Urban runoff is also contributed to the river from Oklahoma City.

Although there are other recreational lakes and parks in the Oklahoma City area, only one of them is in this vicinity of the County. The Deep Fork River is used for fishing now but the opportunities for both fishing and hunting will be increased by a lake project. The plans included a provision for fish and wildlife management.

An adverse effect of any of the alternatives which include either one or two lakes is the necessity to move portions of major roadways, specifically two interstates. It will also be necessary to move railroad lines for Alternatives A, B, and D.

The two lake system provides less water for supply and recreation, and Captain Creek is further from Edmond, which needs the water, than the larger reservoir. This system will provide cleaner water because the tributaries are less subject to degradation of water quality than the Deep Fork River itself.

The large reservoir alternatives will destroy a school district and inundate 45 homes, 50 graves, and three archeological sites. The smaller tributaries will inundate a cemetary and displace 20 families*, and Coffee Creek will cover six oil and gas wells. They will not disrupt the school district.*

The environmental effects of the alternatives are listed on Tables 7 through 14. The more significant aspects are the loss of terrestrial habitat, the additional aquatic habitat which will enlarge the wintering ground for the rare peregrine falcon, some erosion control and some erosion damage, and stability of the downstream ecosystem if flooding is controlled.

Two simplified sort charts for the Arcadia project are in Tables 15 and 16, one for each objective. The ranks were taken from the information in the comparison table for water supply, flood protection, recreation, terrestrial habitat and aquatic habitat. Among the numbers, one is good and eight is bad. The EQ rankings were done on a "least destructive" or "most creative" basis. For terrestrial habitat two rankings were summed to obtain the terrestrial ranking. The two components used were total storage with the most acre-feet taken as the most destructive, and flood protection, with the most acres protected taken as the least destructive. The results of this procedure were as follows in Table 17.

Water quality was judged from the descriptions given with the alternatives. The two tributary lakes are in less urbanized areas and have cleaner water than lakes directly on the Deep Fork River. Archeological resources were, for this instance, a guess, since the only information given on them in the project stated that Alternative A would inundate three of the 16 in the area. Increased growth was based on water supply and flood protection by examining the two columns on the comparison table.

The comparison of the rankings on the the two charts is shown in Table 18. It is at this point that trade-offs and compromises begin. Examination of the results would suggest that in terms of the objectives for water supply, flood control and recreation, Alternative H should be

TABLE 7

PLAN A - MAINSTEM LAKE

Total Acre Feet of Storage	96,340
conservation pool	63,040
flood control pool	27,100
sediment reserve	6,200
Yield	10.8 mgd
Surface Areas for Recreation	3,160
Flood Plain Protection, Acres	23,470
Total Project Costs	$41.987,000
Total Average Annual Benefits	$ 2,698,100
Net Annual Benefit	$93,200

Dam Size: 600 feet; 200 foot spillway

Beneficial Effects

1. flood plain protection
2. provide recreation opportunities
3. increase the size of the aquatic habitat
4. enhance the winter range of the rare peregrine falcon
5. decrease stream turbidity
6. reduce downstream channel erosion
7. increase fishing and hunting opportunities
8. provide a higher level of watershed control from land acquisition and reduced artificial and natural pollution
9. improve downstream water quality by reducing metals and nutrients
10. stabilize downstream habitats and develop downstream ecological climax communities
11. create an aesthetic lake
12. induce a higher quality of wildlife habitat adjacent to the lake
13. increase the quantity of surface water storage
14. increase property values in the area
15. encourage population, business and economic growth
16. reduce upstream erosion
17. reduce potential for downstream flood induced erosion.

TABLE 7 PLAN A - MAINSTEM LAKE (Continued)

Adverse Effects

1. destroy terrestrial habitats
2. loss of agricultural land
3. erosion by wave action, on the shoreline and downstream below the dam
4. create eutrophic conditions in the lake due to the presence of nutrients, notably nitrogen and phosphorus, and to the effects of light and temperature
5. if lake level fluctuates, upstream erosion will increase
6. degradation to the lake and land area by the increase in visitors for recreation purposes
7. excessive amounts of phenols, total dissolved solids, coliforms, ammonia and manganese
8. aesthetic problems with iron and manganese
9. thermal stratification will require selective withdrawal
10. relocate 45 families
11. inundate 50 graves
12. inundate a school district, and possibly one building; it will have to cease functioning
13. inundate 12.4 miles of river; 16.2 miles when flood pool is full
14. relocate: 3.82 miles of highways and roads
    6.21 miles of railroads
    11.8 miles of oil and gas pipelines ,utilities
15. inundate 3 archeological sites
16. contamination of groundwater near lake due to stratification

TABLE 8

PLAN B - MAINSTEM LAKE AT COFFEE CREEK-DOWNSTREAM

Total Acre Feet of Storage	126,730
conservation pool	85,290
flood pool	32,760
sediment reserve	8,860
Yield	14.8 mgd
Surface Acres for Recreation	4214
Flood Plain Protection, Acres	20,170
Total Project Costs	$56,253,000
Total Average Annual Benefits	$ 3,302,200
Net Annual Benefit	$ 128,800

Dam Size: 7600 feet; 300 foot spillway

Beneficial Effects

1. same as Alternative A numbers 1 through 17, and
2. better water quality in the lake and downstream because Coffee Creek is cleaner

Adverse Effects

1. destroys more terrestrial habitat (than Alternative A)
2. loss of more agricultural land inundated than Alternative A
3. loss of 3 oil and gas wells
4. same as Alternative A numbers 1, 3 through 9, 11 through 13, 15 and 16.
5. relocate 40 families*
6. relocate 3 miles of highways and roads*
   8 miles of railroads*
   12 miles of oil and gas pipelines*
7. inundate 2 archeological sites*

TABLE 9

PLAN C - TRIBUTARY WATER SUPPLY AND RECREATION LAKES ON COFFEE AND CAPTAIN CREEKS

Total Acre Feet of Storage	57,480
conservation pools	52,350
flood control pools	None
sediment reserves	5,130
Yield	8.0 mgd
Surface Acres Recreation	3115
Flood Plain Protection, Acres	None
Total Project Costs:	$41,990,000
Total Average Annual Benefits	$ 1,915,500
Net Annual Benefit	$ 763,800

Dam Sizes: 3700 feet and 4600 feet; one 100 foot spillway

Beneficial Effects

1. environmental effects similar to Alternatives A and B, numbers 1 through 17, and
2. better water quality in the lake on Coffee Creek
3. less terrestrial habitat loss
4. will encourage growth but to a lesser extent than Alternatives A and B
5. beneficial effects of recreation and water supply less than Alternatives A and B
6. less aquatic habitat created than in Alternatives A and B

Adverse Effects

1. environmental effects similar to Alternatives A and B, numbers 1 through 9, and
2. Captain Creek is further from an urban area
3. have to cap 7 oil and gas wells*
4. no flood protection
5. no erosion control downstream
6. relocate 30 families*
7. relocate pipelines,utilities*
8. relocate 12 miles of roads*
9. relocate a cemetary*

TABLE 10

PLAN D - DRY LAKE IN SAME LOCATION AS ALTERNATIVE A WITH TWO TRIBUTARY LAKES FOR WATER SUPPLY AND RECREATION AS IN ALTERNATIVE C

Total Acre Feet of Storage	90,780
conservation pools	52,350
flood control pool	27,100
sediment reserve	5,130 (2 lakes) 6200 (dry lake)
Yield	8.0 mgd
Surface Acres for Recreation	3115
Flood Plain Protection, Acres	23,470
Total Project Costs	$67,911,000
Total Average Annual Benefits	$ 2,196,500
Net Annual Benefit	$-2,076,100

Dam Size: 4700 feet for the dry lake; 200 foot spillway
3700 feet and 4600 feet, one 100 foot spillway

Beneficial Effects

1. similar to Alternative C and Alternative A, numbers 1 through 17, and
2. adds flood protection
3. increases euryhydric species
4. reduces channel erosion

Adverse Effects

1. same adverse effects as Alternative C for the two lakes
2. same as Alternative A. numbers 1 through 9, and
3. no permanent flood pool
4. more frequent and intense water fluctuations
5. no stable aquatic or terrestrial system with dry lake
6. creates mud flats, less aesthetic
7. overall greater than alternatives A, C, and C

TABLE 11

PLAN E - TWO TRIBUTARY MULTIPURPOSE LAKES ON COFFEE AND CAPTAIN CREEKS

Total Acre Feet of Storage	78,360
conservation pools	52,350
flood control pools	20,800
sediment reserve	5,130
Yield	8.0 mgd
Surface Acres for Recreation	3115
Flood Plain Protection, Acres	23,470 partial
Total Project Costs	$45,550,000
Total Average Annual Benefits	$ 2,168,500
Net Annual Benefit	$- 777,900

Dam Size: 4700 feet with 100 foot spillway; 4000 feet

Beneficial Effects

1. similar to Alternative C, and
2. flood protection (partial)
3. reduce downstream channel erosion, but less than Alternatives A and B

Adverse Effects

1. same as Alternative C, and
2. lose more terrestrial habitat

TABLE 12

PLAN F - LEVEES WITH TWO TRIBUTARY LAKES FOR WATER SUPPLY AND RECREATION ON COFFEE AND CAPTAIN CREEKS

Total Acre Feet of Storage	57,480
conservation pools	52,350
flood control pool	None
sediment reserve	5,130
Yield	8.0 mgd
Surface Acres for Recreation	3115
Flood Plain Protection, Acres	downstream for 6300 acres from levees for 8400 acres
Total Project Costs	$53,115,000
Total Average Annual Benefits	$ 2,080,400
Net Annual Benefit	$- 944,400

Dam Size: 3700 feet with a 100 foot spillway; 4600 feet

Beneficial Effects

1. same as Alternative C , and
2. create wetlands
3. enhance water fowl habitat
4. added flood protection for mainstream reach of river

Adverse Effects

1. same as Alternative C , and
2. levees change flow characteristic of river
3. levees add to peak flow downstream
4. loss of river banks and species
5. increase upstream and downstream erosion due to channelization
6. increase brine pollution from oil fields

TABLE 13

PLAN G - FLOOD PLAIN ACQUISITION WITH TWO TRIBUTARY LAKES ON COFFEE AND CAPTAIN CREEKS FOR WATER SUPPLY AND RECREATION

Total Acre Feet of Storage	57,480
conservation pools	52,350
flood control pool	None
sediment reserves	5,130
Yield	8.0 mgd
Surface Acres for Recreation	3115
Flood Plain Protection, Acres	5860 in fee 4420 in easements
Total Project Costs	$57,788,000
Total Average Annual Benefits	$ 2,078,600
Net Annual Benefit	$-1,494,100

Dam Size: 3700 feet with a 100 foot spillway; 4600 feet

Beneficial Effects

1. same as Alternative C, and
2. prevent losses to future structures, agriculture and land rentals
3. prevent downstream flood damage

Adverse Effects

1. same as Alternative C, and
2. no increased land utilization
3. relocate people in high hazard area
4. relocate or abandon all commercial and industrial opportunities
5. no crops or livestock

TABLE 14

PLAN H - NO PROJECT OR THE NO ACTION ALTERNATIVE

Total Storage in Acre Feet	None
conservation pools	None
flood control pool	None
Yield	None
Surface Acres for Recreation	Normal stream
Flood Plain Protection, Acres	None
Total Project Costs	None
Total Average Annual Benefits	None from a project
Net Annual Benefits	None

No Dams or Spillways

Beneficial Effects

1. no inundation of agricultural and grazing lands
2. no loss of terrestrial habitat
3. retain natural stream beds
4. no relocation of families, roads, or graves
5. retain school district

Adverse Effects

1. no flood control
2. no added recreation
3. no water supply
4. no increase in aquatic habitat for the peregrine falcon

TABLE 15: NATIONAL ECONOMIC DEVELOPMENT SORT CHART FOR THE ARCADIA LAKE PROJECT

Plan Name	Water Supply	Flood Protection	Recreation	Increased Growth	Total	Rank
Alternative B	1	4	1	1	7	1
Alternative A	2	2.5	2	2	8.5	2
Alternative E	5	1	5	3	14	3
Alternative D	5	2.5	5	5	17.5	4
Alternative G	5	5	5	5	20	5
Alternative F	5	6	5	5	21	6
Alternative C	5	7.5	5	7.5	25	7
Alternative H	8	7.5	8	7.5	31	8

TABLE 16: ENVIRONMENTAL QUALITY SORT CHART FOR THE ARCADIA LAKE PROJECT

Plan Name	Terrestrial Habitat	Aquatic Habitat	Water Quality of Lakes	Archeological Resources	Total	Rank
Alternative B	6	2	6	6	20	6
Alternative A	8	1	7	7.5	23.5	8
Alternative E	7	6	2.5	3.5	19	4.5
Alternative D	3.5	3	5	7.5	19	4.5
Alternative G	1	4	2.5	3.5	11	1
Alternative F	5	6	2.5	3.5	17	3
Alternative C	2	6	2.5	3.5	14	2
Alternative H	3.5	8	8	1	20.5	7

TABLE 17: CALCULATIONS FOR TERRESTRIAL HABITAT

	Total Storage	Flood Protection	Total	Rank
Alternative A	7	2.5	9.5	6
Alternative B	8	4	12	8
Alternative C	3	7.5	10.5	7
Alternative D	6	2.5	8.5	3.5
Alternative E	5	1	6	1
Alternative F	3	6	9	5
Alternative G	3	5	8	2
Alternative H	1	7.5	8.5	3.5

TABLE 18: COMPARED RANKINGS

	NED	EQ
Alternative B	1	6
Alternative A	2	8
Alternative E	3	4.5
Alternative D	4	4.5
Alternative G	5	1
Alternative F	6	3
Alternative C	7	2
Alternative H	8	7

eliminated. Of the remaining alternatives, E and D have similar rankings for both the NED and EQ objectives and would probably be the easiest with which to work.

Alternative D includes a dry lake for flood control the size of Alternative A's flood pool and the two tributary lakes on Coffee and Captain Creeks for water supply, like the lakes in Alternative C. Alternative E is a variation of Alternative C which adds flood control pools to the two lakes making them beneficial for all purposes: water supply, flood control and recreation.

A close examination of the two alternatives reveals that the total cost of Alternative E is over $20 million less than Alternative D. Alternative E provides more flood plain protection, although it has less total storage, and it also has a higher net annual benefit than Alternative D although both of their net annual benefits are negative. Environmentally, Alternative E has a greater loss of terrestrial habitat, and Alternative D more problems with water quality if the flood waters in the dry lake are considered, and a greater loss of archeological sites. They both provide the same water supply and recreational benefits, and alternative E would encourage more economic growth. Based on the objectives of the project, water supply, flood control and recreation, of these two alternatives, Alternative E, two multipurpose tributary lakes, would appear to be the best choice.

If further study is necessary because Alternative E does not supply as much water as Alternatives A and B, then the planners would start with Alternative E and look at either Alternative A or B for a water supply compromise. Both Alternatives A and B, and Alternative D which was just eliminated, have lakes on the Deep Fork River which will be eutrophic. Since this solution was not recommended, the planners will have to try another approach or settle for less water supply from this project and perhaps look at the ground water resources and new technologies for extraction.

CHAPTER FOUR

CONCLUSIONS

The present requirements for water resources planning as set forth in the Establishment of Principles and Standards for Planning Water and Related Land Resources (the Principles and Standards) in 1973 include an environmental analysis as well as the traditional benefit-cost approach. There are also specified six procedures which should be pursued in the development of a plan one of which is the stipulation that more than one alternative be proposed. The strong emphasis on environmental quality and the need to develop more than one plan to fulfill a perceived need are innovative in the field of water resources planning. In addition to these new aspects is a third one, public input or participation, which is supposed to be solicited throughout the planning process.

In order to cope with these innovations, a new approach to planning is necessary. In water resources planning there was a traditional reliance on a benefit-cost model to accomplish the planning function. This kind of model required quantitative data and very little thought was given to the possible environmental effects of a project because they did not have to be calculated. Now they must be, but in a qualitative manner which necessitates the development of models which can handle both quantitative and non-quantitative information. The two kinds of data are displayed in two separate accounts in the new system. The traditional, quantitative benefit-cost analysis in the national economic development account and the qualitative, environmental analysis in the environmental quality account.

The purpose of this study was to devise a simple, non-mathematical model which would formalize and conform with the present requirements for water resources planning. This meant that the model had to be capable of reducing a large number of possible alternative solutions for a project to a feasible few. It also had to cope with both quantitative and qualitative data and be able to evaluate both. The Coarse Sort System with the aid of sort charts does fulfill this need.

Before the sort charts can be used, part of the formal planning process must have taken place. The need for the water resources project must have been recognized, some possible solutions conceived, data gathered for both a national economic development emphasis and an environmental quality emphasis by two highly qualified teams of experts, and alternative plans formulated for each emphasis and ranked according to how close they came to both meeting the needs of the project and the particular emphasis. At this point the ranked plans can be placed on sort charts, and all but the most feasible plans eliminated. Then a process of trade-offs and compromises occurs until a final plan acceptable to the public is presented. The public's feelings on the matter are considered all the way through the procedure.

The test used here, the Arcadia Reservoir project, was designed to illustrate the use of the sort charts and did not use some of the components mentioned in the formal process. The Arcadia project was developed by the Corps of Engineers but not at a time when they were required to develop both the national economic development and environmental quality accounts. As a result, the information for the test came from an environmental impact statement which contained part of the benefit-cost analysis but only a semblance of an environmental quality account. There was also an inadequacy of data in the statement which necessitated the fabrication of some of the information used for the testing process. The reason the test was not performed on a properly prepared document is that one was not available.

Another component of the planning process that may not meet the standards set in this study is the team that developed the plans for the Arcadia project. Although the Corps of Engineers does have experts in many fields on its staff, since the two different accounts were not developed for this project, the teams would not have functioned as required in the Coarse Sort process. There should never be the discrepencies and holes in the data that occur in the Arcadia Reservoir impact statement.

A third component lacking in this study is public participation. Perhaps the ease with which the sort chart procedure was demonstrated would not have been possible if the voice of the public had been heard. An adequate test of the Coarse Sort Model, therefore, requires that it be applied directly to an ongoing planning process from beginning to end. It would probably require at least two years to validate this model in an actual procedure including the planning process and public participation.

With respect to the Coarse Sort System, the Arcadia Reservoir project, on which the model was tested, was fairly easy to handle using the sort charts. A more complicated project would require more trade-offs between the national economic development and environmental quality objectives and more iterations, but the same basic method could be used, at least for the preliminary aspects of the planning process. If public input or the finer points of plan development demanded more detailed study, then a more sophisticated system of sort charts would have to be developed, or some other method used.

It is possible that the Coarse Sort System concept could be applied to other types of planning processes, not just water resources, where alternatives have to be developed and ranked and where the environmental effects of the project must be considered. Housing developments, pipelines, sanitary landfills, wastewater treatment plants, highway projects and so on could all adapt this system for their own use. There would have to be modifications made for each type of project but the basic idea could be used.

It appears possible that the Coarse Sort System and the sort chart method could be computerized. The computer could do its own calculations and ranking for the national economic development objective. The environmental quality information might have to be fed in. After the rankings were figured out, an analysis of variance could be run on them to determine which ones fell within a certain limit. It could be that the best solution would be found among those within the limit. It would take some manipulation to match the environmental quality objective to the national economic development objective but someone might find it challenging to try.

Although the present approach to water resources planning requires a lot more time and effort on the part of the planners, at least it recognizes the fact that environmental quality has been neglected in the past. This country has reached the point where our national resources have become scarce commodities and unchecked development of any kind at the expense of a resource demands second thoughts and serious consideration. There are also projects that the public may be unwilling to accept or pay for and this, too, is now recognized as a component that must be taken into account.

It has not been easy to effect the enlightened outlook of the planning process, nor have the various planning agencies come up with final solutions as to how to implement the Principles and Standards. If nothing else, though, it does make them consider other than the usual benefit-cost approach to the planning of a project. Non-structural alternatives, fewer increments, and flood plain acquisition may start making inroads into planning alternatives. The possibilities for creativity are unlimited.

The Coarse Sort System fits in with the enlightened approach quite well. It uses the formal process of plan formulation mentioned in the six steps in Chapter Two. It also forces the planning teams to be innovative and creative both in formulating their own alternative plans and in effecting trade-offs and compromises. The sort charts help to communicate the planning process to the public and the System itself requires continuous public input in order to work effectively. It remains to be tested on an on-going situation.

BIBLIOGRAPHY

1. Badger, Daniel D. 1966. Recreational aspects of upstream reservoirs. A paper presented at the 16th Annual meeting of the Oklahoma Section, American Society of Agricultural Engineers, 28 October 1966.

2. Barbour, Edmund. 1975. Multiobjective water resource planning. Paper presented at the Second World Congress on Water Resources, New Delhi, India.

3. Bhutani, Joginder, Holberger, Richard, Spewak, Peter, Jacobsen, Willis E., and Truett, J. Bruce. 1975. Impact of hydrologic modifications on water quality. Washington, D. C.: US Environmental Protection Agency, Office of Research and Development.

4. Brown, Carl, Monks, Joseph G., and Park, James R. 1973. Decision-making in water resource allocation. Toronto: D. C. Heath and Co.

5. Burke, Roy III, Dee, Norbert, Drobny, Neil L., Manty, Dale, and Whitlatch, Earl. 1975. Water resource planning methodologies . . . an update. Paper presented at 1975 ASCE Specialty Conference, Fort Collins, Colorado, 9-11 July.

6. Caulfield, Henry P., Steele, Harry A., and Johnson, Sam H. III. 1974. Manual for training in the application of the Principles and Standards of the Water Resources Council. Fort Collins, Colorado, Colorado State University.

7. Eskstein, Otto. 1958. Water resource development: the economics of project evaluation. Cambridge, Mass: Howard University Press.

8. Economic Systems Corporation, 1970. A multi-phasic component study to predict storm water pollution from urban areas. Washington, D. C.: U. S. Department of the Interior. Office of Water Resources Research.

9. Gold, Charles R., McEvoy, James III, and Richerson, Peter, J., editors. 1973. Environmental quality and water development. San Francisco: W. H. Freeman and Company.

10. Heady, Earl O., et. al. 1972. Agricultural and water policies and the environment. Ames, Iowa: Iowa State University. Center for Agricutural and Rural Development.

11. James, L. Douglas and Lee, Robert R. 1971. Economics of water resources planning. New York: McGraw-Hill Book Company.

12. Johnson, William K. 1974a. Approaches for developing alternatives in planning. Water Resources Bulletin, Vol. 10, no. 5.

13. Johnson, William K. 1974b. Creativity and rationality in plan formulation. Water Resources Bulletin, Vol. 10, no. 3.

14. Kneese, Allen V. 1959. Water resources: development and use. Kansas City: Federal Reserve Bank of Kansas City.

15. Kormondy, Edward J. 1976. Concepts of ecology, 2nd edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

16. Lamm, Frank T. 1975. Apply environmental impact statements to metropolitan area water resource projects. American Water Works Association. Proceedings, 95th Annual Conference. Minneapolis, Minn: Denver.

17. Linsley, Ray K., and Franzini, Joseph B. 1972. Water resources engineering, 2nd edition. New York: McGraw-Hill Book Company.

18. Loehr, Raymond C. 1974. Characteristics and comparative magnitude of nonpoint sources. Journal of the Water Pollution Control Federation, vol. 46, no. 8.

19. Maas, Arthur, Hufschmidt, Maynard M., Dorfman, Robert, Thomas, Harold A., Jr., Marglin, Stephen A., and Fair, Gordon, M. 1962. Design of water-resource systems. Cambridge, Mass: Harvard University Press.

20. McCaull, Julian and Crossland, Janice. 1974. Water pollution. Scientists' Institute for Public Information, San Francisco: Harcourt Brace Javanovich, Inc.

21. Mckee, Jack E., and Wolf, Harold W., editors. 1973. Water quality criteria, 2nd Edition. Sacramento, California: State Water Resources Control Board.

22. Michalson, Edgar L., Engelbert, Ernest A., and Andrews, Wade, editors. 1974. Multiple objective planning for water resources. 2 volumes. Proceedings of the University's Council on Water Resources Workshop on Multiple Objective Planning and Decision-Making, Las Vegas, Nevada, 16-18 July. Moscow, Idaho: Idaho Research Foundation, Inc.

23. Miller, William H. 1975. Evironmental impact statements . . . effect on water resources projects. American Water Works Association, 95th Annual Conference Proceedings. Minneapolis, Minn.:Denver.

24. Morgan, Arthur E. 1971. Dams and other disasters. Boston, Mass.: Porter Sargent Publishers.

25. National Water Commission, 1973. New directions in U. S. Water Policy. Washington, D. C.: Government Printing Office.

26. National Water Commission. 1973. Water policies for the future. Washington, D. C.: Government Printing Office.

27. Nemerow, Nelson L. 1974. Scientific stream pollution analysis. Washington, D. C.: McGraw-Hill.

28. Odum, Eugene P. 1971. Fundamentals of ecology, third edition. Philadelphia: W. B. Saunders Company.

29. O'Laoghaire, D. T. and Himmelblau, D. M. 1974. Optimal expansion of a water resources system. New York: Academic Press.

30. Reid, George W., and Law, Silas S.Y. 1973. A methodology for assessment of water resources development; a competitive evaluation model for water resources development planning. Norman, Oklahoma: Bureau of Water Resources Research.

31. Reid, George W., Southard, William R., et. al. 1969. The evaluation of water and related land resource projects: a procedural test. Norman, Oklahoma: Bureau of Water Resources Research.

32. Schaefer, Richard R. 1975. Multiobjective planning and project formulation: ASCE Annual Meeting Preprint 2630.

33. Smith, Stephen C. and Castle, Emery N., editors. 1964. Economics and public policy in water resource development. Ames, Iowa: Iowa State University Press.

34. Stone, Ralph and Smallwood, Herbert. 1973. Intermedia aspects of air and water pollution control. Washington D. C.: U. S. Environmental Protection Agency.

35. Southern Great Plains Research Watershed. 1976. Report to the coordinating committee on water resources research. Chickasha, Oklahoma: Oklahoma Agricultural Research Service.

36. Thomas, Nathan O. and Harbeck, G. Earl, Jr. 1948. Reservoirs in the United States. Geological Survey Water - Supply Paper 1360-A. Washington, D. C.: Government Printing Office.

37. Thorne, William. 1971. Land and water use. Symposium of the American Association for the Advancement of Science. Washington, D. C.

38. U. S. Congress. Senate. 1962. Policies, standards, and procedures in the formulation, evalution, and review of plans for use and development of water and related land resources. S. Doc. 97, 87th Congress, 2nd session.

39. U. S. Congress. Senate and House. 1969. National Environmental Policy Act of 1969, as amended. Public Law 91-190. S. 1075. 91st Congress.

40. U. S. Department of Agriculture. 1974. USDA procedures for planning water and related land resources in programs administered by the Soil Conservation Service. Washington D. C.

41. U. S. Department of the Army. Corps of Engineers. Tulsa District. 1975a. Draft environmental impact statement, Lukfata Lake, Glover Creek,Oklahoma. Tulsa, Oklahoma.

42. U. S. Department of the Army. Corps of Engineers. Tulsa District. 1975b. Draft updated and revised environmental statement, Arcadia Lake, Deep Fork River, Oklahoma. Tulsa, Oklahoma.

43. U. S. Department of the Interior. Bureau of Reclamation. 1972. Guidelines for implementing principles and standards for multiobjective planning of water resources. Review draft. Washington, D. C.

44. U. S. Department of the Interior. Bureau of Reclamation. 1967. Land classification techniques and standards. Denver, Colorado.

45. U. S. Environmental Protection Agency. 1971. Environmental impact of highway de-icing. Edison Water Quality Laboratory.

46. U. S. Environmental Protection Agency, 1973. Processes, procedures, and methods to control pollution from mining activities. Washington, D. C.

47. U. S. Environmental Protection Agency. 1973. Managing the environment. Washington, D. C.

48. U. S. Environmental Protection Agency. Office of Air and Water Programs. 1973. Methods for identifying and evaluating the nature and extent of nonpoint sources of pollutants. Washington D. C.

49. U. S. Water Resources Council. 1968. The Nation's water resources. Washington, D. C.

50. U. S. Water Resources Council. 1973. Principles and standards for planning water and related land resources. Federal Register, vol. 38., no. 174, part III, 10 September.

51. U. S. Water Resources Council. 1972. Summary/Analysis of public response to the proposed Principles and Standards for planning water and related land resources and draft environmental statement. Washington, D. C.

52. Warner, Maurice L. and Preston, Edward H. 1974. A review of environmental impact assessment methodologies. U. S. Environmental Protection Agency. Washington,D. C.: Office of Research and Development.

53. Warner, Maurice L., Moore, John L., Chatterjee, Samar, Cooper, David C., Qeadi, Christopher, Lawhon, William T., Reimers, Robert S. 1974. An assessment methodology for the environmental impact of water resource projects. Washington, D. C.: U. S. Environmental Protection Agency, Office of Research and Development.

54. Watt, Kenneth E. 1973. Principles of environmental science. New York: McGraw-Hill.

55. Whipple, W., Hunter, J. V. and Yu, S. L. 1974. Unrecorded pollution from urban runoff. Journal of the Water Pollution Control Federation, vol. 46, no. 5.

56. White, Gilbert F. 1969. Strategies of American water management. Ann Arbor, Michigan: The University of Michigan Press.

57. White, Gilbert F. and Cook, Howard L. 1962. Making wise use of flood plains. Science, Technology and Development, vol. 1: Natural Resources, Energy, Water and River Basin Development. Washington, D. C.: Government Printing Office.

58. Boffey, Philip M. 1976. "Teton Dam collapse: was it a predictable disaster?" Science, vol. 193, 2 July.

59. Gasparini, Catherine. 1976. "Teton Dam disaster: a case in point" National News Report of the Sierra Club, vol. 8, #21, 11 June.

60. "Idaho Dam breaks: thousands routed". Sunday Oklahoman, 6 June 1976, p. 1.

61. "Teton: eyewitness to disaster." Time, 21 June 1976, p. 56.

62. "Glover River faces new damming effort." Outdoor News, Oklahoma Wildlife Federation, July 1975, p. 1.

63. "Idaho Dam disaster" Los Angeles Times, 6 June 1976, p. 1.

64. Johnson, James. 1975. "Lukfata Dam site sparse on praise." Daily Oklahoman, 23 July, p. 7.

65. "Lukfata Dam hearing set for today." Daily Oklahoman, 22 July 1975, p. 7.

66. Oklahoma Wildlife Federation. 1975. Summary of task force analysis of draft environmental impact statement, Lukfata Dam, Glover River. (a mailing to members).

APPENDICES

APPENDIX A: GLOSSARY

acre-foot - a unit for measuring the volume of water, equal to the quantity of water required to cover 1 acre to a depth of 1 foot, and is equal to 43,560 cubic feet or 325,851 gallons.

aquifer - a body of earth material capable of transmitting water through its pores at a rate sufficient for water supply purposes.

beneficial use of water - the use of water for any purpose from which benefits are derived.

biochemical oxygen demand (BOD) - the quantity of oxygen utilized primarily in the biochemical oxidation of organic matter in a specified time and at a specified temperature.

biomass - the total weight of a population

biota - all the species of plants and animals occurring within a certain area.

bloom - a proliferation of living algae and/or other aquatic plants on the surface of lakes or ponds. Blooms are frequently stimulated by phosphate enrichment.

cfs - cubic feet per second, a measure of the amount of water passing a given point.

channelization - the straightening and deepening of streams to permit water to move faster, to reduce flooding or to drain marshy acreage for farming. However, channelization reduces the organic waste assimilation capacity of the stream and may disturb fish breeding and destroy the stream's natural beauty.

climax community - the theoretical ultimate stage of plant succession under a given set of environmental conditions; a stabilized condition of the dominant vegetation.

coliform organism - any of a number of organisms common to the intestinal tract of man and animals whose presence in waste water is an indicator of pollution and of potentially dangerous bacterial contamination.

conservation storage - storage of water for later release for useful purposes such as municipal water supply, power or irrigation in contrast to storage capacity used for flood control.

contamination - any introduction into water of micro-organisms, chemicals, wastes, or wastewater in a concentration that makes the water unfit for its intended use.

dam - a barrier constructed across a watercourse for the purpose of a) creating a reservoir, b) diverting water therefrom into a conduit or channel, c) creating a head which can be used to generate power, and/or d) improving river navigability.

damsite - a location where the topographical and other physical conditions are favorable for the construction of a dam, or any site where a dam has been built, is being built, or is contemplated.

decomposition - the breakdown of complex material into simpler substances by chemical or biological means.

deposition - the act or process of settling solid material from a fluid suspension.

dissolved oxygen (DO) - the amount of free (not chemically combined) oxygen in water.

dissolved solids - the total amount of dissolved material, organic and inorganic, contained in water or wastes. Excessive dissolved solids make water unpalatable for drinking and unsuitable for industrial uses.

drainage area - the area of a drainage basin or watershed, expressed in acres, square miles, or other unit of area. Also called catchment area, watershed, river basin.

drainage basin - an area from which surface runoff is carried away by a single drainage system, it consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

drawdown - the lowering of the surface elevation of a body of water resulting from the withdrawal of water therefrom.

easement - an acquired legal right to the use of land owned by others.

ecological impact - the total effect of an environmental change, either natural or man-made, on the ecology of the area.

ecology - the interrelationships of living things to one another and to their environment or the study of such interrelationships.

ecosystem - the interacting system of a biological community and its non-living environment.

ecological succession - as the ecosystem evolves, it becomes less suitable for some species and more suitable for other species eventually resulting in a change in the species composition of the lake.

effluent - a discharge of pollutants into the environment, partially or completely treated in its natural state. Generally used in regard to discharges into waters.

environment - the sum of all external conditions and influences affecting the life, development, and ultimately, the survival of an organism.

epilimnion - the upper layer of a body of water having thermal stratification that extends from the surface to the thermocline and has nearly uniform temperature.

erosion - the wearing away of the land surface by wind or water.

eutrophication - the process of overfertilization of a body of water by nutrients which produce more organic matter than the self-purification processes can overcome.

flood - 1) an overflow or inundation that comes from a river or other body of water and causes or threatens damage, 2) any relatively high streamflow over--topping the natural or artificial banks in any reach of a stream.

flood control capacity - that part of the gross reservoir capacity which, at the time under consideration, is reserved for the temporary storage of flood waters.

flood plain - a strip of relatively smooth land bordering a stream, built of sediment carried by the stream and dropped in the slack water beyond the influence of the swiftest current.

flood control storage - storage of water in reservoirs to abate flood damage.

food-web -- the inter-locking pattern of food from different trophic levels.

groundwater - the supply of freshwater under the earth's surface in an aquifer or soil that forms the natural reservoir for man's use.

habitat - the sum total of environmental conditions of a specific place that is occupied by an organism, a population or a community.

hardness - a characteristic of water, imparted by salts of calcium, magnesium, and iron such as bicarbonates, carbonates, sulfates, chlorides, and nitrates that causes curdling of soap and increased consumption of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable taste.

heavy metals - metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Metals that can be precipitated by hydrogen sulfide in acid solution, for example, lead, silver, gold, mercury, bismuth, copper.

hypolimnion - the lower level of a body of water having thermal stratification, which extends from the thermocline to the bottom and which is essentially removed from surface influence.

impoundment - a body of water, such as a pond, confined by a dam, dike, flood gate or other barrier, which is used for storage, regulation, and control of water

irrigation - the controlled application of water to arable lands to supply water requirements not satisfied by rainfall.

land use - (1) the culture of the land surface, which has a determining effect on the broad social and economic conditions of a region and which determines the amount and character of the runoff and erosion; (2) existing or zoned economic use of land, such as residential, industrial, farm, commercial.

levee - a dike or embankment, generally constructed on or parallel to the banks of a stream, lake, or other body of water, intended to protect the land side from inundation by flood waters or to confine the stream flow to its regular channel.

mgd - million gallons a day

multipurpose reservoir - a reservoir constructed and equipped to provide storage and release of water for two or more purposes such as flood control, power development, navigation, irrigation, pollution abatement, domestic water supply.

nutrients - elements or compounds essential as raw materials for organism growth and development; for example, carbon, oxygen, nitrogen and phosphorus.

pesticide - any substance or chemical applied to kill or control pests including weeds, insects, algae, rodents, and other undesirable agents.

phenols - a group of organic compounds that in very low concentrations produce a taste and odor problem in water. In higher concentrations they are toxic to aquatic life.

point source - a stationary source of a large individual emission, generally of an industrial nature.

pollutant - any introduced gas, liquid, or solid that makes a resource unfit for a specific purpose.

productivity - the amount of any specie or net production of living tissue in a species population.

pyritic material - formed of pyrite, a common mineral formed of iron disulfide which yields sulfur dioxide and sulfuric acid.

reservoir - a pond, lake, tank, basin or other space, either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water. Sometimes called an impoundment.

return flow - any flow of water that returns to a stream channel after diversion for irrigation or other purpose.

river basin - the total area drained by a river and its tributaries.

runoff - the portion of rainfall, melted snow or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to the receiving waters.

salinity - (1) the relative concentration of salts, usually sodium chloride, in a given water, (2) a measure of the concentration of dissolved mineral substances in water.

sediment yield - the amount of the eroded soil that is transported and deposited in a stream either as suspended sediment or settled bed material.

sedimentation - the process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.

silt - finely divided particles of soil or rock. Often carried in cloudy suspension in water and eventually deposited as sediment.

silting - the process of filling up or raising the bed of a body of water through deposition of sediment.

stream - a general term for a body of flowing water

stratification - separating into layers

spillway - a waterway in or about a dam or other hydraulic structure, for the escape of excess water

storage - the impounding of water, either in surface or in underground reservoirs, for future use.

thermal pollution - degradation of water quality by the introduction of a heated effluent.

thermal stratification (of a lake) - vertical temperature stratification that shows the following: the upper layer of the lake, the epilimnion, in which the water temperature is virtually uniform; the next stratum, the thermocline, in which there is a marked drop in temperature per unit of depth; the lowermost region, the hypolimnion, in which the temperature is nearly uniform.

thermocline - the layer, in a a body of water having thermal stratification for which the temperature difference is greatest per unit of depth. This layer separates the epilimnion from the hypolimnion.

topography - the configuration of a surface area including its relief, or relative elevations, and the position of its natural and man-made features.

total solids - the sum of dissolved and undissolved constituents in water or wastewater, usually stated in milligrams per liter.

total storage capacity - the volume of a reservoir below the maximum controllable level including dead storage, which is the storage below the most controllable level.

toxicity - the quality or degree of being poisonous or harmful to plant or animal life.

tributary - a stream or body of water, surface or underground, that contributes its water to another and larger stream or body of water.

trophic levels - the discrete energy levels which represent distinct types of biomass in a community.

turbidity - the cloudy condition of water due to suspended silt or finely divided organic matter.

urban runoff - storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes.

water pollution - the addition of sewage, industrial wastes or other harmful or objectionable material to water in concentrations or in sufficient quantities to result in measurable degradation of water quality.

water quality - the chemical, physical and biological characteristics of water with respect to its suitability for a particular purpose. The same water may be of good quality for one purpose or use, and bad for another, depending upon its characteristics and the requirements for the particular use.

watershed - all lands enclosed by a continuous hydrologic drainage divide and lying upslope from a specified point on a stream.

wetlands - swamps or marshes, especially as areas preserved for wildlife.

yield - the quantity of water, expressed as a rate of flow, that can be collected for a given use from surface or groundwater sources on a water.

Sources

1. Joint Editorial Board. 1969. Glossary: water and wastewater control engineering. N.P.: APHA,ASCE,AWWA and WPCF.

2. Rechard, Paul A. and McQuisten, Richard. 1968. Glossary of selected hydrological terms. Laramie, Wyoming: The University of Wyoming, Water Resources Research Institute.

3. Studdard, Gloria J., comp. 1974. Common environmental terms, a glossary. Washington, D. C.: U. S. Environmental Protection Agency.

APPENDIX B: A REVIEW OF CONGRESSIONAL ENACTMENTS AND EXECUTIVE ACTIONS

The Principles for Planning Water and Land Resources define the objectives of national economic development and environmental quality. These objectives provide the basis for the formulation of State, region, and river basin plans for the use of water and land resources to meet foreseeable short and long-term needs and have been explicitly stated or implied in numerous congressional enactments and Executive actions. The most notable of these actions in water and related areas are summarized below.

In the Flood Control Act of 1936, the Congress declared that benefits to whomsoever they may accrue of Federal projects should exceed costs. Interpretation of this statute has resulted in development of various analytical procedures to evaluate the benefits and costs of proposed projects. These procedures have centered around a national economic efficiency analysis and were first published as "Proposed Practices for Economic Analysis of River Basin Projects" in May 1950 and revised in May 1958. Budget Bureau Circular No. A-47 was issued on December 31, 1952, informing the agencies of considerations which would guide the Bureau of the Budget in its evaluations of projects and requiring uniform data that would permit comparisons among projects.

On October 6, 1961, the President requested the Secretaries of Interior, Agriculture, Army, and Health, Education and Welfare to review existing evaluation standards and to recommend improvements. Their report, "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources," was approved by the President on May 15, 1962, and published as Senate Document No. 97, 87th Congress, 2nd Session. This document replaced Budget Bureau Circular No. A-47 and in turn has been superseded by the "Principles for Planning Water and Land Resources", upon their approval by the President, and by these "Standards for Planning Water and Land Resources."

By enacting laws and taking actions enumerated below and others, the Congress and the Present have broadened the objectives to be considered in water and land resources planning.

The two objectives as defined in the principles and set forth in more detail in these standards provide a flexible planning framework that is responsive to and can accommodate changing national needs and priorities.

The statement of the objectives and specification of their components in these standards is without implication concerning priorities to be given to them in the process of plan formulation and evaluation. These standards, nonetheless, do recognize and make provision for a systematic approach by which the general public and decisionmakers can assess the relative merits of achieving alternative levels of satisfaction to the two objectives where there may be conflict, competition, or complementarity between them. This will provide the type of information needed to improve the public decisionmaking process.

Major Congressional Directives

Many laws that give new or more definitive directions to Federal participation in planning for water and land resources have been passed in recent years. Some major enactments are:

The Federal Water Project Recreation Act of 1965 (Public Law 89-72), provides for full consideration of opportunities for recreation and fish and wildlife enhancement in Federal projects under specified cost allocation and cost-sharing provisions.

The Water Resources Planning Act of 1965 (Public Law 89-80), establishes a comprehensive planning approach to the conservation, development and use of water and related land resources. The Act emphasizes joint Federal-State cooperation in planning and consideration of the views of all public and private interests. Section 103 of the Act provides that "The Council shall establish, after such consultation with other interested entities, both Federal and non-Federal, as the Council may find appropriate, and with the approval of the President, principles, standards, and procedures for Federal participants in the preparation of comprehensive regional or river basin plans and for the formulation and evaluation of Federal water and related land resources projects".

The Act further provides in section 102(b) that "The Council shall . . . maintain a continuing study of the relation of regional or river basin plans and programs to the requirements of larger regions of the Nation and of the adequacy of administrative and statutory means for the coordination of the water and related land resources policies and programs of the several Federal agencies; it shall appraise the adequacy of existing and proposed policies and programs to meet such requirements; and it shall make recommendations to the President with respect to Federal policies and programs."

The Act also provides in section 301(b) that "The Council, with the approval of the President, shall prescribe such rules, establish such procedures, and make such arrangements and provisions relating to the performance of its functions under this title, and the use of funds available therefor, as may be necessary in order to assure (1) coordination of the program authorized by this title with related Federal planning assistance programs, including the program authorized under section 701 of the Housing Act of 1954 and (2) appropriate utilization of other Federal agencies administering programs which may contribute to achieving the purpose of this Act."

The Public Works and Economic Development Act of 1965 (Public Law 89-136) establishes national policy to use Federal assistance in planning and constructing public works to create new employment opportunities in areas suffering substantial and persistent unemployment and underemployment. The Act provides for establishing Federal-State regional commissions for regions that have lagged behind the Nation in economic development.

The Water Quality Act of 1965 (Public Law 89-234) and subsequent amendments provides for establishing water quality standards for interstate waters. These water quality standards provide requirements and goals that must be incorporated into planning procedures.

In authorizing the Northeastern Water Supply Study in 1965 (Public Law 89-298), Congress recognized that assuring adequate supplies of water for the great metropolitan centers of the United States has become a problem of such magnitude that the welfare and prosperity of this country require the Federal Government to assist in solution of water supply problems.

The Clean Water Restoration Act of 1966 (Public Law 89-753) provides assistance for developing comprehensive water quality control and abatement plans for river basins.

The Department of Transporation Act of 1966 (Public Law 89-670) provides standards for evaluating navigation projects and provides for the Secretary of Transporation to be a member of the Water Resources Council.

The Wild and Scenic Rivers Act of 1968 (Public Law 97-542) provides that in planning for the use and development of water and related land resources consideration shall be given to potential wild, scenic, and recreational river areas in river basin and project plan reports, and comparisons are to be made with development alternatives which would be precluded by preserving these areas.

The National Flood Insurance Act of 1968 (title XIII, Public Law 90-448) provides that States, to remain eligible for flood insurance, must adopt acceptable arrangements for land use regulation in flood-prone areas. This provision, together with Executive Order 11296, August 10, 1966, places increased emphasis on land use regulations and administrative policies as means of reducing flood damages. Planning policies must include adequate provision for these new enactments and directives in an integrated program of flood-plain management.

The Estuary Protection Act of 1968 (Public Law 90-454) outlines a policy of reasonable balance between the conservation of the natural resources and natural beauty of the Nation's estuarine areas and the need to develop such areas to further the growth and development of the Nation.

The National Environmental Policy Act of 1969 (Public Law 91-190) authorizes and directs Federal agencies in the decision-making process to give appropriate consideration to environmental amenities and values, along with technical considerations. The results of this analysis are to be included in proposals for Federal action.

The Environmental Quality Improvement Act of 1970 (title II of Public Law 91-224) further emphasizes congresssional interest in improving the environment and the major responsibility that State and local governments have for implementing this policy.

The Flood Control Act of 1970 (Public Law 91-611) requires in Section 122 promulgation of guidelines designed to assure that possible adverse economic, social and environmental effects relating to any proposed project have been fully considered in developing such project, and that the final decision on the project are made in the best overall public interest, taking into consideration the need for flood control, navigation and associated purposes, and the cost of eliminating or minimizing such adverse effects and the following:

(1) air, noise, and water pollution;

(2) destruction or disruption of man-made and natural resources aesthetic values, community cohesion and the availability of public facilities and services;

(3) adverse employment effects and tax and property value losses;

(4) injurious displacement of people, businesses, and farms; and

(5) disruption of desirable community and regional growth.

The same Act also includes in Section 209 the following statement: "It is the intent of Congress that the objectives of enhancing regional economic development, the quality of the total environment, including its protection and improvement, the well-being of the people of the United States and the national economic development are the objectives to be including in federally financed water resource projects, and in the evaluation of benefits and costs attributable thereto, giving due consideration to the most feasible alternative means of accomplishing these objectives."

The Rural Development of 1972, Public Law 92-419, provides for improving the economic and living conditions of rural America by broadening and strengthening ongoing programs of financial and technical assistance to farmers and rural communities. It provides for the management of agricultural wastes, storage of water for rural needs, recharge of groundwater, fire protection, long term contract program for land treatment, acquisition of land rights with other Federal funds, farm research, and a land inventory and monitoring program.

The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, establishes the goals that:

(1) the discharge of pollutants into navigable waters be eliminated by 1985;

(2) an interim goal of water quality be provided for the protection of fish, shellfish and wildlife, and for recreation by July 1, 1983;

(3) the discharge of toxic pollutants in toxic amounts be prohibited;

(4) Federal financial assistance be provided to construct publicly owned waste treatment plants;

(5) water quality and areawide waste treatment management planning include multiobjective water resources and land use planning;

(6) regional or river basin (Level B) plans be completed by the Water Resources Council for all river basins in the United States by 1980 (Section 209); and that

(7) a major research and demonstration effort be made to develop technology to eliminate the discharge of pollutants.

The Coastal Zone Management Act of 1972, Public Law 92-583, provides for a comprehensive, long range, and coordinated national program in marine science, to establish a National Council on Marine Resources and Engineering Development, and a Commission on Marine Science, Engineering and Resources; and for annual grants to any coastal State for the purpose of assisting in the development of a management program for the land and water resources of its coastal zone, and for annual grants to any coastal State for not more than 66 2/3 per centum of the costs of administering the State's management program.

Source: Water Resources Council, 1973, Establishment of principles and standards for planning water and related land resources.

APPENDIX C: NATIONAL ECONOMIC DEVELOPMENT OBJECTIVE

The national economic development objective is enhanced by increasing the value of the nation's output of goods and services and improving national economic efficiency.

National economic development reflects increases in the Nation's productive output, an output which is partly reflected in a national product and income accounting framework designed to measure the continuing flows of goods and services into direct consumption or investment.

In addition, national economic development is affected by beneficial and adverse externalities stemming from normal economic production and consumption, imperfect market conditions, and changes in productivity of resource inputs due to investment. National economic development is also affected by the availability of public goods which are not accounted for in the national product and income accounting framework. Thus, the concept of national economic development is broader than that of national income and is used to measure the impact of governmental investment on the total national output. The gross national product and national income accounts do not give a complete accounting of the value of the output of final goods and services resulting from governmental investments because only government expenditures are included. This is especially true in those situations where governmental investment is required to overcome inperfections in the private market. Therefore, national economic development as defined in these standards is only partially reflected in the gross national product and national income accounting framework.

A similar situation prevails where a private investment results in the production of final public goods or externalities that are not exchanged in the market.

Components of the national economic development objective include:

a. The value of increased outputs of goods and services resulting from a plan. Developments of water and land resources result in increased production of goods and services which can be measured in terms of their value to the user. Increases in crop yields, expanding recreational use, and peaking capacity for power systems are examples of direct increases in the Nation's output which result from water and related land resources developments. Moreover, such developments often result in a change in the productivity of natural resources and the productivity of labor and capital used with these resources. Increased earnings from changes in land use, reduced disruption of economic activity due to droughts, floods and fluctuating water supplies, and removal of constraints on production through increased water supplies are examples of direct increases in productivity from water supplies are examples of direct increases in productivity from water and land development that contribute to national output. Development of water and land resources may result in increased production from the employment of otherwise unemployed or underemployed resources, as well as contributions to increased output due to cost savings resulting in the release of resources for employment elsewhere.

b. The value of output resulting from external economies. In addition to the value of goods and services derived by users of outputs of a plan, there may be external gains to other individuals or groups.

Effects on Objectives

For each alternative plan there will be a complete display or accounting of relevant beneficial and adverse effects on the national economic development and environmental quality objectives. Alternative plans will be formulated to optimize their contributions to the two objectives.

Beneficial and adverse effects are measured in both monetary and nonmonetary terms. Estimating these beneficial and adverse effects is undertaken in order to measure and display in appropriate accounts the net changes with respect to particular objectives that are generated by alternative plans.

The priorities and preferences of the various individuals affected will vary and, accordingly, there will likely not be full agreement among all affected on whether certain effects are beneficial or adverse or on the relative trade-offs between objectives. However, when any plan is recommended from among alternative plans, there is an implicit expression of what is considered to be the affected group's priorities and preferences.

Effects on some components of the objectives are generally regarded as favorable. These include, for example, gains in national output. For other objectives and components, however, preferences will differ. This will certainly be true of some of the components making up the environmental quality objective. For such instances, planning provides information which should facilitate planning decisions and reduce conflict over such decisions.

1. Relationship of beneficial and adverse effects to objectives

Beneficial and adverse effects will be identified for national economic development and environmental quality objectives and will be displayed. Also, since beneficial and adverse effects may be of a monetary or non-monetary nature, they may be measured in dollars or in physical, biological, or other quantitative units or qualitative terms as appropriate.

The objectives are not mutually exclusive with respect to beneficial and adverse effects. Comparisons and evaluations of plans require measurement or quantification of similar effects in terms of common standards. The selected standards may be in terms of dollars, acres of land, acre-feet or cubic-feet-per-second of water, miles of trails or streams, number of people, and so on. The nonmonetary measures must include appropriate qualitative dimensions.

2. Incidence of beneficial and adverse effects. The distribution among groups and time of beneficial and adverse effects is an important consideration in the evaluation of plans. Those groups who are affected by a plan should be identified. Those who are benefited or adversely affected by a plan may be located within the planning area or region, or they may be in an area or region immediately adjacent, or they may be in distant regions which are noncontiguous with the planning area. The benefical and adverse effects may also occur immediately or in the future in any of the areas or regions.

3. With and without analysis. In planning water and land resources, beneficial and adverse effects of a proposed plan should be measured by comparing the estimated conditions with the plan with the conditions expected without the plan. Thus, in addition to projecting the benefical and adverse effects expected with the plan in operation, it is necessary to project the conditions likely to occur in the absence of a plan. Economic, social, and environmental conditions are not static, and changes will occur even without a plan. Only the new or additional changes that can be anticipated as a result of a proposed plan should be attributed as beneficial and adverse effects of the plan.

4. Monetary beneficial effects. For many goods and services the conventional market mechanism or simulation thereof provides a valid measure of exchange values, expressed in monetary terms. The values determined by the market may need adjustment to account for imperfect market conditions. Contributions to national economic development and the income component of regional development are of the monetary type of beneficial effects. In addition, certain components of the environmental quality objective can be analyzed in terms of monetary values.

5. Monetary adverse effects. Adverse effects result, just as beneficial effects do, from the implementation of a particular plan. Values for some adverse effects can be based on or derived from actual or simulated market prices. For example, the costs of goods and services used in constructing and operating a project or payment for damages even though no goods or services are being acquired can be derived from actual market prices. The

prices determined by the market may need adjustment to account for imperfect market conditions. Some adverse effects are not represented by actual cash expenditures; but market prices can be used to estimate or derive the appropriate monetary values by use of a simulated market price or by observing market prices for similar goods and services.

6. Nonmonetary beneficial effects. There are many effects which cannot or should not be expressed in monetary values. This is true of many contributions to environmental quality objective.

When effects cannot or should not be expressed in monetary terms, they will be set forth, insofar as is reasonably possible, in approriate quantitative and qualitative physical, biological, or other measures reflecting the enhancement or improvement of the characteristics relevant to the type of effects under consideration.

When specified minimum technical or institutional standards related to the environmental quality objective will be met or otherwise exceeded, they will be explicitly identified.

If particular nonmonetary beneficial effects or services are not amenable to quantitative measurement they should be described as full as possible in appropriate qualitative terms.

7. Nonmonetary adverse effects. There are adverse effects that cannot be valued by market prices and direct compensation for these adverse effects may not be possible. Nevertheless, they should be accounted for by use of appropriate nonmonetary values or described as carefully as possible. The nonmonetary values may be expressed in terms of a physical, biological,

or other quantitative units or qualitative terms.

The adverse effects of a nonmonetary nature will generally be related to environmental quality.

Beneficial Effects on National Economic Development

Beneficial effects in the national economic development account are the increases of the value of the output of goods and services and improvements in national economic efficiency.

1. General measurement concepts. There are two basic sources of increased output of goods and services that contribute toward enhancing national economic development. First, additional resources may be employed using normal production techniques, as, for example, in the application of irrigation water and other associated resources to land for the production of agricultural commodities or in the use of electric power and other associated resources for the production of aluminum. Second, resource productivity changes may be induced by the plan, resulting in more efficient production techniques to be used to achieve a higher level of output from the same resources or the same level of a specific output with fewer resources or the employment of otherwise unemployed or underemployed resources than would be achieved without the plan. In the latter case, the release of productive resources which can be employed elsewhere in the economy for the production of other goods and services ultimately results in an increase in national output as a consequence of a plan. These two sources of increased output may apply to situations in which the plan results in the production of

final consumer goods or intermediate producer goods utilized by direct users; and they may also apply in situations in which firms are indirectly affected through economic interdependence with firms which utilize the intermediate producer goods from the plan.

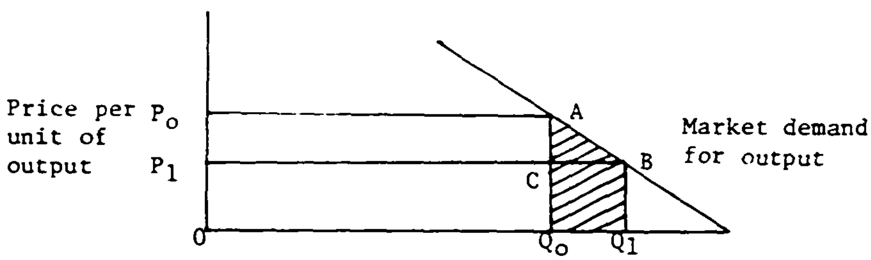
For convenience of measurement and analysis, beneficial effects on national economic development are classified as follows:

a. The value of increased outputs of goods and services from a plan;

b. The value of output resulting from external economies caused by a plan.

In each case, with and without analysis must be applied to ascertain that with a plan there is a net increase in the production of goods and services, regardless of source, over those that would be obtained in the absence of the plan.

The general measurement standard for increases in the national output of goods and services will be the total value of the increase, where total value is defined as the willingness of users to pay for each increment of output from a plan. Such a value would be obtained if the "seller" of the output was able to apply a flexible unit price and charge each user (consumer) an individual price to capture the full value of the output to the user. This concept is illustrated below.



Total Value or Willingness to Pay for Increased Output

Assuming the normal demand-output relationship, additional plan output will be taken by users as the unit price of output falls. If, as a result of the plan, output is increased by an amount $Q_1 - Q_0$, the total value of this additional output to the users is measured by the entire shaded area on the chart. This is a larger amount than would be reflected by the market value. It is the sum of market price times increased quantity (represented by the rectangle CBQ_1Q_0) plus the consumer surplus for that increase (represented by the triangle ABC).

Since, in most instances, it is not possible for the planner to measure the actual demand situation, three alternative techniques can be used to obtain an estimate of the total value of the output of the plan--willingness to pay, change in net income, and the most likely alternative.

If the additional output from a plan is not expected to have a significant effect on price, actual or simulated market prices will closely approximate the total value of the output. This is true because there would be no consumer's surplus. If the additional output is expected to significantly influence market price (as in Figure 1), a price midway between that expected with and without the plan may be used to estimate the total value. This would approximate the willingness to pay, including consumer surpluses, in most cases.

When outputs of a plan are intermediate goods or services, the net income of the (producer) user may be increased. Where changes in net income of each individual user can be estimated, a close approximation of the total value of the output of the plan (including consumer surpluses) will be obtained.

The cost of the most likely alternative means of obtaining the desired output can be used to approximate total value when the willingness to pay or change in net income methods cannot be used. The cost of the most likely alternative means will generally misstate the total value of the output of a plan. This is because it merely indicates what society must pay by the next most likely alternative to secure the output, rather than estimating the real value of the output of a plan to the users. This assumes, of course, that society would in fact undertake the alternative means. Because the planner may not be able to determine whether alternative means would be undertaken in the absence of the project, this procedure for benefit estimation must be used cautiously.

Application of these general measurement standards will necessarily vary, depending upon the source by which output is increased (that is, via direct increases in production or through subsequent employment of released resources), upon the type of good or service produced (whether the output is an intermediate or final good), and upon the type and nature of available alternatives. General measurement methods for each type of situation as well as an indication of the water and land resource plan outputs to which these standards are applicable are presented below.

a. Direct output increases. Direct outputs of water and land resource plans may be in the form of either final consumer goods or intermediate goods. An effective direct or derived demand must exist for the final and intermediate goods, respectively, to include the increased output as a contribution to national economic development.

Certain consumer goods and services may result directly from water projects and be used with no additional production resulting therefrom. Recreation, municipal, water, and electric power for residential use are examples of this type of good or service. Most goods and services produced by water projects are not directly consumed, however, but are intermediate products that serve as inputs for producers of final goods or producers of other intermediate goods. The development of irrigation water for use in producing food and fiber or supplying electric power and water for industry are examples.

The values of increased output resulting directly from plans that produce final consumer goods or services is properly measured as the willingness to pay by final users for such output. When a competitive market price is not directly available, and the increased output will not be large enough to affect prices, total value of output may be estimated by simulated market prices or the use of the cost of the most likely alternative means of producing such final output. Examples of types of outputs to which this method may be applied include:

a. Community and residential water supply;

b. Electric power provided for community and residential use; and

c. Recreation enhancement.

The value of increased output of intermediate goods and services is measured by their total value as inputs to producers of final consumer products. The intermediate product from the plan may enable the producers to increase production of final consumer goods, or reduce costs of production which in effect releases resources for use elsewhere in the economy. In either case, the total value of the intermediate goods or services to the producer is properly measured as the increase in net income received by the producers with a plan as compared with the net income received in the absence of a plan. Net income is defined as the market value of producers' outputs less the market value of producers' inputs exclusive of the cost of the intermediate goods or services resulting from a plan. Examples of types of plan outputs to which this method may be applied include:

a. Agricultural water supply; and

b. Agricultural flood damage alleviation, land stabilization, drainage and related activities.

Where net income changes cannot be directly determined, however, the value of the intermediate goods and services to producers will be measured either in terms of competitive market values, when competitive conditions exist, or approximated by the cost of the likely alternative that the producers would utilize in the absence of a plan to achieve the same level of output. Examples of types of plan outputs to which this method may be applied include:

a. Industrial and commercial water supply;

b. Urban flood damage alleviation;

c. Electric power provided for industrial, commercial, and agricultural uses;

d. Transportation; and

e. Commercial fishery enhancement.

b. Increases in output resulting from external economies. Increased output of individual firms or industries directly affected by the plan may create situations in which related firms or industries are able to take advantage of more efficient production techniques; or consumers may be directly affected by a project (such as through favorable environmental changes). Such productivity changes or technological external economies can be attributed as a benefit to a plan. For example higher levels of output by directly affected firms may enable subsequent processing firms to use more efficient processing techniques and thereby release resources for use in producing other goods and services or permit the higher level of output to be processed with no additional resources.

Present techniques are not well developed for measuring the beneficial effects accruing from external economies. However, in situations where it is thought that the increased output of final consumer goods or intermediate goods used by direct users can be expected to increase the productivity or output of related firms, an attempt should be made to measure the net income change resulting from such externalities. When this is done the methodology should be carefully documented in the report.

2. Measurement of the value to users of increased outputs.

a. Water supply. Plans for the provision of water supply are generally designed to satisfy requirements for water as a final good to domestic and municipal users and as an intermediate good to agriculture and industrial users. Provision of water supply to satisfy requirements in these uses generally requires, either separately or in combination, an increase in water quantity, an improvement in water quality, and an improvement in the reliability of both quantity and quality.

Where it is necessary to use alternative costs for approximation of total value for water supply, as provided herein, the alternative selected must be a likely and realistic alternative directly responsive to achievement of this particular category, namely the additional output of water as an input to industrial, agricultural, and municipal uses or as a final good for community and individual uses. Moreoever, the alternative must be a viable one in terms of engineering and financing and must be institutionally acceptable. It must be more than a hypothetical project. It must be a real alternative that could and would likely be undertaken in the absence of the proposed program, for instance, the reuse or recycling of existing water supplies or the use of available groundwater, including the improvement of its quality, if necessary.

Although water supply can often be considered as a final good, there usually does not exist a market value in terms of price that directly expresses users' valuation of water supply for community and individual use. When this is the case, the total value of the water may be derived using the cost of the alternative that would provide essentially a comparable water supply service, in both quantity and quality, that would in fact be utilized in the absence of the water supply provided by the plan. Where such an alternative source is not available or would not be economically feasible, a market value for the water may be derived on the basis of the price paid by other like users or the average cost of a comparable water service from municipal water supply projects planned or recently constructed in the general region.

The total value of water to the producers using increased supplies is reflected in the change in their net income with a plan for the provision of water supply compared with their net incomes without the plan. It is recognized that for many planning studies it is not possible to either specifically identify net income changes accruing to firms using water supply for productive purposes or always possible to determine what part of a municipal supply is used for productive pursuits or for general community or individual uses as set forth below. In these cases, total value to the users can be approximated by use of the cost of the alternative that would be employed to achieve the same production that would be utilized in the absence of the water supply provided by a plan.

Water supply for irrigation is an input to the production of food and fiber. This may result in a net increase in production of specified products, the reduction in production cost, or a combination of both. Beneficial effects from the application of irrigation water supplies will be based upon total value to agricultural producers and will be measured as the increase in net farm income with and without a plan for providing irrigation water. This may be measured directly as the sum of net incomes of farm enterprises benefiting from a plan for irrigation.

Gross farm income comprises total annual receipts from the sale of crops, livestock, livestock products, and the value of perquisites, such as the rental value of the farm dwelling and value of farm products consumed by the farm family.

Farm expenses are the costs necessary to produce and market farm products and maintain and replace all depreciable items.

Increased net income is measured as the difference between the increase in gross farm income minus the increase in farm expenses analyzed with and without a plan. Changes in net farm income amy be estimated by analyzing changes in gross farm income and expenses for each separate enterprise or by the use of representative farm budgets.

b. Flood control, land stabilization, drainage, and related activities. A number of activities, such as flood control and prevention, flood-plain management, drainage, prevention of sedimentation, land stabilization and erosion control, contribute to the objectives through improving the productivity, use and attractiveness of the Nation's land resources. From the viewpoint of their contribution to national economic development, the effect of these activities on the output of goods and services is manifested by increasing the productivity of land or by reducing the costs of using the land resources, thereby releasing resources for production of goods and services elsewhere. These activities affect land resources in the following manner:

(1) Prevention or reduction of inundation arising from stream overflow, overland waterflow, high lake stages, and high tides, and prevention of damage from inadequate drainage;

(2) Prevention or reduction of soil erosion, including sheet erosion, gullying, flood-plain scouring, streamback cutting, shore or beach erosion, and prevention of sedimentation; and

(3) Prevention or limitation of the uses to which specified land resources will be put.

There are essentially three types of effects on use that may occur as a benefit from including these activities in a plan. The first is an increase in the productivity of land without a change in land use. The second is a shift of land resources to a more intensive use than would occur in the absence of a plan. The third is a shift of land resources to less intensive use than would occur in the absence of a plan. In each case, the general method of calculating benefits is applicable. The distinction is made only to facilitate the application of the general method in different settings and as a means of providing criteria for the use of alternative techniques for estimating net income changes for the three classes of land utilization under the with and without analysis.

The general method to be applied in measuring effects for these and any other activities that result in a change in net productivity or a reduction in the cost of using land resources involves the measurement of the difference in net income accruing to users of land resources benefiting from such activities compared with what these users would earn in the absence of such a plan. This generally defines and establishes the limit of the willingness of users to pay for a plan that results in a change in productivity or reduction in the cost of using land resources.

Willingness to pay of the users, which is the basis for approximating the value of output from these activities, whether it be in the form of increased production of intermediate or final goods or release of resources, may be obtained by the following approaches.

(a) Productivity increase. In this situation, analysis with and without the plan indicates that the current and future enterprises employing given land resources are essentially the same with the plan as they would be without the plan. Further, it is more profitable for the given enterprise to continue to use the given land resource even without the beneficial effect of the plan than to locate at the next most efficient location. Net income change can then be measured as the difference in net income accruing to the enterprise on the specified land resource without the plan compared with what that enterprise would receive as net income with the plan on the same land resource.

(b) Changes in land use. Two situations are covered by changes in land use. These are:

(i) The situation in which the land owner benefiting from the change in land use would only utilize the land resource affected by such activity once the plan has become operative. In other words, it would not be as profitable for the benefiting landowner to utilize the affected land resource unless improved through one of the activities in this category as compared with the next most efficient location. Without such a plan the improved enterprise would occur at an alternative location. Net income change to the landowner will be measured as the difference in net income from the enterprise at an alternative location that would be utilized without the plan compared with the net income received from the enterprise at a new location which is improved or enhanced as a result of the plan.

(ii) The situation in which enterprises that would otherwise employ a given land resource would be precluded from using the given land resources with implementation of the plan. Other enterprises less prone to incur flood damages or other adverse consequences would be allowed to use the given land resources.

Beneficial effects to the enterprises from activities in this category would be evaluated by measuring the net income change for the enterprise precluded from using the given land resources with the plan as compared with the without situation, plus the net income change for the enterprise that would be allowed to use the given land resource with the plan as compared with the without situation.

(c) Estimates of damage prevention and other measures. In the above cases, where it is not possible to directly employ net income changes to derive benefits, the estimate of actual or prospective damages to the physical properties of the enterprises involved can be employed as an approximation of net income change.

In the case of productivity change, where development will be the same with and without the plan, benefits attributable will equal total damages reduced. For the intensive land use cases, where development or use of land will be different with and without the plan, benefits can be approximated as equal to the damages these enterprises could sustain in the absence of protection if lcoated on the affected land.

As a check on benefits derived in the form of net income change or damages prevented, observations of changes in land values for all lands may be employed.

c. Power. With respect to the computation of beneficial and adverse effects of increases in output of electric power it is emphasized that where appropriate, these should be viewed and evaluated as increments to planned or existing systems. Power supplied for general community and residential use can be considered as a final consumer good. Its value as a final good is generally reflected by the satisfaction of individual residents or in terms of improved community services and facilities. Electric power provided to industrial, commercial, and agricultural uses is viewed as an energy input to the production of goods and services from these activities resulting in an increase in the output, reduction in the cost of production or a combination thereof. The total value of electric power to the producers using such power is reflected in their willingness to pay. Where the identification and measurement of willingness to pay and satisfactions accruing to activities using electric power for industrial, municipal, and residential purposes are not possible, total value to the users will be approximated by taking account of the cost of power from the most likely alternative source and using this as the measure of the value of the power creditable to the plan. The alternative selected must be a viable one in terms of engineering, and the financing should be that most likely to the constructing entity. The costs should include any required provisions for protection of the environment. However, since the addition of a hydroelectric project to an electric system in lieu of an alternative power source usually will either increase or decrease the unit cost of producing power by existing generating facilities of the system, this cost differential must be taken into account in determining the power value of the hydroelectric project.

Normally, electric power is evaluated in terms of two components--capacity and energy. The capacity value is derived from a determination of the fixed costs of the selected alternative source of supply. The energy value is determined from those costs of the alternative which relate to and vary with the energy output of the alternative plan. These capacity and energy components of power value are usually expressed in terms of dollars per kilowatt per year of dependable capacity and mills per kilowatt-hour of average annual energy.

d. Transportation (navigation). Plans for the provision of transportation through inland waterways and harbors are established to complement or extend the overall national transportation system within and among regions to achieve an improved movement of goods from the producer to the consumer.

(1) Movement of intermediate or final goods. Transportation as applied to industrial, commercial, and agricultural activities is viewed as an essential service input resulting in savings and creation of utilities in the distribution of intermediate and final goods and services.

The beneficial effects from the movement of traffic are related to the improvements in the transportation services provided enabling the widespread distribution of goods and services, and are measured as:

(a) The savings in the movement of commodities on the waterway when compared with movement via existing alternative modes; and

(b) The expressed willingness to pay by the shippers (producers) of commodity or traffic flow newly induced by a navigation improvement as reflected in the change in their net income.

(2) Where traffic will move in the absence of the waterway improvement. In this situation, navigation studies would include an estimate of the savings to shippers via the considered navigation improvement, measured as the product of the estmiated traffic and the estimated unit savings to shippers from the movement of that traffic via the proposed navigation improvement. The unit savings would be measured as the difference between the charges shippers actually incur for transportation at the time of the study and the charges they would likely incur for transporation via the improvement.

The traffic that is estimated to move via the proposed waterway will be based on a thorough analysis of the existing traffic movements in the tributary area. The potential traffic will be carefully screened to eliminate those movements that are not, for a variety of reasons, susceptible to movement on the waterway. The traffic available for water movement after the screening process is completed will be subject to an analysis of savings as discussed immediately below, and, based on the magnitude of the indicated savings, a decision will be made as to whether or not the movement would be directed to the waterway. Only traffic for which the differences in savings is judged sufficiently large to divert the traffic to the waterway will be included in the estimated waterway traffic. Moreover, as a practical matter, it will be deemed realistic to assume a sharing of the total traffic mvoement among alternative modes rather than to assume complete diversion to the lower cost mode.

The estimate of savings will ordinarily be developed by comparing the full charges for movement from origin to destination via the prevailing mode of transportation with the charges via the waterway being studied where these charges encompass all applicable handling, switching assessorial charges, and net differences in inventory, storage, or other charges due to the change in transportation mode. The alternative modes of transportation to be used in estimating savings to shippers are those actually in use at the time of the study for moving the traffic in question, or, where there are no existing movements, those modes that would most likely be used for such movements. In the latter case, the alternative mode will be chosen on the basis that the shipper would take advantage of the mode affording him the lowest total charges. The competitive, or complementary, effects of existing and authorized waterways not yet constructed, including joint land-waterway routes, should also be taken into account.

(3) Where additional flow of traffic is induced by the plan. By making new sources of supply, or by increasing the net demand for a commodity, the navigation improvement may induce more traffic movement than would be the case in the absence of such improvement. Beneficial effects creditable to the plan for such new traffic are the differences between the cost of transportation by the waterway and the value to shippers, that is, the maximum cost they would be willing to pay for moving the various units of traffic involved.

Where data are available for estimating the value at which various increments of the new traffic could be moved economically, the difference between such values and the charges for transportation by the waterway provides a measure of the estimated beneficial effects attributable to the plan.

In the absence of such data, the probable average charge that could be borne by the induced traffic may be assumed to be half way between the highest and the lowest charges at which any part of it would move. On this basis, the difference between this average and the cost by the waterway applied to the volume of new traffic is the beneficial effect of the plan.

(4) Basis for evalution. Congress has provided the standard for computing the beneficial effects of navigation in section 7(a) of the Department of Transportation Act of 1966, as follows:

> . . . . the primary direct navigation benefits of a water resource project are defined as the product of the savings to shippers using the waterway and the estimated traffic that would use the waterway; where the savings to shippers shall be construed to mean the difference between (a) the freight rate or charges prevailing at the time of the study for the movement by the alternative means and (b) those which would be charged on the proposed waterway; and where the estimate of traffic that would use the waterway will be based on such freight rates, taking into account projections of the economic growth of the area.

Consistent with the approach above outlined, these criteria are the basis on which beneficial effects for waterway plans will be evaluated.

(e) Recreation. As national living standards continue to rise, the average person, with basic needs provided for, uses an increasing percentage of rising real income to satisfy a demand for leisure time and outdoor recreational activities such as swimming, picnicking, boating, hunting, and fishing. With general ownership of automobiles and improvement in highways, travel to distant public recreational areas has become commonplace. Consequently, a large and increasing portion of recreational demand, especially that portion which is water-oriented, is accommodate by development of Federal lands and multi-purpose reservoirs which include specific provision for enhancing recreation activities. This is consistent with the requirements of the Federal Water Projects Recreation Act of 1965 (Public Law 89-72), providing for recreation and fish and wildlife as full and equal partners with all other purposes in Federal water projects.

For the most part, outdoor recreation is produced publicly and distributed in the absence of a viable market mechanism. While the private provision of recreation opportunities has been increasing in recent years, analysis of recreation needs is conducted in the absence of any substantial amount of feedback from effectively functioning markets to guide the evalution of publicly produced recreation goods and services. Under these conditions--and based on a with and without analysis-- the increase in recreation provided by a plan, since it represents a direct consumption good, may be measured or valued on the basis of simulated willingness to pay. In computing the projected recreation demand, however, the analysis should take explicit account of competition from recreation opportunities within the area of influence of the proposed plan.

There are in existance a number of methods, or approaches, to approximating demand and what people are willing to pay for outdoor recreation. A generalized methodology encompassing the travel-distance approach is set forth below.

(1) An analytical approach relating travel cost to distance. Using marginal travel costs (i.e., variable costs of automobile operation directly related to the number of miles driven) taken as a measure of what people are willing to pay for water-oriented recreation and how price effects use, the relationship between price and per capita attendence can be established for recreation stites and market areas. This relationship, the conventional demand curve having a negative slope, sums up the response of users' demand to alternative prices of the recreational product (or experience). Separate demand curves are constructed to reflect each kind of recreation use, whether day-use travel, camping-use travel, or other. If there is no entrance charge at the project, per capita rates for each distance or travel cost would be consistent with the constructed demand curves.

If a fee is charged, however, the cost to the recreationist would then be equal to the fee plus his travel cost, thus diminishing the per capita use rate. Applying a range of reasonable entrance fee charges to the constructed demand schedules, additional separate day-use and camping demand curves, for sites are consturcted to determine respective attendence which may be expected under such conditions. Following this, initial project year day-use and camping-use values are computed by measuring the area under their respective demand curves. These values can be compared with market projections and existing capacities to determine if actual site demand will materialize. The initial year values are then projected throughout the life of the project consistent with the calculated recreational use predictions. The resultant figures, total values for day use and camping use over the life of the project are separately discounted at the prevailing discount rate established by these standards to obtain average annual equivalent values.

(2) Other approaches. A variety of other approaches may be taken toward the evaluation of recreation goods and services. In general, however, no one method is completely satisfactory to the exclusion of all others. The applicable rule to follow, taking cognizance of the unique circumstances of a particular setting, including the availability of actual market data and experience, is to use that procedure which appears to provide the best measure or expression of willingness to pay by the actual consumer of the recreation good or service provided by the plan.

In the interim, while recreation evaluation methodology is being further developed, the following schedule of monetary unit values may be used in the preparation of plans.

(3) Simulated prices per recreation day. A single unit value will be assigned per recreation day regardless of whether the user engages in one activity or several. The unit value, however, may reflect both the quality of activity and the degree to which opportunities to engage in a number of activities are produced.

Type of Outdoor Recreation Day	Range of Unit Day Values
General	$0.75 - $2.25
(A recreation day involving primarily those activities attractive to the majority of outdoor recreationists and which generally require the development and maintenance of convenient access and adequate facilities.)	
Specialized	$3.00 - $9.00
(A recreation day involving primarily those activities for which opportunities, in general, are limited, intensity of use is low, and often may involve a large personal expense by the user.)	

Two classes of outdoor recreation days, general and specialized, are differentiated for evaluation purposes. Estimates of total recreation days of use for both categories, when applicable, will be developed.

The general class, constituting the great majority of all recreation activities associated with water projects, embraces the more usual activities, such as swimming, picnicking, boating, and most warm water fishing.

In view of the fewer alternatives available and the likelihood that higher total costs are generally incurred by those engaged in hunting and fishing activities compared with those engaged in other types of outdoor recreation, it may be anticipated that the monetary unit values applicable to fish and wildlife recreation will ordinarily be larger than those applied to other types of recreation.

The special class includes activities less often associated with water projects, such as big game hunting and salmon fishing.

A separate range of values is provided for each class in order that informed judgement may be employed in determining the applicable unit values for each individual project under consideration. Where considered appropriate, departure from the range of values provided is permissible if a full explanation is given.

(f) Commercial fishing and trapping. Water and land resource plans may include specific measures designed for the purpose of enhancing the fish and wildlife resources and associated opportunities for the direct harvesting of fish and game as a commercial product. Beneficial effects to commercial fishing, hunting, and trapping consist of the value of an increase in the volume or quality of the products expected to be marketed. This increase is determined by comparing values of future production with and without the plan.

The beneficial effects from the increase in output of fish and wildlife products resulting from a plan is measured as the total value to the final users of the output reflected by the applicable market price, minus the expenditures incurred to obtain the fish or game.

(g) Other program outputs. In addition to the more common outputs which have been dealt with in the preceding sections, plans may produce other goods and services which contribute to national economic development. Proper application of the measurement standards to these additional outputs should be guided by analogy to the outputs which have been discussed. Care must be exercised in defining types of outputs to assure that overlapping categories are not used which lead to duplication in the estimates of beneficial effects.

(3) Measurement of increases in output resulting from external economies. Technological external economies are the beneficial effects on individuals,

groups, or industries that may or may not benefit from the direct output of the project. They result from a plan if an increase in the output of final consumer goods or intermediate goods takes place beyond that which would be obtained in the absence of the plan and over and above direct outputs of the plan. This increased output may result from firms which are economically related to the plan taking advantage of more efficient production techniques and thereby releasing resources for use in producing other goods and services. The change in net income of the economically related firms will be used as an indicator of the value of this type of national economic development effect. Changes in the total value of consumer goods due to externalities because of a plan can be accounted for by using measurement techniques like those described above.

If society would obtain the project output of final consumer goods or the output of firms that utilize the intermediate goods of the project from some other source in the absence of the project, then the net income position of the related firms would be unaffected by the plan.

Some examples of potential situations for the occurrence of the external economies associated with final consumer goods and intermediate produced goods are presented below.

(a) Final consumer goods. Provision of additional recreation opportunities and fish and wildlife enhancement for the direct enjoyment of individuals may enable merchants of sporting goods and other suppliers of recreation equipment and services to increase their sales and net income. However, to the extent that the increased expenditures for outdoor sporting equipment and other outdoor recreation services substitute for some other consumer expenditures, there is no real gain in the Nation's output.

The provision of either water supply or electric power for community and residential use will not generally stimulate external economies to enhance national economic development. It is usually assumed that the necessary quantities of these outputs will be provided by some alternatives means in the absence of the plan. As a consequence, firms that are economically related to consumers through the consumption of these projects will experience the same econonic conditions and have the same net income without the plan as compared with the plan.

(b) Intermediate producer goods. The utilization of intermediate goods and services from the plan by direct users may enable them to expand their output. Increased levels of output by direct users of the output of a plan may, in turn, enable economically related firms to improve the efficiency of their operation and/or expand their output and, as a result, increase their net income. Measurement of the change in the net income position of related firms should be made, if it can definitely be established that a change in output by the direct users will generate a corresponding income change for the related firms.

An evaluation should be made of the output levels that will be achieved by the direct users with the plan and without the plan. If the direct users would obtain the same good or service from some other source in the absence of the plan, no external economies occur and the net income position of the related firms would be unaffected by the plan. Some examples of types of plan outputs to which this standards may be applied are presented below.

In situations where water supply is an intermediate good, its utilization by direct users may stimulate more inputs to be acquired from supplying firms, and if there is an increased output from the enterprise of the direct user additional output will be processed by related processing firms. Except for irrigation water supplies and a few industries with high water requirements, water represents a relatively small consideration in the management decision of firms. If firms or industries with relatively small water requirements would obtain their necessary water from some other source in the absence of the plan, no external economies should be included in the calculation of water supply benefits.

The provision of flood control, land stabilization, drainage, and related programs may affect the productivity of and resources resulting in increased levels of output by firms directly affected by the plan. Net income changes may also occur in economically related firms. Measurement of the net income change of the related firms should be made if it can be definitely established that a change in output by the direct users will generate a corresponding income change for the related firms. However, if the plan merely enables economic activities to shift to new locations resulting in more efficient production but no change in total output, then no external economies occur and no attempt should be made to measure net income changes of related input supply or output processing firms.

Electric power provided for industrial, commercial, and agricultural uses will frequently result in higher levels of output from these economic sectors. However, if alternative electric power or alternative energy sources would be utilized in the absence of the plan, the level of output would be unaffected and no external economies would accrue as a benefit to the plan.

To the extent that navigational facilities provide alternative transporation services that would otherwise be provided in the absence of the project, no external economies occur. In situations where the navigational facility provides a unique service, such as providing movement of bulky raw materials that would not otherwise be made available, external economies may occur to the firms economically related to the shippers.

4. Special beneficial effects from use of unemployed or underemployed labor resources. The effects of the use of unemployed or underemployed resources conceptually should be treated as an adjustment to the adverse effects of a plan on national economic development. Since this approach leads to difficulties in cost allocation and cost sharing calculations, the effects from the use of such resources should be treated as an addition to the benefits resulting from a plan.

Beneficial effects from the utilization of unemployed or underemployed labor resources may occur as a result of the plan through employment in the construction or installation of the plan.

The Council, considering data from its economic projections and the economic and rural development programs, will designate planning regions in which unemployed or underemployed labor resources exist.

Where the planning region has been designated as having unemployed or underemployed labor resources and it can be shown that these labor resouces will in fact be employed or more effectively employed in construction or installation of the plan, the net additional payments to the unemployed or underemployed labor resources should be measured as a benefit.

Adverse Effects on National Economic Development

Achievement of beneficial effects on national economic development, and or environmental quality, requires resources to be diverted from alternative uses. The adverse effects on national economic development are the economic value that these resources would have in their alternative uses. Generally, market prices provide a valid measure of the values of goods and services foregone in alternative uses. Both public and private costs associated with the plan will be measured to indicate the total adverse effect on national economic development incurred to realize the desired objectives.

1. Sources of adverse effects. Water and land resource plans result in adverse effects to national economic development in two ways.

a. Resources required or displaced to produce final or intermediate goods and services. In situations where a physical structure is necessary to obtain the desired objective, the adverse effects on national economic development include all explicit cash expenditures for goods and services necessary to construct and operate a project throughout a given period of analysis. They consist of actual expenditures for construction; transfers from other projects, such as costs for reservoir storage; development costs and interest during construction. If the output of the plan is an intermediate good or service, the associated costs incurred by the intermediate produce user in converting it into a marketable form will be measured. These associated costs are borne by the user of the plan output but nevertheless, represent resource requirements necessary to convert the project output into a product demanded by society. Examples are production costs incurred by users of plan outputs, and costs to other producers or to processors that arise in conjunction with the physical flow of the output of the plan. Associated costs should be deducted from the value of gross outputs to obtain net beneficial effects to be compared with the national economic development adverse effects of a plan. These adverse effects occur as a result of certain resources being released and subsequently unemployed as a result of the implementation of the plan.

In situations where nonstructural measures are used to obtain the desired objective, the adverse effects on national economic development will include payments to purchase easements or rights-of-way and costs incurred for management arrangements or to implement and enforce necessary zoning. In some cases, actual cash expenditures will not be involved as when local communities are required to furnish lands, easements and rights-of-way.

b. Decreases in output resulting from external diseconomies. External diseconomies are adverse economic effects of a plan that are not reflected in market prices of project inputs. They result when provision of goods and services for one group necessarily results in an undesirable effect or disservice for another group. For example, the return flow from an irrigation project may create a salinity condition for downstream water users, forcing them to adopt higher cost water treatment practices. These adverse effects (external diseconomies) are not compensated, yet they should be taken into account when deciding on the desirability of a plan.

Another type of external diseconomy may occur if the plan has the direct effect of reducing the output of some firms in the project area, and this reduction causes firms that are linked to the directly affected firms to become less efficient in their operation. For example, the reduction in output by a group of firms which have their output processed by another firm may result in an inefficient operation by the processing firm.

A third type of external diseconomy may occur if the plan has an adverse direct effect on the consumption by individual consumers. For example, if a plan is instrumental in increasing congestion or pollution which results in increased costs to the consumers, this effect should be taken into account in plan evaluation.

c. Cost adjustments. A special case of benefits from cost adjustments arise when a plan creates an opportunity to use resources that would be unemployed or underemployed in the absence of the plan. These resources can include labor, fixed capital, or natural resources. Utilization of such unemployed or underemployed resources may come about (a) as a result of implementing a plan, including construction, operation, maintenance or replacement; (b) as a result of the use of intermediate goods and services resulting from the plan; or (c) as a result of expansion of output by firms who are indirectly affected by the installation of the project or indirectly affected by consumers and firms who use final and intermediate goods, respectively. The latter two effects--(b) and (c) above-- occur when use of the output of a plan results in the employment of unemployed or more effective employment of underemployed resources. Increased national output results in this situation, since with a plan otherwise unemployed or underemployed resources are in effect substituted for resources that would have been drawn from productive activities elsewhere. The market value of the increase of such production will be measured as the difference in the earnings accruing to otherwise unemployed or underemployed resources with a plan as compared with their earnings without a plan. Because of measurement problems, only benefits arising from the use of otherwise unemployed or underemployed labor resources in construction or installation of the plan, will be estimated for the national economic development account.

2. Measurement of adverse effects.

a. Resources required for or displaced by the plan. Resource requirements of the plan are the sum of the market values of the goods and services used for installation; interest during contruction; operation, maintenance, and replacement; and induced costs as defined below.

Installation costs are the market values of goods and services necessary to implement a plan and place it in operation, including management and organizational arrangements, technical services, land, easements, rights-of-way, and water rights; initial and deferred construction; capital outlays to relocate facilities or to prevent or mitigate damages; transfer of installation costs from other projects; and all other expenditures for investigating, surveying, planning, designing, and installing a plan after its authorization.

Operation, maintenance, and replacement costs are the market values of goods and services needed to operate an installed plan and to make repairs and replacements necessary to maintain the physical features in sound operating condition during their economic life.

b. Decreases in output resulting from external diseconomies. While external diseconomies are difficult to measure and the effects are incidental to the project, they are nevertheless recognized adverse effects.

Induced costs are all significant adverse effects caused by the construction and operation of a plan expressed in terms of market prices and whether or not compensation is involved. Compensation for some induced costs is neither required nor possible. Induced costs include estimated net increases in the cost of government services directly resulting from the project and net adverse effects on the economy, such as increased transportation costs.

Source: Water Resources Council, 1973. Establishment of principles and standards for planning water and related land resources

APPENDIX D: ENVIRONMENTAL QUALITY OBJECTIVE

The environmental objective is enhanced by the management, conservation, preservation creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems in the area under study and elsewhere in the Nation. This objective reflects society's concern and emphasis for the natural environment and its maintenance and enhancement as a source of present enjoyment and a heritage for future generations.

Explicit recognition should be given to the desirability of diverting a portion of the Nation's resources from production of more conventional market-oriented goods and services in order to accomplish environmental objectives. As incomes and living levels increase, society appears less willing to accept environmental deterioration in exchange for additional goods and services in the market place.

Responsive to the varied spiritual, psychological, recreational, and material needs, the environmental objective reflects man's abiding concern with the quality of the natural physical-biological system in which all life is sustained.

Components of the environmental objective include the following:

a. Management, protection, enhancement, or creation of areas of natural beauty and human enjoyment such as open and green space, wild and scenic rivers, lakes, beaches, shores, mountain and wilderness areas, and estuaries;

b. Management, preservation, or enhancement of especially valuable or outstanding archeological, historical, biological (including fish and wildlife habitat), and geological resources and ecological systems;

c. Enhancement of quality aspects of water, land, and air by control of pollution or prevention of erosion and restoration of eroded areas embracing the need to harmonize land use objectives in terms of productivity for economic use and development with conservation of the resource;

d. Avoiding irreversible commitments of resources to future uses: While all forms of development and use affect and sometimes change the tenuous balance of fragile aquatic and terrestrial ecosystems, the implication of all possible effects and changes on such systems is imperfectly understood at the present time. In the absence of absolute measures or standards for reliably predicting ecological change, these planning stardards emphasize the need for a cautionary approach in meeting development and use objectives in order to minimize or preclude the possibility of undesirable and possible irreversible changes in the natural environment;

e. Others. Given its broad and pervasive nature, it is not practical to specifically identify in these standards all possible components of the environmental quality objective. If other components are recognized, they should be explicitly identified and accomodated in the planning process.

Beneficial and Adverse Effects on Environmental Quality

A water and land use plan may have a variety of effects--beneficial and adverse--on environmental quality. While effects on environmental quality are characterized by their nonmarket, nonmonetary nature, they provide important evidence for judging the value of proposed plans.

Beneficial effects on the environmental quality account are contributions resulting from the management, preservation, or restoration of one or more of the environmental characteristics of an area under study or elsewhere in the

Nation. Such contributions generally enhance the quality of life.

Adverse environmental effects--generally the obverse of beneficial environmental effects--are consequences of the proposed plan that result in the deterioration of relevant environmental characteristics of an area under study or elsewhere in the Nation, for example, acres of open and green space, wilderness areas, estuaries, or wildlife habitat inundated or altered, or of lands experiencing increased erosion. Such adverse effects generally detract from or diminish the quality of life.

Often, however, an environmental impact of a plan cannot be easily labeled as being beneficial or adverse, since that decision will vary with the perceptions of the individual concerned. In any case, the effect itself should be quantified and displayed for purposes of decisionmaking.

1. Measurement methods. Whether subjectively perceived or objectively measured, the criteria used to describe or evaluate the beneficial or adverse effects of a plan will vary--consistent with the relevant components of environmental quality under consideration. To the extent possible, however, beneficial or adverse effects will be displayed in terms of relevant physical and ecological criteria or dimensions, including the appropriate qualitative dimensions. For example, where the effects of a plan will be visibly evident, quantitative, and qualitative descriptions may be made in terms of established or accepted water and land classification or ecological criteria and related measures.

Where significant physical effects are less easily perceived, it may be necessary to determine their extent through instrumentation or symptomatically by the presence or absence of commonly expected characteristics. As an example, eutrophication of fresh water lakes exemplifies a less easily perceived process that is reflected symptomatically, and which is subject to measurement by instrumentation with statistical analysis of data collected over time.

Therefore, its rate of change is measured by reference to previous dates or periods, with projected rates of future change based on probability analysis. As explicit an account as possible of these effects and supporting analysis should be provided.

Notwithstanding the physical or ecological criteria terms available, certain environmental effects can be presented most effectively by reference to their qualitative dimensions. For instance, it may be necessary to use this approach to show the importance of a reduction in use or availability for use of areas of natural beauty, archeological, or historical significance. Consequently, the analysis should be supported by an appropriate descriptive-qualitative interpretation and evaluation of the effects of the plan on the relevant components of environmental quality.

2. With and without analysis Existing environmental conditions will be described and presented in terms that best characterize the planning perceptions and ecology of the affected area as conditions would exist without any plan. Similar descriptions will be prepared for the time sequence of the conditions to be expected with and without the plan throughout the period of analysis. The conditions before planning is initiated will provide the data from which to evaluate environmental effects--or prediction of change--under alternative proposals, including the consequence of failure to adopt a plan for development and use of resources in the area under study. It should be clear that environmental conditions will not remain static but will, in fact, tend to change over time regardless of whether a plan is adopted.

3. Limitations. It is not presently possible to anticipate or identify, much less measure, all environmental effects or change. Nor are there in existence evaluation standards that permit full and direct quantitative comparisons and ranking of the conditions of identifiable environmental

effects that might be expected to result from a plan. Consequently, reasoned judgments by multidisciplinary teams will be required in many situations. When this is necessary, a frank expression of the state of knowledge and the limitations thereof, as well as the limitations of the analysis in each instance, is essential.

4. Classes of environmental effects. Environmental effects of plans toward the complex of conditions encompassed by the environmental quality objective are best understood and their significance interpreted by evaluating them as separable components. While these are stated in terms of beneficial effects, adverse effects should be read as the converse of each statement. Beneficial effects (and adverse effects) of plans as related to components of the environmental objective are classified and evaluated relevant to:

A. Beneficial effects resulting from the protection, enhancement or creation of open and green space, wild and scenic rivers, lakes, beaches, shores, mountain and wilderness areas, estuaries, or other areas of natural beauty.

With regard to these kinds of resources, beneficial effects on this component of the environmental quality objective are evaluated on the basis of data such as follows, though these are not all inclusive:

1. Open and green space. These are essentially undeveloped, visually attractive natural areas strategically located where most needed to ameliorate intensifying urbanization patterns.

a. Size and measure:

(1) Total acreage (woods, fields, meadows, etc.):

(2) Pattern and distribution;

(3) Juxtaposition to community and urban areas (effect on urban sprawl).

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected open and green space.

c. Improvements:

(1) Accessibility (mileage of public roads or trails provided; easements);

(2) Public amenities (provision for limited facilities, if any);

(3) Other (specify or describe).

d. Protection and preservation:

(1) Physical (fire, bioenvironmental, etc.):

(2) Legal (dedication, easements, institutional, etc.);

(3) Special.

2. Wild and scenic rivers. These are free-flowing streams, with shorelines or watershed essentially or largely undeveloped, which possess outstandingly remarkable scenic, recreational, geological, fish and wildlife, historic, cultural, and other features.

a. Size and measure, including characterization of adjacent primitive or near natural setting:

(1) Total mileage;

(2) White water mileage;

(3) Water quality;

(4) Character and extent or acreage of streamside land;

(5) Juxtaposition to community.

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected wild or scenic river.

c. Improvements:

(1) Accessibility (trails, infrequent roads, or other minimum public access provided; easements);

(2) Public amenities (provision for limited facilities, as boat launching, picnic areas, if any);

(3) Other (specify or describe)

d. Protection and preservation:

(1) Physical (bioenvironmental);

(2) Legal (dedication or withdrawal, institutional, water quality standards, etc.);

3. Lakes. Where their clarity, color scenic setting, or other, characteristics are of special interest, aesthetically pleasing lakes contribute to the quality of human experience.

a. Size and measure:

(1) Surface acreage;

(2) Shoreline mileage;

(3) Cleaning;

(4) Shoreline management, including public amenities;

(5) Other (specify or describe).

d. Protection and preservation:

(1) Physical (bioenvironmental);

(2) Legal (institutional, pollution standards, etc.);

(3) Special.

4.Beaches and shores. The juxtaposition of attractive beaches, distinctive scenic shorelines, and adjacent areas of clean offshore water provides positive public aesthetic values and recreational enjoyment.

a. Size and measure:

(1) Mileage;

(2) Acreage;

(3) Marshland acreage;

(4) Embayments.

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on designated or affected beaches and shores.

c. Improvements:

(1) Accessibility (public orads and trails; easements);

(2) Public amenities;

(3) Nourishment;

(4) Other (specify or describe).

d. Protection and preservation:

(1) Physical (jettys, bulkheads, etc.);

(2) Legal (dedication, institutional, etc.);

(3) Special.

5. <u>Mountains and wilderness areas</u>. Generally occurring at higher altitudes, these pristine areas of natural splendor and scientific interest embrace a very special category of land use. Such areas are designated for the purpose of preserving primeval conditions, as nearly as possible, for aesthetic enjoyment and for limited forms of recreation and other scientific uses.

a. Size and measure:

(1) Acreage;

(2) Biological diversity;

(3) Pattern and distribution;

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected mountain and wilderness area.

c. Improvements:

(1) Accessibility (limited public roads and trails);

(2) Public amenities (limited facilities provided, if any);

(3) Other (specify or describe).

d. Protection and preservation:

(1) Physical (fire, bioenvironmental, etc.);

(2) Legal (dedication, institutional, etc.);

(3) Special.

6. Estuaries. Beyond their critical importance in man's harvest of economically useful living marine resources, many estuaries, coves and bays merit special consideration as visually attractive settings that support diverse life forms of aesthetic value and as marine ecosystems of special interest.

a. Size or measure:

(1) Surface acreage;

(2) Shoreline mileage;

(3) Marshland acreage and shoreline mileage;

(4) Water quality.

b. Biological significance as a nursery, breeding, and feeding ground (name species involved).

c. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected estuary.

d. Improvements

(1) Accessibility;

(2) Public amenities (facilities provided, if any);

(3) Other (specify or describe).

e. Protection and preservation:

(1) Physical;

(2) Legal;

(3) Special.

7. Other areas of natural beauty. These include any other examples of nature's visual magnificance and scenic grandeur, not accomodated in the above-specified classes, which have special appeal to the aesthetic faculties of man.

a. Size or measure:

(1) Acreage;

(2) Mileage.

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on designated or affected areas of natural beauty.

c. Improvements:

(1) Accessibility (public roads and trails; easements);

(2) Screening;

(3) Plantings (seedlings, grassed cover, etc.);

(4) Public amenities (scenic overlooks, if any);

(5) Other (specify or describe).

d. Protection and preservation:

(1) Physical (fire, bioenvironmental, etc.);

(2) Legal;

(3) Special.

Conversely, and in a generally parallel manner, adverse effects of a plan result from the inundation, adverse alteration, or decreases in the availability, use and aesthetic quality of these resources.

B. Beneficial effects resulting from the preservation or enhancement of especially valuable archeological, historical, biological, and geological resources and selected ecological systems.

Excluding ecological systems which are separately evaluated below, beneficial effects on this component of the environmental objective are evaluated on the basis of data such as follows, though these are not all inclusive:

1. <u>Archeological resources</u>. Preservation of these resources provides a continuing opportunity for studying the development of human settlements and understanding man's cultural heritage.

a. Size or measure:

(1) Acreage;

(2) Square footage;

(3) Height or depth from ground level.

b. A descriptive-qualitative interpretation including an evaluation of the effects of a plan on the designated or affected archeological resource areas.

c. Educational:

(1) General education;

(2) Special and scientific.

d. Improvements:

(1) Accessibility (public roads and trails; easements);

(2) Interpretation and monumentation;

(3) Other (specify or describe).

e. Protection and preservation:

(1) Physical;

(2) Legal (dedication, other);

(3) Special.

2. <u>Historical resources</u>. Preservation of these resources provides for the study, understanding, and appreciation of the Nation's origins and the evolution of its institutions as well as its scientific and technical progress.

a. Size and measure:

(1) Acreage;

(2) Number of units (of whatever kind).

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected historical resource area.

c. Educational values:

(1) General education;

(2) Specialist.

d. Improvements:

(1) Accessibility (public roads and trails; easements);

(2) Availability (as appropriate to particular site or materials preserved;

(3) Interpretation and monumentation;

(4) Other (specify or describe).

e. Protection and preservation:

(1) Physical;

(2) Legal (dedication, other);

(3) Special.

3. Biological resources. The opportunity to observe and study biological resources--terrestrial and aquatic--leads to an enlarged understanding and appreciation of the natural world as the habitat of man.

a. Size and measure (wide variating depending on characteristics of particular animal or plant):

(1) Total land and surface acreage and shoreline mileage;

(a) Land acreage (forest, woodland, grassland, etc.);

(b) Water surface acreage and shoreline mileage;

(c) Marshland acreage and shoreline mileage.

(2) Population estimates and characteristics of fish and wildlife to include as nearly as possible:

(a) Age and size classes;

(b) Sex ratios;

(c) Distribution (density).

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected biological resource or resources.

c. Educational:

(1) General;

(2) Special and scientific.

d. Improvements:

(1) Accessibility (public roads and trails, easements);

(2) Habitat enhancement or site improvement:

(a) Sanitation;

(b) Stabilization;

(c) Increasing edges;

(d) Harvesting (to maintain balance with environmental food supply);

(e) Cover planting (species, including number or acreage);

(f) Stocking:

(i) Wildlife (species and number);

(ii) Fish (species and number);

(3) Other (specify or describe):

e. Protection and preservation:

(1) Physical;

(2) Legal (dedication, other);

(3) Special.

4. Geological resources. When of outstanding geologic or geomorphologic significance, preservation of these resources contributes to man's knowledge and appreciation of his physical environment.

a. Size and measure:

(1) Surface acreage;

(2) Subsurface acreage (estimated);

(3) Quantity (estimated in appropriate units).

b. A descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the designated or affected geological resources.

c. Educational:

(1) General education;

(2) Special and scientific.

d. Improvements:

(1) Accessibility (public roads and trails; easements);

(2) Interpretation and monumentation;

(3) Other (specify and describe);

e. Protection and preservation:

(1) Physical;

(2) Legal (dedication, other);

(3) Special.

Conversely, and in a generally parallel manner, adverse effects result from the inundation, deterioration, or disruption of like kinds of resources.

5. Ecological systems. Apart from the contributions which use of the natural resource base makes to man's basic needs for food, shelter, clothing,

and employment opportunities, covered elsewhere, the environmental objective embraces the concept and appreciation of the values inherent in preservation of ecological systems per se.

Each natural area, such as a watershed, a vegetation and soil type, a tidal salt marsh, a swamp, a lake, or a stream complex, represents an ecosystem, an interdependent physical and biotic environment that functions as a continuing dynamic unit, possessing not only intrinsic values but also contributing to the enrichment of the general quality of life in a variety of subtle ways. Conversely, when such natural areas are lost or otherwise diminished in size or quality, there are corresponding adverse environmental effects borne by society.

Beneficial effects resulting from preservation of ecological systems include:

a. The maintenance of a natural environment in a state of equilibrium as an intrinsic value to society;

b. The provision of the purest form of aesthetic contact with nature;

c. Contributions to the development, appreciation, and integration of a "land ethic" or environmental conscience as a part of man's culture; and

d. Scientific understanding derived from the preservation and study of natural ecological systems which contributes to the conservation of natural resources in general, the most important practical application of ecology.

Conversely, adverse effects are the reduction or loss of opportunity to society as a result of a plan.

C. Beneficial effects resulting from the enhancement of selected quality aspects of water, land, and air by control of pollution.

1. Water quality. The beneficial effects of water quality improvements will be reflected in increased value to water users and will be recorded under the national economic development or regional development objective. For example, increases in the value of the Nation's output of goods and services from improvements in water quality will be accommodated under the national economic development objective. A great deal of improvement is needed in the methods of measuring these values.

There will be other water quality beneficial effects, however, that cannot be measured in monetary terms but are nonetheless of value to the Nation. Examples of such benefits are usually in the aesthetic and ecological areas so important to mankind. Beneficial effects from these kinds of improvements are contributions to the environmental quality account and are identified, measured, and described in nonmonetary terms.

Beneficial effects to the environmental quality account from water quality control may be defined in relation to the State standards or goals established under the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). Reservoir storage and flow regulation for water quality may be utilized where it is the least-cost way of meeting these standards or goals.

Consistent with water quality standards or goals established for the affected planning area, water quality control beneficial effects are identified, measured, and described by methods and terms such as:

a. Physical and chemical tests including but not limited to:

(1) Dissolved oxygen;

(2) Dissolved solids;

(3) Temperature;

(4) Acidity/alkalinity;

(5) Nutrients.

b. Biological indicators including but not limited to:

(1) Coliform;

(2) Macro and micro organisms;

(3) Algae.

c. Description: By a descriptive-qualitative interpretation, including an evaluation of the effects of a plan on the aquatic community as a whole.

Conversely, adverse effects will be reflected as departures from the established water quality standards, including related damages, as a result of a plan.

2. Air quality. Air pollution is primarily a regional problem stemming principally from urban centers containing concentrations of people, industry, and transportation. In addition to its diverse social impacts, air pollution causes direct injury to natural environments, including ground cover, trees, and wildlife. In its purely physical dimensions, air pollution is accommodated within the environmental objective.

Beneficial effects to the environmental objective from air quality control may be defined in relation to regional air quality standards established under the Clean Air Act of 1970.

Consistent with air quality standards established for the affected planning area, air quality control beneficial effects are identified, measured, and described by;

a. The amount and use of open space between sources of air pollution and concentrations of people to assist in the process of atmospheric dispersion and dilution.

b. Reductions in the use of fossil fuels.

c. Reductions in damages to:

(1) Wildlife:

(a) Species;

(b) Number or density;

(c) Distribution;

(d) A descriptive-qualitative interpretation and evaluation of effects as appropriate.

(2) Ground cover;

(a) Species;

(b) Acreage and density;

(c) Distribution;

(d) A descriptive-qualitative interpretation and evaluation of effects as appropriate.

(3) Forests:

(a) Species or types;

(b) Acreage;

(c) Growth rates;

(d) Distribution;

(e) A descriptive-qualitative interpretation and evaluation of effects as appropriate.

d. Enhancement of possiblities for visual enjoyment and aesthetic appeal of natural settings and scenic landscapes.

Conversely, adverse effects will be reflected as departures from established air quality standards, including related damages, as a result of a plan.

3. Land quality. Where erosion is prevalent or spreading--largely because of inadequate land use planning and management--it, among other things, seriously detracts from the general use, appreciation, and enjoyment of terrestrial and aquatic environments.

As encompassed in the environmental quality objective soil is valued as a basic national resource rather than for its more traditional role as a primary production factor contributing to increases in national output.

Beneficial erosion control effects improving the visual attractiveness of the natural landscape include:

a. Reductions in sediment on beaches and public recreation areas;

b. Reductions in turbidity and sediment pollution of water in rivers, streams and lakes;

c. Restoration of cull banks from strip mines and other eroded sites;

d. Bank stabilization on mainline and secondary roads.

Conversely, adverse effects will reflect any increases in sedimentation, bank sloughing, or other kinds of erosion resulting from a plan.

D. Beneficial effects resulting from the preservation of freedom of choice to future resource users by actions that minimize or avoid irreversible or irretrievable effects or, conversely, the adverse effects resulting from failure to take such actions.

While the previous discussion and outline of effects of the various components has been organized essentially in terms of programs or actions affecting environmental conditions, it may also be useful to view environmental effects of a plan in broad categories emphazing the predominant considerations of each, whether aesthetic, ecological, or cultural. Following such a classification, aesthetic values in the environment generally encompass lakes, estuaries, beaches, shores, open and green space, wild and scenic rivers, wilderness areas, and other areas of natural beauty; ecological values in the environment generally embrace the physical quality of water, air, and land (erosion), biological resources, and interrelated ecological systems; and cultural values in the environment are generally accommodated by historical, archeological, and geological resources. As this system of classification is not mutually exclusive, however, it is possible for multiple public values to be reflected within each of the components.

Source: Water Resources Council, 1973. Establishment of principles and standards for planning water and related land resources.